PROCEEDINGS

of the

THIRD ANNUAL RECENT GRADUATE CONFERENCE

AMERICAN ASSOCIATION OF BOVINE PRACTITIONERS

February 20-22, 2020

Columbus, Ohio

AABP
1130 E. Main St., Suite 302
Ashland, Ohio 44805
Tel: (419) 496-0685; Fax: (419) 496-0697
e-mail: aabphq@aabp.org
http://www.aabp.org

EDITOR:
ROBERT A. SMITH, DVM
3404 Live Oak Lane
Stillwater, Oklahoma 74075
Cell: (405) 747-9133
Fax: (405) 743-8422
cowdr@sbcglobal.net

PUBLISHER:
VM PUBLISHING COMPANY, LLC
205 W. 7th Avenue, Suite 201
Stillwater, Oklahoma 74074
Tel/Fax: (405) 533-1883
kellijo.vmpubco@gmail.com

 ISSN 1079-9737

Table of Contents

French translations by Mr. Guy Beauchamp. Revisions by Dr. Emile Bouchard.

Confidence comes with time and the time is now!

W. Mark Hilton, DVM, PAS, DABVP (beef cattle)
Technical Consultant, Elanco Animal Health, West Lafayette, IN 47906

Abstract

A lack of confidence is a common concern among recent veterinary graduates. We as professionals can build our confidence through practice, asking questions, discovering more about the client's business, and asking their goals. All of these things add to the building of trust between doctor and client. As trust grows, our confidence grows.

Key words: confidence, goals, consultation, trust, mentor

Résumé

Un manque de confiance est une préoccupation fréquente chez les vétérinaires nouvellement diplômés. En tant que professionnels, nous pouvons bâtir notre confiance par la pratique, en posant des questions, en découvrant plus de choses sur les affaires de nos clients et en leur demandant leurs buts. Tous ces éléments permettent le développement d'une relation de confiance entre le docteur et le client. Lorsque la confiance se renforce, notre assurance s'améliore.

Introduction

A quick Google search gives the definition of confidence as "a feeling of self-assurance arising from one's appreciation of one's own abilities or qualities" and gender appropriately gives the example "she's brimming with confidence"

Confidence can be described as a belief in oneself, that one has the ability to meet life's challenges and to succeed, and acting in a way that conveys that belief. Being confident requires having a realistic sense of one's capabilities and feeling secure in that knowledge.[3] Confidence is the felt sense of a "can-do" attitude.[4]

Projecting just enough confidence helps people gain credibility, make a strong first impression, deal with pressure, and tackle personal and professional challenges. It is also attractive interpersonally, as projecting confidence helps put others at ease.[3]

So, is 'success' always feeling confident? If so, then you are surely overconfident. There will absolutely be times in your career that you ***need*** to feel underconfident. Some examples would include seeing a problem or case you have never seen before, a surgery that has an unexpected finding well into the procedure or being questioned on your thoughts/ideas by a very experienced owner. The list could go on and on. Practice tip: when you are asked how many times you have done a procedure when it is actually your first time, simply say, "You don't even want to ***know*** how many times I have done this." Adding hand motions will further dramatize your point.

You and the people around you impact your confidence. What can you do to influence how others see you if you want to become an asset to others? What can you do so they may react to you in a positive manner? Some ideas are, be honest, humble, transparent, empathetic, interested and positive. Ask your clients their goals and follow with "how can all of us at ABC Veterinary Clinic help you to achieve your goals?" Say "thank you", make deposits into their 'emotional bank account' and give them a compliment whenever deserved. An example is that after a successful OB call I always turn to the producer, shake his or her hand and say, "This is your success. Thank you for calling quickly so ***we*** could get a live calf."

Speak up when your voice is needed. Take actions that move you toward your goals and your owner's goals even if it seems hard to take those risks. With both speaking up and taking action, it is not that you have confidence and then speak or do something; instead, it is through speaking and taking action that you develop confidence.[4] Doing these things allows you to earn the trust of others and this is the key to solidifying your role as a confident advisor for their business.

If we are asking the client their goals, we also need to know our goals. What is your goal for improving your confidence? Our profession has a suicide rate well above average in the US. Female veterinarians were 3.5 times and male veterinarians were 2.1 times more likely to die from suicide compared to the population as a whole.[6] When people are sufficiently convinced that their lives will not get better, they may consider the possibility that life is not worth living. Of course, the point at which they will be most tempted to end it is the point at which they feel most pessimistic about the value of their lives.[5] Becoming more confident (if that is needed) will allow us to see that what we do has value, that our life has value.

The cost of underconfidence is the opportunity cost of adventures not undertaken, delights undiscovered, the life unlived. Therefore, the errors of underconfidence that we make are often invisible because we do not know what we have missed. The careers where we would have been successful do not unfold.[5] I often told our sons as they were growing up that they will have more regrets from saying "no" than from saying "yes". The point was to stretch them. Yes, get a summer job in Yellowstone National Park. Yes, study abroad in Denmark. Do not have regrets.

If 1 of your goals of developing more confidence is to strengthen your role as a consultant on the farm, here are some tips that have helped me in my career.

- Learn more about your client's business. I use the

open-ended question, "tell me about your beef/dairy business". "Tell me about _____ is the question that gives me the most information about what is really important to them. You may learn how many generations have been on this farm, why the owner decided on this profession, etc. Take notes so you will have this information for future conversations.

- Ask, "What do you enjoy most about your business?" Notice I always say "business", not "raising cattle", "milking cows", etc. I want to establish the mindset that I am dealing with a business. I need to be a business consultant to them.
- "What keeps you up at night?" This should reveal their biggest frustration. The follow-up question, "What can my colleagues and I at ABC Veterinary Clinic do to help you tackle that concern?"
- "What are your short (1 to 2 years) and long (5 to 10 years) term goals for the business" Write these down and see if there is something on the short term list that you can target for immediate action.
- You need to be the expert in your clinic on something that is important to your client's business and your veterinary business. Group practices should have experts in different areas.
- Join Toastmasters International. This is a service organization that teaches you to have better speaking skills. The additional benefits are that it teaches you to be a better listener and better speaking and listening skills leads to increased confidence.
- You need to have mentors throughout your career. You need different mentors for different needs. If you really want to grow, become a mentor.
- Read books that stretch you. Some that have positively impacted my career are:
  - How to Win Friends and Influence People by Dale Carnegie;
  - Strengthsfinder by Tom Rath;
  - Start with Why by Simon Sinek;
  - The Power of Positive Thinking by Dr. Norman Vincent Peale;
  - Mindset by Carol Dweck;
  - any book by John Maxwell.
- Books recommended by others:
  - The Magic of Thinking Big by David Schwartz;
  - Think & Grow Rich by Napoleon Hill;
  - Daring Greatly by Brené Brown;
  - Awaken the Giant Within by Tony Robbins;
  - Quiet Strength by Tony Dungy.
- Ask for advice, not feedback. Advice means "how can I improve", feedback asks, "what did I do well".

Learn about your clients as humans. These are great questions to ask early in your working relationship:

- "Tell me about your family"
- "Do you have any hobbies?" (could be a trap for an overworked dairyman). A better question may be, "What do you enjoy doing when you are not working?"

Later in the relationship, ask, "What is a fun fact that I might be surprised to learn about you?" The key to all of these questions is to show that "it is better to be ***interested*** than interesting" as my Grandfather always said.

On sick animal calls, my first question is always, "When was the last time the animal was perfectly normal?" and not, "When did you notice she was sick?" The former question does not make the owner feel guilty about possibly missing the animal's plight for a day or two. Our job is not to criticize the owner and make them feel guilty. Our job is to have the best information to solve the case. If we find that we have a client that frequently calls too late, that is something that needs to be tactfully addressed at another time.

Continuing to Grow Your Confidence

William S. Burroughs said, "If you're not growing, you're dying". No matter where you are today in your practice career, if you do not continue to grow you will quickly become obsolete. The pinnacle of your career should coincide with the day you retire. If this is not the case, then you have let someone down. Would you want your physician say, "I am at a point in my career that I feel I can coast from this point forward with no need to continue to learn"?

I am a firm believer that you need to reinvent yourself every so often. I think how often depends on your personality. Do this mean you need to change jobs or change careers? For most people, I would say "No". It might mean adding a Registered Veterinary Technician to your practice and training her to do all of the jobs she can legally do, maybe you have a handful of clients that want you to do employee training or maybe it is becoming the expert in your clinic on growth implant protocols. I think we can all get in a rut by simply perfecting our already excellent skills. We need new challenges to keep us moving forward, building our confidence in new areas.

Veterinary practice is a wonderful career, but it is not wonderful all of the time. That is normal. When I see someone receive an award and they say, "I loved my job so much that I don't feel like I've ever really worked a day in my life" or "Every day of my career has been great day" I wonder "Are they serious?" I have loved all 3 of my careers in veterinary medicine, but I have had some horrible days! Again, I think most would agree that it is very normal to have some bad days. I told our students that took the food animal ambulatory block at Purdue that the goal every day was to: 1) learn something; 2) help someone; and 3) have fun. Most days we achieved our goal.

What if the "bad days" are a significant portion of your work life? This is not normal. If things are not going well at your current job, you have 3 options and 3 only.

1. Change things.
2. Accept that you cannot change things and leave.

3. Accept that you cannot change things and learn to be happy with that.

Option number 1 can become a win-win situation and that is the ideal. The problem is that if the culture is so negative, change is very unlikely to happen. Then number 2 becomes the next best option. "You will become the practice" is a quote I like to use and if the practice is not a "fit" for you, that does not mean you are the problem. You may be the problem, but from my dealings with former students, that is the exception to the rule. If you select option number 3 then you are not allowed to gripe to anyone about your job. You selected number 3 and that does not allow you to lament about your mediocre job to your spouse, parents, co-workers or friends. Notice the last 6 words are "learn to be happy with that".

Earning the Consultant Role

I want to revisit becoming more of a consultant for your herd owners. Your time is now! You have achieved the level of confidence that it takes to earn the trust of the producer.

The key to adding additional service/becoming more of a consultant to your existing clients is to always ask them their goals as has been mentioned previously. Do we regularly do this? Dirks[1] concluded that "Veterinarians that do not clearly seek the views of their clients, often do not fully engage in the advisory process." Their study showed that only 24% of the time did the veterinarian and producer set herd performance goals. Veterinarians who did not set goals indicated that they and the producer 'intuitively knew' what each wanted to achieve, and that the setting of these performance goals was considered 'too formal'. Veterinarians often could not identify a producer's main goal. During on-farm conversations, veterinarians did not actively seek to identify the producers' goals or problems, suggest a co-operative strategy or summarize any advice given.[1] These results should be an embarrassment to any veterinarian that does bovine work. The study also concluded that the veterinarian needs to actively seek out the goals of the producer because the producers did not readily volunteer this information.[1] I am going to repeat this. We must ask the producer their goals! Do not expect the client to offer this information! The awareness of the producer's goals is paramount to compliance by the producer and successful attainment of the producer's goals. If we want to become an asset to the producer, we must stop telling them what to do and instead seek to understand their top priorities for the improvement of their business. Focus on perceived benefits and remove or reduce barriers to successful implementation of a solution.[2] Producers perceive the veterinarian as an appreciated, important, and frequently contacted information source. In this study, producers stated that they appreciated their veterinarian organizing 'producer study groups' to collaborate on specific health issues.[2]

Our practice developed a total beef herd health program and we invited the clients that were a part of that program to a 'year-end' meeting each January. The meeting consisted of a talk on a subject of importance to the group and concluded with a 'round-table' discussion where the producers shared their successes and failures of the previous year. Many of the clients stated that it was the best meeting they attended all year. Producers learning from each other and being leaders in specific areas turned out to be one of our best ideas ever for sustaining and growing our beef cow-calf production medicine program.

Communication/Creating Demand for Advice

The prevention of complex problems requires customized communication strategies as well as an integrated approach. Two factors of producer mindset are the most important behavioral determinants for improvement: believing there is a problem in the herd and belief in the effectiveness of management to solve that problem.[2] These 2 keys become the template on how to initiate a production medicine program. The program needs to be customized to the specific livestock business and the owner must believe that some aspect of their business can be improved with input from the herd health veterinarian. It is imperative that the producer takes ownership in the thought that improvements can be made. To close the loop in production medicine consultation, the solution must be reasonable to accomplish and the owner must validate the solution. The more the owner takes possession of the concern and the solution the more likely the change will happen. If the veterinarian identifies the concern and the producer feels that we are telling them what to do, the chance for success becomes minimal. A DVM friend explains it this way: "If it's my idea, it's a bad idea. If it's your idea, it's a great idea." Ask the producer their goals (ensure they share ownership of the concern), admire the problem and only after thorough investigation finally propose a solution and ask if the solution is reasonable. If a solution is unknown at the time, this is not a concern. Many problems will be complex in nature and will take time for the veterinarian to develop a plan to solve the problem. The key is to respond to the client in a reasonable timeframe with a proposed solution. In my experience, the veterinarian is regarded just as highly if they immediately know the solution or if it comes after some research.

The use of open-ended questions such as "what are your short-term and long-term goals for your agricultural business?" If there are multiple decision makers in the business, these goals need to be universally accepted. Be sure to ask the entire management team so that you can get buy-in from everyone on the team. After the producer states his or her goals, the herd health veterinarian should ask, "How can our veterinary business help you achieve these goals?" It has been my experience that when you ask about goals and how your business can be an asset to your client's business, you develop a stronger relationship. Other businesses that deal with this producer are not asking these questions. The fact

that we are asking them these questions puts us in a stronger position to become an asset to the producer's business.

An improvement in communications skills may be necessary to become more of an advisor to beef and dairy producers. According to dairy producers, veterinarians have difficulties in being proactive advisors and applying essential communication. Jansen et al found that producers say that veterinarians are persistent in their curatively oriented, prescriptive, reactive expert role that prevails in veterinarian–farmer contacts. These producers' advice is that veterinarians should take on the role of coach, sparring partner, and facilitator instead of being merely a technical expert.[2]

Just as veterinarians have different ways of learning and using information, so do producers. Communication strategies need to be customized to the specific learning style of each client. Producers may be segmented into information seekers, do-it-yourselfers, wait-and-seers, and reclusive traditionalists according to Jansen.[2] While 1 beef producer may be quickly convinced to make a herd management change if informed, "you will save $5000/year by limit feeding your hay vs supplying it *ad lib*", another producer might decline because he does not see how the change is possible. While not every producer will heed the advice given, others that initially decline will make changes if you ask additional questions. Asking probing questions will provide a deeper understanding of an issue or topic.

Another key to the communication strategy is to utilize a team of experts, e.g. nutritionist, forage specialist, banker. These outside experts can bring a level of knowledge that the veterinarian does not possess and the veterinarian can then more thoroughly concentrate on areas of their expertise. Another advantage of having additional advisors is that the outside expert may repeat something that was mentioned by the herd health veterinarian in an earlier visit. This suggestion may be made in a similar or different way, but now it is seen or heard in a different light. Even though the advice may be 'old' to the client, the advice may be heard through 'new ears' and may now be taken. The goal is to help the producer achieve success and who gets the 'credit' for helping should not matter. If you are the veterinarian that invited the outside expert in to help the producer reach his or her goals, you will be seen as a more humble and confident leader to the producer. They now see you as the person that 'checked your ego' and was the key to solving the issue.

As a consultant, we must not be impatient when it comes to herd improvements. Even when a client identifies a need and we provide a solution, it may take years to implement the change. Herd concerns are generally long-term problems that may have taken years to develop. A problem that took years to develop will likely take months or years to be fully resolved.

Developing confidence is learnable and actionable.[4] Improvement comes just like any other skill that you wish to develop; you need to practice. Next week, make it a goal to practice developing confidence.

If you have a Monday morning herd check at a dairy where the owner is frustrated with transition cow issues, ask if you could assist with this issue. Let him or her know that you just attended a CE meeting and learned some new information from Dr. K. Fred Gingrich, an expert in this issue. Ask to make an appointment later in the week to thoroughly discuss the issue.

If you have a beef cow-calf herd owner that mentioned that their vaccination protocol seems to be haphazard, call the owner on Monday morning. Ask if you could schedule a time to help them develop a minimalistic but thorough protocol for their herd for the upcoming year. Share that you learned the latest from Dr. Christine Navarre who is known across the US as an expert in beef herd health. Let them know you want to be an asset to their herd and you want them to have the most up-to-date plan for disease prevention possible.

Practice developing confidence again on Tuesday and Wednesday and . . . . . practice building your confidence every day and your satisfaction with your career will continue to grow.

References

1. Derks M, van Woudenbergh B, Boender M, Kremer W, van Werven T, Hogeveen H. Veterinarian awareness of farmer goals and attitudes to herd health management in The Netherlands. *Vet J* 2013;198:224-228.
2. Jansen J, Lam TJ. The role of communication in improving udder health. *Vet Clin North Am Food Anim Pract* 2012;28:363-379.
3. Psychology Today. Available at: https://www.psychologytoday.com/us/basics/confidence. Accessed 11/15/2019.
4. Psychology Today. Available at: https://www.psychologytoday.com/us/blog/emotional-mastery/201903/5-daily-actions-build-your-confidence. Accessed 11/15/2019.
5. Psychology Today. Available at: https://www.psychologytoday.com/us/blog/perfectly-confident/201806/why-you-should-be-worried-about-underconfidence. Accessed 11/15/2019.
6. Tomasi SE, Fechter-Leggett ED, Edwards NT, Reddish AD, Crosby AE, Nett RJ. Suicide among veterinarians in the United States from 1979 through 2015. *J Am Vet Med Assoc* 2019;254:104-112.

Overcoming imposter syndrome

Audrey Ruple, DVM, MS, PhD, DipACVPM, MRCVS
Assistant Professor of One Health Epidemiology, College of Veterinary Medicine, Purdue University, W. Lafayette, IN 47907

Abstract

Feeling like an imposter is commonly reported by veterinary students and new graduates. In fact, this phenomenon is frequently reported by high-achievers in many professions. Several characteristics have been attributed to this complex syndrome, including self-criticism, feelings of insecurity, and the overwhelming surety that one does not really belong in this profession. The imposter syndrome is also a predictor of psychological distress and can negatively impact career advancement. Understanding how this syndrome arises can help to develop strategies that can be useful in overcoming it. This paper introduces some of the causes of imposter syndrome as well as some approaches that can be utilized by veterinarians to increase their resilience and coping skills in order to overcome imposter syndrome.

Key words: imposter syndrome, wellbeing, emotional wellbeing

Résumé

Se sentir comme un imposteur est souvent rapporté par les étudiants vétérinaires et les vétérinaires nouvellement diplômés. En fait, ce sentiment est souvent rapporté par les gens hautement performants dans plusieurs professions. Plusieurs caractéristiques ont été attribuées à ce syndrome complexe incluant l'autocritique, le sentiment d'insécurité et la certitude accablante qu'on n'a pas notre place dans cette profession. Le syndrome de l'imposteur est aussi un prédicteur de détresse psychologique et peut avoir un impact négatif sur les perspectives de carrière. Bien comprendre comment ce syndrome se développe peut aider à développer des stratégies pour le surmonter. Cet article présente certaines des causes du syndrome de l'imposteur de même que certaines approches que les vétérinaires peuvent utiliser pour accroître leur persévérance et leurs habilités d'adaptation afin de surmonter le syndrome de l'imposteur.

Introduction

Imposter syndrome, also known as imposter phenomenon, affects high-achieving individuals. This manifests as a pattern of beliefs that result in them feeling they are less competent than others perceive them to be, despite the measurable success that has been determined by external standards.[1] In fact, they often attribute their success to luck or good timing rather than to their own abilities and intelligence.[1] This can cause them to believe their success is not really theirs, and therefore results in them feeling they are a fraud and they do not belong.[7]

Individuals who experience imposter syndrome do not have a psychological disorder, but these beliefs can cause psychological distress. People affected by imposter syndrome may experience generalized anxiety, lack of self-confidence, depression, perfectionism, cynicism, depersonalization, and burnout.[2,3] Many clinicians have reported feeling paralyzed, which interfered with their ability to make decisions or ask for opportunities or promotions and ultimately led to meaningful career setbacks.[5] Ironically, the more successful an individual becomes, the more symptoms of imposter syndrome they may experience. However, their external appearance of success may also decrease the likelihood that others will identify their distress, and those suffering from imposter syndrome often do so alone.

Causes

Imposter syndrome can feel like an internal problem or a self-inflicted wound. This may be why historical research wrongly associated personality characteristics, such as introversion, and demographic information, such as being a woman or from a minority group, as the causal reasons for why the syndrome occurs.[5] More recently, imposter syndrome has been studied as a reaction to external situations.[4] Under this interpretation, imposter syndrome is seen as a response to a situation that has prompted the generation of fraudulent feelings.[4]

There are reasons to believe that the experience of being educated in a medical school – with either human or animal patients – can actually elicit the response that is interpreted as imposter syndrome. Work completed at Colorado State University showed that veterinary students' levels of personal distress increased during the first 3 years of their training, while their levels of empathy decreased over the same time period.[6] Other work has shown that medical students have a similar drop in wellness indices and a concurrent increase in imposter phenomenon scores during their time in school.[2] Thus, the psychological impact of the experiences endured while training to become a veterinarian may very well be part of the reason we see such a large proportion of people in our profession affected by this syndrome.

How to Overcome Imposter Syndrome

There are individual techniques that can help to increase your resilience and coping skills. A brief list of some of these techniques follows.

Recognize this is not a "you" problem

Veterinarians are trained in a way that may increase the likelihood of feeling like a fraud. Reframing these fraudulent feelings as symptoms of a stressful educational experience might help you to better identify them as inaccurate thoughts rather than internalizing them as truthful.

Talk to others

Peer support has been shown to be an effective way to help normalize the feelings of insecurity and self-doubt experienced by clinicians. Openly and vulnerably talking to others at similar points in their career can increase your comfort with both admitting what you do not know and asking for help from others.

Talk to yourself

Imposter syndrome can manifest as an internalized dialogue that is typically negative and irrational. Disable this negative self-talk by tapping into your rational mind. Remember that only successful, highly-achieving people experience imposter syndrome in the first place.

Align your work with your values

Integration of personal ideals with professional values has been shown to promote personal growth and improve wellness in medical professionals. This helps to build your professional identity and can reduce the feelings associated with the imposter syndrome.

Get comfortable with failure

You will experience failure over and over again in your career. It is truly unavoidable. Reframing these failure events as learning opportunities can help you to grow more fully into your professional role.

Conclusion

Increasing resilience and coping skills can help individuals to overcome imposter syndrome and function more like the professional they were trained to be. It is important to recognize, however, that these practices treat symptoms of a systemic problem, which we should address as a profession in order to decrease the occurrence of imposter syndrome in our new graduates.

References

1. Clance PR, Imes SA. The imposter phenomenon in high achieving women: Dynamics and therapeutic intervention. *Psychotherapy: Theory, Research & Practice* 1978; 15:241–247.
2. Houseknecht VE, Roman B, Stolfi A, Borges NJ. A longitudinal assessment of professional identity, wellness, imposter phenomenon, and calling to medicine among medical students. *Medical Sci Educ* 2019; 29:493-497.
3. Kolligan J and Sternberg RJ. Perceived fraudulence in young adults: Is there an 'imposter syndrome'? *J Personality Assessment* 1991; 56:308-326.
4. Maqsood H, Shakeel HA, Hussain H, Khan AR, Ali B, Ishaq A, Shah SAY. The descriptive study of imposter syndrome in medical students. *International J Res Med Sci* 2018; 6:3431-3434.
5. Mullangi S, Jagsi R. Imposter syndrome: Treat the cause, not the symptom. *J Am Med Assoc* 2019; 322:403-404.
6. Schoenfeld-Tacher RM, Kogan LR, Meyer-Parsons B, Royal KD, Shaw JR. Educational research report: Changes in students' levels of empathy during the didactic portion of a veterinary program. *J Vet Med Educ* 2015; 42:194-205.
7. Slank S. Rethinking the imposter phenomenon. *Ethical Theory and Moral Pract* 2019; 22:205-218.

Tips from a physical therapist

Scott Jeffrey Uhlenhake, PT
Orthopedic Certified Specialist, P.T. Services, Inc. Minster, OH 45865

Abstract

Bovine veterinarians must perform very physically challenging tasks and often disregard simple injury prevention techniques due to such things as a lack of knowledge, prioritizing the animals over themselves, and/or not taking the time to consider options. Applying basic principles of body mechanics while performing essential duties could assist with decreasing stress on their bodies and prevent or at least delay the onset of pain or other symptoms. Additional knowledge regarding topics such as good posture, sleep positioning, and basic orthopedic care including stretching could improve the health of the veterinarian, allowing them to continue providing veterinary care while also being able to participate with activities outside of work as desired. A physical therapist spent significant time with a group of bovine veterinarians providing individual examinations and observing job tasks in a wide range of environments. To be indispensable for the long term, bovine veterinarians must become more aware of HUMAN injury prevention and treatment options for themselves.

Key words: bovine veterinarian, injury care, injury prevention, bovine palpation, birthing calves

Résumé

Les vétérinaires bovins doivent faire des tâches physiques très exigeantes et ignorent souvent des techniques simples de prévention des blessures par manque de connaissance, en mettant les animaux avant eux-mêmes et/ou en ne prenant pas le temps de considérer les options. L'application de principes de base du fonctionnement du corps lors de la performance de tâches essentielles peut aider à décroître le stress sur leurs corps et prévenir ou à tout le moins retarder l'apparition de la douleur ou d'autres symptômes. Des connaissances supplémentaires sur des sujets tels que la bonne posture, la position de sommeil et les soins de base en orthopédie incluant l'étirement pourraient améliorer la santé du vétérinaire lui permettant de continuer à prodiguer des soins vétérinaires tout en l'aidant à participer à des activités en dehors du travail selon son goût. Un physiothérapeute a passé beaucoup de temps avec un groupe de vétérinaires bovins où il a fait des examens individuels et observé les tâches reliées au travail dans plusieurs milieux. Afin d'être indispensables à long terme, les vétérinaires bovins doivent devenir plus conscients de la prévention des blessures HUMAINES et des options de traitement qui leurs sont disponibles.

Introduction

I grew up in Saint Henry in rural west central Ohio. I grew up with a variety of dogs and enjoying sports of all kinds but also regularly spent time helping friends and family with various farming activities. Eventually, I developed an interest in medicine and ultimately chose to attend The Ohio State University and pursue a degree in physical therapy. I am now an orthopedic certified specialist and the industrial rehab director for P.T. Services in west central Ohio. I have 23 years of industrial rehab experience including transitional work programs, functional capacity evaluations, ergonomics assessments, early intervention screenings and employer/employee educational programs. Settings for these services range from a wide variety of factories and trucking companies to medical facilities and office environments. I have also overseen development and operation of an onsite industrial physical therapy clinic.

Why Physical Therapy?

Physical therapists are considered experts in HUMAN anatomy and kinesiology, while also having extensive knowledge regarding orthopedic and neurological pathology. Physical therapists can evaluate and treat a wide range of orthopedic and neurological conditions. Treatment commonly includes a combination of therapeutic exercise, manual techniques, passive modalities, gait/transfer training, and many other methods while educating patients to help facilitate faster recovery and prevent future recurrence. Physical therapists can also apply that knowledge and experience to analyze the ergonomics, body mechanics, and associated risk factors of any activity in any work setting.

In 2000, the American Physical Therapy Association (APTA) House of Delegates provided formal direction for the profession in APTA Vision 2020. Similar to the national healthcare trend, the physical therapy profession was steered towards increasing its involvement in preventative medicine and wellness services.

Direct access for consumers is another component specifically mentioned in Vision 2020. All 50 states now allow patients to seek some level of evaluation and treatment from a licensed physical therapist without a prescription or referral from a physician. Medical insurance companies are recognizing the cost savings associated with direct access to physical therapy, which has resulted in a steadily increasing portion of insurance plans providing coverage for physical therapy services without physician referral.

Background

Veterinarians in a local practice were experiencing increasing complaints of pain and a variety of other symptoms that were causing difficulty performing and/or tolerating work tasks. The owners of the practice took a proactive attitude to benefit both the employees and the practice by contacting me to see if I could help. We discussed intervention options and decided on a multi-faceted approach.

All veterinarians in the practice were offered a physical therapy consultation conducted privately and confidentially in my outpatient clinic. Direct access allowed these evaluations to be completed without physician referral. Evaluations were scheduled for an hour and arranged around the work schedules of the veterinarians.

On-site job analysis was completed in cooperation with 1 of the veterinarians that was having some of the most difficulties. This analysis included a variety of bovine operations including a couple of smaller, family farms in Ohio and an extremely large dairy operation in Indiana, which allowed observation of a range of working conditions.

A meeting was held at the veterinary practice to review findings, observations, and recommendations. This included sharing pictures of the job analysis and discussing ideal body mechanics with each situation. I provided a home exercise program for general preventative purposes which could be used by anyone, even if they did not participate in the individual consultations.

A student from The Ohio State University was in that meeting and later asked me to present the information to a group of students who were interested in large animal veterinary practice. As an OSU alumnus, I was honored to be invited. The students were very attentive and I had a long line of students with questions for me to answer before heading home.

The content of this special project was the starting point for the information in the remainder of this presentation. Modifications have been made and information has been supplemented based upon current evidence-based physical therapy practice.

Ergonomics and Body Mechanics

Ergonomics is fitting jobs and job demands to the capabilities and limitations of the population. The primary goal of ergonomics is to reduce the frequency of illness and injury which reduces associated costs, including monetary and quality of life. Basic ergonomics concepts include maintaining optimal sitting and standing postures as much as possible while also avoiding extreme joint positions, minimizing reaching distances, and reducing the number of repetitive tasks performed within a particular timeframe. Further discussion of this topic is not possible due to my time constraints, but it is also not vitally important because the nature of bovine veterinary practice often doesn't allow for much adaptation of the working conditions. Body mechanics awareness is therefore absolutely crucial to injury prevention.

Whether at home, in a controlled work environment or on the farm, the basic principles of body mechanics should be followed to decrease body stresses and minimize the risk of injury. You should move as close as possible to your work surface or activity to minimize reaching while performing tasks, thereby decreasing stress on the upper extremities and spine. You should also try to balance stress between both arms if possible, but it is completely understandable that some tasks such as palpation are typically completed only with your dominant arm.

Prior to performing lifting and carrying tasks, you should make sure that both the weight and size are appropriate. If you are unsure of the weight, consider opening the container to examine the contents or pushing the container to estimate its weight. When in doubt about your ability to handle an object safely and independently due to weight and/or shape, you should seek out help or separate the task into multiple lifts.

Always lift and carry objects as close to your body as possible to minimize stress on your shoulders and back. Lifting or carrying at arm's length can increase the stress on your spine by as much as ten times compared to performing the task against your body. Heavier and more etitive tasks should be placed between thigh and chest height if possible.

Maintaining the normal gentle spinal curves during lifting minimizes your risk of injury. Injury risk steadily increases as you increase the deviation from ideal spinal posture. To reach an object down low that you intend to lift, you should bend at your knees and hips instead of your spine. Tightening your core muscles by pulling your navel up and in helps support your spine to assist in maintaining the natural curves and decreasing the risk of injury.

You must look down as you are grasping an object you are intending to handle; however, most people make the mistake of continuing to look down while lifting. After securing your grip on the load, you should bring your head up to a level position and look straight ahead prior to lifting. It is also important to breathe out while lifting to prevent the abrupt blood pressure elevation and related heart stress caused by holding your breath in a Valsalva maneuver.

Turning while holding an object is often done incorrectly by twisting the spine. This causes sheer forces on the intervertebral disc, which has been shown to increase the risk of suffering a back injury. Repetitive sheer forces gradually break down the annulus fibrosis portion of the disc and eventually could result in herniation of the nucleus pulposus. Spinal curves can be maintained and rotation can be avoided by taking steps instead of twisting.

All of these concepts were considered as I completed my assessments of the physical tasks involved in bovine palpation and calving.

Bovine Palpation

This task was the primary concern expressed by the veterinarians. Palpation inherently has a risk of significant injury caused directly by the animals. There is also risk associated with the repetitive motion and forces necessary to complete the task on a herd of animals. Ideally, you should try to maintain a position as close as possible with a line between your shoulders almost perpendicular to the bovine spine. To minimize stress on the shoulder joint used for palpation and a wide variety of adjacent structures, you should minimize elevation of the arm and keep the scapula depressed and retracted while also avoiding rotation away from the inserted arm. Insertion force should be applied by stepping or lunging forward, not reaching.

Free stalls pose the biggest danger due to the lack of bovine control. Stepping up onto an available platform decreases shoulder elevation so there is less stress on the shoulder joint and other nearby structures; however, there is an increased risk due to being up on the step. Staying down on the floor surface provides a safer standing position, but it requires increased shoulder elevation and reaching which increases shoulder stress.

Lockups provide more bovine control but there is still risk of lateral movement so you must be ready to move to help prevent sprain, strain or more serious injury.

Rails provide even better bovine control, as well as an opportunity for an ideal insertion position; however, it could cause significantly greater stress if you do not set up this scenario properly. If you have oriented the herd properly and your shoulders are perpendicular to the bovine's spine, your palpation arm should be slightly closer to the rails and the herd. If your body is perpendicular to the rail and you are reaching away from the midline to reach the bovine for palpation, you do not have an ideal setup so you will be palpating in a position that will cause significantly more stress on the upper extremity as well as the spine. Therefore, it is very important to think through these body mechanics prior to lining up the animals in the rails so the ideal scenario is created whenever possible to minimize stress on the body.

Using an assistant to mark the herd prevents prolonged static use of the non-palpating hand for holding the paint stick.

Birthing Calves

Another task in bovine veterinary practice that poses significant risk for injury is birthing calves. The work environment may or may not be modifiable depending upon the farm, the cow or heifer, the urgency of the situation, etc. If the situation is modifiable, your height compared to the height of the animal should be a factor in your decision-making. Consider using a gate, bales or other items to help you get "taller", and therefore closer to the animal.

There are several tasks that warrant some education regarding risk factors, considerations and/or recommendations. First, you all know that grip and other hand strength are very important. You have more grip strength with your elbow in a bent position. Getting as close as possible to your work and minimizing grip with the elbow extended also prevents premature fatigue while decreasing stress on the elbow, thereby lessening the risk of tendonitis.

Pulling directly on the calf, on the chains or on the handle of a calving jack can involve a large amount of force and therefore should be done with caution. First, you should get as close as possible to anything you are pushing or pulling. Keep your elbows close to your body and try to lock in your arm position. A wide, staggered stance with your legs provides you with good stability and allows you to use the power of your legs, which is more efficient and safe than relying on your arms. When there is an option, such as with use of a calving jack, you should push rather than pull. You should absolutely avoid any type of jerking motion or trunk flexion due to the significantly increased injury risk. Be sure to engage your core while you are applying your push or pull force.

Pay attention to the duration of your efforts. You may need to consider alternate interventions such as fetotomy or C-section before you or the animal are completely exhausted.

Driving

I know that some veterinarians can spend a good portion of their day driving. If you are in a good posture while driving, this can serve as a recovery period; however, if you are in a poor posture, it will only continue with stresses which are similar to those experienced while working with the animals. Prior to entering the vehicle and after exiting the vehicle, you should strongly consider stretching of some type.

The most common mistakes with driving posture are cause by poor seat position, such as the seat pan being too far away from the steering wheel and/or the backrest being reclined too far. Each of these mistakes adds to the distance between you and the steering wheel which requires more reaching, and therefore more elbow extension and shoulder protraction with rounding. A forward head position is also often involved and adds stress to the neck.

Trial a seat position that is both closer and more upright, but be sure the legs are still in a comfortable position. You could also consider periodically making small adjustments to your seat position during your workday which will change your body position and the related stresses.

Individual Physical Therapy Consultations

Each veterinarian completed a patient history questionnaire. A subjective examination was performed with the patient describing all symptoms including location, quality, intensity, and duration. Relieving and aggravating factors were also discussed.

It was also very important to ask the right questions to obtain a complete understanding of the related functional

difficulties and limitations, both at work and at home including sleep. This enhanced my ability to help the individual, but also provided some insight into the work environment and specific concerns of the veterinarians prior to doing any direct observation of work tasks.

The objective portion of the examinations included posture assessment, range of motion testing, strength testing, joint mobility assessment, palpation, and tests of provocation.

At the end of the consultation, each veterinarian was educated in the evaluation findings, proper posture, sleep positioning, heat/cold/cream use, and activity recommendations specific for their situation. Individualized home exercise programs were instructed and handouts were provided to assist with follow-through. Follow-up appointments were completed as needed.

Common Conditions Suspected Among the Veterinarians

Provocation tests performed during individual physical therapy consultations are intended to stress specific tissues in an attempt to reproduce and/or relieve the symptoms described by the patient. These tests alone are not sufficient for medical diagnosis, but are typically able to identify high suspicion for certain conditions based upon the test performed and the response of the person being examined. Tests for cervical radiculopathy, thoracic outlet syndrome, shoulder impingement, elbow tendonitis, ulnar neuritis, and carpal tunnel syndrome were regularly positive during the individual examinations.

Cervical Degeneration

Loss of intervertebral disc height and/or arthritic changes can result in a smaller opening for spinal nerves. Nerve impingement may occur which could cause neck pain, muscle tightness, headaches and/or radicular symptoms. Radicular symptoms can include pain, numbness and/or tingling in the scapula, shoulder and/or the remainder of the upper extremity.

Thoracic Outlet Syndrome

This condition could involve a wide range of presenting symptoms and therefore is commonly overlooked or misdiagnosed. Compression of the brachial plexus with or without vascular disturbance can occur within the scalene muscles in the neck, due to pectoralis minor tightness or because of a cervical or elevated first rib. Symptoms can involve any portion or all of the upper extremity including pain, numbness, tingling, muscle weakness, premature muscle fatigue and/or muscle cramping.

Shoulder Impingement

Poor posture, posterior shoulder capsule tightness, and pectoralis minor tightness are common contributors to decreased space for the rotator cuff. The human body can often tolerate this situation for a prolonged period even with repetitive arm use and progressively worse posture as we get older. Eventually, this can lead to rotator cuff tendonitis and eventually could even cause a rotator cuff tear. **Provocation** can be done with the patient raising the arm forward and up as far as possible then someone applying additional pressure into same direction or the patient placing a hand on top of the opposite shoulder, then someone lifting the elbow above shoulder height. Sharp pinching or pain in front of, or on top of, the shoulder with either test indicates suspicion for shoulder impingement.

Elbow Tendonitis

The origin of the muscles involved in the use of the wrist and hand are concentrated in the small areas of the common flexor and extensor tendons at the epicondyles of the elbow. This stress is worsened when these forces are applied with the elbow closer to a fully extended position, which is 1 of the reasons we always advocate for getting as close to your work as possible. Lateral epicondylitis is much more common and known as "tennis elbow", while medial epicondylitis is known as "golfer's elbow". **Provocation** for lateral epicondylitis should be done with the elbow fully extended. If symptoms are more severe, it may only require someone passively bending the wrist fully into flexion. If symptoms are less severe, the person being examined should fully extend the wrist and then attempt to hold that position while someone else attempts to bend the wrist. Lateral elbow pain during either test would indicate suspicion for lateral epicondylitis.

Ulnar Neuritis

Prolonged or repetitive elbow flexion, repetitive gripping and/or long durations of direct pressure can cause inflammation of the ulnar nerve. This inflammation could cause pain, numbness and/or tingling into the 4^{th} or 5^{th} digits of the hand. **Provocation** can be done by someone tapping the ulnar nerve at the elbow and a positive result is tingling into the 4^{th} or 5^{th} digits. The ulnar nerve is located just posterior and lateral to the medial epicondyle in the ulnar groove. **Basic intervention** to control ulnar nerve symptoms involves preventing prolonged elbow flexion greater than 90 degrees while sleeping. This can be done by gently holding a pillow or spouse. In extreme cases, you could purchase a brace/splint or place a rolled towel in the crease of the elbow and hold it in place with an elastic wrap.

Carpal Tunnel Syndrome

Inflammation can cause compression of the median nerve as it passes under the transverse carpal ligament in the anterior wrist. The most common cause is repetitive use of the finger flexors for gripping, and the most common first symptom is waking up regularly with your hands numb and/or tingling. Pregnancy increases incidence due to fluid retention and can even occur if there is no repetitive use. **Provocation** is done by placing the backs of the hands

together in front of you with the forearms horizontal. Apply a steady pressure between the hands for up to 30 seconds while monitoring for numbness and/or tingling into the 1st, 2nd, or 3rd digits of either hand. **Basic intervention** is regular cold pack use immediately after work or other repetitive activity as well as just prior to going to bed. Also, splinting of the wrists while sleeping prevents the natural tendency to maintain a flexed wrist position that restricts space in the carpal tunnel. With a neutral wrist position, you maintain better circulation and more space for structures in the carpal tunnel, thereby improving recovery from daily stresses and decreasing your risk for carpal tunnel syndrome. Some patients are able to limit the use of splints to only those nights after heavier upper extremity use during the day. If you have an episode of waking up with hands tingling, assume a prayer position and symptoms are likely to quickly resolve.

Patient Education Topics

Posture

Proper posture can assist in preventing fatigue and controlling symptoms by positioning joints for ideal weight distribution and optimal biomechanics, thereby minimizing the risk of injury. Poor posture can predispose an individual to conditions such as sprain/strain, tendonitis, bursitis, neuritis, and degeneration of the joints or spinal discs. This can include a wide range of symptoms and related functional limitations.

Assessment of posture can be done by having someone else observe you from the side or someone else could take a picture that you can then examine yourself. Common misalignments include a forward head, rounded shoulders, increased thoracic kyphosis, increased lumbar lordosis, and knee hyperextension. Initially requiring cognitive thought, awareness, and correction of abnormal posture can be difficult and frustrating, but typically it becomes easier over time. The goal is for proper posture to become your "normal" without the need for cognitive thought.

Proper standing posture should be maintained as much as possible during static standing, walking, and all related activities. An imaginary vertical line should connect the earlobe, shoulder, hip, knee and ankle. Proper spinal alignment includes gradual inward curves (lordosis) in the neck and lower back and a gradual outward curve (kyphosis) in the middle back. Proper sitting posture has the same head, torso/spine, and hip alignment while the knees should be bent no more than 90 degrees. The feet should be flat on the floor or another object. Core muscles should be engaged throughout the day in both sitting and standing to help maintain good posture and prevent injury.

With the shoulder in its proper position, a forward head will present with the earlobe in an anterior position compared to the shoulder. To achieve proper alignment, you can perform a "chin tuck" by keeping your eyes level while pulling your head back. Initially, this can be a difficult movement to achieve and it may cause mild stretching in the back of the neck.

Rounded shoulders are often accompanied by an increased thoracic kyphosis. While observing from the side, the shoulder should be pointed directly to the side and the scapulae should be close to a vertical position; however, it is very common for the scapula to be protracted causing the shoulder to be directed forward while the superior portion of the scapulae are also tipped anteriorly. This can be corrected by pulling the shoulder blades back and down at a comfortable intensity. Overcorrection is likely to be uncomfortable, and may cause a change in lower back alignment.

Excessive lumbar lordosis can be caused by protruding abdominal weight, a lack of core muscle engagement, anterior hip muscle tightness and/or knee hyperextension. To correct this abnormal spinal alignment, start by making sure your knees are not in a hyperextended or "locked out" position, which can make core muscle engagement difficult. The knees should be "soft" or slightly bent which decreases knee stress while also making core engagement easier. To engage the core and decrease the inward curve of the lower back, use the abdominal and buttock muscles together to pull the navel up and in to a comfort position called "pelvic neutral". Avoid trying too hard which could cause a strain, excessive flattening of the lumbar curve and/or quick fatigue.

Medial foot arches

Proper arch position, whether obtained through natural structure or maintained by appropriate footwear, is important for the good lower extremity alignment necessary to minimize lower extremity stress and fatigue, which decreases the risk of injury.

To assess your arches, you must be in a standing position with your shoes and socks off. There are a wide range of assessment techniques from simple observation to the very common "wet test" that is advocated by many shoe manufacturers to the navicular drop measurement which is performed by some physical therapists.

"Flat feet" or pes planus is a very common problem that can contribute to a wide range of problems from the foot to the lower back. If you have pes planus, a very simple preventative measure that can be taken is the purchase of proper footwear and/or inserts. Stability tennis shoes provide the additional support needed to maintain a neutral arch position and better lower extremity alignment during standing and walking activities. Stability tennis shoe options can often be identified by consulting a manufacturer's website. Selection of a person's ideal stability shoe is based upon individual comfort due to the differences in support, cushioning, heel width, toe box width, lacing systems, etc.

Increased support can also be achieved by using a custom or over-the-counter insert. Custom inserts can cost up to $800 and often are difficult to get approved by insurance. Luckily, you can usually avoid custom inserts unless you have other problems such as a foot deformity or diabetes. Over-the-counter inserts typically cost $35 to $75, but should be selected carefully because many fail to provide the level of

support needed. I recommend removing the insert from the box, placing it on a hard surface and pushing down on the arch area of the insert with the heel of your hand. Consider how it would support your body weight over the course of a day. Patients commonly ask about the foot assessment kiosks and inserts available in large retail stores. In my opinion, these inserts are not adequate for someone with pes planus.

For people with pes planus, it is very common to need the additional support of an insert inside of a boot used for work due to the lack of support contained in the structure of the boot. I also often recommend people with pes planus avoid or minimize the use of traditional sandals; however, there are several manufacturers that now offer options for sandals that have stability contained within its structure.

"High arches" or pes cavus is much less common and less likely to cause similar problems. If you have pes cavus, your anatomy is providing adequate support so neutral shoes which are typically lighter and more flexible are more popular. Inserts for boots are typically not necessary.

A quality shoe store, often associated with running, typically has knowledgeable staff that can assist with arch evaluation and make recommendations from a wide range of options for shoes and inserts. They also give you the opportunity to try on multiple different options prior to making a choice instead of taking a guess while shopping online. I regularly recommend a locally-owned running store to my patients. Their shoes are not just for runners and you could just use the store as a resource for quality boot inserts. Bring your boots with you!

Sleep Positioning

Good duration and quality of sleep is incredibly important for your health. Recommendations are for 7 to 9 hours of sleep per night for adults and the internet provides a wide range of interventions to improve the quality of sleep. Many medical professionals feel sleep is just as important as eating healthy and exercising. Studies have shown that better sleep can significantly improve speed, accuracy, reaction time, mental well-being, and immune system function while also lowering the inflammation levels that contribute to orthopedic conditions.

Supporting joints in a neutral position while resting decreases joint stress, improves circulation, and promotes muscle relaxation for improved body comfort. This should help you fall asleep faster and stay asleep longer to allow optimal recovery from the physical and mental stresses of your day. Optimal positioning should also make it more likely for you to wake up in the morning and feel ready to go without any initial pain or stiffness.

My patients commonly ask me to make a recommendation regarding a mattress. First, most people keep their mattresses well beyond the recommended 8 to 10 years. I don't endorse a specific manufacturer but I do advise that a common mistake is a mattress that is too soft. If a patient comments about preferring a softer mattress, I ask them to consider a pillow-top mattress which provides a firm mattress with a softer pad on top. Another option for a softer mattress is a bed with adjustable firmness. The mattress industry has changed significantly in the past 5 years with quite a few manufacturers shipping directly to your home and offering free trial periods with free return shipping. This provides consumers with an alternative to typical retail settings and I commonly recommend my patients consider this option.

I educate my patients regarding some basic rules of sleep positioning. First, sleeping on your stomach should be the last option considered for sleeping primarily due to the stress placed on your neck. Second, your elbows should be kept below the level of your shoulders to decrease the stress on your shoulders. Putting your hands under your pillow is typically not a problem. If you sleep on your side, you should first try the side opposite any painful shoulder or hip.

Neck pain is a common patient complaint that hinders good sleep and/or causes difficulty upon waking. Patients sometimes mention rolling up their pillow, but this support is not dense enough and typically does not stay in place. Contour pillows for the neck can be expensive and are typically not adjustable. How can one size of neck roll be the ideal thickness for both a petite woman and a broad-shouldered man? It can't! Therefore, I advocate using a towel roll placed inside the lower portion of the pillowcase of your top pillow. The thickness of this towel roll can be adjusted for an ideal fit to the stature of the individual and there is no associated cost. Typically, this same towel roll can be used whether laying on your back or your side. If you decide to try this towel roll, you may also need to make changes to the number and/or thickness of the pillow(s) being used at your head.

Many patients tell me that they are unable to sleep on their back but are unable to identify the reason. While sleeping on your back with your legs out straight, the weight of your legs pulls down on your pelvis and causes increased pressure in your hips and lower back. I feel this is one common reason that people avoid sleeping supine. Bending the knees and supporting the weight of your legs will decrease this pressure. Patients commonly mention using pillows under the knees; however, pillows typically do not work well because they are too soft and often do not stay in position. I recommend making a tight blanket roll that is wider than your knees to prevent your legs from falling off. The height is also important because it needs to be high enough to relieve the pressure, but you need to avoid making the roll so big that your heels are unable to rest on the bed. You should also consider using 1 unfolded thin pillow under each arm to lift your elbows off the bed and prevent your hands from resting on your stomach.

While sleeping on their side, most people only use pillows at their head. I recommend also using a thin pillow under your top arm to lift your arm off your side. You should also use 1 thick or 2 thin pillows between your knees and ankles, which decreases stress on your lower back and hips.

A common mistake is to put this support only between your knees, which does relieve some stress but fails to achieve optimal positioning. The amount of bend in your knees is based upon personal preference.

Laying on your stomach is not recommended, but it may be the only position that works for some people. While laying on their stomach, people commonly turn their head the same direction when trying to fall asleep. This causes significantly greater stress to 1 side of the neck. Therefore, I recommend using 1 thin or no pillow under your head and alternating which direction you rotate your head while falling asleep in the prone position. The prone position also tends to cause an increase in the lumbar lordosis and therefore increased pressure in the joints of the lower back. You can alleviate this increased pressure by placing a pillow at your waistline that is thicker than what you use at your head. Another option is to place a thin pillow at your waistline but none at your head.

Ideal Resting or Recovery Position

Research studies have measured lumbar disc pressures in various body positions such as proper postures, improper postures, and various resting positions. Higher lumbar disc pressures are caused by slouching in sitting and lifting improperly. The lowest pressure is in what I have labeled the "90-90" position, while others have used the terms "static back" position or "constructive rest" position. This position involves lying flat on your back with your hips and knees bent to 90 degrees, which places your thighs vertically and your lower legs horizontally. A common way to assume this position is to lay on the floor with your lower legs supported on either the couch or an ottoman. This has been most effective for my patients to relieve pain or pressure after prolonged standing, prolonged sitting or an extended duration of heavy activity. A duration of 20 to 30 minutes has been effective and some choose to simultaneously use a moist heating pad during this time. Be sure to avoid falling asleep in this position due to circulation concerns and the potential for a temporary loss of sensation.

Injury Recognition

Muscle fatigue and general soreness should be expected when starting new work tasks, changing work processes or increasing work pace or duration. New aches or pains may also occur intermittently for no apparent reason. If symptoms occur, initiate treatment immediately and perform it consistently to try to resolve the problem. Strongly consider seeking medical attention if your initial symptoms impact your functional ability, symptoms steadily worsen despite basic injury care or there is no improvement with 2 weeks of basic injury care.

Basic Orthopedic Care

Simple first steps include increased awareness of posture, body mechanics, and sleep positioning. It may also be helpful to modify your work schedule such as changing work assignments to provide variety throughout your day, avoiding problematic work on consecutive days or temporarily eliminating problematic tasks.

A well-known guideline for treatment of a new injury is Rest, Ice, Compression and Elevation (RICE), which has been advocated for a long time but there is limited evidence of its effectiveness. Another option is Protection, Optimal Loading, Ice, Compression and Elevation (POLICE). This is a newer line of thought that tries to avoid excessive rest, which can delay your return to normal mobility and activity. Optimal Loading refers to choosing an appropriate lighter activity level and progressing steadily based upon symptoms and common sense. A physical therapist can be a valuable resource to help guide a gradual return to your prior functional level, especially if surgery or a period of immobilization was necessary to treat the injury or condition.

Stretching could be included as another component of basic orthopedic care. It absolutely should be pain-free. Typically, you should start with shorter hold times, less repetitions, and lower intensities. Progression can be made with caution as appropriate and tolerated.

Cold Application

Cold should be used exclusively for the first 72 hours after your initial injury or onset of symptoms. You may continue to use cold packs beyond the 72-hour mark if you feel it is still helpful.

Cold can be applied using a commercial cold pack, bags of frozen vegetables (recommend peas or corn), ice in a plastic bag or a cold pack made using an online recipe. You must have clothing, a towel or another type of material between your skin and the ice to prevent frostbite. Of course, a thinner material such as a pillowcase provides a colder sensation.

Cold application should be limited to a maximum of 20 minutes per hour to prevent frostbite. The remaining 40 minutes of the hour allows the skin to return to a normal temperature prior to reapplying.

Heat Application

Moist heat provides deeper penetration than dry heat. Methods of applying moist heat include hot showers, hot baths, hot tubs or heating pads. Electric heating pads are preferred over microwaveable versions because the user has the choice of several intensity levels and a steady heat is maintained for the entire duration of application. Older electric heating pads should not be made wet due to the risk of being shocked. Newer electric heating pads are constructed differently which eliminates the risk of shock and they have a sponge that is made wet then placed inside the outer cover to provide the moisture.

Heat is an appropriate option when at least 72 hours has transpired since the initial injury or symptoms. Use should be limited to a maximum of 30 minutes per hour to prevent excessive fatigue caused by prolonged heat dissipa-

tion and to allow the skin to return to a normal temperature prior to reapplying.

Cream Application

A wide variety of pain-relieving creams are available to assist with symptom control. You should not apply heat within 3 hours of applying a pain-relieving cream because the heat may cause a reaction with the cream which could result in skin lesions. Therefore, I typically recommend using creams when going to bed to assist with sleep and/or when leaving home to improve tolerance to activities such as work, running errands or a prolonged ride in a vehicle.

Stretching

Benefits of stretching include decreasing tension in tight muscles, improving circulation, and making it easier to assume better posture. Tightness and related abnormal postures cause increased stress on muscles, tendons, and nerves. Therefore, stretching helps prevent injuries and conditions that can occur during home activities, work tasks, exercise, etc.

Research shows benefits for both dynamic and static stretching. I have found that a dynamic warm-up followed by static stretching is effective as a pre-work program with my various clients. The dynamic warm-up increases blood flow and warms up tissues prior to performing the static stretching. Dynamic warm-up should start relatively slowly within a small range of motion and then gradually increased in speed and range within individual tolerances. Be careful to avoid any discomfort or loss of balance. Examples of dynamic warm-up include squatting combined with an overhead reach, backwards arm circles, leg swings, and back rotation.

Static stretching should be held for a minimum of 15 seconds to improve flexibility but up to 30 seconds is relatively common. Typically, each stretch is completed several times within a session but a single stretch is better than none. Rest time is necessary between stretches, so typically I recommend alternating sides with the same stretch or alternating between 2 different stretches on the same side. You should always stop when you reach a strong, comfortable stretch and hold that position without bouncing or trying to go any further. The motto of "No pain, No gain" should never be applied to stretching.

To aggressively attempt to gain flexibility, I recommend completing 3 to 5 repetitions of each stretch for 15 to 30 seconds at least twice a day and maintaining this frequency for several weeks. To maintain flexibility gains, I typically advocate completion at least 3 times per week.

Posture Reversal

Continuously performing similar tasks is much harder on the body than alternating between tasks which stress the body differently. For example, alternating between palpation and other types of exams or treatment allows for a change in posture and related body stress. Fatiguing muscles and stressed joints have time to rest while the alternate task is being performed, which should decrease the risk of injury.

Posture reversal, assuming an opposite posture, can assist in tissue recovery and facilitate a return to a better posture prior to resuming the same work or an alternate task. These posture reversal techniques can be the same as common stretches, but they do not need to be held for 15 seconds. Some people find it more helpful to do several shorter repetitions with only a brief pause between repetitions. These techniques could be done while walking to a different area on a farm, while talking to a contact person or while waiting for an animal, supplies, etc.

Sustained or repetitive arm use in front of the body is a very common working position, and therefore many people can benefit from a brief break for a posture reversal that could be done seated or standing. A chest and biceps stretch is done by interlocking your fingers behind your back and lifting your hands as high as possible. Keep your torso upright and shoulders down.

Another option for postural reversal to counteract repetitive arm use would be a chest stretch combined with a nerve glide. To perform this, point your arms at a downward angle towards the floor with your palms facing forward. Pull the shoulders back and down, then draw the arms back as far as comfortably possible. Gently pump your hands back and forth up to 20 times but be sure to avoid causing any numbness or tingling in your hands.

I also advocate backward bending for posture reversal to counteract sustained or repetitive trunk flexion. This is done in standing with your hands on your hips. One hand may be placed on a stationary object if there is a balance concern. Lean your torso backwards but avoid any pinching or pain in the lower back. Again, this position could be held for 15 seconds but you may find it more helpful to perform multiple repetitions of shorter duration.

Basic Preventative, Treatment and Posture Reversal Exercises

Remember stretches should be held for 15 to 30 seconds each. Then you should alternate with another stretch or take a 30-second break between stretches. If performing for posture reversal purposes, shorter hold times are sufficient and only a few seconds between repetitions is common. The most commonly used posture reversal techniques were discussed earlier in this presentation.

Pectoral Stretching

I advocate using a doorway for this stretching for better control, but some people prefer to use a corner. A staggered stance allows better control of stretch intensity and you should rest your arms down at your sides between repetitions. To stretch pectoralis major, the elbows should be slightly below shoulder level or lower before gently lunging forward to create a stretch in front of the chest and shoulders.

You can choose the arm angle(s) which provide you with the best stretch sensation. The pectoralis major stretch can improve posture and could be used a posture reversal technique.

To stretch pectoralis minor, raise the arms at an angle overhead with the elbows straight. When looked at from the back, the person performing the stretch looks like a capital "Y". Lunge forward gently to create a different stretch in front of the shoulders. The pectoralis minor stretch is important for good posture, especially to address thoracic outlet and impingement syndromes.

Chest / Biceps Stretch

In a seated or standing position, interlock your fingers behind your back with your palms together. Keep your shoulders down as you squeeze the shoulder blades together. Keep an upright posture and maintain your shoulder position while you raise your hands up as far as possible. This stretch can be used to help with maintaining good posture, which helps prevent impingement syndrome.

Posterior Capsule Stretch

Keep your right shoulder down while you use the left arm to pull the right arm across your chest to produce a stretch on the back of the shoulder. If a pinch or pain occurs in front or on top of the right shoulder, then the stretch should be done at a lower height. This stretch is usually done by alternating sides and is vital to the prevention and treatment of impingement syndrome.

Inferior Shoulder Glide with Upper Trapezius Stretch

While seated, grasp the edge of your chair and lean your torso gently away while tipping your head in the same direction you are leaning. This stretch is often done by alternating sides. This stretch can help relieve neck tightness and address impingement syndrome concerns. It could also be used as a posture reversal after prolonged arm use.

Median Nerve Glide

While seated or standing, point your arms at a downward angle towards the floor with your palms facing forward. Pull the shoulders back and down then draw the arms back as far as comfortably possible. Gently pump your hands back and forth up to 20 times but be sure to avoid causing any numbness or tingling in your hands. This can be used as a posture reversal technique and it can help with prevention or treatment of carpal tunnel syndrome.

Elbow Stretch

To stretch the right elbow, keep the right elbow straight with the palm down and use the left hand to push down on the back of the right hand. If this is ineffective, try keeping your right elbow straight but rotate your right arm inward so your fingers are pointing outward prior to pushing down with your left hand. This can be used as a posture reversal for sustained or repetitive gripping or other hand use.

Finger Stretch

Spread your hands open as far as possible and place the tips of your fingers together in front of your chest with your thumbs pointed down. Push your fingers and thumbs towards each other as far as possible while keeping your palms apart. This can be used as a hand stretch for posture reversal after prolonged use. It can also assist in the prevention and/or recovery from muscle fatigue, muscle soreness, muscle cramping and trigger fingers.

Healthy Lifestyle

Living a healthier lifestyle can be used as a preventative measure or as a component of treating a current problem. Common examples include achieving an ideal body weight, stopping smoking, performing regular aerobic exercise, participating in some type of resistance training, and limiting or quitting caffeine and alcohol use.

Food for thought…research shows that your hips, knees, and ankles bear 3 to 5 times your total body weight while you are walking. For every pound you are overweight, you are adding 3 to 5 lb (2.2 to 6.2 kg) of extra weight during each and every step. If you lost 10 lb (4.5 kg), it would be the equivalent of subtracting 30 to 50 lb (14 to 23 kg) of weight from every step. Consider how many steps you take in a typical day and how this weight loss could significantly lessen joint stresses, thereby slowing down degenerative changes.

Supplementation of a healthy diet could also be considered but should be done in consultation with your family practitioner and/or your pharmacist. Vitamin B supplementation has been shown to improve nerve health but you must be careful to avoid excessive intake due to side effects. Fish oil and turmeric have been promoted as having an anti-inflammatory effect which can help with joint pain and stiffness including symptoms caused by arthritis; however, it is crucial that you consult a pharmacist or physician if you are taking other anti-inflammatories, blood thinners or other heart medications due to potential dangers.

Perspective on Practicing Veterinarians

Unfortunately, none of us can do anything about the way we practiced in the past. We certainly can intervene now to slow down and potentially reverse some of the effects of the physical demands of veterinary practice.

Some of you would argue that you didn't know about ergonomics or body mechanics. Now you know the basics, and some specifics, and can apply this information to other situations.

Some of you would argue that you didn't know what exercise would be beneficial. Now you have options to address a wide range of common orthopedic problems and I hope this will motivate you to also find information to intervene with other problems as needed.

Some of you would argue that you didn't know that your symptoms were a problem or how to treat it. That information has been shared so now you need to put it to use.

Some of you would argue that you don't have the time. It takes little or no additional time to perform tasks in a different manner for decreased body stress or to complete posture reversal techniques that will assist in recovery. Exercise for prevention or treatment can often be incorporated into your day such as while eating a meal, reading emails or talking on the phone. Use of cold or heat could be done while driving during your workday or in the evening while watching television, sitting at a computer or interacting with your family.

Take action NOW so that you can be healthy enough to function in your veterinary practice as long as you would like! Your overall quality of life will also be improved because you will be able to keep your ability to participate with your family, hobbies, social activities, etc.

Perspective on Recent Graduates

The AABP had the foresight to provide you information to help you prevent orthopedic problems related to your veterinary practice.

It is important to start practicing veterinary medicine with a conscious effort to consider ergonomics and body mechanics with everything you do. This should facilitate development of a good habit so that it eventually becomes second nature to consider the stress on your body while approaching each work task and other activities throughout your day.

Posture reversal should be started immediately so this prevention technique becomes second nature as well.

If you choose to take time for a preventative stretching program, I would recommend a minimum of 5 repetitions of each exercise with a frequency of at least 3 times per week. Additional time can be spent as problems arise and time allows.

This mindset could prevent or at least delay any breakdown of your body. You have the opportunity to avoid or minimize pain, numbness, tingling, etc. and any associated functional limitations. Start NOW!

Future Physical Therapy Options

I appreciate the opportunity to present to your organization to assist with education, injury prevention, and basic intervention techniques. I am willing to serve as a resource for a wide range of potential future needs…

- Additional Large Education Venues
- Problem-Solving for Ergonomics and Body Mechanics with Work Scenarios
- Employee Education
- More Extensive General Stretching Programs
- Introductory General Strengthening Programs
- Individualized Stretching and/or Strengthening Programs

I would also encourage you to strongly consider consulting a physical therapist near you to address any current or future concerns. Physical therapy is evidence-based and focuses on patient education to assist with resolution of your current problem and long-term maintenance to try to prevent any recurrence.

Feel free to contact me by email at sjuhlenhake@icloud.com or suhlenhake@ptsrehab.com. You are also welcome to contact me on my cell phone @ 419-733-4736.

Acknowledgement

The content is not intended to be a substitute for individual professional medical advice. You should contact your own physician, physical therapist or other qualified healthcare provider with any questions you may have regarding your symptoms, diagnosis and/or treatments. You should not delay seeking professional medical advice based upon this content. Relying on the information presented is done at your own risk.

How to make money in food animal practice plus stuff they might not have taught you in school

Lowell T. Midla, MS VMD
Department Of Veterinary Preventive Medicine, College Of Veterinary Medicine, The Ohio State University, Columbus, OH 43210

Abstract

On the day that you graduate from veterinary school, you have the greatest amount of knowledge that you will ever have. However, you are not the best veterinarian that you will ever be on the day that you graduate. As you progress through your practice career, you will gain wisdom. Wisdom is gained through experience, but only if you pay attention and learn from your mistakes. You may not be the best veterinarian that you ever were on the day that you retire due to your knowledge both being lost over time and becoming outdated. However, you can always be improving as a veterinarian through continuing education, learning from clients, peers, and experience, and most importantly: curiosity. "*Semper curiosus!*"

Key words: practice profitability, practice tips

Résumé

La journée où vous obtenez votre diplôme d'une école vétérinaire, vous possédez les plus grandes connaissances que vous n'allez jamais avoir. Toutefois, vous n'êtes pas le meilleur vétérinaire que vous allez devenir lorsque vous recevez votre diplôme. Vous acquérez la sagesse en progressant dans votre carrière en pratique. La sagesse s'acquiert avec l'expérience mais seulement si vous faites attention et apprenez de vos erreurs. Vous ne serez peut-être pas le meilleur vétérinaire que vous avez déjà été à votre retraite car vous allez perdre certaines connaissances ou celles-ci deviendront dépassées. Toutefois, vous pouvez toujours vous améliorer en tant que vétérinaire avec la formation continue, en apprenant de vos clients, de vos collègues et de vos expériences et surtout en étant curieux. "*Semper curiosus!*"

Practice Profitability

Don't ever let anyone tell you that you can't make money doing large animal veterinary work. However, the opportunity cost of time on the road is the greatest impediment to large animal ambulatory practice profitability. Therefore, you must either practice in an area of high patient density or charge an adequate hourly rate to compensate you for your time on the road.

Regarding your charges, remember that you must put more milk in the bulk tank than you take out (in terms of dollars). If you take more milk ($) out of the bulk tank than you put in, then you are nothing but a parasite. In that case, it is a correct business decision on the part of the dairy owner to hire a different veterinarian. After every farm call, you should ask yourself if you made the client money.

Diagnosis

The diagnosis is our main "product" as veterinarians. That is what we sell. In most cases, if the diagnosis is correct, the treatment is both obvious and simple. Diagnosis is a 2-step process. Veterinarians tend to focus upon step 2 – that is: "From the information that we have, formulating the diagnosis". When I have made a diagnostic error in my career, I have almost never made a mistake in step 2… the mistake was almost always in step 1. Step 1 is simply: "Gather in all of the available information before proceeding to step 2!" You'll miss the lymphoma if you don't palpate the lymph nodes.

Recommended resources:

- Read some Sherlock Holmes mysteries. Holmes never solves the crime because he, using the same information as the police, reached a different conclusion. Holmes always solves the crime because he went into step 2 with information that he noticed but the police did not.
- Go to the BCI website via the AABP website and listen to "Addressing Diagnostic Error" by Mark Graber delivered at the AABP meeting in Omaha in 2017.

The Exam of Life is Cumulative

The more chemistry, physics, mathematics, epidemiology, and statistics that you remember and use, the better veterinarian you will be. You are not a good food animal veterinarian if you do not use math, epidemiology, and statistics every day. If you use these skills every day, they will become very sharp tools in your toolbox. If you do not use these skills, they will atrophy and die.

Midla's Advice Regarding Building Your Practice

- You tend to like to do what you do well.
- You tend to do well what you like to do.
  - Don't listen to ANYONE (including me) trying to tell you what the future of bovine veterinary practice will be like – make it whatever you want.

Note that you might have to be flexible with respect to geography to find a place where you can make money doing what you like to do.

- You get what you build.
  - If a client calls at 3 o'clock on a Saturday afternoon asking you to come out and castrate 3 calves and you go out and do it, then you are teaching your clients that that is something they can expect you to do. If your fees are the lowest in the area, then don't expect to have clients willing to spend money on diagnostic testing to properly work up a case. The point is that you should do things the way that you think they should be done from the beginning. You will then attract and keep clients who appreciate your style of practice.

Following rules 1 and 2 will lead to practice satisfaction and practice success.

The Disease Triangle

The importance of the disease triangle (host – environment – pathogen), in my opinion, cannot be over-emphasized. Veterinarians tend to focus too much upon pathogens. The real underlying problem in most cases involves the host (e.g. did not receive adequate colostrum) or the environment/management (e.g. weaned, castrated, dehorned, sent to the sale barn all on the same day). There are a myriad of examples, but a great one is the "Sand Hills Calving System".

Midla's 3 Rules for Hitting a Vein Applies to all Species

1. Excellent patient restraint:
   Who is more important when trying to hit the jugular on a cat – the person restraining the cat or the person trying to hit the vein? Clearly the answer is the person restraining the cat. If the cow/steer/sheep/pig/etc. is not adequately restrained, then do not try to hit the vein until it is.
2. Completely occlude the vein:
   If you can't see the cephalic vein on the hit-by-car dog with the technician holding it off, then apply a tourniquet.
3. Patience!
   Wait for the vein to fill so that you can clearly see it before trying to hit it.

If you follow these rules, the vein will always stand up and you will always hit it. I realize that these seem obvious. However, when you get frustrated trying to hit a vein, step back, take a moment, remember these rules, implement them, and start over again.

Calf Catheterization

Always do a "cut down". The pressure required to get through bovine skin flattens the vein.

Remember, they use bovine hide for the soles of shoes for a reason – it is very tough stuff. In the case of any extremely dehydrated animal, use gravity. Place the part of the animal where the vein is located that you are trying to hit below the rest of the animal. Gravity will result in a distended/easy to hit vein.

Chest Pocket Cell Phone Flap

The chest pocket is best because the phone is least likely to become damaged here and you can answer it with either hand. However, when you bend over the phone will fall out. The most likely time for it to fall out is when you are washing your hands in a bucket – and it inevitably falls into the bucket. When you get new coveralls, sew a flap with a snap over the pocket (or take it to a local seamstress – usually costs just a few dollars).

Breakaway Cord for Vet Box

Construct a cord that is only 2 feet long with a standard male end and a female end with a plug to fit your vet box. The main reason is so that the cord will come unplugged at the male end when you accidentally drive away with the unit still plugged in (and you will do this). A side benefit is that you can throw this cord into your truck and take it with you so that you can plug your vet box in anywhere.

Notes:

1. Use a heavy duty cord – the funky 20-amp female plug is on there for a reason: the unit draws a lot of current.
2. Plug and unplug the male end periodically to be sure that it functions smoothly so that it will come unplugged when it is supposed to do so.

Boots and Boot Drying

I strongly recommend that you wear work shoes with rubber over-boots rather than rubber "Wellingtons"/Muck style boots etc. Shoes are better for your feet/knees/back/posture/health. When you get things like manure and fetal fluids in your rubber over-boots and must hose them out, they can be stored <u>inverted</u> in the space between the truck cab and the truck bed between calls. Unless it is really pouring rain, and even most times when it is, they will be dry inside before you reach the next stop.

Dystocia Tips

Everyone has their favorite tips and methods for relieving dystocia. Below are just a couple that you might not hear elsewhere.

- How to determine, unequivocally, whether the foot in your hand is a front foot or a back foot: Note that the "elbow" (humerus-radius/ulna joint) and the

hock are almost indistinguishable when the calf is still inside of the cow. However, as you move distally on the forelimb, you run into a carpus before you get to the dewclaws. There is no such joint on hindlimb between the hock and the dewclaws.
- For a retained limb, actively move the proximal part of the limb laterally and the distal part of the limb medially. You will wind up doing this passively, but doing it actively greatly facilitates limb retrieval. This works on both front and hind limbs. Try it on yourself – limbs bend this way naturally quite easily.

The Oscillating Pendulum Cow

When there is a single cow to be palpated in a row of headlocks without any cows on either side of her, sometimes she begins to swing her hind end back and forth, making it difficult to palpate her and also putting your shoulder at risk of injury. Keeping her attention with your non-palpating hand can often fix this problem.

Ammo Boxes and Milk Crates

The problem with nearly all toolboxes that you buy from the hardware store is that their shape makes it such that they take up more space on the exterior than they hold on the interior. Used ammunition boxes (available on-line) make great cases for catheterization supplies, foot blocking supplies, etc. Milk crates can hold halters, ropes, etc. Ammo boxes and milk crates have the advantage of not taking up any extra space in your truck.

Easy Bull Ring Insertion

Use the bloat trocar (with the cannula on it) to make the hole. Place the point of the bull ring in the cannula and easily feed the bull ring back through the nose.

Rules for Tying and Releasing a Cow that is Trying to Kill You

- Know where you are going to tie her BEFORE you get the halter on.
- Do NOT tie an animal to a lone support post in the center of a barn.
- Tying the cow to a post on the wall = 180° swing; tying the cow to a post in the corner = 90° swing.
- Going around the post twice with the rope makes the knot less likely to cinch too tightly to be released.
- If you think you know how to tie a quick release knot, think again. Learn how to tie a true quick release knot.
- To release a cow that is pulling hard on the halter:
  - Tie a second rope to the halter.
  - Tie the second rope to the post.
  - Untie the halter – the second rope will pull the halter off of the cow.

Fluid Therapy

Stop memorizing formulas. With the following 6 tools, any fluid therapy question can be answered:
- 1 liter = 1 kilogram
- Extra-cellular fluid space = approximately 1/3 body weight (a bit higher in neonates).
- 6 – 9 – 12 rule of dehydration (<6% is difficult to detect clinically; >12% is near death)
- 5 – 10 – 15 rule of bicarbonate deficit (5 – 10 – 15 correlates to mild – moderate – severe)
- 1 to 2 ml/lb/hour is the approximate maintenance fluid requirement.
- Periodic table of the elements

Necropsy Philosophy

My necropsy philosophy is based upon:
- A diagnostic test is only valuable insofar as it potentially alters the intervention.
- Common diseases occur commonly.
- Necropsy is an underutilized tool on most cattle operations with the exception of feedlots.

In most cases (not all but at least many) instead of doing a "complete" necropsy (expensive due to time and lab fees) which leads to never being called back to do another one, do a 10-minute "quickie". Your diagnostic power to detect pathology (which you can actually make management changes to prevent) will ultimately be greater by having a greater sample size.

Anabolic implant strategies in beef production: A practical guide

Sandi Lee Parr, MS, PhD

Abstract

Anabolic implants reduce the cost of production in all phases of beef production from suckling calves to finishing. There are many types of implants available with varying dosages and payout mechanisms. The value of different implants and implant strategies have been well documented in the literature, allowing for economic models to be easily generated based on biological outcomes. These data can aid in designing the optimal strategy for each phase of beef production across operational logistics.

Key words: beef cattle, implants, implant strategies

Résumé

Les implants anaboliques réduisent le coût de production à chaque étape de production du bœuf allant des veaux allaitants jusqu'à la finition. Il existe plusieurs types d'implants disponibles avec différents mécanismes de dosage et de libération. La valeur des différents types d'implants et des différentes stratégies d'implantation est bien détaillée dans la littérature ce qui permet de générer aisément des modèles économiques basés sur des résultats biologiques. Ces données peuvent aider à élaborer une stratégie optimale pour chaque étape de la production de bœuf pour plusieurs types de logistique opérationnelle.

Introduction

Anabolic implants have been used by U.S. beef producers to optimize gain efficiency and increase rate of gain since the 1950s.[4] Over the years, implant technology has evolved, and implants have been developed with different dosages, payout mechanisms, and carrier systems to target specific phases of beef production. The objective of this paper is to provide a practical guide to describe the different implants available for use, how to use them, and the value of implanting.

Active ingredients

Implants are generally categorized by their active ingredient as estrogenic, androgenic, or a combination. Estrogenic implants usually are classified as such because they contain estradiol 17-β (E2) or estradiol benzoate (EB) on their own or in combination with progesterone. Ralgro (Merck Animal Health, De Soto, KS) is also considered an estrogenic implant with zeranol (Z) as an active ingredient. Androgenic implants include testosterone propionate or trenbolone acetate on their own as an active ingredient. Finally, combination implants contain both estrogenic and androgenic compounds. Based on the dose and category of the active ingredient(s), implants are commonly categorized as low, moderate, or high-dose (alternatively labelled as terminal) implants. A list of anabolic implants available for use in the US and a general categorization by implant is included in Table 1 for reference. Component (Elanco Animal Health, Greenfield, IN) implants may include the addition of an extra pellet containing tylosin tartrate to help prevent infection and abscessing of the implant site after administration.

Drug delivery systems

Drug delivery occurs by compressed pelleted implants or silastic rubber implants infused with the active ingredient. The compressed pellet is the more common delivery system. During the manufacture of a compressed pellet the active ingredient is mixed with a carrier before compression and pelleting. Common carriers include cholesterol, lactose, and polyethylene glycol. The latest development in implant technology has been for manufactures to apply a polymer coating onto the pellets. The result of this coating is to cause a slower release of the active ingredient extending the payout of the implant. This coating may be applied to some or all the pellets. Throughout this paper, the term "traditional implants" will be used to describe implants without the polymer coating on pellets and "extended release implants" will be used to describe implants with polymer coating applied to some or all pellets. A list of anabolic implants available for use in the U.S. and a general description of number of pellets and coating can be found in Table 1.

Implant payout and different payout types

The term "implant payout" is used to describe the duration and characteristics of the release of the active ingredient(s) over time and practically describes how long the implant is "working" (stimulating increased anabolic action or practically improving gain and efficiency). Implants increase anabolic action for a finite period; beyond that period, the implant has diminished pay out and re-implanting

Table 1. Implants available for use in the US.

Implant	Dose[1]	When to Use[1]	Manufacturer	ANT (mg)[2]	E (mg)[2]	A (mg)[2]	P (mg)[2]	Pellets	Coated pellets	SC[3]	STCK[3]	FDLT[3]
Ralgro	LE	Calf - Flexible	Merck		36 Z			3		SH	SH	SH
Synovex-C	LE	Calf	Zoetis		10 EB		100	4		SH		S
Component E-C	LE	Calf	Elanco	29 TT Pellet	10 EB		100	4+1		SH		
Revalor-G	LC	Stocker	Merck		8 E2	40 TBA		2			SH	
Component TE-G	LC	Stocker	Elanco	29 TT Pellet	8 E2	40 TBA		2+1			SH	
Synovex-S	ME	Stocker/BG	Zoetis		20 EB		200	8			S	S
Component E-S	ME	Stocker/BG	Elanco	29 TT Pellet	20 EB		200	8+1			S	S
Synovex-H	MC	Stocker/BG	Zoetis		20 EB	200 TP		8			H	H
Component E-H	MC	Stocker/BG	Elanco	29 TT Pellet	20 EB	200 TP		8+1			H	H
Revalor-IS	MC	Initial Feedlot	Merck		16 E2	80 TBA		4				S
Component TE-IS	MC	Initial Feedlot	Elanco	29 TT Pellet	16 E2	80 TBA		4+1				S
Synovex-Choice	MC	Initial Feedlot	Zoetis		14 EB	100 TBA		4				SH
Revalor-IH	MC	Initial Feedlot	Merck		8 E2	80 TBA		4				H
Component TE-IH	MC	Initial Feedlot	Elanco	29 TT Pellet	8 E2	80 TBA		4+1				H
Revalor-S	HC	Terminal	Merck		24 E2	120 TBA		6				S
Component TE-S	HC	Terminal	Elanco	29 TT Pellet	24 E2	120 TBA		6+1				S
Revalor-H	HC	Terminal	Merck		14 E2	140 TBA		7				H
Component TE-H	HC	Terminal	Elanco	29 TT Pellet	14 E2	140 TBA		7+1				H
Revalor-200	HC	Terminal	Merck		20 E2	200 TBA		10				SH
Component TE-200	HC	Terminal	Elanco	29 TT Pellet	20 E2	200 TBA		10+1				SH
Synovex-Plus	HC	Terminal	Zoetis		28 EB	200 TBA		8				SH
Finaplix-H	HA	Terminal	Merck			200 TBA		10				H
Compudose	ME	Flexible	Elanco	0.5 OTC	25.7 E2					S	S	SH
Encore	HE	Flexible	Elanco	0.5 OTC	43.9 E2					S	S	SH
Revalor-XS	HC	Feedlot	Merck		40 E2	200 TBA		10	6			S
Revalor-XH	HC	Feedlot	Merck		20 E2	200 TBA		10	6			H
Synovex-One-Fdlot	HC	Feedlot	Zoetis		28 EB	200 TBA		8	8			SH
Synovex-One-Grass	MC	Stocker	Zoetis		21 EB	150 TBA		6	6		SH	

[1]LE=low dose estrogenic; LC=low dose combination; ME=moderate dose estrogenic; MC=moderate dose combination; HC=high dose combination; HA=high dose androgenic; HE=high dose estrogenic; BG=backgrounding in confinement

[2]ANT=Antibiotic; TT=Tylosin Tartrate; OTC=Oxytetracycline; E=Estrogenic; A=Androgenic; P=Progesterone; Z=Zeranol; E2=Estradiol 17-β; EB=Estradiol Benzoate; TBA=Trenbolone Acetate; TP=Testosterone Propionate.

[3]SC=Indicated use for sucking calves; STCK=Indicated use for stocker cattle; FDLT=Indicated use for feedlot cattle; SH=Steers and heifers; S=Steers only; H=Heifers only

is required to maintain an elevated level of growth and efficiency. Therefore, it is pivotal to understand the payout duration of the implant used, as this information is incorporated into implant strategy design. Traditional implants have shorter payout period(s) compared to the newer, extended release implants. Generally, traditional estrogenic implants have a payout of approximately 50 to 90 days, traditional low to moderate dose combinatio n implants have a payout of approximately 70 to 100 days, and traditional high dose combination implants have a payout of approximately 90 to 140 days. The extended release implants were designed to last the duration of two traditional implants (160 to 210 days), though some are indicated to last longer. Published data or manufacturer information is available for reference indicating implant duration based on the phase of production and plane of nutrition.

Value of implanting

Increased average daily gain as a result of implanting both steers and heifers has been well documented across all phases of beef production. A review of sucking calves

reported a 0.097 lb (0.044 kg) to 0.11 lb (0.050 kg) increase in daily gain of suckling steers and a 0.12 lb (0.054 kg) increase for suckling heifers implanted a single time.[5] Assuming a 90-day period, daily gain increases translate to an addition 9 to 11 lb (4.1 to 5.0 kg) of saleable weight. Stockers grazing on pasture across different U.S geographical regions are expected to have a 14.0% to 16.1% increase in gain per day for steers and 10.7% to 15.3% increase for heifers.[3] Assuming the trial days on pasture (94 or 116) that equates to 19 to 27 lb (8.6 to 12.2 kg) of additional saleable weight. Most published data with respect to implanting focuses on the finishing phase of production. Duckett et al[1] compiled a comprehensive review indicating that during the finishing phase, implanting increases gain, efficiency, carcass weight, and rib-eye area while decreasing the proportion of carcasses grading USDA Choice (during a fixed DOF period or common endpoint). The variables of greatest economic importance during the finishing phase are daily gain and feed efficiency. On average combination implant strategies increase daily gain 16.2% and improve feed efficiency 10.4%.[2]

How to implant

Proper sanitation is the foundation of good implanting technique. Start with a clean implant gun and needle. Implant guns and loading mechanisms differ by manufacturer, requiring the user to become familiar with the implant gun, cartridge, and how to load and unload the gun. Replace the needle or make sure the needle is sharp, straight, and free of burrs. Use a clean implant tray with a sponge or roller soaked in disinfectant (dilute 2% chlorhexidine). Make sure the disinfectant solution remains free of debris, discard old solution and refill as needed. Disinfect the needle after implanting each animal by wiping the needle on the sponge or roller, avoid dipping the needle in solution as this often results in getting pellets wet and jamming the implant gun. If debris is present on the ear, use a brush and the disinfectant solution to clean the ear before implanting (brush with the hair). Remember to re-disinfect the needle if you must abort an implant attempt, avoid inserting a dirty needle into the animal. Besides sanitation, another key factor is proper restraint of the animal's head. Training the chute operator on the proper way to contain an animal for implanting is extremely beneficial. After proper sanitation and restraint, analyze where to place the implant. The most common site of implant insertion is in the middle 1/3 of the ear in the valley between the ribs. Avoid ear tags, old tag holes, old implants or other blemishes. A good rule is to have a thumbs distance between implant and blemish. The middle 1/3 of the ear is commonly not available because of tags or old implants, the second choice would the plateau of the ear, and the last choice is placement in the ridge of the ear. The goal is to avoid blood vessels, cartilage, and the base of the ear. Insert the needle under the skin, pull the trigger and pull out the needle. Palpate the ear to check implant placement and that all pellets are present. Commonly operators will press the insertion site to close it off, this practice likely should be avoided as it could be doing more harm than good by introducing bacteria into the open wound. In the event of a problem, push out the remaining pellets (or explant in worse case scenario) and try again in a different location.

How to train crews to implant

Creating a system that combines classroom and hands on learning is often an effective approach. Present the information in the above section and use pictures to demonstrate. Follow up with chute-side training for each crew member. Lastly, create a system for continual feedback by systematically conducting implant evaluations on each crew member. Palpate and evaluate implant sites 20-30 days after implanting and evaluate a sub-sample of the pen or the whole pen depending on time and logistics. Having the crew observe results of their implanting is an effective training tool. Granted this type training is often only feasible when cattle are fed in confinement, but aspects of this methodology can be applied to other systems. Often during evaluations old implants will be palpated and found. Crews may conclude that old implants are not working properly or that the old implant is still effective, and money was wasted by re-implanting. In a compressed pellet system, the carrier fraction of the pellets softens and disintegrates over time, but presence of carrier is not indicating presence or concentration of the active ingredient. Palpation of the pellets in the ear is not a good method to determine if an implant is still viable. Rather viability of the implant should be based on days after implanting as described in previous sections. When silastic rubber implants are used, the rubber matrix remains in the ear of the animal and will always be found by palpation regardless of the payout status. Palpation of the implant site is effective for documenting implant placement, presence of pellets, and incidence of local infection or abscess.

Practical applications

Suckling Calf

There are three types of implants available for suckling calves Z, EB plus P, and E2. In beef calves Z and EB plus P are more commonly used and both can be used in potential replacement heifer calves (both have a minimum day of age on the label). Pregnancy rates of implanted heifers is a common concern. If it is known that the heifer will be bred, then there is little value in implanting. If heifer status is unknown at the time of implanting, then the value of the additional weight sold should be compared against decreased pregnancy rates. Implanting with Z at birth (off label) resulted in a 39.0% decrease in pregnancy rate.[5] Implanting with Z at 30-90 days of age resulted in a 0.8% decrease in pregnancy which is minimal compared to the additional weight that could be sold for the non-retained heifers.[5] Implanting heifers with

EB plus P at 30 to 90 days of age resulted in 3.2% decrease in pregnancy.[5]

Waiting until weaning and implanting heifers with Z resulted in a 1.7% decrease in pregnancy while implanting suckling heifers two times with Z decreased pregnancy rate by 7.3%.[5] This data would indicate that implanting once with Z at 30-90 days or at weaning is minimally detrimental to pregnancy rate, but likely selection of the breeding population should occur before the second Z implant. Another option would be to generate an economic model comparing weight value to cost of decreased pregnancy rate to aid in making the correct implanting decision regarding re-implanting suckling heifer calves that may be retained and bred.

Stockers

Stocker cattle implants are generally categorized as estrogenic or combination and are available both as traditional and extended release implants. The days on pasture is a consideration and when days exceed 130-150 for traditional implants, re-implanting mid way through the grazing period improves gain 3 to 5%.[3] An alternative to re-implanting is to use longer duration implants. When the gain of the animal is low because of poorer nutrient status, the gain response to implant is less than if the animal was gaining at a greater rate. However, published data available would still support implanting stockers, independent of plain of nutrition.[3] Often producers will consider breeding heifers that were implanted as a yearling with a combination implant. Heifers that were bred 82 days after implanting with 8 mg E2 and 40 mg trenbolone acetate and kept on pasture exhibited a 18.0% reduction in first pregnancy rate and 3.0% reduction second breeding pregnancy rate (Tibbitts et al., 2016). Based on the data available the expectation would be that pregnancy rate would decline further with additional combination implants and little is known about the effect of extended payout combination implants on pregnancy rate. Depending on market conditions it may make sense to retain single implant yearling heifers. An economic model can easily be developed based on published data to address that question.

Backgrounders

Background rations typically are lower in caloric density verses finishing rations. The goal of the backgrounding phase is often to hold gain to a set target and therefore implant strategies for backgrounded cattle usually fall between stockers and feedlot. There are three key considerations when designing the backgrounding implant strategy: 1) read the implant label as some implants are not labelled for cattle fed in confinement for slaughter; 2) due to the lower plane of nutrition and rate of gain it likely is inefficient to use an implant with a dose greater than moderate combination; and 3) cattle ownership status at completion of the backgrounding phase. When designing backgrounder implant strategies consider the management after backgrounding. If cattle will be retained onto full feed, then accounting for the feedlot implant strategy is important. If the feedlot implant strategy is average to moderate, then utilize a low combination to moderate estrogen strategy. If cattle will not be retained or if the feedlot implant strategy will be aggressive then it may make sense to utilize moderate combination implants.

Feedlot Native Beef

In general, implant strategies that utilize combination implants optimize gain and feed efficiency over estrogenic or androgenic implants.[1] Therefore, many feedlot strategies take advantage of combination implants. Implant strategies can be broken out into moderate, average, aggressive, and duration categories. An aggressive implant strategy utilizes one or more terminal dose implants and may incorporate re-implanting more frequently during the feeding period. A moderate implant strategy is designed to avoid using terminal implants and often involves re-implanting with the same (moderate) dose implant within the ranges of initial implant projected payout days. Most implant strategies are designed to ramp up the dose over time so an average implant strategy would, for example, use a low or moderate dose combination implant initially, followed by a terminal implant. Duration strategies incorporate the extended release implants and can be aggressive, moderate, or average in design. When designing feedlot implant strategies, three main areas must be considered: 1) how the cattle will be sold; 2) the operational incidence of bullers and operational ability to manage bullers; and 3) the operational ability to easily and inexpensively re-implant cattle. If cattle will be sold without a grid or if the grid is yield based, then an aggressive implant strategy makes sense unless bullers are a challenge. If bullers are a challenge or the operation has little tolerance for bullers then a moderate to average implant strategy should be used. If cattle are sold on a grid, then a moderate or average implant strategy should be recommended. Using published biological outcomes to create an economic model is often beneficial to determine if a terminal implant should be used. Finally, if re-implanting cattle is a challenge for the operation, then an extended-duration strategy should be considered. The extended release implants in most scenarios are, at best, equal to a well managed traditional re-implant strategy but have a greater purchase cost. If re-implanting logistics are not a major concern, then an economic model is required to determine if extended release implants should be utilized.

Feedlot Dairy Beef

There are two key considerations that may necessitate dairy beef implant strategies to differ from native beef cattle strategies. First, the days on feed typically is greater than most beef animals and second, dairy beef, specifically Holsteins, have a greater incidence of behavioral problems and bulling activity. Due to these unique challenges, dairy beef implant strategies commonly avoid using high dose combination implants, and dairy implant strategies may have a greater delay before initial implant. The extended

release implants could be used more frequently in dairy beef to decrease the number of re-implants required. However, data indicating influence of implant release rate on incidence of bullers should be considered when designing dairy beef implant strategies.

Conclusions

Implanting has great value across all phases of beef production. Implant protocols can be easily implemented, and the main considerations regarding implementation is sanitation, restraint, training, and practice to perfect implant technique. During the suckling calf phase, the main consideration is the plan for retaining heifers. The stocker side is also straightforward, and the main consideration is days on pasture and designing a strategy to match payout days. The feedlot sector of production can be the most complicated in terms of creating implant strategies, but if focus is centered on cattle marketing, cattle behavior, and re-implanting logistics a strategy can be designed effectively. Ample published data is available as a resource and generating economic models using published biological outcomes is the most efficient method to design a strategy. Implants are the most cost-effective technology available to beef producers and are one of the greatest assets to aid in resource optimization and cost of production reduction.

References

1. Duckett S, Owens F, Andrae JG. Effects of implants on performance and carcass traits of feedlot steers and heifers, in impact of implants on performance and carcass value of beef cattle symposium. *Oklahoma Agric Exp Stn P-957* 1997;63-82.
2. Guiroy PJ, Tedeschi LO, Fox DG, Hutcheson JP. The effects of implant strategy on finished body weight of beef cattle. *J Anim Sci* 2002;80:1791-1800.
3. Kuhl G. Stocker cattle response to implants, in impact of implants on performance and carcass value of beef cattle symposium. *Oklahoma Agric Exp Stn P-957* 1997;51-62.
4. Raun A, Preston R. History of hormonal modifier use in impact of implants on performance and carcass value of beef cattle symposium. *Oklahoma Agric Exp Stn P-957* 1997;1-10.
5. Selk G. Implants for suckling steer and heifer calves and potential replacement heifers, in impact of implants on performance and carcass value of beef cattle symposium. *Oklahoma Agric Exp Stn P-957* 1997;40-50.
6. Tibbitts BT, Nielson HR, Ramsay KH, Funston RN. Growth and reproductive performance of yearling beef heifers implanted with Revalor G in the Nebraska Sandhills. *Prof Anim Sci* 2016;33:92-96.

Practical and applied use of veterinary feed directives in production

M. J. Quinn, MS, PhD
Feedlot Health Management Services, Okotoks, Alberta T1S 2A2 Canada

Abstract

Feed additives are important tools for livestock producers to improve animal health, wellbeing, and productivity in modern livestock production. Feed additives used for the improvement of efficiency, weight gain, and carcass characteristics have been well documented in the literature. Feed additives with animal health implications require a more diligent approach to use, and therefore require a higher level of evaluation. There are numerous labels, combinations, and dose ranges associated with feed additive use. In the current regulatory environment, the understanding of these labels and how to effectively implement the compounds which require veterinary feed directives in a practical manner is important to both those who create the directives, and those who implement them. Practical, cost-effective decisions with respect to the use of in-feed antimicrobials are multi-faceted and complex.

Key words: feed additives, veterinary feed directive, medicated feed

Résumé

Les additifs alimentaires sont des outils importants pour les producteurs de bétail afin d'améliorer la santé, le bien-être et la productivité dans les élevages modernes de production. Les additifs alimentaires utilisés pour améliorer l'efficacité, le gain de poids et les caractéristiques de la carcasse ont bien été documentées dans la littérature. L'utilisation d'additifs alimentaires ayant des implications pour la santé animale requière une approche plus assidue et donc une évaluation à un plus haut niveau. Il existe plusieurs étiquettes, plusieurs combinaisons possibles et un éventail de doses associés à l'utilisation d'additifs alimentaires. Dans le contexte actuel de réglementation, connaître ces étiquettes et savoir comment mettre en œuvre de façon pratique les composés qui nécessitent des directives pour aliments vétérinaires sont importants à la fois pour ceux qui émettent les directives et pour ceux qui les mettent en œuvre. Prendre des décisions pratiques et plus économiques concernant l'utilisation d'antimicrobiens dans l'alimentation comporte plusieurs facettes et est complexe.

Introduction

Medicated feed additives (**MFA**) were first introduced for livestock disease control and production enhancement in the mid-1940s.[12] As agricultural systems and livestock production technology advanced, many new compounds were investigated and commercialized. New classes of compounds that could be included in feed were discovered, some of which not only had animal health application, but also produced improvements in productivity and weight gain. At present, many compounds exist as tools for livestock producers to improve health, production, and thus, economic efficiency within operations.

Generally, MFA fall into 2 categories: 1) products utilized for disease treatment and prevention; and 2) products utilized to improve feed efficiency, weight gain, and carcass characteristics. Some of these products, such as ionophores, are useful for coccidiosis prevention as well as improving productivity through modification of the rumen microflora. Other production-enhancing MFA work through directing nutrients to lean tissue deposition, or via modification of natural hormonal cycles to suppress estrus. These technologies have proven to be cost-effective, valuable tools in modern livestock production.[27]

Regarding the use of in-feed antimicrobials, growing governmental concern and consumer interest about antimicrobial resistance of importance to human medicine led to more diligent oversight to ensure judicious use of these compounds in food animal production. Thus, in 2017, veterinary feed directives (**VFD**) became mandatory for all medically important antimicrobials **(MIAs)** to be included in feeds administered for livestock production.

Categories of Medicated Feeds

While the use of in-feed MIAs requires a VFD, there are several other non-MIA MFAs available commercially with a myriad of combination clearances. Many of these combination clearances exist in conjunction with in-feed MIAs that require VFDs. Therefore, it is incumbent upon the veterinarian to have a firm comprehension of what regulations exist with respect to MFA that require VFDs as well as what combinations are allowed in conjunction with the product of interest.

The US Food and Drug Administration[9] organizes labeling with respect to MFA into 2 categories. They can be classified as either Category I, which require no withdrawal period or Category II, which are drugs that require a withdrawal period at the lowest use level for at least 1 species that they are approved for. Most commonly used MFA in cattle production fall under Category I, and a bulk of what will be

discussed in the current manuscript will be in reference to Category I MFA. The FDA also categorizes feeds containing MFA into 3 categories. Type A medicated articles are those used to manufacture other Type A medicated articles and/or used to manufacture Type B/C medicated feeds. Type B medicated feeds are used in the manufacturing of other Type B or Type C medicated feeds. Type C feeds are usually intended to be fed as a complete feed or used to manufacture other Type C feeds as a top dress or free-choice supplement.

The designation of differing types of feed categories is important due to varied dose ranges approved across each of the indications for use. These are most commonly differentiated between Type B and Type C feeds. It should be noted that co-clearances can differ for MFA used in either Type B or Type C feeds, where a co-clearance exists for Type C but not Type B feeds. Those writing VFDs should understand and be familiar with the definitions used by FDA-CVM.

Veterinary Feed Directives and Application

There are several medically important MFA commonly utilized in dairy and beef production including macrolides, tetracyclines, and some streptogramins. The following discussion relative to practical considerations when utilizing these compounds will primarily focus on application of macrolides and tetracyclines in medicated feeds. As mentioned in the previous text, based on the type of medicated feed utilized in an operation the grams/ton concentration and/or (if applicable) the mg/hd/d indication for the use of several of these medicated feeds may differ slightly and therefore require a different concentration on the VFD. Secondarily, one must be cognizant that indications for various concentrations of some VFD products may be on a 100% dry matter (**DM**) basis or a 90% DM basis. Additionally, some labels may not address DM percentage for dosing products altogether. In practical terms, it is important to understand what implications this may serve in terms of the magnitude and frequency with which VFDs may need to be updated, corrected, or changed within commercial operations.

Several in-feed antimicrobials are approved for reduction in liver abscess rates in cattle fed in confinement for slaughter. These are bacitracin methylene disalicylate, chlortetracycline, oxytetracycline, tylosin, and virginiamycin. The most common in-feed product used in cattle fed in confinement for slaughter is tylosin phosphate (**TYL**).[20] Tylosin phosphate is approved to be fed continuously for the reduction in liver abscesses in steers and heifers fed in confinement for slaughter. Several studies evaluating the use of TYL have demonstrated a reduction in liver abscess rates[3] compared with a negative control. Tylosin has demonstrated a decrease in incidence of liver abscess rates ranging from 40 to 70%.[15] Of compounds currently commercially available, TYL is the most effective at reducing liver abscess incidence, with other MFA demonstrating a reduction less than TYL.[15] The mode of action for reduction of liver abscess via TYL occurs primarily through the inhibition of *Fusobacterium necrophorum* in the rumen. Because of its categorization (macrolide) as an antimicrobial of critical importance with respect to human health use (FDA), TYL is only allowed under the issue of a VFD. Although a VFD is required for its use in confined feeding situations, TYL is still widely used among feedlot operations. The approved dose ranges for TYL make it difficult in some situations to effectively maintain an accurate dose of the compound and remain within approved ranges. For example, TYL is approved to be fed at a rate of 8 to 10 g/ton (90% DM basis) to provide 60-90 mg/hd/d (no DM referenced on label). This may present challenges in terms of accurately staying within labeled doses in situations of very high (i.e., >24 lb [11 kg] DMI) or very low intake (i.e., <12 lb [5.4 kg] DMI) periods on an operation. For cattle with relatively low DM intake, in order to provide the minimum approved dose on mg/hd/d basis (60 mg/hd/d), one might have to increase the concentration of the product and thereby exceed the 10 g/ton maximum allowed dosage in the feed. Conversely, in cattle with very high intakes, the minimum concentration approved in feed (8 g/ton; 90% DM basis) may result in animals consuming greater than 90 mg/hd/d. Due to the restrictive nature of the label dose of TYL it is imperative that veterinarians issuing VFDs coordinate with the nutritionist/feed company formulating the rations as well as FDA inspectors to clarify if both dose ranges cannot be met, which is the most important criteria? In some cases, direction has been issued to meet the mg/hd dose range rather than the g/ton concentration in the feed (personal communication). From a practical standpoint, meeting the mg/hd dose criteria makes sense from a judicious use standpoint, rather than a concentration in the feed.

The tetracycline class of MFAs has been widely used as a therapeutic in-feed treatment for several bacterial-related diseases in cattle production. Tetracyclines are categorized as highly important antimicrobials from a human health perspective and therefore require a VFD for use in feed. Chlortetracycline (**CTC**) and oxytetracycline (**OTC**) are the most common of this class utilized in beef and dairy operations. Other products have approval as combinations of CTC and OTC with other antimicrobials (CTC + sulfamethazine; neomycin + OTC). Chlortetracycline has approvals for control of bacterial pneumonia associated with shipping fever complex (350 mg/hd/d), treatment of bacterial enteritis caused by *Escherichia coli* and bacterial pneumonia caused by *Pasteurella multocida* (10 mg/lb [22 mg/kg] BW up to 5 days), and control of active infection of anaplasmosis caused by *Anaplasma marginale* (350 mg/hd/d for <700 lb [318 kg] stocker/pasture animals; 0.5 mg/lb [1.1 mg/kg] BW for >700 lb [318 kg] stocker/pasture animals). Oxytetracycline has similar, albeit slightly different, approvals in cattle. These include treatment of bacterial enteritis caused by *E. coli* and pneumonia caused by *P. multocida* susceptible to OTC (10 mg/lb [22 mg/kg] BW for 7 to 14 days).

While these have a broad range of approvals and may provide some ease of use in feed, it is important to weigh the

cost effectiveness of the use of these products compared with other potentially more effective parenteral antimicrobials. This can present a complex decision-making process that should include determinations of the baseline mortality, historical or expected mortality of the population in question, morbidity (expected or current), logistical constraints at the operation, reduction of stress to the animal by additional handling, husbandry practices that may alleviate the need for antimicrobials in the operation, current inventory cost of the animals to be treated, and current antimicrobial protocols. Likewise, for cow-calf producers who may investigate the use of CTC for control of anaplasmosis, how likely is the disease to affect the herd in question, has it been detected in the region, and what will the cost be to provide this product across every animal in question?

Relative to the use of tetracyclines in confined settings, Szasz et al evaluated the use of either CTC administration at 4 g/hd/d for 3 5-d therapeutic regimes compared with 14 consecutive days of OTC administration at 4 g/hd/d beginning at 10 DOF in calf-fed Holstein steers (arrival weight 310 lb [140.9 kg]). These in-feed antimicrobial regimes were conducted in conjunction with tulathromycin (TUL) metaphylaxis on arrival compared to TUL alone or CTC feeding alone. Szasz et al observed decreased morbidity in populations receiving CTC and TUL compared with those receiving OTC and TUL, CTC alone, or TUL alone.[24] No differences were observed between treatments for overall mortality or BRD-related death loss. It should be noted that overall mortality for cattle used in the study was 1.98%. Additionally, there was no negative control treatment to determine what the baseline mortality might have been had no antimicrobials been given. Therefore, although there was a benefit in terms of reductions in morbidity with CTC administration, the baseline mortality rate in this population may have been too low to accurately determine the effectiveness of CTC administration on overall mortality. Similarly, cattle only administered CTC (those that did not receive TUL at arrival) had a mortality rate that was 1.92%, which was numerically lower than the average across the study. Duff et al observed similar effects when evaluating the use of CTC in combination with either arrival or pre-shipping administration of tilmicosin phosphate (**TIL**).[7] When TIL was administered on arrival in conjunction with a therapeutic dose of in-feed CTC in beef calves, the authors observed lower morbidity compared with those animals not receiving CTC. These same researchers reported no death loss in the study, thereby suggesting that the risk classification of the cattle may not have been high enough to warrant CTC therapy and/or determine what a true contribution of CTC use would be on mortality. Additionally, pen size in the study was relatively small (10 to 11 hd/pen), which in some cases may impact rate of disease transmission when compared with larger commercial operations with greater pen sizes.

While some benefits to the use of CTC in production systems on morbidity have been reported, there may also be indirect performance benefits to the animals. Booker et al reported improvements in performance with the administration of metaphylactic TUL on arrival in beef cattle.[2] This would suggest that when antimicrobials are determined to be the appropriate course of action for a particular population, creating a healthier overall population may also help improve performance later in the feeding period through reductions in morbidity and mortality. Some authors have reported increased intake and ADG from the use of CTC, or CTC and sulfamethazine in combination on newly received beef cattle.[10,13] This observation is most likely due to improving the overall health of the population through reduced morbidity and mortality, thereby creating a population that likely consumed more feed throughout the feeding period.[5]

Given the variable outcomes associated with mortality and the use of MFA, it is important to identify the cost effectiveness of these products in combination with or without the use of metaphylactic microbials used on arrival. For example, with a cost of $0.06/g of CTC and an animal inventory cost of $800.00 for a 500 lb (227 kg) steer, absolute mortality would need to be decreased by approximately 0.188% to break even with the cost of one 5-day therapeutic treatment with CTC at 10 mg/lb (22 mg/kg) BW ($1.50/hd total cost). If 2 5-day therapies are needed ($3.00/hd total cost for both regimes), the absolute mortality reduction necessary to break even would be 0.376%. This simple example only looks at impacts on mortality, and does not take into account ancillary benefits, such as decreased morbidity or secondary improved performance, which may or may not exist depending on the baseline risk factors for the population of interest.

In-feed MIAs are also commonly used in milk replacers at dairy calf rearing facilities.[11] Approvals for commonly used in-feed MIAs include OTC for the treatment of bacterial enteritis caused by *E. coli* susceptible to OTC; CTC for the treatment of bacterial enteritis caused by *E. coli* susceptible to CTC; neomycin/OTC for the treatment of bacterial enteritis caused by *E. coli* and for control of colibacillosis caused by *E. coli* susceptible to neomycin. Care must be taken when determining what products fall under these specific approvals, as many combination products exist in the market that may not qualify under these approvals. While the combination of neomycin and OTC is approved for use in milk replacers, some neomycin products are only approved for the treatment of calves on an *individual* basis rather than through batching of an MIA in milk replacer for populations or groups of calves to be fed. Additionally, some labels may allow for batches of treatments in a water-soluble form to treat animals individually via water drench or in a divided watering application. In this scenario, the product would be used under a water-soluble approved method, thereby requiring a veterinary prescription rather than falling under the requirement of a VFD.

The use of OTC/neomycin combination product has been reported to reduce morbidity and mortality in calves challenged with *E. coli* during the initial 7 days in the rearing facility.[18] The authors noted improved health parameters and attitude score, suggesting that MFA in milk replacers can be

beneficial under these conditions. The authors did note that the animals received no other antimicrobial treatment on arrival, and therefore the cost effectiveness in combination with other injectable antimicrobials is not known. Similar to examples in confined feeding and/or stocker operations, one must carefully consider the potential animal health risk classification, inventory cost, and other antimicrobial metaphylactic interventions that may provide ancillary benefits as compared to the use of MFA for therapeutic purposes.

Tilmicosin phosphate is available as an in-feed product for use in cattle confined for slaughter. The VFD requirements associated with in-feed TIL use are relatively restrictive as compared to some more broad-spectrum in-feed MIAs. In-feed TIL is approved for the control of bovine respiratory disease associated with *Mannheimia haemolytica, P. multocida*, and *Histophilus somni* in groups of beef and non-lactating dairy cattle, where active BRD has been diagnosed in at least 10% of the animals in the group. Additionally, in-feed TIL cannot be used under a VFD if the population intended for treatment has been administered a macrolide or within a 3-day period of a non-macrolide. This approval requires that if TIL in feed is to be used it must occur within 45 d of arrival to the facility, and the course of TIL treatment is for a single 14 d period. Effectively, the restrictions on the in-feed use of TIL make it very difficult to 1) find populations of cattle that would fit these criteria and 2) if populations are identified, determine that in-feed TIL is more cost-effective than parenteral use of other licensed antimicrobials to control BRD. If a population of cattle arrives at a facility with a risk profile large enough to warrant 14 d in-feed antimicrobial therapy, then it stands to reason that the population may benefit greater from the use of an injectable metaphylactic macrolide at arrival. If the population is deemed low-enough risk that metaphylaxis is not required, but then has morbidity exceeding 10%, an intervention with an injectable macrolide at the individual animal level utilizing some sort of diagnostic test (such as rectal temperature) for BRD may be a more judicious use than in-feed treatment.

Feed Additives in Production

Ionophores

Ionophores are some of the most commonly used MFA in cattle production to date[20,25] for disease control and preventative for coccidiosis and for improvements in weight gain and feed efficiency. The most common ionophores in use with feed efficiency and weight gain approvals are monensin sodium (**MS**), lasalocid sodium (**LS**), and laidlomycin propionate (**LP**). The improvements in feed efficiency and weight gain are attributable to selection for gram-negative bacteria and subsequently greater propionate production in the rumen.[1] The animal absorbs this propionate and converts that VFA into glucose, thereby improving energy retention and feed efficiency. The shift in the microbial population is also responsible for a decrease in ammonia production and more efficient microbial crude protein production in the rumen. Improvements in microbial efficiency allow for greater microbial crude protein to pass on to the hindgut for absorption. Due to increased microbial protein flow to the small intestine ionophores such as MS for example, elicit a "protein sparing" effect in the rumen.[1] The improvements in feed efficiency attributable to MS, LS, and LP administration range between 3 and 6% in confined settings when cattle are fed high-concentrate diets.[8,22,26] Some of the improvement in feed efficiency may be explained by reductions in subacute, ruminal acidosis, due to inhibition of major lactic acid-producing bacteria like *S. bovis*[16] and reduced intake variation.[23] The effects of ionophores on ruminal fermentation, reducing ruminal fluid viscosity, and reducing intake variation are also positive for controlling bloat mortality in both feedlot and grazing cattle.[4]

Additionally, both MS and LS are approved to be fed to cattle in pasture settings for increased weight gain. Monensin has also shown improved milk production efficiency in dairy cattle.[14] Both MS and LS are approved for prevention and control of coccidiosis with differing minimum effective doses of 0.14 mg/lb (0.31 mg/kg) of BW and 0.455 mg/lb (1.0 mg/kg) BW, respectively.

Coccidiostats and Antimicrobial Rumen Modifiers

Other MFA that are approved for prevention and control of coccidiosis (*Eimeria bovis* and *Eimeria zuernii*) are decoquinate and amprolium. While amprolium is approved for a prevention dose (2.27 mg/lb [5 mg/kg] BW), it is the only MFA commercially available with approval for treatment of clinical coccidiosis (4.54 mg/lb [10 mg/kg] BW) at a higher dose in cattle.

Bambermycin is another MFA characterized as a rumen modifier that has demonstrated some production efficiency.[21] These improvements primarily occur through increases in gain and/or efficiency compared with a negative control.

Performance Enhancing MFA

Melengestrol acetate (**MGA**) has been used as an MFA in heifers fed in confinement for slaughter since the 1950s. The primary mode of action for MGA is through suppression of estrus in intact heifers. The prevention of estrus serves to decrease the net energy of maintenance of the animal and results in improved slaughter weight, carcass weight, weight gain, dry matter intake, reduced riding behavior, improved average daily gain, feed efficiency, and greater quality grade compared with no administration of MGA, as well as lower BRD related mortality in heifers fed MGA compared to heifers not fed MGA.

Beta-agonists, such as ractopamine, act as repartitioning agents that direct nutrients away from fat deposition and toward lean tissue deposition. This generally occurs through an increase in protein synthesis and/or a decrease in protein degradation. There are 2 beta-agonists currently approved for use in the US, zilpaterol hydrochloride (**ZIL**) and racto-

pamine hydrochloride (**RAC**). Zilpaterol, while approved, has been voluntarily pulled from the market and is no longer commonly used in the US. Ractopamine hydrochloride is commonly utilized in beef cattle production and is labeled to be fed the final 28 to 42 days-on-feed in steers or heifers fed in confinement for slaughter. Ractopamine hydrochloride is labeled for improvements in weight gain and feed efficiency, as well as improvements in carcass leanness.

Conclusion

There are many MFA licensed for use in cattle production and these technologies improve the profitability and sustainability of operations throughout North America by improving animal health and increasing production. However, products requiring VFDs should only be used in a manner that presents the most cost-effective and judicious application and in the best interest of not only operation but also the animal's well-being.

References

1. Bergen WG, Bates DB. Ionophores: Their effect on production efficiency and mode of action. *J Anim Sci* 1984;58:1465-1483.
2. Booker CW, Abutarbush SM, Schunict OC, Jim GK, Perrett T, Wildman BK, Guichon PT, Pittman TJ, Jones C, Pollock CM. Evaluation of the efficacy of tulathromycin as a metaphylactic antimicrobial in feedlot calves. *Vet Therapy* 2007;8:183-200.
3. Brown H, Bing RF, Grueter HP, McAskill JW, Cooley CO, Rathmacher RP. Tylosin and chlortetracycline for the prevention of liver abscesses, improved weight gains and feed efficiency in feedlot cattle. *J Anim Sci* 1975;40:207-213.
4. Cheng KJ, McAllister TA, Popp JD, Hristov AN, Mir Z, Shin HT. A review of bloat in feedlot cattle. *J Anim Sci* 1998;76:299-308.
5. Cole NA. Review of bovine respiratory disease: Nutrition and disease interactions. In: Smith RA, ed. *Bovine respiratory disease: Sourcebook for the veterinary professional.* Trenton, NJ: Veterinary Learning Systems Co., Inc., 1996, 57-74.
6. *Compendium of veterinary products* – US Edition, Animalytix LLC, 2019. Available from: https://bayerall.cvpservice.com/ Accessed June 30, 2019.
7. Duff GC, Walker DA, Malcolm-Callis KJ, Wiseman MW, Hallford DM. Effects of preshipping vs. arrival medication with tilmicosin phosphate and feeding chlortetracycline on health and performance of newly received beef cattle. *J Anim Sci* 2000;78:267-274.
8. Duffield TF, Merrill JK, Bagg RN. Meta-analysis of the effects of monensin in beef cattle on feed efficiency, body weight gain, and dry matter intake. *J Anim Sci* 2012;90:4583-4592.
9. FDA. *Medicated feeds.* 2019. Available at: https://www.fda.gov/animal-veterinary/animal-food-feeds/medicated-feeds Accessed Jan 15, 2020.
10. Gallo GF, Berg JL. Efficacy of a feed-additive antibacterial combination for improving feedlot cattle performance and health. *Can Vet J* 1995;36:223-229.
11. Heinrichs AJ, Wells SJ, Losinger WC. A study of the use of milk replacers for dairy calves in the United States. *J Dairy Sci* 1995;78:2831-2837.
12. Johnson BA, Anker HS, Meleney FL. Bacitracin: A new antibiotic produced by a member of the *B. subtilis* group. *Science* 1945;102:376-377.
13. Kreikemeier KG, Stokka G, Martson T. Influence of delayed processing and mass medication with either chlortetracycline or tilmicosin phosphate on health and growth of highly stressed calves. *Southwest Kansas Res Ext Center Prog Rep* 1996;773:23-27.
14. McGuffey RK, Richardson LF, Wilkinson JID. Ionophores for dairy cattle: Current states and future outlook. *J Dairy Sci* 2001;84:(E-Suppl.)194-203.
15. Nagaraja TG, Chengappa MM. Liver abscesses in feedlot cattle: A review. *J Anim Sci* 1998;76:287-298.
16. Nagaraja TG, Taylor MB, Harmon DL, Boyer JE. In vitro lactic acid inhibition and alterations in volatile fatty acid production by antimicrobial feed additives. *J Anim Sci* 1987;65:1064-1076.
17. Perrett T, Wildman BK, Jim GK, Vogstad AR, Fenton RK, Hannon SJ, Schunicht OC, Abutarbush SM, Booker CW. Evaluation of the efficacy and cost-effectiveness of melengestrol acetate in feedlot heifer calves in Western Canada. *Vet Ther* 2008;9:223-240.
18. Quigley JD, Drew MD. Effects of oral antibiotics or bovine plasma on survival, health and growth in dairy calves challenged with *Escherichia coli*. *Food and Agric Immunol* 2000;12:311-318.
19. Rogers JA, Branine ME, Miller CR, Wray MI, Bartle SJ, Preston RL, Gill DR, Pritchard RH, Stilborn RP, Bechtol DT. Effects of dietary virginiamycin on performance and liver abscess incidence in feedlot cattle. *J Anim Sci* 1995;79:9-20.
20. Samuelson KL, Hubbert ME, Galyean ML, Loest CA. Nutritional recommendations of feedlot consulting nutritionists: The 2015 New Mexico State and Texas Tech University survey. *J Anim Sci* 2016;94:2648-2663.
21. Smith ZK, Crawford GI, Loe ER. Effect of bambermycin and dietary distillers grains concentration on growth performance and carcass characteristics of finishing steers. *Trans Anim Sci* 2020;1:1-7.
22. Spires HR, Olmsted A, Berger LL, Fontenot JP, Gill DR, Riley JG, Wray MI, Zinn RA. Efficacy of laidlomycin propionate for increasing rate and efficiency of gain by feedlot cattle. *J Anim Sci* 1990;68:3382-3391.
23. Stock RA, Laudert SB, Stroup WW, Larson EM, Parrott JC, Britton RA. Effect of monensin and monensin and tylosin combination on feed intake variation of feedlot steers. *J Anim Sci* 1995;73:39-44.
24. Szasz JI, McMurphy CP, Bryant TC, Luque J, Barcelo C, Sepulveda G, Blood KS, Bernhard BC, Hughes HD. Influence of therapeutic use of feedgrade tetracyclines in combination with tulathromycin metaphylaxis on animal health and performance of Holstein steer calves. *J Anim Sci* 2019;3:185-194.
25. Vasconcelos JT, Galyean ML. Nutritional recommendations of feedlot consulting nutritionists. The 2007 Texas Tech University survey. *J Anim Sci* 2007;85:2772-2781.
26. Vogel G. Rumensin efficacy: A review of large pen research trials. In: Scientific Update on Rumensin/Tylan/Micotil for the Professional Feedlot Consultant. Indianapolis, IN: Elanco Animal Health. 1996, B1-B10.
27. Wileman BW, Thomson DU, Reinhardt CD, Renter DG. Analysis of modern technologies commonly used in beef cattle production: Conventional beef production versus nonconventional production using meta-analysis. *J Anim Sci* 2009;87:3418-3426.

Using DC 305 to help your clients achieve success

Michael Capel, DVM
Perry Veterinary Clinic, Perry, NY 14530

Abstract

Dairy Comp 305 is a dairy management software program designed to help producers manage the cows on their farm. It allows the user to record important pieces of information about each cow for later retrieval and use by dairy employees and consultants. Veterinarians, through their understanding of biology, animal husbandry and farm operations, are uniquely qualified to help producers utilize this program to manage their farms, monitor trends, and intervene quickly when problems arise. Additionally, management programs like Dairy Comp 305 will be critical in helping farms remain compliant with regulatory guidelines. Veterinarians can help farms design and implement data recording, generate "action" lists of cows requiring management intervention, provide concise and easy reports to evaluate disease trends, and regularly monitor reproduction and milk production. A sound understanding of dairy management software opens considerable opportunities for the engaged practitioner to demonstrate value and help their clients achieve success.

Key words: Dairy Comp 305, management, success

Résumé

Le logiciel de gestion de production laitière Dairy Comp 305 a été conçu pour aider les producteurs à prendre en charge les vaches dans leur ferme. Le logiciel permet à l'utilisateur d'enregistrer d'importantes informations sur chaque vache que les employés de la ferme et les consultants pourront accéder et utiliser plus tard. Les vétérinaires en raison de leurs connaissances en biologie et sur l'élevage des animaux et des opérations de la ferme sont uniquement qualifiés pour aider les producteurs à utiliser ce logiciel pour gérer leurs fermes, faire un suivi des tendances et intervenir rapidement lorsque des problèmes surgissent. De plus, des logiciels de gestion comme Dairy Comp 305 seront essentiels pour aider les fermes à demeurer conformes aux exigences réglementaires. Les vétérinaires peuvent aider les fermes à planifier et à mettre en œuvre l'enregistrement des données, à générer des listes d'action pour des vaches qui nécessitent des interventions de gestion, à créer des rapports brefs et pratiques pour l'évaluation des tendances de maladies et à surveiller régulièrement la reproduction et la production laitière. Une connaissance approfondie d'un logiciel de gestion de production laitière ouvre la voie à de nombreuses opportunités pour le praticien impliqué de prouver sa valeur et d'aider ses clients à réussir.

Recording Data

Proper data recording is the foundation of any record keeping system. Data should be recorded contemporaneously, consistently, and in a format that is easy to retrieve. In Dairy Comp 305, data about a specific cow is stored in 2 different forms: Items and Events.

Items are used for storing simple "facts" about an animal. There are 2 basic item classifications: Stored Items and Calculated Items. Stored Items record independent information about a cow that usually stays the same for that cow. Examples include ID number, birthdate, and Sire ID. Stored Items are also useful for data that may change each lactation such as calf total protein, fresh cow BHBA (β-hydroxybutyric acid), or calving ease score. Calculated Items are pieces of data that are determined by other factors in the cow's history. Calculated Items change over time and include information such as DIM (days-in-milk), DSLH (days since last heat), and DCC (days carried calf). Many Items come preprogrammed into Dairy Comp, however, flexibility exists to build new Items that are useful to the farm and practitioner. There are over 150 Item types that can be used for storing a wide variety of data. Items types can be viewed using the ALTER menu and selecting option 2 (Items). Once on the Items page, select ADD to begin building a new Item and display all of the Item types available. Item types include number ranges, alphanumeric codes, calculated dates, event descriptors, test day Items, daily milk Items, and average daily gain Items for youngstock. Consistency is important when building new Items. They should have a logical, easy to remember name and should be created and named the same way for all herds to help with consistency in data analysis. Understanding how to build Items and the types of Items available for use can be very important for the practitioner in helping the farm record and evaluate important information.

An Event is something that happens to a cow. Events can be related to a management action (FRESH, BRED, DRY, SOLD) or a disease (DA, RP, MAST (mastitis)). Unlike Items, where only 1 piece of data can be stored, Events allow for more data to be stored or calculated. For example, data regarding the date of an Event, the DIM at an Event, the month an Event occurred, and the number of occurrences of an Event are all recorded. This information can be critical to describing and understanding the dynamics of the Event. Dairy Comp allows for a total of 63 Events. The first 18 Events are fixed in Dairy Comp and should not be changed. If a dairy is not utilizing all 63 Events, new Events can be created using the ALTER menu, selecting option 9 (User Defined Events) and clicking the ADD button. If there is a desire to create a new Event and

the dairy is utilizing all their Events, contact support personnel and have a discussion with the farm to determine if any Events can be repurposed. It is important to utilize support personnel to make certain that this is done properly without negative effects on other data being recorded.

It is critical for data to be recorded consistently. Perhaps the best area for recording consistency can be found in the example of recording disease Events. Some disease Events, such as DIED, are recorded consistently on almost all dairies. Others, such as MAST (mastitis), RP (retained placenta) or KETOSIS can be recorded differently across farms and among farm workers on a specific farm. Depending upon the dairy, MAST may be used to record any cow with clinical mastitis (abnormal milk) or any animal that has an udder health issue based on some other test (CMT (California Mastitis Test)-positive animals, animals with a high conductivity or animals with a high test-day somatic cell score) in addition to animals with just clinical mastitis. Some dairies may reserve the MAST event for only animals that are being treated for clinical mastitis. It is easy to see how the incidence of MAST would vary widely across these 3 scenarios. Similarly, some dairies may use RP to record any animal that is being treated as a result of the RP while others may record any animal with retained fetal membranes present 24 hours after calving. Again, these approaches could drastically change the incidence of RP and create confusion when evaluating farms. Establishing clear case definitions for each disease and properly training employees is vital to accurately recording data. Keeping case definitions consistent across farms allows the consultant to accurately summarize disease for comparison and benchmarking.

Improving data integrity on the dairy is essential for quick and accurate data recording and retrieval. Working with data collection systems and data recording can help the practitioner demonstrate value to the producer and creates additional opportunities for on-farm training, protocol development, and data analysis.

Routine Action Lists

There are many tasks to perform on the farm each day. Developing lists of cows for dry off, foot trimming, vaccination, and synchronization program injections, for example, needs to be done quickly and reliably, allowing farm staff to spend less time in front of a computer and more time working with cows. Veterinarians are often very involved in designing management protocols for farms, but less involved in helping the farm with the logistics of accomplishing these tasks. Utilizing Dairy Comp to generate lists of animals requiring management intervention can be a great way to ensure compliance and help the dairy be more efficient. Lists can be created to include important information, such as cow ID and pen number, that employees need to find cows. Additional information can also be included to help the employees make decisions about an animal's value or risk for disease. One example of this would include listing milk production, DIM, and lactation on a list of animals due for pregnancy examination. This information could help make the decision of whether a cow diagnosed "open" should be re-enrolled in an estrus synchronization program for rebreeding. Another example would be listing previous cases of mastitis and somatic cell history on a list of cows due to be dried off. These items can be useful in determining a cow's risk for subclinical mastitis infection in herds interested in utilizing a selective dry-cow therapy program.

Lists of cows that are "out of compliance" with herd protocols are also very helpful for farms. Such lists include cows past a predetermined voluntary wait period or heifers past a certain age that haven't been serviced, animals above a certain number of days carried calf that haven't been dried off or above a certain number of days carried calf that haven't calved or animals that are past their milk residue date and are therefore eligible to be evaluated for a move from the hospital pen to a milking pen. These types of lists help farms identify animals out of compliance with farm protocols that would benefit from immediate action. Generating lists of cows for herd management and intervention provides an excellent opportunity for the practitioner to help dairies accomplish routine tasks and improve efficiency.

Routine Reports

Veterinarians must be able to review farm performance quickly and confidently. Early recognition of changes in disease rates, reproductive performance, and production can be critical. Routinely reviewing farm performance is essential to picking up changes early. Practitioners should make a list of key areas on the farm that are important to monitor. These parameters should be easy to retrieve, quick to change, reflect current conditions on the farm, not be influenced by historical performance, and minimally biased by other events on the dairy.

Most practitioners do not visit each of their clients daily. As such, there is a need at the beginning of each scheduled visit to quickly review the herd's history since the last visit and identify areas of opportunity. In herds with individual ID and daily milk weight data, daily and weekly production information can be helpful to track changes to cow performance. Reports summarizing events that occurred on the dairy allow for monitoring of management activity as well as disease history. Using this report can help the practitioner identify any change in the number of animals freshening, bred, dried-off or sold for example, as well as identify any change in the amount of disease. Examples of additional reports include a review of maternity pen management, youngstock disease rates, breeding, and health. These reports can all be programmed into easy to run commands that provide the practitioner with an accessible, consistent and reliable account of farm performance, allowing the focus to shift from "what happened" to "why did it happen and how can we fix it."

GUIDE is a section of Dairy Comp that contains numerous preprogrammed reports. It is accessible by typing GUIDE into the command line and provides a wide variety of reports, graphs, and tables for evaluating different areas of the dairy. Dairy Comp users less comfortable with generating their own commands, as well as more experienced users, can benefit from exploring the reports within GUIDE.

Treatment Protocols

Society demands that animal agriculture employ principles of prudent drug use. FDA guidelines, prescription laws, and FARM (Farmers Assuring Responsible Management) program updates require veterinary oversight and monitoring of pharmaceutical use on farms. Designing on-farm treatment protocols, training farm staff, and monitoring compliance all require veterinary involvement, clear communication, and an easy and reliable system for implementation. Dairy Comp can be instrumental in this process. The ALTER menu option 7 (Protocols) provides access to a Protocol table, allowing the user to enter disease-specific treatment plans. Data including the condition being treated, drug and dose to be used, duration of therapy and milk and meat residue information can be entered for each protocol. This data should match the written on-farm treatment protocols and assists the farm in maintaining protocol compliance. When disease events and treatment regimens are properly entered into Dairy Comp, a daily action list of cows requiring therapy can be generated, ensuring that animals receive the treatment they need each day. Customized reports of disease history and protocol usage can also be generated to monitor protocol compliance. The new Cow Care module of Dairy Comp provides additional opportunity to inventory drugs on farm, deducting drug use from current inventory, and providing for complete drug traceability.

Summary

Veterinarians have an opportunity to be involved not only in the development of management and therapeutic protocols, but also to help the farm accomplish these tasks. Veterinarians play a vital role in helping farms identify disease and performance trends, generate action lists for management tasks, identify animals not in compliance with farm protocols, and meet the growing requirements of regulatory agencies. On-farm management software such as Dairy Comp 305 are essential to performing these tasks and providing these services to clients.

Building confidence in transition cow consulting

K. Fred Gingrich II, DVM
Executive Director, AABP, Ashland, OH 44805, email: fred@aabp.org

Abstract

Nutrition can greatly impact the health and productivity of the lactating dairy cow. Nutrition and management during the dry period and immediately prior to calving have a tremendous impact on the success of the cow to transition into lactation. The veterinarian may be asked to intervene on individual sick cows with transition problems (i.e. ketosis, displaced abomasum [LDA], hypocalcemia) or evaluate a herd that has a higher incidence of transition cow disease than expected. Veterinarians should develop the skills necessary to consult producers on how to diagnose whether the transition cows are having a negative impact on herd health and productivity, evaluate the cause of the increased herd-level incidence, and recommend management and nutritional changes to correct the problem. This paper will primarily focus on clinical and subclinical ketosis prevention and its sequelae.

Key words: transition cow, ketosis, nutrition

Résumé

La nutrition peut avoir un impact considérable sur la santé et la productivité des vaches laitières en lactation. La nutrition et la gestion durant le tarissement et juste avant le vêlage ont un impact majeur sur le succès de la vache en transition vers la lactation. On peut demander au vétérinaire d'intervenir auprès de vaches malades avec des problèmes de transition (i.e. acétonémie, déplacement de caillette, hypocalcémie) ou pour l'évaluation d'un troupeau avec une incidence de maladie plus élevée qu'attendue chez les vaches en transition. Les vétérinaires devraient développer les compétences nécessaires pour aider les producteurs à déterminer si les vaches en transition ont un impact négatif sur la santé et la productivité du troupeau, pour les aider à évaluer la cause de la hausse d'incidence dans le troupeau et pour recommander des changements de gestion et d'alimentation pour corriger le problème. Cet article mettra l'accent sur la prévention de l'acétonémie clinique et subclinique et ses séquelles.

Diagnosing Transition Cow Problems

Various diagnostic tests are available to evaluate individual cows for clinical ketosis. Testing for acetoacetate in the urine or milk can be performed. Comparisons have been done evaluating the sensitivity and specificity of ketosis testing methodologies.[1] Laboratories can be utilized to measure beta-hydroxy butyric acid (BHBA); however, the lag time from sample collection to receiving results makes this test impractical in many situations. The use of cow-side hand-held glucometer type devices have been used to measure BHBA, and studies have been published demonstrating the utility of the device for dairy cows.[3] These devices can be used to measure BHBA on clinically ill cows as well as herd-level diagnostic screening.[6] These tests can be performed on a population of at-risk animals to determine if a herd-based problem exists. A typical testing strategy would be to test animals twice during the first 7 to 10 days-in-milk (DIM). BHBA levels > 1.4 mmol/liter indicate subclinical ketosis. Herds with more than 15 to 20% of cows with elevated BHBA levels have higher rates of performance problems.[4] In practice, this means that I would typically test 10 to 20 cows and intervene if 2 to 4 cows were above 1.4 mmol/liter. On small herds, routine monitoring of fresh cows with cow-side blood BHBA meters and recording results in a log can be useful to prevent outbreaks and gather enough data.

Workup of Herd-based Ketosis Problem

Once a herd has been diagnosed with an abnormal incidence of subclinical or clinical ketosis, the veterinarian can perform a systematic evaluation regarding risk factors predisposing the herd to these issues. An initial evaluation can be performed without a complete nutritional analysis; however, a full consultation should include an evaluation of the formulated ration. This paper will provide general steps to a herd-based workup for evaluating transition cow problems associated with ketosis. The size of the herd, use of a 1-group vs far-off dry and close-up pens, mixed parity pens, available feedstuffs, and individual management factors must be considered when applying these principles to individual farms.

Dry-Matter Intake Offered

Calculation of dry matter intake of each dry-cow group is a key component of the nutritional evaluation. Knowing what the cows are actually consuming is just as important, if not more important, than the formulated ration. First, review the mix sheet to make sure the producer or feed manager is mixing the ration as formulated. Review each feed ingredient and make an estimation of the amount of dry-matter pounds *being fed.* The goal for a one-group mixed parity pen is 27 lb (12.2 kg) of dry matter consumed.[2] The next step is to evaluate if the cows are consuming the amount fed or if there are any red flags that might indicate we are overestimating the amount of dry matter cows are consuming. For instance, the farm may be using "free choice long stem hay" and overestimating the amount consumed. In my experience, it is

difficult for cows to consume more than 10 lb (4.5 kg) dry matter of long-stem hay per day, depending on quality and management factors.

Energy

Controlling the amount of energy dry cows consume can greatly influence the success of transition. Feeding excess dry matter can result in overfeeding energy which will increase the risk of the cow to be hypersensitive to adipose tissue breakdown and ketosis. Controlled energy diets attempt to feed the correct amount of dry-matter intake that provides the correct amount of energy.[2] A goal for a controlled energy diet would be in the range of 0.59 to 0.63 Mcal Nel/lb of dry matter. The veterinarian should look at the formulated ration or input the feeds into ration software to calculate the predicted calories consumed. A common scenario is overfeeding corn silage to dry cows to increase dry-matter intake when hay quality is poor or scarce.

Management Factors Limiting Dry-matter Intake

There are several management factors that increase the risk of inhibiting dry matter intake.[5] The 3 most common scenarios I have encountered include inadequate bunk space, overcrowding, and inappropriate pen moves. Dry cows should have 3 linear feet (0.91 m) of bunk space per head. If there are headlocks in the dry pens, but nowhere else for that management group, it might inhibit intakes, especially in heifers. Dry pens that utilize loose housing should have 100 square feet (9.3 square meters) of resting space per cow and ideally be stocked at 80% density. Moving animals between pens less than 3 weeks before anticipated calving can also inhibit dry-matter intake. For small herds, I recommend a 1-group dry pen to prevent inappropriate pen moves as well as utilize labor resources more efficiently. For larger herds that utilize a far-off and close-up pen, evaluate time spent in the close-up pen to determine actual days in close-up to determine if inappropriate pen moves are a risk factor. Overconditioned cows also have an increased risk for ketosis. Often this can be linked to reproductive problems, resulting in cows that spend too much time in late lactation putting on an excessive amount of body weight before the dry pen. This can also be seen with excessive dry period length (> 70 days). Culling reproductive failures is often a better strategy vs investing resources into animals at high risk of failure in the first 60 DIM.

Dietary Recommendations

I have had the best success managing transition cows with 1-group dry pens on a controlled energy diet.[2] It is imperative that if a high-fiber/low-energy ration is used, forages must be chopped to ensure appropriate dry-matter intake. Two common scenarios I have seen fail are excessive corn silage or haylage feeding and feeding long-stem dry hay of poor quality. I follow the guidelines from Drackley[2] for formulating these rations which includes:

- DMI of 27 lb (12.2 kg) per day;
- Energy density of 0.59 to 0.63 MCal Nel per day;
- Protein of 1000 to 1200 grams per day of metabolizable protein (MP);
- Starch content of 12 to 16% on a dry matter basis;
- Forage neutral detergent fiber (NDF) of 40 to 50%.

These diets are typically composed of corn silage and chopped straw with a protein supplement, and balanced for dietary cation-anion balance (DCAD). The straw must be chopped to 1 to 1.5-inch (2.5 to 3.8 cm) chop length. I have found the easiest way to do this is to pre-chop it prior to it going into the mixer. My clients have utilized silage bags for chopped straw after harvesting it through a forage processor as well as storing in a commodity shed.

It is critical that the ration offered provides adequate dry-matter intake and that no management factors inhibit access to the feed. These farms often utilize just-in-time calving, where cows are moved to calving pens when feet are showing.

Some farms will experience low volume of colostrum with these dry-cow diets. I have anecdotally found that ensuring adequate starch and protein intake will correct this problem. If the cows are producing 1 gallon of colostrum, I do not intervene.

Conclusions

Veterinarians are often the only consultant on the dairy that has oversight of many areas of the farm operation. This can include cow health, productivity, judicious use of medication, treatment protocols, individual animal treatment, and employee training. Offering transition cow consulting, due to its inherent effects on cow health and productivity, is an ideal first step to nutrition consulting for the recent graduate veterinarian. Specific dietary formulations and ration balancing are not requirements to evaluating transition cow problems. Evaluating dry-matter intake and management factors can occur cow-side during a routine herd visit. Including the nutritionist in these conversations is imperative to developing a team approach with the best interests of the dairy producer in mind. Continued monitoring of BHBA levels in fresh cows as well as performance indicators, such as peak milk production, will help to ensure continued success of the transition cow program.

References

1. Carrier J, Stewart S, Godden S, Fetrow J, Rapnicki P. Evaluation and use of three cow-side tests for detection of subclinical ketosis in early postpartum cows. *J Dairy Sci* 2004;87:3725-3735.
2. Drackley JK, Janovick-Guretzky N. Controlled energy diets for dry cows. *Proceedings.* Western Dairy Management Conf 2007.
3. Iwersen M, Falkenberg U, Voigtsberger R, Forderung D, Heuwieser W. Evaluation of an electronic cowside test to detect subclinical ketosis in dairy cows. *J Dairy Sci* 2009;92:2618-2624.

4. McArt JA, Nydam DV, Oetzel GR, Overton TR, Opsina PA. Elevated non-esterifed fatty acids and β-hydroxybutyrate and their association with transition dairy cow performance. *Vet J* 2013;198:560-570.
5. Nordlund K, Cook N, Oetzel G. Comingling dairy cows: Pen moves, stocking density and health. *Proceedings.* Annu Conf Am Assoc Bov Pract 2006;39:36-42.
6. Oetzel G. Monitoring and testing dairy herds for metabolic disease. *Vet Clin North Am Food Anim Pract* 2004;20:651-674.

Calving detours: Cesarean section

Margaret A. Masterson, DVM, MD, Diplomate, ACVPM
Department of Veterinary Medicine, College of Veterinary Medicine, The Ohio State University, Columbus, OH 43040

Abstract

Many times, it is not possible to deliver a calf vaginally. Veterinarians need to be familiar with the indications for a cesarean section (C-section), how to perform the surgery, and to move on to this option in a timely manner to achieve the best results. This paper will cover the indications for a C-section. There are several surgical approaches, but in general the left flank approach is the easiest to perform. Anesthesia is typically achieved with a paravertebral block of inverted "L". Once the abdomen is open, the uterus is brought to the incision. A uterine incision starting at the hock and extending to and around the hoof is made through which the calf is delivered. If the uterus cannot be brought to the incision, it can be opened in the abdomen with the aid of a letter opener. Severely contaminated calvings may require a special approach. Once the calf is delivered, the uterus is closed with an inverting pattern, and the body wall is closed in a standard manner. Knowing how to perform a C-section in the field will give the veterinarian another option when a calving detour is indicated.

Key words: bovine, dystocia, cesarean section, surgery

Résumé

Le vêlage d'un veau n'est pas toujours possible par voie vaginale. Les vétérinaires doivent être familiers avec les situations exigeants une césarienne et la procédure chirurgicale requise et aussi savoir quand passer à cette option en temps opportun pour obtenir les meilleurs résultats. Cet article couvrira les situations exigeant une césarienne. Il existe plusieurs approches chirurgicales mais en général l'approche par le flanc gauche est la plus facile à faire. L'anesthésie se fait typiquement à l'aide d'un bloc paravertébral en L inversé. Lorsque l'abdomen est ouvert, on extériorise l'utérus pour l'incision. On fait une incision utérine partant du sommet et s'étendant jusqu'au bas par laquelle sortira le veau. Si on ne peut pas extérioriser l'utérus pour l'incision, il peut être ouvert dans l'abdomen avec l'aide d'un coupe-papier. Les vêlages très contaminés peuvent nécessiter une approche spéciale. Lorsque le veau est sorti, l'utérus est fermé avec un patron inversé et la cavité corporelle est fermé de manière habituelle. Savoir comment faire une césarienne sur le terrain donnera au vétérinaire une autre option lorsqu'une voie alternative de vêlage s'impose.

Case Selection

One of the first things to consider with a cesarean section (C-section) is case selection. We all hope that when we are called out to a dystocia that it will end successfully with a live delivery, but when that is not possible we need to consider a calving detour. Common indications for a C-section are malpresentation that cannot be corrected, uterine torsion, a deformed calf or deformed maternal pelvis. The most common indication for a C- section is fetal-maternal mismatch, or a calf that is simply too big for the cow to deliver.

Veterinarians are persistent individuals, unwilling to give up (that is how you got through vet school, right?). We have all heard the horror stories of a veterinarian stuck doing a middle of the night, 5-hour dystocia. These often occur because despite the fact that the calf is presented incorrectly or is just too big, we get caught up in the notion that if we just reach a little further or pull a little harder we will get this baby delivered. Therefore, I would suggest you follow the 15 minute rule. That means you should work for 15 minutes to correct the problem, and if you have not made significant progress in that time, do something else. In other words, if it was a true breech and at the end of 15 minutes you have 1 leg up, great, keep working but if it is still a true breech in 15 minutes, move on to the C-section or fetotomy. Often vets, especially new graduates spend too much time trying to correct the dystocia and by the time they realize they need to do a C-section they are too exhausted to successfully perform the surgery and the cow is too stressed for a good outcome.

If the calf is anticipated to be large, veterinarians may opt for an elective C-section. Elective C-sections are usually easier, in that the uterus is not contracting on the calf. The calf is not in distress and it can be scheduled during regular working hours. The author has had good success in planning the procedure for about 2 days before the expected due date. Giving the cow 0.02 mg/lb (0.04 mg/kg) dexamethasone intramuscular 24 hours before the procedure helps to insure that the calf's lungs are mature. The owner can also give a dose of prostaglandin about 6 hours pre-operatively if desired.

Cows with dead or emphysematous calves have a poorer prognosis and are not ideal surgical candidates. It is nearly impossible to perform a C-section and not contaminate the cow's abdomen with some uterine fluid. With an emphysematous fetus, this increases the risk of peritonitis. A procedure is described later in this paper for performing a C-section on a rotten calf, but if possible, these are best dealt with by fetotomy.

Approaches

Surgical approaches for C-sections have been described for the high or low, left or right flank, the midline, and the paramedian. Most veterinarians prefer to do standard C-sections from the standing left flank approach, regardless of which horn the cow is pregnant in. Having the cow standing allows the surgeon to use gravity to help extract the calf and is more comfortable for the surgeon. The rumen holds the intestines in during the procedure, which often want to eviscerate when the calf is being pulled in a right approach. If the cow is weak or tired and you feel like she may not want to remain standing for the entire procedure, you are better off to cast her down and do the entire procedure down than to have her fall mid-surgery, and perhaps go down on the incision.

Performing the procedure in a chute in a heated facility with good lighting is ideal, but I have done many C-sections in barns. You do need good restraint. You can put the cow in a chute, an old stanchion or tie her to a post against a wall so she cannot swing around. A rope placed around the cow's neck and then tied very low back along the side of her can help prevent her swinging around. One of the "tools" I keep in my truck is a trouble light and extension cord for doing surgery in dark barns.

Anesthesia

In dairy cows, anesthesia of the paralumbar fossa is generally achieved with a proximal or distal paravertebral block. In beef cows, due to their heavy conditioning, I will usually perform an inverted "L" block. Just remember that you will need a vertical incision 14 to 18" (35.5 to 45.7 cm) long. I like to avoid line blocks, as they make the closure more difficult and contaminate the deeper muscle layers directly at the site of the incision, but they are the only real option for paramedian and midline approaches. If the cow is straining, perform a light epidural (1 mL/200 lb [91 kg] BW lidocaine). Unless the cow is so aggressive that she needs to be tranquilized for safety reasons, I try to avoid any types of systemic tranquilizer as this may cross over into the calf. Additionally, xylazine increases uterine tone making the uterus harder to manipulate. If systemic tranquilizers must be used, the calf should be reversed once it is delivered.

Preparation

The cow should have her tail tied away from the surgical site. The area is clipped from the backbone to the milk vein and from the first transverse process to behind the wing of the ileum for a flank approach. The area should then be scrubbed with soap to get the major dirt off. Once the dirty scrub is complete, the paralumbar fossa is blocked. The area should them be prepped with a 5-minute surgical scrub with sterile 4 x 4s, and then wiped with alcohol. Meanwhile, the surgeon should lay out a sterile instrument pack. An old table, upside-down barrel or 2 bales of hay stacked up work well as an instrument table. Be sure to set the table out of the range of where the cow could knock it over, or contaminate it with feces. Also, be sure it is where other curious cows will not contaminate it.

In addition to instruments you will need at least 3 packages of #3 gut, a scalpel blade, a drape, sterile palpation sleeves, saline lavage, sterile 4 x 4s and #3 skin suture. The obstetrical handles and chains should be placed in a nearby bucket with water and disinfectant. The use of a drape helps if the surgeon needs to push the cow during surgery or needs somewhere to rest their hands.

I prefer to wear a gown and gloves when performing surgery, as I often find that shorter stature surgeons may need to extend their whole arm and shoulder into the incision. Further you may need to hug the calf to you to facilitate removal from the cow. You can wear a palpation sleeve protector or full OB suit under the surgery gown to prevent fetal fluids from soaking clear through the gown. This also helps to keep the surgeon warm in cold months.

Surgery

An incision is made starting a hand's width or about 4 inches (10 cm) below the transverse process and extending about 14 inches (35 cm) ventrally. The more contaminated the surgery, the lower the incision should be made. The muscle is incised layer by layer until the abdomen is entered. At this point the surgeon should don 2 sterile palpation sleeves. Palpate the uterus and identify the greater curvature. If it is an anterior presentation, grasp the rear foot and hock of the calf, driving with the hock, applying upward and lateral force to the hoof to try to bring the leg to the incision. Once at the incision, you can turn the leg horizontal to the incision and it should hold there. If the calf is presented posterior, grab a front leg and bring it to the incision. However this is more difficult, as the leg will want to bend.

A 14 to 16-inch (35.5 to 40.5 cm) incision is then made full thickness into the uterus. It is important to start at the hock or carpus and cut toward and around the hoof. If you start at the hoof, the calf's leg will pop out the hole and slide down the leg and you will not have a big enough incision through which to deliver the calf.

While it is preferable to exteriorize the uterus, you may not be able to, depending on the size of the calf and the surgeon. As long as the contents are healthy, you can open the uterus in the abdomen. This is best done with a hand-held letter opener. The point and blade of the letter opener can be guarded with the hand as you guide the instrument to the greater curvature. Once at the site of the incision, the point is poked through the uterine wall and the opener is slid along the wall until there is an incision adequate to deliver the calf. The hand guards the front of the opener, pushing any intestines away from the blade.

Place the obstetrical chains on the calf's legs with 2 half hitches. The chains can then be handed off to the farmer or assistants to pull the calf, while the surgeon monitors the size of the incision and helps assist the pull. The surgeon needs to monitor both the uterine incision and the skin incision, extending either as needed to avoid tears. Large incisions are much easier and less traumatic than tears to close. Once the calf is extracted, check for twins, trauma, and tears.

If the calf is emphysematous or the uterus is badly contaminated, the surgery should be done down. The incision is made in the left paramedian space or on the midline. Once the uterus is exteriorized, the cow's back legs are pulled up mid-surgery by an assistant so the cow is in dorsal recumbency, and the uterus is flopped to the side with the body wall incision above it. Use caution when manipulating the uterus, as it is often tissue-paper thin and may easily rupture. The calf can be extracted, the incision closed and thoroughly rinsed. The surgeon can then re-glove to replace the uterus and finish the surgery.

The uterus should be lifted out of the body incision and a vulsellum forceps or assistant should hold the top of the incision, closest to the uterine body and this is where the suture line should begin. The uterus is closed with #3 cat gut in an inverting Utrecht or guard rumen stitch pattern. The uterus is a very forgiving organ, so be sure that the stitches are placed in healthy tissue even if a considerable part of the uterus is inverted. Sutures will often tear out of weak, bruised or edematous tissue. Ignore the fetal membranes until the incision is closed enough that they will stay in the uterus when tucked in a 3 to 4 inch (7.6 to 10 cm) opening. Many new surgeons spend a lot of time trying to get fetal membranes to stay in the uterus when the opening is too large. If a large amount of membranes are hanging out of the uterus, they can be trimmed to decrease the weight and contamination.

Once closed, the uterus is rinsed with sterile saline to remove clots and avoid adhesions and replaced. Be especially careful that the ovary and fossa are free of clots. The abdomen may be flushed as well. The body wall is then closed in a standard manner. When closing the skin it is advisable to put a seroma stitch at the bottom of the incision if a continuous pattern is used. In this way, if the incision becomes infected it can be drained without having to try to retie the continuous suture.

Post Op Care

The cow should receive oxytocin following surgery and antibiotics if the surgery was performed in a barn. Antibiotics may be indicated for several days. Several low doses (20 to 40 IU) of oxytocin should be given in the 24 hr following surgery to facilitate involution. Additionally the cow may need pain medication, calcium, and fluids as supportive therapy. The sutures are removed in 10 to 14 days.

While we always hope for that easy live-birth calving, being prepared to take a calving detour and deliver the calf with a C-section. This often results in better outcomes and actually getting back to bed sooner.

References

1. Frazer G, Perkins N. Cesarean section *Vet Clin North Am Food Anim Pract* 1995;2:19-35.
2. Newman K. Bovine cesarean section in the field. *Vet Clin North Am Food Anim Pract* 2008;24:273-293.

Teat surgery

Margaret A. Masterson, DVM, MD, Diplomate, ACVPM
Department of Veterinary Medicine, College of Veterinary Medicine, The Ohio State University, Columbus, OH 43040

Abstract

Veterinarians are often called to perform teat surgery, whether due to congenital malformations of the teats or due to trauma. Anytime that teat surgery is performed, sterility is extremely important as one does not want to create a case of mastitis. This paper will cover the basics of common teat surgeries including supernumerary teats, slow milkers, teat obstructions, teat spiders, fistulas and repair of teat lacerations.

Key words: bovine, surgery, teat, supernumerary

Résumé

On appelle souvent les vétérinaires à faire une chirurgie du trayon en raison de malformations congénitales des trayons ou suite à un traumatisme. Pour toute chirurgie du trayon, la stérilité est extrêmement importante parce qu'on ne veut pas causer un cas de mammite. Cet article couvrira les rudiments des chirurgies fréquentes du trayon incluant les trayons surnuméraires, les trayons à faible débit, les obstructions de trayon, les lésions du trayon, les fistules et la réparation des lacérations du trayon.

Supernumerary Teats = Extras

The best time to remove supernumerary teats is before breeding (at Brucella Vaccination). At this age no anesthesia, except tailing the heifer up, is required. Clamp onto the tip with a hemostat and pull down so you can visualize the teat udder junction. Cut longitudinally (cranial-caudal), not transversely. Longitudinal cuts leave less of a scar than transverse cuts.

If in lactation, wait until the cow is dry. Do a local block at the base of the teat with about 10 ml lidocaine for anesthesia. Use a hemostat, elastrator band or emasculatome (burdizzo) for hemostasis. Extra teats that are removed on adults may require suturing in a continuous pattern with 3-0 to 5-0 suture to prevent hemorrhage.

Hard/Slow Milker

Hard milkers usually result from teat trauma, such as being stepped on, frostbite, or excessively high vacuum. If the trauma is recent and the teat only needs to be stretched a little, a teat dilator, inserted sterilely may be all that is needed. Be aware, however, that any time there is a dilator in a cow she is more prone to infection. The dilator may need be used for several days until swelling goes down and you can see if the teat needs to be opened more.

A Lichtie Teat Knife is used for teats that require larger opening. Using sterile prep, insert the knife while applying pressure with thumb. The amount of pressure applied with the thumb will determine how deep the cut is. If needed, turn knife 90° and again pull out with pressure on thumb (2nd cut). Up to 4 cuts can be made in this manner if needed.

Following opening the sphincter, you generally want milk to drip for 1 to 2 minutes after you milk out a stream. After opening, the cow should be milked every 15 minutes for 2 to 3 hours, then once per hour until milking.

When using a Lichtie knife remember that it is always better to stop too soon, and let the teat heal, before you cut further. It is better to have to make a second trip to open the teat more than to deal with a leaky teat.

Teat Obstruction

There are several different types of teat obstructions, but generally they all present with a teat that has milk in it, but the milk does not flow as it should. Producers will complain that either the cow has a blind quarter or that she takes excessively long to milk out. By using ultrasound veterinarians can usually visualize obstruction and thereby plan the best way to eliminate it. Annular rings form at the top of teat between the teat and gland cistern and often consist of a thin membrane. Using a long 6-inch (15 cm) needle inserted sterilely into the teat orifice, the membrane can be punctured and then torn to allow milk to flow into the teat cistern.

Obstructions can also occur at the teat sphincter, due to an incomplete streak canal. Often if you squeeze the teat you can visualize where the orifice should be, as an area where the milk budges up. It can then be opened using sterile technique with a 14-gauge needle. Owners may need to vigorously massage the teat end or use a dilator for several days to keep the opening from scarring back down.

Teat Spider = Pea in the Teat

Teat spiders results from trauma to the mucosal wall of the teat. Trauma leads to a hematoma on the inside of the teat that then coalesces into fibrous ball of tissue with stalk of blood supply. Typical history is that the cow can be hand milked, but not machine milked, as the tissue serves as a ball valve blocking the teat sphincter. While these can be quite large, they can usually be removed through the teat orifice with a Hugg's tumor extractor, mosquito hemostat or alligator forceps. Large masses may require that the ball of tissue

be broken up, so that it will fit through the sphincter. Giving the cow a dose of oxytocin (5 IU) will often allow her to let down milk, making the tissue easier to keep milked down to the end of the teat. This also allows the veterinarian to use the milk to build up some pressure so that the obstruction can be milked out once it has been detached from the wall.

If the obstruction is not moveable, it is probably still in the mural hematoma stage. It is better to wait until it pedunculates off, or do a thelotomy from the side opposite the swelling, excise swollen tissue then close as a laceration. It is important that the mucosa be completely closed in this procedure or granulation tissue will once again obstruct the teat.

Teat Fistula

Teat fistula is a hole in the side of the teat, through which milk leaks. If the fistula is small, it can be closed with silver nitrate sticks, scarifying the sides of the fistula and causing it to heal.

Alternatively, if large, cut an elliptical incision around the fistula into the teat cistern and close as you would a teat laceration.

Teat Laceration

Several things affect the prognosis for teat lacerations. Vertical lacerations have a better prognosis than horizontal lacerations. Lacerations that are not full thickness have a better prognosis than ones that are into the teat cistern. Fresh lacerations (<4 hr) heal better than old ones (>12 hr). Lacerations that just involve the body of the teat heal better than ones that involve the sphincter.

If you have access to a tilt table this is ideal; if not, repair can be done in parlor. Anesthesia usually consists of a ring block with 8 to 10 mL lidocaine, using a 25-gauge needle at the base of the teat. Lidocaine (3 to 5 ml) may also be infused into the teat to block the mucosa. Additionally, depending on the temperament of the cow and the extent of the laceration, general sedation may be indicated. Xylazine given at 0.05 to 0.1 mg/lb (0.05 to 0.1 mg/0.45 kg) will typically calm the cow but keep her standing. If hemostasis is a problem you can use umbilical tape at the base of the teat as a tourniquet.

Close any laceration that penetrates the teat in a 3-layer closure. Debride the laceration until the fresh edges bleed. Close the mucosa with 4-0 or 5-0 absorbable suture in a simple continuous pattern. This layer needs to be "milk tight". Close the submucosa with a simple continuous pattern, using absorbable 4-0 or 5-0 suture. Close the skin with simple interrupted sutures of 2-0 to 3-0 non-braided, non-absorbable suture. If there is a lot of tension on the incision, you can replace some of the interrupted sutures with vertical mattress sutures to provide support. If the laceration is not full thickness, it can be closed in 2 layers and/or with tissue adhesive.

After the laceration is repaired, it is best to machine-milk the cow as usual, as the machine will help to massage the swelling out of the teat. If the teat is too swollen to machine-milk, you may need to drain the teat with a teat cannula; try to avoid the use of dilators. Medicate the cow with nonsteroidal anti-inflammatories to minimize swelling. The use of systemic or intramammary antibiotics will depend on the cleanliness of the laceration. The cow may need oxytocin at milking to help with milk let-down. The sutures should be removed in 10 to 14 days.

Reference

Hull B. Teat and udder surgery. *Vet Clin North Am Food Anim Pract* 1995;2:1-17.

Sorting out umbilical abnormalities in the young calf

Eric D. Gordon, DVM, DACVPM

Abstract

Umbilical abnormalities in the calf can result from multiple underlying problems. Given the potential complicities of some of those conditions, umbilical growths can be daunting for some practitioners to handle in the field. A systematic approach to diagnosis utilizing palpation and ultrasound, along with aspiration in some cases, can allow for accurate diagnosis and successful first line treatment. Surgical evaluation is sometimes required to confirm the diagnosis and often necessary for resolution. This article will offer practical tips for the workup of umbilical disorders.

Key words: umbilical mass, umbilical abscess, umbilical hernia, herniorrhaphy

Résumé

Les anomalies ombilicales chez le veau peuvent découler de plusieurs problèmes sous-jacents. En raison de la combinaison de certaines de ces conditions, le traitement des problèmes ombilicaux sur le terrain peut poser un grand défi à certains praticiens. Une approche diagnostique systématique utilisant la palpation et l'échographie de même que l'aspiration dans certains cas peut permettre un diagnostic précis et un traitement de première ligne efficace. L'évaluation chirurgicale est parfois requise pour confirmer le diagnostic et est souvent nécessaire pour la résolution. Cet article offrira des conseils pratiques pour l'examen des troubles ombilicaux.

Introduction

Umbilical disease can be a common postpartum occurrence in neonatal calves. Omphalophlebitis (infection of the umbilical vein) has been described as the 4th most common disease in calves, following diarrhea, respiratory disease, and ringworm in calves 0 to 90 days of age.[3] During a normal birth, the umbilical structures (urachus, umbilical arteries, umbilical vein) retract into the abdomen, helping to protect them from environmental contamination and thus prevent umbilical complications. Calves born via cesarean section have a greater risk of umbilical infection due to the differences in clamping the cord versus "stretching", preventing the normal retraction of umbilical structures.[1] Some umbilical abnormalities have also been documented in cloned calves.[1] There is also anecdotal evidence that *in vitro* fertilized bovine embryo calves have a higher incidence of umbilical complications after birth, but a likely correlation exists that a larger proportion of those calves are also delivered by C-section.

Infection and herniation are the primary problems associated with the umbilicus in calves. Either one of these can lead to enlargement of the umbilicus. An umbilical mass is not always an umbilical hernia. Infection with environmental bacteria following birth is the most common source of infection; however a generalized septicemia can seed bacteria into the umbilical remnants. Environmental pathogens most commonly isolated from umbilical infections are *Trueperrella pyogenes* and *Escherichia coli*.[1,6]

Proper dipping of the external umbilicus after birth is an important management tool in preventing umbilical infection and possible subsequent herniation. Strong iodine (7%) is recommended by the author as an effective dip against navel infections. A Cornell study showed that calves with non-dipped navels had an 18% death rate, compared to 7% for calves with dipped navels.[4]

Umbilical disorders can be divided into 5 categories: 1) uncomplicated umbilical hernia; 2) umbilical hernias with subcutaneous infection/abscesses; 3) umbilical hernias with umbilical remnant infections; 4) umbilical abscess (chronic omphalitis); and 5) urachal cysts/ruptures.[6] In cases of umbilical hernias, others have chosen to describe them as complicated or uncomplicated. Uncomplicated hernias are the result of heritable defects of the body wall or developed after mild infections of umbilicus that go unnoticed.[5] Uncomplicated congenital hernias have been proven heritable in Holsteins.[1] Umbilical hernias are the most common bovine congenital defect, with a reported incidence between 0.65% and 1.04%.[6] These uncomplicated hernias are typically easily reducible by manual palpation, unpainful, and have likely had little impact on the growth and performance of the calf unless gastrointestinal contents become strangulated within the hernia sac. Complicated hernias are described as non-reducible and/or infected. They may be painful and the calves may show systemic signs of depression or poor growth.[3,5]

Therapy decisions are largely based on making an accurate diagnosis. This can be challenging, especially in the case of deep umbilical remnant infections. Diagnosis is typically made by performing a thorough physical exam including deep palpation of the umbilical enlargement. Care should be taken not to apply too much force, especially for hernias that aren't readily and easily reducible, so as not to rupture deeper abscesses/infected structures. Placing the calf in lateral recumbency, with or without sedation, can assist in thorough palpation of the umbilical structures. The presence of infected umbilical remnants is often easier to determine in the recumbent calf.[2] Pollakiuria can indicate urachal infection/inflammation, and fever, diarrhea, septic

joints, and meningitis may indicate septicemia.[3]

Ultrasonography is a useful tool in determining the type and scope of the umbilical mass. A linear ultrasound probe, such as is commonly used for rectal reproductive ultrasound, is sufficient to visualize most umbilical disorders. Ultrasound is typically performed with the calf standing, although it can also be applied while the calf is in lateral recumbency for examination or even in dorsal recumbency under anesthesia prior to surgical exploration to confirm to absence or presence of enlarged/infected umbilical remnants. Ultrasound can differentiate between external or internal abcessation, can aid in evaluating the integrity of the abdominal wall, and can also help to determine which, if any, of the umbilical remnants are involved/infected.

For suspected external umbilical infection with intact body wall (verified by ultrasound and/or palpation), aspiration of a fluid viscus with a 16-gauge or 14-gauge needle can be helpful ruling in or ruling out abscess.

In some cases, surgical exploratory via ventral midline laparotomy is required to determine the extent of involvement/infection of internal structures. Laparoscopic evaluation of intra-abdominal umbilical structures has been shown to be a potentially useful adjunct to physical exam and ultrasound. In 1 study, laparoscopy was performed in calves under general anesthesia in dorsal recumbency. Scope portals were placed 10 cm cranial to the umbilicus and 5 cm off midline. In some cases laparoscopy detected adhesions that were not suspected on ultrasound, as well as focal enlargements of the umbilical arteries and urachus close to the bladder.[7]

Treatment of uncomplicated umbilical hernias can be surgical or non-surgical and often are accomplished in the field. For hernias less than 3 cm in diameter, a belly band or umbilical support (hernia belt) can be applied to the abdomen over the hernia site. Various devices have been used to hold the hernia sac inside the abdomen. A smooth metal lid from a frozen juice concentrate can or a plastic ear tag glued to the hair of the abdomen, both followed by taping or placing a band around the abdomen has good success. Elastikon (4" width) applied snugly over the hernia site and also extended several inches cranial and caudal to the edges of the hernia and left in place for 2 weeks is very effective in allowing small (<3 cm) uncomplicated hernias to fibrose. The Elastikon or tape should be applied with the calf standing following the return of hernia contents into the abdomen.[3] Hernia clamps have also been used for uncomplicated hernia repair, but the author has mixed experience with clamps. For uncomplicated hernias >3 cm, surgical repair is nearly always necessary.

Surgical repair of uncomplicated hernias can be accomplished in the field under injectable anesthesia or in clinic via gas inhalation. Field anesthesia can be accomplished with 0.1 mg/lb (0.22 mg/kg) BW of xylazine along with 3 mg/lb (6.6 mg/kg) BW of ketamine mixed together and injected IM. Alternate protocols include xylazine (0.09 mg/lb; 0.20 mg/kg IM) followed by ketamine (1.8 mg/lb; 4 mg/kg IV). Xylazine and ketamine can be repeated every 20 to 30 minutes as needed. Alternatively, simple hernias can be repaired using xylazine sedation (0.045 mg/lb; 0.10 mg/kg IM) and lumbosacral epidural of 2% lidocaine (1 ml/10 lb [4.5 kg] BW).[3] Calves should be held off feed for 24 to 26 hours prior to surgical repair of any umbilical mass to facilitate abdominal exploratory and closure of the body wall.

Approach to the hernia involves an elliptical incision around the hernia removing the excess skin. A combination of sharp and blunt dissection is used to expose the shiny external rectus sheath. Cut through the external rectus sheath, then internal rectus sheath, then peritoneum. Enter the abdomen through the edge of the hernia sac at 3 or 9 o'clock (laterally) to avoid the umbilical vein (cranial) and umbilical arteries and urachus (caudally) if still present.[3] After making an initial 2 cm incision laterally, the underlying tissues should be explored digitally to determine if underlying tissues are adhered to the hernia capsule. Most commonly adhered are the abomasum and/or omentum. All umbilical hernia tissue should be removed and the body wall edges debrided and freshened. Closure by simple apposition of the unscarred hernia ring with minimal tension is thought to lead to ideal healing.[6] Several suture patterns may be used. Some surgeons suggest simple interrupted, simple continuous or interrupted cruciate patterns to close the body wall. This author typically uses a "vest over pants"/near-far-far-near pattern placed at regular intervals for body wall closure. This tension relieving pattern may be especially necessary for larger (>5 cm) hernias. Vicryl or PDS are acceptable absorbable sutures for closure of the internal and external rectus layers. The leading edge of the body wall is then over-sewn with absorbable chromic gut with swedged-on taper needle. Skin is closed by surgeon's preference with non-absorbable monofilament suture. Alternate body wall closure has been proposed as: peritoneum and internal rectus sheath, simple continuous (0 or 2/0 PDS or Maxon); external rectus sheath (the strength closure), simple interrupted (0 PDS or Maxon); skin closure.[3]

Perioperative antibiotics (procaine penicillin G 10,000 U/lb [4,500 U/kg] IM or ceftiofur 1 mg/lb [0.45 mg/kg] IM) 1 hour before surgery should be initiated.[3] Systemic antibiotics are recommended for 5 days following surgery. Tetanus vaccination is also prudent as is pain mitigation by flunixin at labeled dose or meloxicam (0.45 mg/lb; 1 mg/kg orally).

Calves with an umbilical hernia associated with subcutaneous infection usually have a history of an enlarged umbilicus since birth. The mass may not be present until the calf is several weeks old. Palpation of the mass reveals a reducible dorsal hernia and firm non-reducible ventral portion attached to the skin. Many of these hernias are secondary to original umbilical infection that weakened the body wall and created a hernia. Surgical removal of the abscess/cellulitis, together with hernia repair, is the treatment of choice.[6] Surgical repair of the hernia continues as described above for uncomplicated herniorrhaphy. In cases of draining abscesses superficially over the hernia site, this author has

found it prudent to treat the calf with procaine penicillin G (10,000 U/lb [4,500 U/kg] IM) twice daily for 5 to 7 days prior to attempting surgical repair.

Umbilical hernias with umbilical remnant infection (omphalophlebitis, omphaloarteritis, and infection/abscessation of the urachus) are more complicated. Surgical reduction should not be attempted in the field. Referral may be necessary. The typical history of these calves is intermittent purulent drainage from the umbilicus beginning at 1 to 2 weeks of age. The drainage is often followed by a rapidly enlarging mass over the next several weeks. These calves are often unthrifty and small for their age and may have concurrent pneumonia, septic arthritis, peritonitis or bacteremia.[6] Ultrasound of the ventral abdomen is a great way to determine which, if any, umbilical remnant structures are involved.

The urachus is the most frequently infected umbilical remnant. Dysuria, pollakiuria, pyuria, and cystitis are all potential sequella to urachal infections in calves.[6] In some cases, the urachal infections extend all the way to the apex of the bladder. The umbilical vein is the next most likely infected remnant. Often there is a clearly delineable mark on the umbilical vein between infected and uninfected portions. Infections of the umbilical vein that extend to the liver can lead to liver abscesses, septicemia, bacteremia, and poor performance.

Surgical repair with removal of all infected/inflamed umbilical remnants followed by hernia repair is necessary in these cases. Removal of all infected urachal tissues is necessary and when the urachal infections extend to the apex of the bladder, surgical resection of the apex of the bladder is necessary. The entire urachus, umbilical arteries, hernia tissue, and overlying skin are removed en bloc to prevent contamination of the abdomen.[6] In cases of omphalophlebitis, the umbilical vein is ligated and transected proximally to the infected area. When the umbilical vein infection extends all the way to the liver, the umbilical vein stump is marsupialized to the body wall and skin through a separate incision cranial to the herniorrhaphy. This allows drainage of the infected vein +/- lavage of the umbilical artery following surgery. Care should be taken with lavage of the umbilical vein so as not to rupture the vein internally or flush with such pressure as to cause an ascending infection into the liver, which could lead to septicemia. Closure of the hernia is continued as outlined above once all infected/inflamed remnant tissues have been removed.

Umbilical abscesses are common sequelae to contained omphalitis.[6] The umbilical mass can develop shortly after birth but may also be delayed until the animal is over 1 year of age in some cases. Palpation of an intact body wall is a common finding, although some cases may have an evident "stalk" extending toward or through the body wall. Ultrasonography is useful to document the presence of purulent material inside a well encapsulated umbilicus. Ultrasound may also be able to determine if the infection travels deeper through any intact remnants.

Needle aspiration to confirm the presence of purulent material follows palpation and ultrasound of the umbilical enlargement. If the body wall is intact, a 2 to 4 cm incision travelling cranial to caudal along the umbilical abscess is made with a scalpel to establish good drainage. Lavage of the abscess should be attempted twice a day for 3 to 5 days using a dilute betadine solution.

The need for surgery depends on how well the infection responds to medical treatment and the cosmetic appearance required. The possibility of infection extending into the umbilical remnants must be considered and monitored.[6] Surgical excision is necessary if the infection extends deeper into abdominal remnants. Systemic antibiotics (procaine penicillin G or ceftiofur) as described above should be instituted for 5 days following excision and drainage.

Urachal cysts/ruptures can be imaged by ultrasound and are typically confirmed at surgery. Ultrasound with or without abdominocentesis can confirm the presence of free urine in the abdomen. Surgical reduction and removal of involved urachal tissue is necessary and subsequent closure of the body wall is continued as described above.

Conclusion

Umbilical masses in the calf can seem daunting to some practitioners in the field. Systematically working through physical examination, good history taking, and ultrasonography can help categorize these abnormalities into 1 of 5 categories: 1) Uncomplicated umbilical hernia; 2) Umbilical hernias with subcutaneous infection/abscesses; 3) Umbilical hernias with umbilical remnant infections; 4) Umbilical abscess (chronic omphalitis); 5) Urachal cysts/ruptures. Further categorization of an umbilical hernia into complicated vs uncomplicated can delineate between on-farm management with belly wrap or surgery or referral for extensive surgical exploratory and correction. Deeper infected umbilical remnant tissues (urachus, umbilical vein, and umbilical arteries) generally cause systemic illness to the calf and poor performance, as well as require extensive surgical excision. Exceptional management through proper navel dipping and pen/stall cleanliness is critical to prevention of many umbilical issues.

References

1. Anderson DE. Surgical diseases of the neonate. *Proceedings*. 23rd World Buiatrics Congress, Quebec, Canada, 2004.
2. Baird AN. Umbilical surgery in calves. *Vet Clin North Am Food Anim Pract* 2008;24:467-477.
3. Constable PD. Management of calves with umbilical disease and arthritis. *Proceedings*. *DVM360.com* 2011-08-01.
4. Leadley S. Navel dipping: Are you putting calves at risk? *Dairy herd management online.* 2012; August.
6. Navarre C. How to manage umbilical masses in cattle. *DVM360.com,* 2005-10-01.
7. Ortved K. Miscellaneous abnormalities of the calf. In: *Farm animal surgery.* 2nd ed. St. Louis, MO: Elsevier, 2017; 540-550.
5. Robert M, Touzot-Jourde G, Nikolayenkova-Topie O, Cesbron N, Fellah B, Tessier C, Gauthier O. Laparoscopic evaluation of umbilical disorders in calves. *Vet Surg* 2016;45:1041-1048.

Approach to right-sided pings in the dairy cow

Eric D. Gordon, DVM, DACVPM

Abstract

The diagnosis and approach to the right-sided abomasal displacement in the bovine can be frustrating for any dairy practitioner. Right-sided abdominal pings are varied and often troublesome to diagnose, but a systemic workup can assist the practitioner in successful identification and resolution of these cases. This article is a review of types of right-side abomasal displacements in the dairy cow, typical presenting signs, and approaches to correct diagnosis and positive outcomes.

Key words: right abomasal displacement, RDA, AV, right-side ping

Résumé

Le diagnostic et l'approche du déplacement abomasal à droite chez le bovin peuvent être frustrants pour tout praticien laitier. Les paires abdominales à droite sont variées et souvent difficiles à diagnostiquer, mais un examen systémique peut aider le praticien à identifier et à résoudre ces cas avec succès. Le présent article est un examen des types de déplacements abomasaux du côté droit chez la vache laitière, des signes typiques de présentation et des approches pour corriger le diagnostic et les résultats positifs.

Introduction

While a left displaced abomasum (LDA) is usually a relatively simple diagnosis, right-sided gastrointestinal abnormalities of the bovine can be difficult to accurately determine. Several different structures can be displaced on the right side of the cow resulting in a variety of "pings" (high pitched sound on simultaneous auscultation and percussion of the abdomen) in a variety of locations. This can be particularly troublesome for the recent graduate who has the disadvantage of a smaller caseload experience to sort out right-sided displacements and make a correct pre-surgical diagnosis.

Abdominal structures that can result in an audible "ping" include the following: right displaced abomasum (RDA), abomasal volvulus (AV), cecal dilatation and rotation, gas in the ascending colon, gas in the rectum, spiral colon gas, duodenal gas, and more rarely pneumoperitoneum and gas in the uterus.

Eighty percent of abomasal displacements are seen within 1 month of parturition. Left displaced abomasum is more common than RDA generally 1 RDA to every 30 LDA.[3] Cases of AV are more common than RDA, with 1 AV to every 10 LDA.[1,3.] A further report from a veterinary teaching hospital reported cases of AV to LDA had a ratio of 1 to 7.4.[4] Three different manifestations of AV exist: AV (60% of cases), omasal-abomasal volvulus (40% of cases), and reticulo-omasal-abomasal volvulus (rare).[3]

An understanding of the evolution of the right-side abomasal displacement can be helpful in making an accurate diagnosis. A RDA is best described as counter-clockwise rotation of the abomasum when viewed from behind the cow, and is therefore the mirror image of an LDA.[4] In AV, the abomasum (after an initial 180° counterclockwise rotation as viewed from the rear) and its supporting structures rotate in a counterclockwise direction (as viewed from above the cow) around an axis through the center of the lesser omentum, causing the cranial duodenum to become trapped by the distended abomasal body.[5] Knowing this anatomy and the surrounding structures can help differentiate at least the type of right-side abomasal disorder.

The ping associated with RDA is commonly located in the area between the 10th and 13th ribs on the right side of the abdomen.[2] The location and integrity of the ping from an RDA can be the same as a common LDA on the opposite side of the cow. These pings are difficult to distinguish from the ping of functional ileus, which underlies ribs 12 or 13 and can extend as far forward as the 10th rib.[2] Cecal dilatation and rotation also result in a right-side ping, but the ping is usually located more caudally, well into the paralumbar fossa.[2] Pings resulting from spiral or descending colon gas tend to extend caudal to the ribs and, much like the ping of ilieus, are variable in pitch, frequency, and persistence. A consistent ping in the cranial paralumbar fossa extending under the 12th and 13th ribs that also maintains a fluid "splashing" sound on ballottement of the middle third of the right lateral abdomen with simultaneous auscultation over the ping "area" (succussion). This suggests a fluid-filled viscus which is consistent with both RDA and AV.[4] This is often referred to by the author as the abomasal "tinkle test".

Typically the ping from an AV is larger than that of an RDA and extends more craniad (cranial to the 10th rib). In many cases the AV ping can outline with a diameter of greater than 30cm and extend as far forward as the 7th or 8th rib space. Abdominal ballottement (succussion) also yields a consistent splashing sound in AV.

Furthermore, rectal palpation can be helpful to diagnose the presence of an AV. In the early stages of AV, the partially distended abomasum may be palpable with the tips of the fingers in the right lower quadrant of the abdomen. It may not be palpable in large cows. In the advanced stage,

the distended tense viscus is usually palpable in the right abdomen anywhere from the upper to the lower quadrant.[4] A RDA is virtually never palpable per rectum; however, rectal palpation can be helpful in differentiating an RDA from cecal dilatation or rotation.[2]

Ultrasound can be a useful tool in confirming the diagnosis of LDA, RDA or AV.[2] In some cases of AV, the liver is displaced medially and this change may be detectable by ultrasound.

Additional physical exam findings can help differentiate the right-side displacements. As with LDA, the typical history of the right side abomasal displacement includes anorexia, decreased milk production, and decreased rumination. In AV, the anorexia is complete, milk production is more markedly reduced and the clinical deterioration is rapid.[2] Furthermore, cows experiencing AV have tachycardia. This tachycardia can increase with the chronicity and severity of the AV as high as 120 beats per minute. The cow with an AV is more depressed, and signs of weakness, toxemia, and dehydration develop as the disease progresses and the animal may become recumbent within 49 to 72 hours after developing volvulus.[2] Recent parturition, partial anorexia, and decreased milk production suggest displacement. Blood chemistry analysis on cows with abomasal displacements include metabolic alkalosis with hypochoremia and hypokalemia. In cattle with AV, blood l-lactate concentrations increase.[2]

With AV, the omasum is displaced medially and can be involved in the volvulus (omasal-abomasal volvulus). The blood supply to the abomasum and proximal duodenum is compromised, eventually resulting in ischemic necrosis of the abomasum[2] For these reasons, the right-side abomasal displacement is considered an emergency condition.[1] This is, in part, due to the difficulty of on-farm personnel in differentiating between RDA and AV. This can be frustrating for the bovine practitioner who finds themselves responding in emergency fashion to a cow that either does not have an AV or may not even have a displacement at all.

Patience during the examination, consistency of the ping over several minutes of evaluation, presence or lack of the tinkling/splashing sound on succussion, and clinician experience are all important in making the proper diagnosis of the right-side ping. Despite a thorough physical exam, rectal palpation, possible ultrasound, and serum chemistry analysis, the final diagnosis is sometimes made during exploratory laparotomy. A good abdominal exploratory is simply an extension of the physical exam and can be a common necessity in dealing with right side pings in the cow. More often than not an inconsistent, small or transient ping or "pong" (lower pitched sound) indicates no abomasal displacement is present and may resolve with medical therapy. Care should be taken to not overlook the AV patient, and when in doubt, an exploratory should be attempted.

Several pre-surgical prognostic indicators should be considered in cases of AV. Heart rates over 80 bpm to 100 bpm are considered poor candidates for survival.[3,4] Blood l-lactate concentrations ≤2 mmol/L indicate a positive outcome with surgical correction, whereas cattle with blood l-lactate concentrations ≥6 mmol/L carry a high probability of a negative outcome.[2] Additionally, the level of dehydration, duration of the condition, and serum ALP activity are important indicators.[3] Cows with AV present for greater than 24 hours generally have lower survival rates than those diagnosed earlier. The abomasum in AV can fill with a large quantity of chorine-rich fluid (over 40 liters). This not only contributes to the hypochloremia, but more chronic cases of AV become so fluid filled that surgical reduction can be especially challenging.

Surgical correction is typically accomplished by right flank laparotomy. However, a right paramedian approach can be used for the recumbent cow. Omentopexy, pyloropexy or a combination thereof can be used for fixation similar to LDA surgeries once reduction is successful. In most cases of AV, evacuation of the intraluminal gas viscous is necessary to complete reduction. This may also help reduce postoperative abomasal hypomotility. Care should be taken on approach to any right-side abomasal displacement, especially AV, as the distended abomasum can extended underneath the incision area in the paralumbar fossa. This could result in inadvertent laceration on approach.

The secrets to improving survival rate of a cow experiencing AV are: 1) early diagnosis; 2) surgical technique; 3) perioperative intravenous fluids; and 4) antibiotics to prevent peritonitis.[3] If hypomotility is present, erythromycin at 4.5 mg/lb (10 mg/kg) BW can be used to increase emptying rates and increase milk production postoperatively.[2] IV or oral calcium supplementation after surgery can help resolve abomasal motility problems. Hypokalemia and hypochloremia are common and can be corrected with 120 grams of KCL twice a day for 2 days.[3] In the simple RDA, fluid and electrolyte abnormalities can correct spontaneously with access to water and salt. Oral drench of water with electrolytes (60 grams sodium chloride and 30 grams potassium chloride) via stomach tube is helpful in cases of longer duration.[2]

Prognosis for LDA and RDA is good – typically 95%. Survival after correction of AV is variable. Published data indicates survival rates of 35 to 80% with an average of 70%.[1,2] Cows with high heart rates, severe dehydration, vascular compromise to the abomasal tissue, and involvement of omasum have decreased survival rates.

Conclusion

The right-side abdominal ping in the bovine can be difficult to accurately diagnose. This is particularly true for on-farm personnel and veterinarians with less experience. A thorough physical exam utilizing patience while performing percussion, succussion, rectal palpation, possible ultrasound, and potential blood chemistry can help guide the practitioner to a the correct diagnosis and successful case outcome. In some cases, an exploratory laparotomy is necessary for ac-

curate diagnosis.

Right-side abomasal displacements should be treated as emergency conditions given that AV is more likely than simple RDA. Cows experiencing AV should have corrective surgery and concurrent post-operative supportive care within 24 hours of onset. Early diagnosis, supportive IV or oral fluids with electrolytes, and perioperative antibiotics are keys to more successful outcomes.

References

1. Brett J. Treating a right displaced abomasum. *Dairy Herd Management Online* 2011; January.
2. Constable PD. Left or right displaced abomasum and abomasal volvulus. *Merckvetmanual.com*; 2017.
3. Constable PD. Surgical management of the right-sided ping. *Proceedings*. *DVM360.com*, 2011-08-01.
4. Constable PD, Hinchcliff KW, Done SH, Grunberg W. Diseases of the abomasum. *Veterinary medicine, a textbook of diseases of cattle, horses, sheep, pigs and goats.* 11th ed. St. Louis, MO: Elsevier, 2017; 501-523.
5. Gonzalez-Martin JV, Perez-Villalobos N, Baumgartner W, Astiz S. An investigation into the development of right displaced abomasum by rolling 268 dairy cows with left displaced abomasum. *J Dairy Sci* 2019;102:11268-11279.

A chance to cut is a chance to cure: Practical tips for performing a rumenostomy

Elizabeth R. Homerosky, DVM, MSc, DABVP (Beef Cattle Practice)
Veterinary Agri-Health Services Ltd., 201-151 East Lake Blvd. NE, Airdrie, Alberta, T4A 2G1, Tel: +1 403 948 2253, Email: elizabethh@vahs.net (Dr. Elizabeth R. Homerosky)

Abstract

A rumenostomy is a quick and easy surgery that can help remedy recurrent bloat refractory to medical therapy. This clean-contaminated surgery is particularly useful among cattle experiencing chronic vagal indigestion, and is a common surgery performed in feedlot cattle. Preoperative analgesia should be provided; however, choice of antibiotic therapy is generally left to the discretion of the surgeon. Following local anesthesia and surgical prep of the left paralumbar fossa, a circular incision is made through the skin. Muscle layers are removed or bluntly dissected and the peritoneum is incised to visualize the rumen. The rumen wall is exteriorized and stay sutures are applied to reduce the risk of rumen contents contaminating the abdomen. A stoma into the rumen is created and a tight seal between the rumen wall and skin is achieved via several different suture pattern options. Patient prognosis is generally good regardless of surgical technique, pending no severe underlying medical conditions are present.

Key words: rumen fistula, bloat, vagal indigestion, feedlot cattle

Résumé

La ruménostomie est une chirurgie rapide et facile qui peut aider à remédier le ballonnement récurrent réfractaire au traitement médical. Cette chirurgie propre-contaminée est particulièrement utile chez les bovins qui souffrent d'indigestion vagale chronique et est souvent utilisée chez les bovins dans les parcs d'engraissement. L'analgésie préopératoire est requise mais le choix de la thérapie antibiotique est généralement laissé à la discrétion du chirurgien. Après l'anesthésie locale et la préparation à la chirurgie de la fosse paralombaire gauche, une incision circulaire est faite à travers la peau. Les couches musculaires sont enlevées ou disséquées grossièrement et le péritoine est incisé pour exposer le rumen. La paroi du rumen est extériorisée et des sutures de fixation sont appliquées pour réduire le risque que le contenu du rumen contamine l'abdomen. Une stomie dans le rumen est créée at un joint étanche entre la paroi du rumen et la peau est établi en utilisant diverses options de type de sutures. Le pronostic pour le patient est généralement bon peu importe la technique chirurgicale sauf s'il existe d'autres conditions médicales sous-jacentes sévères.

Introduction

A rumenostomy is a clean-contaminated standing surgical procedure commonly performed in a feedlot setting. It is considered adjunct therapy for the treatment of recurrent free gas bloat.[3] Surgery is warranted when orogastric intubation is unsuccessful or daily intubations are required. The author recommends performing a rumenostomy in cases refractory to medical therapy, where intubation is required for more than 3 consecutive days. Trocarization is strongly discouraged due to likelihood of peritonitis, but is occasionally performed in emergency situations, such as respiratory distress.[3] In these cases, it is recommended that a rumenostomy encompassing the trocarized location be performed as soon as possible. A rumenostomy may provide short to long-term relief of rumen tympany while underlying predisposing diseases or conditions are given time to resolve.[1]

Preoperative Considerations and Ancillary Therapy

A thorough clinical examination should be performed before electing to perform a rumenostomy.

Performing orogastric intubation is recommended to rule out of the possibility of frothy bloat. Cattle experiencing frothy bloat are predisposed to severe complications such as peritonitis and should not be considered surgical candidates. Collecting an adequate history is also of upmost importance. If there is no history of treatment for bovine respiratory disease (BRD), but pneumonia is diagnosed upon clinical examination, the author will often recommend antibiotic treatment for first pull BRD per protocol. If the history reveals treatment for BRD, then that should also be taken into consideration as the free-gas bloat is likely a sequele to vagal indigestion. Though not fully described, damage to the vagus nerve or enlarged mediastinal lymph nodes resulting from pneumonia, fibrinous pleuritis, or other intrathoracic inflammation are believed to inhibit normal rumenations and eructation.[1] Cases diagnosed with chronic pneumonia and in poor body condition should not be considered surgical candidates, as a rumenostomy will not remedy the underlying issue.

Cases of recurrent free gas bloat with no history or evidence of disease are likely to result from dietary causes. The risk of surgical complications increases among cattle over 1000 lb (454 kg) and it is recommended these cattle be marketed to the packer as soon as possible. Although

increasing roughage in the diet is ideal, this may not be practical for lighter cattle and performing a rumenostomy is often the most economical solution. The author does not routinely administer antibiotics in these types of cases. However, if surgical complications occur and peritonitis is of concern, broad-spectrum antibiotics such as ampicillin or oxytetracycline are prescribed, depending on animal weight and reasonable allotted time for meat withdrawal.

Analgesia and local anesthesia should be administered preoperatively. Meloxicam is highly recommended for long-term analgesia. The most common form of local anesthesia is subcutaneous and intramuscular lidocaine administered in an inverted-L pattern in the left paralumbar fossa following clipping and the first surgical scrub. The use of drapes is inconsistent among feedlot practitioners and commonly left to the discretion of the surgeon.[1] Good restraint throughout the procedure is critical, and in some cases it may be advantageous to restrain the left hind limb.

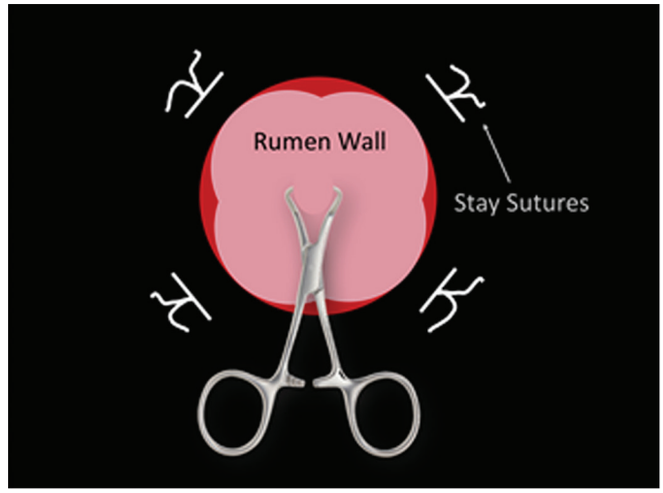

Figure 1. Depiction of stay sutures used to appose rumen wall to skin before incising the rumen.

Surgical Technique

A number of surgical techniques including various sized circular, elliptical, and linear incisions have been observed and are noted to result in similar outcomes.[1] Following full surgical site preparation, the author makes a silver dollar-sized circular incision 2 to 3 fingers caudal to the last ribs and 2 to 3 fingers ventral to the transverse processes using a #22 scalpel blade. Subcutaneous tissues and the external oblique muscle layer are excised. The internal oblique and transversus abdominis muscles should not be surgically excised unless the surgeon exemplifies notable experience and skill. Rather, blunt dissection to the level of the peritoneum is preferred.

Before entering the abdomen, the peritoneum should be retracted using hemostats to ensure the rumen is not prematurely incised. Severe rumen distension will complicate this step, however, alleviation of gas should have been achieved by passing an orogastric tube during the preoperative examination. Scissors should be used to extend the incision through the peritoneum. It is common for the animal to react as the peritoneum will not be anesthetized. One or 2 digits should be used to palpate the medial side of the peritoneum to ensure no adhesions are present. A pair of towel clamps are then used to retract and exteriorize the rumen.

Pending no adhesions or other complications, 4 stay sutures are placed to secure the rumen wall in place. The author prefers to place 2 cm horizontal mattress sutures in the 1:30, 4:30, 7:30, and 10:30 positions so that the hanging towel clamp placed on the rumen does not interfere with stay suture placement (Figure 1). The rumen serosa should be tightly apposed to hypodermis. Next, a quarter-sized circular incision is made into the rumen causing the freshly cut edges to evert.

A variety of suture materials and patterns can be utilized to create a tight seal between the rumen wall and skin. The author prefers 3 catgut chrom in a simple continuous pattern using an S-curve needle due to ease and speed; however, supramid in a simple interrupted pattern provides enhanced security. The suture is started in the 12:00 position and continues from skin to rumen (right to left) in a clockwise fashion. Sutures should be placed no more than 1 cm apart approximately 1 cm from the freshly incised skin in order to create a tight seal. The author ties off the suture at the 6:00 position. This achieves 3 things: 1) provides enhanced security in the event that the suture line breaks, 2) prevents the creation of a purse-string effect, thereby maintaining the original size of stoma, and 3) allows the surgeon to change the direction of the suture if so desired. Restarting the simple continuous suture pattern at the 6:00 position allows the surgeon to continue suturing from right to left by going from rumen to skin. The suture line is completed in the 12:00 position and the site is cleaned and checked for a tight seal (Figure 2). Simple interrupted sutures should be placed in any locations where rumen wall and skin are not tightly apposed to prevent contamination of the abdominal wall or abdomen. The stay sutures are often left in place.

Granulation tissue should create a tight seal by 2 weeks following surgery and sutures may be removed. In some cases, the stoma may prematurely close by second intention. However, a cannula or syringe casing may be placed to ensure the rumenostomy remains patent.[1]

Prognosis and Follow-up Therapy

Prognosis following a rumenostomy is generally regarded as good. It is estimated only 13% of surgical candidates experience short-term complications such as incisional infection, peritonitis, or death.[2] In many cases, death is attributed to the underlying disease causing recurrent free gas bloat, such as BRD, and is not directly related to the surgery itself.

Figure 2. Completed rumenostomy site with adequately apposed rumen wall and skin using a simple continuous suture pattern.

On rare occasions the author has witnessed hysteria among animals immediately following surgery. It is hypothesized that fluid sounds and expelled steam arising from the surgical site frighten the animal. In a failed attempt to escape the unfamiliarity, panicking cattle occasionally run directly into fences or gates, sustaining severe life-threatening injuries to the cranium or spinal column.

The most common long-term complication is premature closure of the stoma. A second rumenostomy is not warranted, as the rumen should be tightly adhered to the interior abdominal wall. Rather, it is recommended that a stainless steel trocar be inserted through the center of the fibrotic tissue and secured in place using supramid suture.

Conclusion

A rumenostomy is a quick and easy surgery that can help remedy recurrent bloat refractory to medical therapy. This clean-contaminated surgery is particularly useful among cattle experiencing vagal indigestion as a sequele to pneumonia or fibrinous pleuritis and is a common surgery performed in feedlot cattle. Preoperative analgesia should be provided; however, choice of antibiotic therapy is generally left to the discretion of the surgeon. Numerous surgical techniques have been observed and typically yield similar results as long as a tight seal between the rumen wall and skin is achieved. Patient prognosis is generally good, pending no severe underlying medical conditions are present.

Conflicts of Interest

The author declares no conflicts of interest.

References

1. Callan RJ, Applegate TJ. Temporary rumenostomy for the treatment of forestomach diseases and enteral nutrition. *Vet Clin North Am Food Anim Pract* 2017;33: 525–537.
2. Hartnack AK, Niehaus AJ, Rousseau M, et al. Indications for and factors relating to outcome after rumenotomy or rumenostomy in cattle: 95 cases (1999-2011). *J Am Vet Med Assoc* 2015;247:659–664.
3. Lozier JW, Niehaus AJ. Surgery of the forestomach. *Vet Clin North Am Food Anim Pract* 2016;32:617–628.

Practical application of techniques for performing C-sections in beef cows

Keelan Lewis, DVM
Salt Creek Veterinary Hospital, Olnye, TX 76374

Abstract

As a newly graduated veterinarian, the idea of a calf delivery via cesarean section is daunting. As a young veterinarian I would avoid c-sections so readily I would be exhausted by the time the procedure was the last remaining option. Mentorship and functional tricks can help avoid this misguided fear in new veterinarians.

Key words: dystocia, calving, C-section, cesarean

Résumé

Peu de temps après l'obtention du diplôme, l'idée de délivrer un veau par césarienne est intimidante pour un vétérinaire. Comme jeune vétérinaire j'évitais les césariennes si facilement que j'étais épuisé au moment où cette procédure devenait la dernière option. Le mentorat et des trucs pratiques peuvent aider à prévenir cette peur malavisée chez les jeunes vétérinaires.

Set Appropriate Client Expectations

Bovine cesareans are frequently medical procedures determined by economics. In our practice, the determination to cut is readily associated with the price of the animal's replacement and prognosis of the dam. Data associated with live dam and calf and return to fertility in subsequent calving cycles varies widely. Deciding projected prognosis of the dam, in my hands, depends on stability of cow/heifer, state of degradation of the fetus, ability of practitioner, and efficiency. This number is subjectively decided chute-side based on my experience and very little refereed data. As a rule for new associates, I set the time limit to attempting a vaginal delivery alone at 30 minutes. At this time, they should reach out to more experienced clinical veterinarians or perform a c-section. Being stubborn does not benefit you or your patient in this situation.

Anesthesia

I administer a caudal epidural to all bovine obstetrics at first presentation. This assists some in pain control, keeps you from being slapped with the tail and adds to general public perception of pain modulation. As a general rule I administer 3 ml of lidocaine to an animal less than 900 lb (409 kg) and 5 ml to a bovine over that weight limit.

In all bovine surgical procedures we administer a ketamine stun. Route and dose depends on goal of procedure. I refer to "Chemical Restraint of Ruminants – Ketamine Stun Technique" by Eric J. Abrahamsen, DVM, DACVA, for doses and route selection. For midline approach, I select IV recumbent dosing that I administer via jugular vein. Then using cotton ropes, hydraulic chute, and electric wench roll the cow/heifer into lateral with hind limbs pulled into dorsal recumbency.

Lidocaine block: varying options. Again, my suggestion here is use what you are comfortable with, likely enough lidocaine in any pattern will work. For midline approach, I use solely a line block from 1 hand width above the navel to the udder.

Epinephrine: when commercially available, I always administer 10 ml of epinephrine IM. I find this to help notably with pliability of the uterus. Please reach out to AABP about current status of the medically necessary waiver to allow production of commercial epinephrine. Refer to compounding law for a decision on administering compounded product to food-producing animals.

Approach

Our clinicians perform predominantly midline approach to the uterus, with the remainder being left flank. For this discussion I will focus mainly on the midline incision approach to the uterus. Preference for midline approach in our practice is 3-fold. Primarily the animals we perform C-sections on are small feeder or replacement heifers weighing less than 900 lb (409 kg), making obstetrics facilities to fit them hard. This animal is also very likely to "give up" and lay down on their own. Secondly, our clientele mostly encompasses western ranches, allowing the vast majority of animals presented for dystocia to have dead and necrotic calves or have had extensive on ranch attempts for fetal extraction. Lastly, we find it to be notably less physically taxing and we can more efficiently perform the procedure. Decision for the approach should be made based on your practice demographic, bovine population, and mentoring ability.

At this point the animal is anesthetized, in dorsal recumbency from abdomen caudally, and has had a line block administered with lidocaine. A simple incisions is made into the abdomen through the linea. Any structure within the uterus is pulled up to the body wall incision and the uterus is incised. Chains hooked to feet and either another human or wench keeps tension on the fetus while a uterine incision large enough to extract the fetus is made. The fetus is

removed and attempt is made to exteriorize the uterus only enough to help ensure amniotic fluid does not spill into the abdomen.

The uterus is closed with 0 PDS in the Utrecht pattern, then lavaged with LRS and returned into the abdomen. Body wall closure is in 3 layers: linea, subcutaneous tissue, skin. For the inner layers I choose PDS 2, and the skin is closed with Braunamid 8.

Post-operative Care

The above procedure from time of anesthetic administration to cow/heifer standing averages 30 minutes. Be careful to pick up placental materials, blood, and fluid before allowing the cow to stand to help ensure she doesn't slip when standing.

Administration of antibiotic of choice is warranted based on state of metritis and appropriately labeled and spectrum drugs. A NSAID is always administered to the dam.

Regional Limb Perfusion

Sarah M. Depenbrock, DVM, MS, DACVIM (LAIM)
Assistant Professor or Livestock Medicine, UC Davis School of Veterinary Medicine

Abstract

This session will discuss the use of regional limb perfusion in cattle.

Key words: deep digital sepsis, septic arthritis, lameness, RLP, RIVP, cattle, bovine, distal extremity

Résumé

Cette session discutera de l'utilisation de la perfusion régionale d'un membre chez les bovins.

Introduction

Infections in the distal extremities are a common source of lameness and welfare concern in cattle.[14,20] Preventing lameness is of paramount importance; however, even excellent management systems will have occasional failures that result in some form of infection that extends beyond the protective layers of the foot. These infections of the deeper tissues of the distal extremity are sometimes collectively referred to as deep digital sepsis (DDS). Goals of treatment for DDS include debridement of damaged or devitalized tissues, treatment of infection in remaining tissue and provision of pain management.

Regional Limb Perfusion

When building your toolbox of skills to combat DDS, 1 technique to remember is the application of regional limb perfusion (RLP). The RLP can be used both for provision of temporarily anesthesia and administration of antibiotic to treat the localized infection. Injection of an antimicrobial directly into the circulation of the distal extremity as an RLP can be an effective method of treating the localized infection in large animals.[7,11,19] This technique involves application of a tourniquet around the distal extremity, proximal to the lesion, and injection of an antibiotic directly into the local venous access. The tourniquet is typically left in place for 30 to 45 min (*variable durations are reported in the literature*) to allow drug diffusion into the tissues of the distal extremity. When using an RLP to provide local anesthesia, this technique is called a Bier block, after German surgeon August Bier. When treating DDS in cattle, the distal extremity is often anesthetized using a Bier block to allow surgical debridement of the lesion, and antibiotics can be injected into the same vessel (following or preceding analgesia) to provide regional antibiosis. It is not recommended to mix the lidocaine and antibiotic directly in the syringe before administration, as many antibiotics precipitate when mixed directly.

The practitioner needs a few basic supplies to perform an RLP. It is necessary to have a safe method of restraint that allows for complete immobilization of the foot, such as a trim chute or recumbent chemical restraint. Supplies to properly clean the site of injection are also necessary. The equipment to perform the RLP itself is simply an effective tourniquet, and a needle and syringe. Different types of tourniquets have been studied in large animals; hydraulic tourniquets outperform manual ones, and flat tourniquets outperform round ones.[2,13] It is much easier to use a butterfly needle to administer the injection because it allows the foot to move a little during injection without losing IV access.

The RLP technique for provision of antibiotics has some advantages over other methods of local or systemic antibiotic administration. Regional perfusion of antibiotic provides high local concentration of drug compared to systemic administration.[9,10,12,15-18] Other options for regional drug administration include intra-articular (IA) or intrarosseous (IO) administration. Challenges with IA injection are possible chemical synovitis and a risk for introducing pathogens, particularly if injecting through an area of cellulitis. Performing IO perfusions in large animals typically requires use of a specialized screw with injection port, and this technique reportedly results in more evidence of discomfort during injection than RLP.

The pharmacokinetics of several antibiotics have been described when used as an RLP in cattle, including: tetracycline, cefazolin, ceftiofur, florfenicol, ampicillin, and marbofloxacin.[3,5,9,10,16,18]

Selection of the right drug for regional perfusion in each case should be based on a number of factors. The intended spectrum of activity is of paramount importance, especially whether or not mycoplasma is expected or known to be present in the case at hand. The most common pathogens associated with cases of deep digital sepsis are *Trueperella pyogenes* and *Fusobacterium necrophorum* in adult cattle, and *Streptococcus* (catalase negative), *Trueperella pyogenes,* Pasteurellaceae, Enterobacteriaceae, and *Mycoplasma bovis* in calves.[4,6,8] A farm history of mycoplasma, or concurrent pneumonia, otitis or mastitis may increase suspicion of mycoplasma. The intended use of the animal and implications of off-label drug use and the associated withdrawal recommendation are also very important to consider before selection of an antibiotic for RLP. No drug is labeled for RLP in cattle (or any other species that the author is aware of) so all RLPs constitute extra label drug use. Drugs that are prohibited from off label use, such as fluoroquinolones,

should not be used as an RLP in livestock. The guidelines of AMDUCA should be followed.[1] The drug selected should be known to be safe if given IV, and preference should be given to drugs with pharmacokinetic data available for RLP use to aid in determining withdrawal intervals.

RLP can be a useful tool as part of the treatment plan for DDS, and the pharmacokinetics of several antibiotics have been investigated for use as RLP in cattle. The provision of high levels of antibiotic directly to the site of infection, in what may be poorly perfused or compromised tissue, is an attractive therapeutic strategy. This technique should be used to complement, not replace, other methods of treatment including appropriate debridement, cleaning, and appropriate nursing care. It should also be noted that there is minimal evidence presented in the peer-reviewed literature critically evaluating outcomes in cases of DDS using RLP or comparing RLP in clinical cases of DDS to other methods of antibiotic treatment such as systemic administration, intrarosseous, or intra-articular administration.

References

1. Acts, Rules & Regulations - Animal Medicinal Drug Use Clarification Act of 1994 (AMDUCA). Available at: http://www.fda.gov/AnimalVeterinary/GuidanceComplianceEnforcement/ActsRulesRegulations/ucm085377.htm. Accessed April 4, 2016.
2. Alkabes S, Adams S, Moore G, Alkabes K. Comparison of two tourniquets and determination of amikacin sulfate concentrations after metacarpophalangeal joint lavage performed simultaneously with. *Am J Vet Res* 2011;72:613-619. Available at: http://avmajournals.avma.org/doi/abs/10.2460/ajvr.72.5.613. Accessed March 3, 2015.
3. Celani G, Tulini SMR, Montesano C, et al. Pharmacokinetics of marbofloxacin administered via intravenous regional limb perfusion in dairy cows: Evaluation of two different tourniquets. *Vet Rec Open* 2017;4. doi:10.1136/vetreco-2017-000227
4. Constant C, Nichols S, Desrochers A, et al. Clinical findings and diagnostic test results for calves with septic arthritis: 64 cases (2009-2014). *J Am Vet Med Assoc* 2018;252:995-1005. doi:10.2460/javma.252.8.995
5. Depenbrock SM, Simpson KM, Niehaus AJ, Lakritz J, Papich MG. Pharmacokinetics of ampicillin-sulbactam in serum and synovial fluid samples following regional intravenous perfusion in the distal portion of a hind limb of adult cattle. *Am J Vet Res* 2017;78:1372-1379. doi:10.2460/ajvr.78.12.1372
6. Desrochers A, Francoz D. Clinical management of septic arthritis in cattle. *Vet Clin North Am Food Anim Pract* 2014;30:177-203. http://www.sciencedirect.com/science/article/pii/S0749072013000911. Accessed March 9, 2015.
7. Fiorello C V, Beagley J, Citino SB. Antibiotic intravenous regional perfusion for successful resolution of distal limb infections: Two cases. *J Zoo Wildl Med* 2008;39:438-444.
8. Francoz D, Desrochers A, Fecteau G. A retrospective study of joint bacterial culture in 172 cases of septic arthritis in cattle. In: *20th ACVIM Forum*, Dallas, May 29-June 1. ; 2002.
9. Gagnon H, Ferguson J, Papich M, Baily J. Single-dose pharmacokinetics of cefazolin in bovine synovial fluid after intravenous regional injection. *J Vet Pharmacol Ther* 1994;17:31-37.
10. Gilliam JN, Streeter RN, Papich MG, Washburn KE, Payton ME. Pharmacokinetics of florfenicol in serum and synovial fluid after regional intravenous perfusion in the distal portion of the hind limb of adult cows. *Am J Vet Res* 2008;69:997-1004.
11. Kelmer G, Bell GC, Martin-Jimenez T, et al. Evaluation of regional limb perfusion with erythromycin using the saphenous, cephalic, or palmar digital veins in standing horses. *J Vet Pharmacol Ther* 2012;36:236-240.
12. Kelmer G, Tatz AJ, Famini S, Bdolah-Abram T, Soback S, Britzi M. Evaluation of regional limb perfusion with chloramphenicol using the saphenous or cephalic vein in standing horses. *J Vet Pharmacol Ther* 2015;38:35-40. doi:10.1111/jvp.12140
13. Levine DG, Epstein KL, Ahern BJ, Richardson DW. Efficacy of three tourniquet types for intravenous antimicrobial regional limb perfusion in standing horses. *Vet Surg* 2010;39:1021-1024. doi:10.1111/j.1532-950X.2010.00732.x
14. Ley SJ, Waterman AE, Livingston A. Measurement of mechanical thresholds, plasma cortisol and catecholamines in control and lame cattle: A preliminary study. *Res Vet Sci* 1996;61:172-173.
15. Lloyd K, Stover SM, Pascoe J, Baggot J, Kurpershoek C, Hietala S. Plasma and synovial fluid concentrations of gentamicin in horses after intra-articular administration of buffered and unbuffered gentamicin. *Am J Vet Res* 1988;49:644-649.
16. Navarre C, Zhang L, Sunkara G. Ceftiofur distribution in plasma and joint fluid following regional limb injection in cattle. *J Vet Pharmacol Ther* 1999;22:13-19. http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2885.1999.00186.x/full. Accessed March 3, 2015.
17. Pille F, De Baere S, Ceelen L, et al. Synovial fluid and plasma concentrations of ceftiofur after regional intravenous perfusion in the horse. *Vet Surg* 2005;34:610-617. doi:10.1111/j.1532-950X.2005.00095.x
18. Rodrigues C, Hussni CA, Nascimento E, Esteban C, Perri S. Pharmacokinetics of tetracycline in plasma, synovial fluid and milk using single intravenous and single intravenous regional doses in dairy cattle with papillomatous digital dermatitis. *J Vet Pharmacol Ther* 2010;33:363-370. doi:10.1111/j.1365-2885.2009.01138.x.Pharmacokinetics
19. Rubio-Martínez L, Elmas C, Black B, Monteith G. Clinical use of antimicrobial regional limb perfusion in horses: 174 cases (1999–2009). *J Am Vet Med Assoc* 2012;241:1650-1658. http://avmajournals.avma.org/doi/abs/10.2460/javma.241.12.1650. Accessed March 3, 2015.
20. Whay HR, Waterman AE, Webster AJ, O'Brien JK. The influence of lesion type on the duration of hyperalgesia associated with hindlimb lameness in dairy cattle. *Vet J* 1998;156:23-29. http://www.ncbi.nlm.nih.gov/pubmed/9691848. Accessed March 18, 2015.

Diagnosis and therapy of feedlot lameness

Michael D. Apley, DVM, PhD, DACVCP
Kansas State University

Abstract

While not at an incidence level comparative to bovine respiratory disease, lameness in feedlots still presents a significant challenge and results in significant economic loss. These proceedings address the basics of diagnosis and therapy of infectious pododermatitis (foot rot), septic arthritis, toe abscesses (toe tip necrosis syndrome), and papillomatous digital dermatitis (hairy heel wart). The benefits of surgical intervention in selected lameness cases are recognized but are beyond the scope of this presentation. Understanding of the causal factors for each disease is pivotal in minimizing additional cases.

Key words: lameness, feedlot, diagnosis, therapy

Résumé

Bien qu'elle ne soit pas à une incidence comparable à celle du syndrome respiratoire bovin, la boiterie dans les parcs d'engraissement représente quand même un défi considérable et entraine des pertes économiques importantes. Cette présentation aborde les rudiments du diagnostic et du traitement de la pododermatite infectieuse (piétin), de l'arthrite septique, de l'abcès de l'onglon apical (syndrome de la nécrose de l'onglon apical) et de la dermatite digitale papillomateuse (verrues du talon). Les bénéfices de l'intervention chirurgicale dans des cas particuliers de boiterie sont connus mais débordent du cadre de la présentation. La connaissance des facteurs déterminants de chaque maladie est essentielle pour limiter les cas additionnels.

Introduction

While not at an incidence level comparative to bovine respiratory disease, lameness in feedlots still presents a significant challenge. Terrell and co-workers characterized lameness incidence in 6 commercial feedlots in Kansas and Nebraska for a period of 12 months during 2012 and 2013.[25] During this period, 524,780 head were received in the 6 feedlots with 2,532 cases of lameness identified, for a calculated incidence rate of 1.04 cases per 100 animal years (36,500 animal days), or 0.48% of received cattle. A diagnostic algorithm was used to classify lameness. The relative proportion of lameness cases and mean days-on-feed (DOF) when diagnosed are presented in Table 1.

In a survey of veterinarians, nutritionists, and feedlot managers, Terrell and co-workers found that the median response for estimated lameness incidence in feedlots was 2% with a mean of 3.8%.[26] Participants indicated that foot rot, injury, and toe abscesses were the most common causes. Major contributing factors identified for non-infectious lameness were cattle handling pre- and post-arrival, pen surface conditions, and cattle temperament. For infectious causes, pen surface and condition, cattle handling prior to arrival, and weather were listed as important factors.

These proceedings focus on the diagnosis and pharmacological therapy of infectious pododermatitis (foot rot), septic arthritis, toe abscesses (toe tip necrosis syndrome), and papillomatous digital dermatitis (hairy heel wart). The benefits of surgical intervention in selected lameness cases is recognized but is beyond the scope of this presentation.

Diagnosis and Therapy of Infectious Pododermatitis (foot rot)

A typical presentation of foot rot is swelling of the foot and associated tissues with foul smelling, broken tissue between the claws. The animal is typically first recognized due to a pronounced lameness in a single affected limb. As indicated by the number needed to treat (NNT) values discussed below, the expected treatment response with early intervention in the disease process is very good. Immediate treatment response from a single injectable antimicrobial regimen would be less common for the other lameness diseases discussed in these proceedings. Therapeutic outcomes are anticipated to be worse in more advanced stages of foot rot such as "club foot", where swelling has progressed up the leg from the initial more localized disease.

A review of the literature related to clinical outcomes for acute foot rot therapy has been published.[1] In this review, all references comparing a treatment to a negative control group were freedom of information (FOI) summaries of studies conducted during the approval process. Values for the Number Needed to Treat (NNT) for each antimicrobial were 2, 2, 1, and 3 for ceftiofur sodium, ceftiofur crystalline free acid, florfenicol, and tulathromycin, respectively.[4,5,14,27]

The NNT is calculated from the difference between treatment response rates in the negative control and treated groups; it estimates the number of animals that must be treated to make a clinical outcome difference in 1 animal. It is important to note that a lower NNT for an antimicrobial in 1 study compared to another antimicrobial in another study does not constitute evidence that the antimicrobial with the lower NNT is superior. The studies involve different populations; the only way to directly compare the antimicrobials is to conduct a direct comparison study within the same population of animals.

Table 1. Relative incidence of lameness identified in commercial feedlots.

Lameness diagnosis	Percentage	Mean (SD) days on feed at diagnosis
Upper limb lameness	35.6	70 (56)
Undefined	27.1	68 (50)
Septic joint or deep digital sepsis	10.2	44 (41)
Interdigital phlegmon (foot rot)	8.8	40 (44)
Sole ulcer or abscess	5.5	29 (37)
Toe ulcer or abscess	5.1	25 (41)
Laminitis	3.9	79 (56)
Laceration of the foot or hoof wall	3.2	42 (45)
Digital dermatitis (hairy heel wart)	0.8	137 (49)

Aggressive therapy involves prolonged administration of antimicrobials, anti-inflammatories, and possibly joint lavage.[13] In the feedlot environment, joint lavage is very unlikely. It is reasonable that the selected antimicrobial is capable of efficacy against both *Mycoplasma bovis* and *Histophilus somni*. This requirement rules out the beta-lactam antimicrobials, including penicillin G, ampicillin trihydrate, and ceftiofur, which have no activity against *Mycoplasma bovis* due to the absence of a cell wall in this pathogen. Of the macrolides, tilmicosin has demonstrated elevated minimal inhibitory concentration (MIC) values against *Mycoplasma bovis* in relation to the MIC values against other organisms for which clinical efficacy has been demonstrated.[2] In-vitro activity of beta-lactams, erythromycin, and tilmicosin have been evaluated for multiple isolates within the United States from 2002-2003.[22] This study demonstrated a lack of activity at the highest concentrations tested for these antimicrobials. In contrast, Minimal Inhibitory Concentration (MIC) values for oxytetracycline and florfenicol were 0.125 and 0.25 µg/ml, respectively, compared to BRDC *Mannheimia haemolytica* susceptible breakpoints of 2µg/ml for both compounds. These findings suggest that the *Mycoplasma bovis* MIC values for oxytetracycline and florfenicol are in a range where efficacy has been demonstrated for other pathogens in another disease. However, the methods for *Mycoplasma bovis* susceptibility testing are not standardized, and comparison between results from different investigators should be carried out with caution. Implications of clinical efficacy for *Mycoplasma bovis* or *Histophilus somni* in septic arthritis from in-vitro activity have not been clinically established.

Multiple antimicrobials have demonstrated efficacy against *Mycoplasma bovis* in the BRDC complex and have this organism on their label. These include tulathromycin, gamithromycin, and florfenicol. While enrofloxacin also includes *Mycoplasma bovis* as a label BRDC indication, septic arthritis is not on the label and extralabel use of fluoroquinolones in food animals is prohibited by the FDA in the United States. Label indications for a pathogen in another disease are encouraging, but do not assure clinical efficacy in an extralabel indication.

Consideration should be given to prolonged antimicrobial therapy, although no clear guidance exists as to the optimal duration of therapy. It is difficult to differentiate ongoing lameness due to continued pathogen activity in the joint from prolonged tissue damage with subsequent inflammatory signs which will take an extended period to resolve.

Anti-inflammatory agents are considered a standard for therapy of septic arthritis. The use of non-steroidal anti-inflammatory agents are much better suited for prolonged therapy than dexamethasone, where immunosuppression is expected with multiple administrations. Many of the experimental models discussed under foot rot also apply to septic joints, especially those of the lower leg. There are no pain or anti-inflammatory NSAIDs labeled for septic arthritis. While transdermal flunixin solution is not approved specifically for septic arthritis, the AMDUCA regulations require that it be considered first for extralabel use due to being the only food animal product labeled for pain, and more specifically in cattle.[15] Meloxicam fits in the third step of the AMDUCA regulations, which addresses the extralabel use of non-food animal veterinary-labeled products and human-labeled products. In all extralabel uses in food animals, the veterinarian is responsible for assigning an exaggerated slaughter withdrawal time and assuring that no violative residues enter the food chain.

Practically, a major component of septic arthritis therapy is the decision related to prognosis and when euthanasia is the most humane option. Debilitated cattle which are unable to maintain body weight and with multiple affected joints should be carefully evaluated for the potential for recovery.

Diagnosis and therapy of toe abscesses (toe tip necrosis syndrome)

Toe abscesses initially present as lower leg lameness which may occur in multiple feet, with the lateral claw of the hind feet most commonly affected. If related to transit-related or initial processing-related injuries to the sole of the claw, it is common for cases to develop soon after transit or processing; this timing often contributes to the initial diagnosis when multiple animals in a pen are affected. A prospective case-control study supported the hypothesis that this disease is initiated by wear along the white line, which leads to separation and infection of the 3rd phalanx and soft tissues.[20]

Diagnosis involves differentiating the lameness from an acute foot rot case. While hoof testers may be of some value, diagnosis often involves "tipping" the toe to allow drainage where the presence of purulent exudate is considered diagnostic. **Figure 1** is an example of cutting off the tip of the claw using a pair of nippers. The objective is to remove enough claw to expose damaged tissue and promote drainage, but to not go so far as to cut into the tip of P3. **Figure 2** demonstrates drainage obtained after toe tipping. **Figure 3** illustrates a cavity uncovered in the sole of another calf;

Figure 1. Tipping the toe of a suspected toe tip necrosis claw.

Figure 2. Drainage after tipping the toe.

Figure 3. A dry lesion after paring down from a sole lesion to the cavity within the claw.

this calf was lame but the lesion at this time was dry with no drainage.

The terminology for this disease is not without controversy. In describing a longitudinal study of western Canadian feedlot heifers, Jelinski and co-workers describe the different terminology that has been applied and suggest the term "toe tip necrosis syndrome (TTNS)" (Jelinski, et al., 2018).[16] This term encompasses the initial necrosis of the horn and P3 osteolysis as well as sequelae such as extensive pedal bone osteolysis, tenosynovitis, movement of infection and inflammation up the leg, and systemic bacteremia which may result in diffuse septic arthritis or embolic pneumonia. Regardless of the preferred terminology, the TTNS term describes the complex nature of the disease and emphasizes the need for early recognition and intervention.

Figure 4 illustrates an advanced case of TTNS with extensive swelling proximal to the coronary band and drainage from the coronary band. **Figure 5** is after removing a significant amount of the tip of each claw with a band saw to demonstrate the normal claw on the right and the toe with extensive necrosis on the left; removing this amount of tissue is for display purposes only and goes much further proximal than should normally be removed in a toe tipping procedure. **Figure 6** is a cross-sectional view of the same claw; the thumb forceps are removing fibrin from the joint. Notice that the sole is separating. This entire claw is close to sloughing.

Septic arthritis of the distal interphalangeal joint is a common component of TTNS. Asymmetric swelling at the coronary band and lameness score have been evaluated for their relationship to a diagnosis of septic arthritis of the distal interphalangeal joint.[6] Odds ratios were calculated in comparison to cattle with no asymmetry and with lameness scores < 3 out of 5. Cattle with a single leg lameness

Figure 4. Illustration of swelling above the coronary band and drainage from the coronary band.

Figure 5. Normal claw (right) and swollen claw (left) displaying inflammation and necrosis.

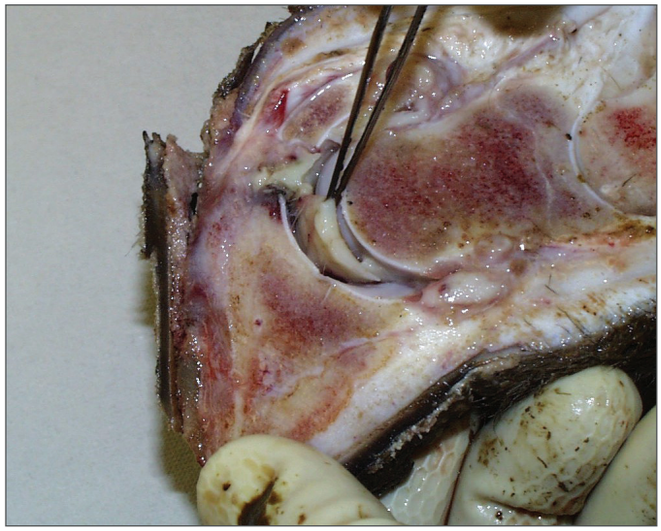

Figure 6. Cross sectional view of the same claw in Figures 4 and 5. Note the thumb forceps removing fibrin from the joint and the separation of the sole. P3 is undergoing extensive necrosis.

with asymmetric swelling of the coronary band were 63.2 times more likely to have a diagnosis of septic arthritis as compared to the no-swelling and lameness score < 3 group. An animal with an elevated lameness score (≥ 4 out of 5) was 120 times more likely to have septic arthritis compared to the no-swelling / lameness score < 3 group.

Therapy of TTNS involves establishing drainage, administering antimicrobials and anti-inflammatories/pain management, and possibly putting a block on the other claw. Surgical removal of the affected claw in cases of involvement of the distal interphalangeal joint may be a pivotal part of therapy. Antimicrobial selection and NSAIDs would be very similar to foot rot as discussed above. However, using antimicrobials and NSAIDS without careful debridement has been shown in multiple studies to result in limited to no improvement.[17] The tipping of the toe has been proposed to primarily be for diagnosis, with the more aggressive removal of necrotic tissue from the sole of the foot required to facilitate recovery.

In a longitudinal study of 21 Angus-cross yearling heifers presenting with TTNS, 5 of the heifers were euthanized over the 7 months from treatment to slaughter due to sequelae such as myositis or cellulitis.[16] Treatment consisted of antimicrobials, NSAIDs, and surgical removal of necrotic tissue to facilitate drainage. At slaughter, all lesions had healed in the 16 remaining heifers with indications of remodeling of the 3rd phalangeal bone in some of the animals.

Diagnosis and therapy of papillomatous digital dermatitis (hairy heel wart)

Papillomatous digital dermatitis (PDD) was initially relegated to dairy environments but has since transitioned to appearance in beef cattle herds and beef feedlots. A detailed review of etiology and epidemiology of the disease is beyond the scope of these proceedings; extensive reviews of the etiology, epidemiology, clinical presentation, and therapy of the disease in cattle have been published.[1,21,28] It is clear that PDD involves more than 1 pathogen, with the presence of *Treponema* spp alone insufficient to instigate clinical disease in studies of induced models.[19]

One of the first diagnostic clues for PDD cattle in feedlots is the typical stance where weight is taken off the sore heel resulting in a toe-touching resting position. **Figure 7** illustrates this typical stance in the left front foot of the black heifer and the left rear foot of the white heifer. Upon closer physical exam, some cases will present with the classic hairy heel wart or strawberry foot rot appearance as in **Figure 8**. **Figure 9** illustrates the extensive involvement between the claws and progressing to the front of the foot which may be present. All of the lesions in Figures 8 and 9 were biopsy-positive for *Treponema* spp.

Therapeutic options include individual-animal topical therapy, systemic therapy, and herd therapy through the use of foot baths. Clinical response to therapy varies by the stage of the disease. An individual-animal topical treatment suited to the feedlot environment is a topical tetracycline formulation. The efficacy of a topical tetracycline has been well established in dairy cattle.[1] Application in feedlots may be by using water-soluble formulations to make a paste, or direct use of a tetracycline powder, either of which may then be covered by a bandage, for which some use duct tape as a final covering. Topical sprays using antimicrobials of the tetracycline class have also been used in feedlot settings.

The use of a bandage over tetracycline powder has been compared to a tetracycline paste with no bandage in dairy cattle.[12] The investigators found that the tetracycline paste with no bandage was as effective as tetracycline powder with a bandage, thereby eliminating the need for bandage removal. Extrapolating this study to feedlot cattle requires consider-

Figure 7. Typical stances of papillomatous digital dermatitis-affected cattle in a feedlot setting. The affected feet are the left front on the black heifer and the left rear on the white heifer.

ation of the environment the cattle will be in and the effects on duration of exposure of the paste without protection from the environment, especially wet pen conditions.

Systemic therapy of PDD lacks clinical trial confirmation and is supported only by anecdotal or case report evidence at the time of this writing. It is important to note that recovered cattle are susceptible to a subsequent infection.

A review of footbath design and management for dairy cattle has been published.[11] Copper sulfate predominates in dairy systems, but environmental loading is a consideration. Before instituting a footbath strategy for control of PDD in a feedlot, careful consideration should be given to disposal and safety for all options. The different environment of the feedlot presents challenges in fouling of the footbath with organic matter. Some confinement beef cattle feeding systems have incorporated foot baths into the cattle processing systems.

Figure 8. Classic strawberry foot rot and hairy heel wart presentation of papillomatous digital dermatitis in a feedlot animal.

Conclusion

Success of therapeutic intervention in lameness of feedlot cattle depends on early, accurate differential diagnosis. Therapy of infectious pododermatitis (foot rot), septic joints, toe abscesses (toe tip necrosis syndrome), and papillomatous digital dermatitis (hairy heel wart) involves antimicrobials when appropriate, pain control, anti-inflammatories, and possibly surgical intervention. Understanding of the causal factors for each disease is pivotal in minimizing additional cases.

Endnote

[a]Banamine Transdermal, Merck Animal Health, Madison, NJ

References

1. Apley MD. Clinical evidence for individual animal therapy of papillomatous digital dermatitis (hairy heel wart) and infectious bovine pododermatitis (foot rot). *Vet Clin North Am Food Anim Pract* 2015; 31:81-95, 2015.
2. Ayling RD, Baker SE, Peek ML, Simon AJ, Nicholas RA. Comparison of in vitro activity of danofloxacin, florfenicol, oxytetracycline, spectinomycin and tilmicosin against recent field isolates of *Mycoplasma bovis*. *Vet Rec* 2000; 146:745-747.

Figure 9. Alternate clinical presentations of papillomatous digital dermatitis in feedlot animals with extensive involvement between the claws and progressing to the front of the foot.

3. Banamine® Transdermal. Flunixin transdermal solution, NADA 141-450. Merck Animal Health. Approved July 21, 2017.
4. Ceftiofur sodium freedom of information summary. Food and Drug Administration Center for Veterinary Medicine. Supplemental New Animal Drug Application, NADA 140-338, Naxcel Sterile Powder, for the treatment of interdigital necrobacillosis (foot rot, pododermatitis). 1995.
5. Ceftiofur crystalline free acid freedom of information summary. Food and Drug Administration Center for Veterinary Medicine. Supplemental New Animal Drug Application, NADA 141-209, Excede Sterile Suspension, for the treatment of bovine foot rot (interdigital necrobacillosis). 2008.
6. Chamorro MF, Reppert EJ, Robinson L, Cernicchiaro N, Biller D, Miesner M. Factors associated with septic arthritis of the distal interphalangeal joint in beef cattle: A case-control study. *Vet J* 2019; 244:104-111.
7. Coetzee JF, Kukanich B, Mosher R, Allen PS. Pharmacokinetics of intravenous and oral meloxicam in ruminant calves. *Vet Ther* 2009;10:E1-8.
8. Coetzee JF, Mosher RA, Anderson DE, Robert B, Kohake LE, Gehring R, White BJ, Kukanich B, Wang C. Impact of oral meloxicam administered alone or in combination with gabapentin on experimentally induced lameness in beef calves. *J Anim Sci* 2014;92:816-829.
9. Coetzee JF, Mosher RA, Griffith GR, Gehring R, Anderson DE, Kukanich B, Miesner M. Pharmacokinetics and tissue disposition of meloxicam in beef calves after repeated oral administration. *J Vet Pharmacol Ther* 2015;38:556-562.
10. Coetzee JF, Shearer JK, Stock ML, Kleinhenz MD, van Amstel SR. An update on the assessment and management of pain associated with lameness in cattle. *Vet Clin North Am Food Anim Pract* 2017; 33:389-411.
11. Cook NB. A review of the design and management of footbaths for dairy cattle. *Vet Clin North Am Food Anim Pract* 2017;33:195-225.
12. Cutler JH, Cramer G, Waller JJ, Millman ST, Kelton Df. Randomized clinical trial of tetracycline hydrochloride bandage and paste treatments for resolution of lesions and pain associated with digital dermatitis in dairy cattle. *J Dairy Sci* 2013;96:7550-7557.
13. Desrochers A, Francoz D. Clinical management of septic arthritis in cattle. *Vet Clin North Am Food Anim Pract* 2014; 30:177-203.
14. Florfenicol freedom of information summary. Food and Drug Administration Center for Veterinary Medicine. Supplemental New Animal Drug Application, NADA 141-063, Nuflor Injectable Solution, for the treatment of bovine interdigital phlegmon (foot rot, acute interdigital necrobacillosis, infectious pododermatitis). 1999.
15. Food and Drug Administration Center for Veterinary Medicine. Animal Medicinal Drug Use Clarification Act. 1994. Available at: https://www.fda.gov/animal-veterinary/acts-rules-regulations/animal-medicinal-drug-use-clarification-act-1994-amduca Accessed February 3, 2020.
16. Jelinski M, Marti S, Janzen E, Schwarzkopf-Genswein K. A longitudinal investigation of an outbreak of toe tip necrosis syndrome in western Canadian feedlot cattle. *Can Vet J* 2018;59:1202-1208.
17. Kofler J. Pathogenesis and treatment of toe lesions in cattle including "nonhealing" toe lesions. *Vet Clin North Am Food Anim Pract* 2017;33:301-328.
18. Morck DW, Olson ME, Louie TJ, Koppe A, Quinn B. Comparison of ceftiofur sodium and oxytetracycline for treatment of acute interdigital phlegmon (foot rot) in feedlot cattle. *J Am Vet Med Assoc* 1998; 212:254-257.
19. Orsel K, Plummer P, Shearer J, De Buck J, Carter SD, Guatteo R, Barkema HW. Missing pieces of the puzzle to effectively control digital dermatitis. *Transbound Emerg Dis* 2018:65 suppl:186-198.
20. Paetsch C, Fenton K, Perrett T, Janzen E, Clark T, Shearer J, Jelinski M. Prospective case-control study of toe tip necrosis syndrome (TTNS) in western Canadian feedlot cattle. *Can Vet J* 2017;58:247-254.
21. Plummer PJ, Krull A. Clinical perspectives of digital dermatitis in dairy and beef cattle. *Vet Clin North Am Food Anim Pract* 2017;33:165-181.
22. Rosenbusch RF, Kinyon JM, Apley MD, Funk ND, Smith S, Hoffman LJ. In vitro antimicrobial inhibition profiles of *Mycoplasma bovis* isolates recovered from various regions of the United States from 2002 to 2003. *J Vet Diagn Invest* 2005; 17:436-441.
23. Schulz KL, Anderson DE, Coetzee JF, White BJ, Miesner MD. Effect of flunixin meglumine on the amelioration of lameness in dairy steers with amphotericin B-induced transient synovitis-arthritis. *Am J Vet Res* 2011; 72:1431-1438.
24. Shearer JK, Stock ML, Van Amstel SR, Coetzee JF. Assessment and management of pain associated with lameness in cattle. *Vet Clin North Am Food Anim Pract* 2013; 29:135-156.
25. Terrell SP, Reinhardt CD, Larson CK, Vahl CL, Thomson DU. Incidence of lameness and association of cause and severity of lameness on the outcome for cattle on six commercial beef feedlots. *J Am Vet Med Assoc* 2017; 250:437-445.
26. Terrell SP, Thomson DU, Reinhardt CD, Apley MD, Larson CK, Stackhouse-Lawson KR. Perception of lameness management, education, and effects on animal welfare of feedlot cattle by consulting nutritionists, veterinarians, and feedlot managers. *Bov Pract* 2014: 48:53-60.
27. Tulathromycin freedom of information summary. Food and Drug Administration Center for Veterinary Medicine. Supplemental New Animal Drug Application, NADA 141-244, Draxxin Injectable Solution, for the treatment of bovine foot rot (interdigital necrobacillosis). 2008.
28. Wilson-Welder JH, Alt DP, Nally JE. The etiology of digital dermatitis in ruminants: Recent perspectives. *Vet Med (Auckl)* 2015:6:155-164.
29. Warner R, Kleinhenz MD, Ydstie JA, Schleining J, Wulf LW, Coetzee JF, Gorden PJ. Comparison of analgesics for control of lameness-associated pain in lactating dairy cattle, in *Proceedings*. 51st Annu Conf Am Assoc Bov Pract 2018;62.

Heifer management decisions

Glenn M. Rogers, DVM, MS, DABVP (Beef Cattle)
Grassy Ridge Consulting, Graford, TX 76449

Abstract

This presentation represents my experiences with a beef heifer development enterprise. Hopefully, this information can benefit some of your clients' operations, or at least challenge your thoughts on heifer development.

Résumé

Cette présentation constitue mes expériences dans un élevage d'engraissement de génisses de boucherie. Espérons que ces informations pourront être utiles aux opérations de vos clients ou à tout le moins pour remettre en question vos idées sur l'engraissement des génisses.

Introduction

After spending 11 years in rural practice in North Texas, I spent 9 years in academia. Two years were spent in graduate school at Kansas State and 7 years on the faculty at the North Carolina State University, College of Veterinary Medicine. During that time, I took time to consider what beef cattle niche would be the most profitable once I returned to Texas and resumed my ranching interests. Since 2001, I have been heavily involved in a beef heifer development business in Palo Pinto County, Texas.

In this presentation, I will describe my heifer development operation in North Central Texas, how we add value to purchased weaned heifer calves, and how I would approach various heifer decisions in a cow/calf enterprise.

Holt River Ranch "Value Added" Heifer Program

History

Starting in 2001 with about 250 heifers, we have developed heifers every year. Typically, 800-1000 annually are developed, bred and sold, with the majority bred to calve in the spring and a smaller number to calve in the fall.

Procurement

Some raised heifers go into our heifer development program, but the majority are purchased. Almost all heifers are purchased in single source load lots, usually from producers with whom we have historical performance information. Some heifer calves in smaller lots are purchased out of bred heifers we have previously sold. Weaned (> 45 days) heifer calves with 2 rounds of viral and clostridial vaccines, calfhood vaccinated for *Brucellosis* and "guaranteed open" are usually purchased.

Arrival Protocol

In the typical scenario, cattle are unloaded in our receiving pens or directly into a 5-acre grass trap. Free-choice hay (mostly average to good quality coastal Bermuda), free-choice trace mineral, and a 50:50 mix of soyhull pellets and corn gluten feed are provided. Heifers are usually kept in the receiving pen for 2 weeks prior to turn-out on wheat pasture (if available) or native pasture. The 2-week period is designed for acclimation and hot wire training. Generally, within a week of arrival, heifers are processed. If we are comfortable with the weaning vaccination and health program from the source, additional respiratory virals or clostridials are not administered. Deworming will depend on prior history as well. All arriving heifers are tested for BVD-PI and tagged with a large white bangle tag with a 4-digit number. The first number represents the year the heifers are to be bred. We cross reference the bangle tag with the Brucellosis vaccination tag. If there is pertinent information available from an existing bangle tag, we will also record this information. RFID tags will be utilized beginning this fall.

Even though almost all purchased heifers have been weaned for at least 45 days, commingling of groups is avoided for another 45 days. Very few respiratory cases are treated with this approach.

Nutritional Management

Our heifer development nutrition program is typically based on non-irrigated wheat pasture. The ranch is in a drought-prone area in north central Texas and in some years wheat is not available to graze until the March-May time period. Heifers are grazed on dormant winter range with protein supplementation, prior to turn-out on wheat pasture. Alternatively, in very dry years, heifers are fed in "grass" traps until suitable forage is available. Typically, some of the best breeding results are on heifers that are slightly behind on reaching target weights, but then get a good flush of wheat 6 weeks to 2 months prior to breeding. The calculated target weights at breeding do not have to be achieved with a consistent daily gain. Heifers can be essentially roughed through the winter on native pasture and then pushed on wheat in late winter/early spring. There have been reports of poor reproductive performance on heifers developed on good quality wheat pasture. This has been blamed on over-conditioning or protein excess affecting reproduction. We have not experienced this phenomenon, likely because our no-till, lower-input, and later-planted wheat is not good enough to cause these problems.

Labor

There are generally around 1000 animals in inventory, counting the overlap between breeding seasons and a small cow herd. Additionally, some steers are grazed on wheat. There are no full-time employees, although 1 employee lives on the ranch and divides his time between my ranch and another family ranch. Contract day labor is utilized extensively, especially during breeding seasons.

Cattle Handling

Low-stress stockmanship techniques are used and there is a consistent effort to improve in this area. Cattle are intentionally handled by several methods to accommodate diverse handling styles of buyers. Heifers are acclimated to horses, 4-wheelers, and people on the ground. A 'bud box" type system is utilized, and hot shots are very rarely needed. Multiple trips (6 to 8) through our chute system creates the occasional "balking" heifer.

Prebreeding

Prebreeding exams and immunizations are routinely administered 30 to 60 days prior to our fixed-time AI date. The rectal exam includes identifying pregnancies and reproductive tract scoring. Purchased weaned heifer calves are almost always purchased as "guaranteed open", but often about 1 precocious pregnancy per truckload is identified. Reproductive tract scoring is done primarily to identify juvenile tracts, freemartins, and other causes of non-breeding. We typically only cull those with a 1 score. Pelvic measurements are performed to identify a few outliers to cull, but mostly as a marketing tool. Prebreeding immunizations include IBR-BVD, lepto, and a clostridial booster. Modified-live viral products are used. Prebreeding immunizations are important and allow a peak immunologic response at the time of greatest exposure to reproductive disease agents early in the breeding season. Many producers do a good job of vaccinating around weaning time, but fail to administer reproductive disease vaccines 30 to 60 days prior to breeding.

Synchronization

Proven, fixed-time AI protocols have made the need for heat detection obsolete in commercial beef heifer breeding programs. Far too much time is spent by beef producers (and their advisers) in switching synchronization protocols and trying to tweak existing, proven protocols. Any of the protocols approved by the Beef Reproduction Task Force have enough data to support their effectiveness. My suggestion is to pick 1 of these protocols that fits the unique management and resource potential of an operation, stick with this protocol, and focus on execution. We do not use any heat-detection devices. I have confidence in the AI protocol selected and do not want to be confused by trying to monitor heat response. We have been using the 14-day CIDR protocol. The disadvantage of this program is that it requires 4 trips through the chute, and it requires significantly more forward planning, since CIDRs are inserted 33 days prior to fixed-time AI. This program works well for us when we have our heifers on wheat pasture close by and can move them several times from pasture to the working facility. Even though there are 4 trips to the chute, the number of total products administered is less and 1 trip (removing CIDRs) does not require head restraint.

Breeding Program

Typically, our groups are set up to average 125 head per AI event. These can easily be bred within a 2-hour window. An experienced AI technician is utilized that has been doing all our fixed-time AI for 8 to 10 years. Care is taken to have a person thawing straws that pays attention to detail. Currently, the heifers being developed are almost 100% Red Angus. Both AI and clean-up sires must be in the top 20% of the breed for Calving Ease Direct (CED) EPD. The CED target is currently + 14 or greater. Although calving ease genetics are heavily emphasized, there is a focus on growth and maternal traits, with goals of top 1/3 for growth and at least the top 1/3 for maternal traits (Stayability and Herd Builder Index). We try to stay above breed average on carcass EPDs. The most important trait for our heifer development business continues to be Calving Ease, since a live calf is required before other traits really matter.

Post Breeding

We strive to maintain access to a "spring flush" of grass (or the same prebreeding nutrition program) for at least 21 days post fixed-time AI breeding. Heifers are moved back to pasture immediately after breeding and movement is avoided after 4 days and before 45 days post AI.

Pregnancy Diagnosis

At Holt River Ranch the fixed-time AI protocol is followed by clean-up bull turnout 10 to 14 days post AI. At 30 days, a Biopryn blood test is performed to determine which heifers are AI pregnancies. Later, AI pregnancies are confirmed, and clean-up bull pregnancies are staged with ultrasound. Another pregnancy exam is usually performed prior to shipment, particularly if much time has elapsed between the last pregnancy examination. Our contract has a pregnancy guarantee which states any heifer found to be open within 30 days of purchase will be replaced or the buyer can take the heifer to a local auction market and be compensated for the difference between sale and purchase price.

Marketing

Buyers consist mostly of repeat customers, word of mouth contacts, and those that see our cattle on Cattlerange.com. Cattlerange.com provides a free listing service, where cattle are described by completing a standard form and providing digital images and/or videos. The commission paid is based on the honor system. No commission is paid unless the listed cattle sell based on contacts made

through the Cattlerange website. Commission ranges from $8 to 15/head, depending on volume represented.

Some loads of heifers are sold by forward contract early in the year. For instance, this year (as of early April) 3 loads of confirmed AI bred heifers are contracted, with deposit paid, for August delivery.

Follow-up

Each customer is provided with a list of primary and secondary IDs and projected calving dates along with a letter thanking them for their purchase. Other information, such as pelvic measurements, is made available on request. Calls are made to check on each customer during or immediately after the calving season. Feedback is actively pursued and utilized.

Production and Financial Goals

Below is a summary of our established and realistic operational goals.

	Baseline goal	Stretch goal
Return on Investment (ROI)	10%	20%
Fixed-time AI preg rate	60%	65%
Overall preg rate (60 day)	88%	92%
"Turnover"	Sold before 6 mos preg	Sold before 3 mos preg
Customer satisfaction	100%	110%

Competitive Advantages

The Holt River Ranch Heifer Development program has 2 distinct competitive advantages over others:

1. Detailed production cost information, including indirect costs.
2. Expertise in reproductive management.

These 2 competitive advantages should be marketed by veterinarians working with cow/calf operations developing their own heifers, custom heifer development operations, and "value-added" heifer developers. These competitive advantages can improve each operation.

Heifer Decisions for the Cow/Calf Producer

Should I buy or raise my replacements?

Every lecture or article on heifer development addresses this question. This question should be preceded by a another, "Should I raise heifers, buy bred heifers or buy bred cows?" There are situations when the best option is to sell all heifers and buy bred cows (rather than heifers). Good, young bred cows are often more difficult to locate and purchase than bred heifers. Nevertheless, this option should be considered when analyzing the traditional buy or raising options for specific operational goals.

If the decision is made that cows are not an option, then what questions need to be answered to make the purchase vs raise decision? Following are a few questions to answer:

1. **Do I know my heifer development costs?** Dr. Jim McGrann, retired Ag Economist from Texas A&M, continues to support a series of Beef Decision Aids, including some excellent tools for calculating heifer development costs. These can be found at http://agecoext.tamu.edu/resources/decisionaids/beef An example of a Beef Replacement Heifer Budget Summary and Fixed-Time AI Costs are included at the end of this paper. As exhibited by this budget, the heifer purchase cost is by far the largest production cost. A loss or profit is largely determined by the initial purchase cost, regardless of production performance. With knowledge of production costs and prices, "buying a profit" is more certain.
   These examples represent real data but are only examples. Downloading the spreadsheet and utilizing your own numbers will provide more meaningful information.
   For the producer to make sound decisions on heifer development options, these costs must be known. Likewise, for a veterinarian to optimally assist a producer in making these decisions, these costs must be known. Knowledge and understanding of production costs may be the #1 driver in illustrating the value and ultimate implementation of expanded and cost-effective veterinary services.
2. **Do I have the management resources available to properly select, wean, develop and calve out my own replacement heifers?** The honest answer to this question is often "NO". A good analogy for potential skill or resource deficiencies for heifer development on the ranch is a preconditioning program. Traditional preconditioning converts a ranch into a temporary feedlot environment, which may not be a wise choice for many operations. Likewise, heifer development is a totally different enterprise for the cow/calf operation. Even if, after careful analysis, the decision is made that the ranch has the expertise and resources to properly develop heifers, the decision still may be to purchase rather than raise. Heifer development is expensive and diverts ranch resources away from other ranch activities.
3. **Are there high-quality, bred replacement heifers from reputable sources in my area?** Producers often cite the low availability of reliable sources for genetically similar or superior heifers as the prime reason for raising their own. A Beef Heifer Buyer's Guide can be found as an attachment. This document is based on my experiences as a bred heifer supplier and observations, especially over the last 20 years.

Decision to Raise. Once a decision is made to raise and develop replacements, based on the answers listed above, how are heifers selected to retain in an operation?

Phenotype, size, age, genetic indicators, disposition are all commonly used criteria for selection. On many ranches, the

heifers "I like" are kept and the heifers "I don't like" are sold. Typically, a replacement rate of 15-20% would be expected, so in a 100 -cow herd with 90 calves and 45 heifers, one might keep 20-25 and sell 20-25. The replacement heifers would then be managed in a separate group and developed to weigh approximately 65% of their projected mature weight at breeding. (1300 X .65 = 845 lbs.). To reach these target weights, nutritional inputs requiring approximately 1.25-1.5 lb. ADG would be needed. The extra costs for labor, feed and facilities to manage and keep heifers separate from the herd needs to be calculated.

Alternatively, almost all the heifers (let's say 43 to account for two obvious culls) could be kept. Now, the plan involves exposing all the heifers and basing the selection decision almost entirely with the bull. Only those breeding early are kept for replacements. This could be only those pregnant to fixed-time AI or those breeding in the first cycle. The target weight (and expense per heifer) can now be reduced since there are far more heifers than are needed. Based on numerous studies and experiences, these heifers can be developed to a target weight of ~55% (1300 X .55 = 715 lbs.) with minimal loss in reproductive performance. Assuming 575 lb. heifer weaning weights and 180 days from weaning to beginning of breeding, the required ADG would be 1.5 and .78, for traditional versus lower input development, respectively. The lower input heifer development system, when properly implemented and managed, may provide the most economical approach to raising heifers on the ranch. This approach places increased selection pressure to only retain heifers that match their environment and are capable of very early conception.

Decision to Purchase. Dr. Jim McGrann, developer of the IRM-SPA program, states that based on his data, if a producer owns less than 200 cows, purchasing bred heifers is usually a better economic alternative. Few cow/calf producers have a good handle on financial production costs and even fewer know their economic production costs (including opportunity cost, return to operator labor and management, etc.). Even if one accepts that raising and developing heifers is usually more expensive than purchasing bred heifers, there are still other considerations. Heifer quality, health history, disposition and seller reliability are among other considerations when deciding to purchase bred heifers. Some groups of bred heifers are misrepresented by unknowing or unscrupulous sellers. Nevertheless, assuming a seller of bred heifers is reliable, purchasing versus raising is often a sound economic decision.

U.S. Number Beef Cows by Herd Size - 2017 Census					
Size of Herds	Number of	% by	Head of	% by	Average
Head	Operations	Herd Size	Beef Cows	Herd Size	Sized Hd.
1 to 49	576,735	79.1%	8,616,893	27.2%	15
50 to 99	80,411	11.0%	5,373,199	16.9%	67
Less than 100	657,146	90.1%	13,990,092	44.1%	21
100 to 199	42,774	5.9%	5,652,042	17.8%	132
200 to 499	23,188	3.2%	6,609,375	20.8%	285
500 or more	5,938	0.8%	5,470,530	17.2%	921
200 or more	29,126	**4.0%**	2,079,905	38.1%	415
Total	729,046		31,722,039		44

What should a bred heifer be worth? The answer to this question depends on whether you are buying or selling. An old rule of thumb was that a bred heifer should be worth twice the value of an open heifer. This no longer appears to be accurate. To quote Harlan Hughes, "A bred heifer today is worth all of her future annual net cash incomes, including her cull value, discounted back to today's dollars." Another rule of thumb, that we utilized for several years, was based on the price of 550 lb. feeder steers from the previous year (see chart below). This relationship was not accurate in 2018, as bred heifers were priced relatively lower than feeder cattle. The depressed cull cow market appeared to drive down the bred heifer price. In our operation, with current prices and expenses, we need ~$700 added to the price of the purchased weaned heifer calf to recover production costs.

Cattle Fax Monthly Feeder for 550 lb Steer Price and Valuation of Bred Heifers

	Sept	Oct	Nov	Dec		550 Lbs.			
	9	10	11	12	Average	Steers	Bred Heifers in the next year		
					Price	$/Hd. X	Repl Heif	Repl Heif	Repl Heif
2009	$104.19	$99.28	$101.79	$103.64	$102.23	$562	1.50	1.75	2.00
2010	$117.75	$117.48	$121.90	$129.14	$121.57	$669	$843	$984	$1,124
2011	$137.99	$145.19	$153.27	$159.64	$149.02	$820	$1,003	$1,170	$1,337
2012	$157.16	$158.01	$158.79	$164.27	$159.56	$878	$1,229	$1,434	$1,639
2013	$171.96	$178.30	$183.25	$187.24	$180.19	$991	$1,316	$1,536	$1,755
2014	$263.76	$277.42	$280.64	$281.21	$275.76	$1,517	$1,487	$1,734	$1,982
2015	$226.70	$214.00	$203.27	$180.57	$206.14	$1,134	$2,275	$2,654	$3,033
2016	$141.50	$127.09	$137.90	$145.34	$137.96	$759	$1,701	$1,984	$2,267
2017	$166.45	$166.73	$171.06	$171.18	$168.86	$929	$1,138	$1,328	$1,518
2018	$171.10	$171.06	$166.06	$166.04	$168.57	$927	$1,393	$1,625	$1,857
2019							$1,391	$1,622	$1,854
					Average for Years	$918			

Heifer Development Opportunities for Veterinarians

There is likely no better opportunity for expanding services to cow/calf producers than providing various levels of professional expertise for ranch heifer development programs. The lack of adoption of reproductive technologies for beef cattle, particularly with heifers, is mind boggling (see below). When the costs associated with these technologies are closely examined, it is clear cost is not the issue. Producer education, availability and convenience are the key drivers for producer acceptance and implementation.

Adoption of Reproductive Technology, NAHMS		
	Beef 2007-2008 %	**Beef 2017 %**
Estrus Synchronization	7.9	7.3
Artificial Insemination	7.6	11.6
Palpation for Pregnancy	18.0	19.3
Blood Test for Pregnancy	NA	3.5
Ultrasound for Pregnancy	2.2	8.8
Pelvic Measurement	3.9	6.6
Body Condition Scoring	14.3	13.6
Semen Evaluation	19.5	19.6
Embryo Transfer	1.6	3.0
Any of the Above	35%	

In addition to the producer options mentioned previously, there may be an opportunity to provide **Custom On-Ranch Heifer Development** services. This *"Turn-Key" Heifer Development and Breeding Service* might include the following:

1. Selection – weight, frame score, disposition, phenotype
2. Prebreeding exams – reproductive tract score, pelvic measurement, open confirmation
3. Reproductive disease immunization protocol
4. Parasite control
5. Synchronization protocol
6. AI Set-Up (2-3 trips)
7. Fixed-time AI
8. Pregnancy Diagnosis (Blood, rectal, ultrasound)
9. Fetal sexing
10. Records Management
11. Capturing and utilizing DNA information
12. Genomic counseling
13. Bull Breeding Soundness Exams

Summary. This information is written from the perspective of a producer/heifer developer (who happens to be a beef veterinarian). The perspective includes many different aspects of the beef industry including experience in rural private practice, academia, the corporate world and ranching.

When considering opportunities to expand cow/calf service in veterinary practice, heifer development seems to be "low hanging fruit." Increased individual services, a package of services or even a "turnkey" On-Ranch Custom Heifer Development Service are potential growth opportunities in many practice environments. Progressive producers, with a better understanding of production costs, would likely be willing to invest considerably more financial resources to increase efficiency and allow increased opportunity to focus on other areas of the ranch enterprise. As stated earlier, producer education, availability and convenience are more important drivers than service costs.

The key to adoption of expanded heifer development services is access and utilization of accurate financial and managerial accounting information. When a producer truly has a good handle on detailed production cost information it is much easier to recognize the value of investment in competent veterinary services. In the sample budget provided, the entire breeding system costs are less than 7%. In numerous cow/calf budget examples, total veterinary costs rarely exceed 4%, including product and services. Producers with sound financial information can clearly visualize the cost effectiveness of their total health and reproductive technology investment.

How to assist your beef clients with bull buying decisions using herd goals and Expected Progeny Differences (EPDs)

W. Mark Hilton, DVM, PAS, DABVP (beef cattle)
Technical Consultant, Elanco Animal Health, West Lafayette, IN 47906

Abstract

Beef cow-calf veterinarians are relied upon more and more to provide advice and consulting to their clients. While issues of health are the mainstay of many conversations, progressive producers are asking their herd health veterinarians about non-health subjects that have a financial impact on their herds. Providing unbiased information on improving the genetics of a herd can make a significant impact on the producer's bottom line.

Key words: genetics, expected progeny differences, genomically enhanced EPDs, crossbreeding, hybrid vigor, heterosis

Résumé

On se fie de plus en plus aux vétérinaires de troupeaux vaches-veaux (bovins allaitants) pour donner des conseils et des consultations à leurs clients. Bien que les questions concernant la santé soient souvent le sujet des conversations, les producteurs d'avant-garde demandent à leurs vétérinaires spécialisé en médecine de troupeau des questions sur des sujets qui ne touchent par la santé mais qui ont un impact économique sur leur troupeau. Fournir des informations impartiales sur l'amélioration de la génétique d'un troupeau peut avoir un impact significatif sur le bénéfice net du producteur.

In November 2019, a survey created by veterinary student Aimee Sink, was sent in an email to the student members of AABP. The survey collected 240 responses through October 2018.

The goal of the survey was to gauge the level of preparedness and interest in several different aspects of genetics and genomics to veterinary students interested in bovine medicine so that the AABP Genetics and Genomics committee can better serve the needs of the student members.

For the question, "Out of the following, what three things would you be most interested in learning more about?" The top responses were:

1. Embryo transfer – 96
2. Reading pedigrees – 87
3. Using hormones in reproductive programs – 82
4. Breed-specific genetic conditions – 80

When asked, "How well prepared do you feel about the following topics?" those with the least amount of confidence were (combined answers "what is this" and "not prepared":

1. Reading/interpreting genomically enhanced EPDs or PTAs – 140 (with 42 saying, "what is this?")
2. Reading bull/cow EPDs or PTAs – 136 (52)
3. Giving advice on sire selection – 134 (8)
4. Reading pedigrees – 129 (6)
5. Using genetic tests to look into the future – 128 (11)

The final question was, "How important do you think the following are in regards to being a bovine practitioner?" (combined answers, "very important and "important"):

1. Using hormones in reproductive programs – 228 (with 185 saying, "very important")
2. Breed-specific genetic conditions – 221 (141)
3. Bull BSEs – 219 (167)
4. Artificial insemination – 216 (158)
5. Recognizing conformational faults – 216 (134)

In this talk, we will cover:

- Questions to ask your producers before consulting on genetics;
- Breed specific genetic defects;
- Expected progeny differences (EPDs) and how to use them in primarily sire selection;
- What are across breed EPD adjustments and how to use these;
- How genomic testing can benefit your beef producers;
- Understanding percentile ranking of EPD traits;
- Does your owner need a maternal or terminal bull?;
- Advantages of hybrid vigor.

Questions to Ask your Producers Before Consulting on Genetics

Before you embark on making genetic recommendations, there are numerous questions you need to ask your producer.

- Is the bull for heifers, cows or both?
  - If the bull is for heifers, calving ease becomes the most important trait.
  - If the bull is for cows, what is the plan for the calves?
    - keep back replacements or not?

- sell feeder calves or finish to slaughter?
  - if sell to slaughter, do you sell live or on a grid?
- What are your short and long-term herd goals?
- In what way(s) is your herd above average?
- From a genetic standpoint, what do you think you need to do even better yet (EBY)?
- Others?

After you obtain answers to these questions, you now have the opportunity to be an asset to your producer in regards to his or her genetic plan.

Breed-specific Genetic Defects

There are numerous genetic defects in the beef cattle population, but the chance of encountering these conditions in a typical practice is rare. Our knowledge of the inheritance of the most common genetic defects is quite solid, and most all defects have a genetic test available. All new AI sires have to be either tested free or be known free based on their pedigree. With some genetic defects, carrier animals have their registration papers revoked so no more of their offspring can be registered.

A good summary on genetic defects is available at: http://extensionpublications.unl.edu/assets/html/g2055/build/g2055.htm This is a University of Nebraska Extension paper and it explains the most common genetic defects, as of the 2011 publication date. The genetic defect developmental duplication (DD) was discovered in 2013 so it is not included in this publication. A table from the publication is below with DD added (Table 1). More information on DD can be found at www.angus.org.

Another helpful reference is a Kansas State PowerPoint by Dr. Dan Mosier, who is now president of Angus Genetics Inc. https://www.asi.k-state.edu/doc/agents/gendefects.pdf. This publication lists sires that are commonly in the pedigree of affected animals.

If a carrier bull is mated to a carrier cow and the defect has a simple recessive mode of inheritance, there is a 25% chance the calf will be free of the disease (AA in Figure 1), 50% chance of being a carrier (Aa), and 25% chance to have the disease (aa).

Two techniques are helpful in greatly reducing or even eliminating the chance of producing a calf with a known genetic defect. First, beef clients should never purchase carrier animals. Before a beef producer purchases a bull, it should be either tested clean or be free of all known genetic defects via pedigree. Via pedigree means, it has no carrier animals in the pedigree or both sire and dam have been tested free. If there are suspect animals in the pedigree, the bull should be tested before purchase.

Second, the use of crossbreeding is a proven way to greatly reduce or eliminate genetic defects, as most genetic defects are confined to a single or very few breeds. If the owner of a herd of Angus or Angus cross cows purchased a bull that was a carrier of AM unknowingly 15 years ago, daughters and granddaughters of that bull are most likely in the herd. The purchase of a Gelbvieh or Simmental or other breed bull would eliminate the chance of producing calves that are homozygous for the AM trait. Now, if the producer purchases a Balancer (Gelbvieh-Angus composite) or SimAngus (Simmental-Angus composite) bull, this bull would need to be free of AM as the bull has Angus in his pedigree.

In a commercial herd there is little to no reason to test the cows for genetic defects. Simply purchase bulls that are free. If the herd uses AI and producers their own bulls, then those bulls should be tested to be sure they are clean if known carriers were used in the past.

Conditions like corkscrew claw and scissor claw are more difficult to eliminate from a herd because the mode of inheritance is unknown. Bulls should be thoroughly scrutinized prior to purchase for feet issues. Bulls that develop these conditions should be reported to the breed association. To give assurance of selling animals free of these conditions,

Table 1.

Genetic abnormality	Common term	Primary breeds(s) of incidence	Lethal or Nonlethal	DNA test available
Alpha (a)-Mannosidosis		Red Angus	Lethal	Yes
Arthrogryposis Multiplex (AM)	Curly calf	Angus	Lethal	Yes
Beta (b)-Mannosidosis		Sales	Lethal	Yes
Contractural Arachnodactyly (CA)	Fawn calf syndrome	Angus	Nonlethal	Yes
Developmental duplication (DD)		Angus	Nonlethal*	Yes
Neuropathic Hydrocephalus (NH)		Angus	Lethal	Yes
Hypotrichosis (hairless calf)		Hereford	Nonlethal	No
Idiopathic Epilepsy		Hereford	Nonlethal	Yes
Osteopetrosis	Marble bone	Angus and Red Angus	Lethal	Yes
Protoporphyria		Limousin	Nonlethal	Yes
Pulmonary Hypoplasia and Anasarca (PHA)		Maine-Anjou and Shorthorn	Lethal	Yes

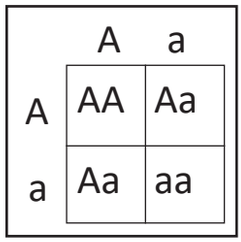

Figure 1. Punnet square to show potential offspring from mating two carriers of condition "a" where "A" is the normal gene.

sellers should guarantee bulls free of these defects. Daughters should not be kept from bulls with these disorders and daughters of affected cows should be fed for slaughter and not retained in the herd.

Expected Progeny Differences (EPDs) and how to use them in Sire Selection

Expected Progeny Difference (EPD) is the prediction of how future progeny of each animal are expected to perform relative to the progeny of other animals listed in the database. EPDs are expressed in units of measure for the trait, plus or minus. A very good review can be found at the University of Nebraska site: http://extensionpublications.unl.edu/assets/html/g1967/build/g1967.htm. The use of EPDs is 7 to 9 times more effective than utilizing actual phenotypes of an animal.[2] For example, if Bull A had a weaning weight of 650 lb (295 kg) and Bull B had weaning weight of 575 lb (260 kg) we might assume that bull A would be the superior choice if the goal was to increase weaning weight. This raw data does not take into account when the bulls were born, the age of the dam, whether the calves were creep fed or not, and many other environmental factors. The heritability of weaning weight is only 0.28[3] according the data found at https://www.angus.org/Nce/Heritabilities.aspx. That means 72% of the variation in calves' weaning weight is due to non-genetic factors. If we had EPDs on these bulls and bull A had a WW EPD of 60 and Bull B had a WW EPD of 70, we are 7 to 9 times more likely to be correct if we select bull B to improve our weaning weights.

One common fallacy is that the EPD of zero is breed average. That is almost never the case now. When EPDs were introduced in 1983, that was the average for many of the traits. Now, it means almost nothing. The "D" in EPDs is the key to how we use EPDs. As in the example above, bull B had a 10 lb (4.5 kg) (70-60=10) advantage (**D**ifference) compared to Bull A on WW EPD.

Another factor that needs to be considered is the *accuracy* of the EPD. Accuracy can be defined as the relationship between the estimated EPD of the animal and the «true» EPD of the animal.[4] This relationship is expressed numerically from 0 to 1. As the accuracy value approaches 1.0, the EPD reported is more likely to represent the true genetic merit of the animal. Young bulls with no progeny will have a lower accuracy than an older bull with many progeny recorded. When mating heifers via AI, it is important to select a bull with greater accuracy as this increases our confidence that the calving ease of this bull is closer to his "true" EPD.

EPDs are dynamic and will change over time. A very young bull that initially appears to be a good candidate to use on heifers may turn out not to be a wise choice as more and more calves are born and recorded. Once a bull's accuracy gets above about 0.80, very little change should occur. I use the analogy of your "grade" after 2 quizzes in a class vs your "grade" after 20 quizzes, 4 tests, and 2 projects. Your grade may change significantly after an exam in the former example, but not much in the latter. This is the same as an animal's EPDs.

If a producer is comparing bulls of 2 different breeds, an EPD adjustment needs to be made so the bulls can be compared on an equal genetic basis. Each breed has their own EPD base and direct comparisons cannot be made without using the adjustments. This is why the Meat Animal Research Center in Nebraska publishes an adjustment table each year. Angus is used as the "base" breed so the Angus adjustment for each EPD that can be compared is 0. For example, a producer is looking at an Angus bull with a YW EPD of 100. She is comparing the Angus bull to a Charolais bull with a YW EPD of 90. At first glance, the Angus appears to have a 10 lb (4.5 kg) advantage, but when we look at the conversion chart for YW, the Charolais has an adjustment factor of 23.2.[5] Therefore, the Charolais, adjusted to the Angus basis (called the Across Breed EPD), is actually 113.2 compared to the Angus at 90.

How Genomic Testing can Benefit your Beef Producers

The industry has made great strides on the utilization of genomic testing in beef cattle. Genomic, or DNA, test results are used to enhance predictability of current selection tools, to achieve more accuracy on EPDs for younger animals, and to characterize genetics for traits that are difficult or expensive to measure, such as feed efficiency, carcass traits in breeding stock or maternal traits in bulls. The area that seems to have the largest impact is the ability to genomically enhance the EPDs of young animals so that the EPD accuracy improves and the animal's EPDs are closer to its true EPDs at a much younger age. A challenge of purchasing a yearling bull for a group of heifers has been the low accuracy of the bull's calving ease direct (CED) EPD. Now with genomically enhanced (GE-EPDs), instead of the bull's EPDs only being calculated based on his pedigree, calving ease score, birth weight and contemporary group data, it is as if the bull has already sired 26 calves where calving ease data was recorded.[6] Do not be confused. This is not a guarantee of calving ease. Just as a bull with high accuracy for calving ease can produce calves that result in a dystocia, so can a bull with GE EPDs that predict calving ease. The fact remains that it is the best tool we currently have to predict calving ease on a virgin bull.

Understanding Percentile Ranking of EPD Traits

EPDs have evolved from only comparing 2 or more animals based on the expected *difference* of their progeny to evaluating where a bull ranks within the breed based on certain EPDs. This is especially popular for marketing purposes. Touting that a bull is in the top 1% of the entire breed for some trait seems to excite potential buyers. The question that we will not take time to discuss here is "Does the buyer *need* a bull in the top 1% of a certain trait?"

Many producers do find using this data to be useful when selecting an AI sire to use on a group of heifers. As stated earlier, calving ease is the most important trait to consider for the majority of producers that are breeding heifers. It is common to hear experts recommend using a high accuracy bull in the "top 10% of the breed for CED". Every breed has an EPD percentile chart and you as an advisor need to be familiar with what is above and below average or a certain threshold when helping a producer select a sire. You don't need to memorize these, as they are easy to find on each breed's website. If you work with a particular breed frequently, you will become familiar with some of the traits. For example, if you suggest SimAngus bulls for many of your commercial herds, you may know that a YW EPD of 110 is well above average for the breed (actually top 25% currently).

Many seedstock producers will have traits where they are placing much selection pressure and others where they place very little pressure. If a seedstock herd is selling bulls to commercial producers that retain females for replacements and retain ownership of cattle into the feedlot, he or she may select AI sires that rank in the top 25% for calving ease and docility, bottom 50% for frame score and mature weight, top 40% YW, and top 10% marbling. The list of bulls that is generated is then further scrutinized for other traits like scrotal circumference, milk, and stayability. It would be rare to impossible find a bull in the top say 25% of the breed for every trait a producer felt was economically important. Some concessions need to be made in your selection criteria.

If a search of AI sires with the above criteria results in 70 bulls selected, adding selection pressure to some other traits will help reduce the list to a manageable level. If on the other hand, the search yields zero bulls, reducing the selection pressure on 1 or more traits is where to begin.

If the bull selected is to be used on heifers, CED EPD should have the most selection pressure. Do not look at birthweight (BW) EPD as it is a proxy for calving ease direct. CED measures actual calving ease scores from heifers. The 2 traits are correlated, but CED already takes into account BW EPD, so simply look at CED and not BW EPD. Do not be concerned with actual birth weight except on rare instances. Actual BW is influenced by non-genetic factors. CED is a direct measurement of calving ease on heifers. It is disappointing to read surveys and see that actual birthweight of bulls is 1 of the traits where producers place the highest selection pressure. I hope that you can train your clients to mostly ignore this number.

Does your Owner need a Maternal or Terminal Bull?

Most commercial herds retain their own heifers for replacements, and whether that is ideal or not is up for debate. Nevertheless, most herds *intend* to buy a maternal bull; one where they will keep replacement females. Traits that are deemed important would likely include docility, fertility, longevity, structural integrity, moderate frame/mature size, calving ease, moderate milk, hybrid vigor, acceptable growth, and marbling. The problem is that from a marketing standpoint it is easier to tout "top 1% YW EPD" if the goal is to get top dollar for the bull. Expressing that a bull is very good to good in a number of areas and average in others does not excite buyers. If we compare a dairy cow to a beef cow, the dairy cow needs to give a lot of milk that is high in components. We bring her feed to her every day, we accept a 25% first-service conception rate and if she has a calving interval of 14 months and only lasts 3 lactations, we accept that. Longevity is not part of the equation. Our beef cow needs to get pregnant in the first 30 to 42 days (ideal) of her first breeding season, calve unassisted, get bred back 3 months after calving, wean off an acceptable calf at 6 months of age, graze forage for 7 to 9 months of the year, keep body condition in a variety of environmental conditions, and do this every year for hopefully 10 to 15 years. Beef producers cannot single-trait select or even select for just a few traits. We need balance in our EPD selection criteria in the beef world. Too many producers are buying terminal bulls (high growth, large frame, high marbling, large ribeye) when they really need a maternal bull.

If your herd owner is not keeping back replacement heifers, he or she should buy a terminal bull. In the past, we might have thought of using a Charolais or Simmental bull. When we think of these breeds, we think muscle and growth. When we examine the most modern genetic choices and apply the across-breed EPD adjustments, there are actually many Angus bulls that excel as terminal sires. These bulls would have high carcass weight, yearling weight, and marbling EPDs. They tend to be large-framed and have high mature weight EPDs (correlated positively with carcass weight). Carcass weight is a large driver in the equation, as is marbling. The Angus breed has an index that is a terminal index, $Beef ($B).

Compared to any of the Continental breeds, the Angus will be far superior on marbling. If there is a hefty premium for prime and/or the choice/select spread is significant, the carcass premiums will be much higher for the Angus-sired cattle. Not every Angus would be a good choice as a terminal bull. Look at $B and if a bull is near the top of the breed in that trait, he is an excellent choice as a terminal bull.

When I work with large herds that feed their own calves to slaughter, I often recommend breeding about 40% of the mature cowherd to terminal bulls. A well-managed herd has only a 10 to 18% replacement rate, so they will only need to keep back about 15 to 25 heifers in a 100-cow herd. If 60% of the herd is bred maternal, that gives the owner about 25

to 30 heifer calves born from the maternal sires and ~20 from the terminal sire. Those heifers and their steer mates should all be more valuable as feedlot animals, as compared to the maternal-sired animals that will end up in the feedlot.

Advantages of Hybrid Vigor

The benefits of crossbreeding in beef cattle have been documented for many years. In a 1949 circular from the USDA, Knapp et al reviewed the earliest work.[7]

> *"Black and coworkers (1934) and Rhoad and Black (1943) have reported greater weight-for-age for crosses between the Brahman and breeds of English origin in the Gulf Coast area than for the English breeds. Wentworth (1912) reported a crossbreeding experiment at the Iowa Agricultural Experiment Station in which he concluded that "blue-gray" cattle (crosses between Shorthorn and Aberdeen-Angus or Galloway) have demonstrated their equality or even superiority, as market animals to parent breeds. Deakin and Muir (1935) found that crosses of yak and bison with domestic cattle showed remarkable vigor as expressed by stamina, size and longevity. In swine, Winters and associated (1935) found that the three-breed crosses excelled either the two-breed cross or the purebred breeds in the production of market pigs."*

This is not new news, doctors! In the swine and poultry world, virtually all animals are hybrids. Why are we still debating something that we have known to be true for over 100 years? Have some breeds done a tremendous job of marketing? Are producers 'loyal' to certain breeds? During a webinar on cattle genetics, the participants were asked if a producer used 2 distinct "lines" of the same breed would the resulting offspring display any hybrid vigor. Over 50% of the attendees said "Yes", when the answer is "No"!

Here is the science on the advantages of the crossbred calf:[8]

Trait	Observed improvement	% Heterosis
Calving rate	3.2	4.4
Survival to weaning	1.4	1.9
Birth weight	1.7	2.4
Weaning weight	16.3	3.9
Average daily gain	0.08	2.6
Yearling weight	29.1	3.8
Longevity	1.36	16.2

Crossbreeding advantages of the crossbred cow: [8]

Cow lifetime production	Observed improvement	% Heterosis
Number of calves	0.97	17.0
Cumulative weaning weight	600	25.3

In a study published in 1994, the authors showed that maternal heterosis increased net profit nearly $70/cow/year compared to straightbred cows.[1] In 2018, Dr. Bob Weaber at Kansas State put that figure at $150/cow/year. Therefore, in a 50-cow herd, having 100% crossbred cows could net the owner $7500/year more profit at virtually no extra cost. If your herd owner has slipped into a nearly purebred herd, helping him or her find a complimentary breed for their goals and then retaining those crossbred cows could have a very positive financial impact.

If you are going to be an advisor to your beef cow-calf clients on genetics, you will need to understand the herd owner's goals, be able to examine which traits are important to them and how to use EPDs to make the best mating decision. Adding hybrid vigor is paramount to improving cow longevity and herd profit.

References

1. Davis KC, Tess MW, Kress DD, Doornbos DE, Anderson DC. Life cycle evaluation of five biological types of beef cattle in a cow-calf range production system: II. Biological and economic performance. *J Anim Sci* 1994;72:2591-2598.
2. http://extensionpublications.unl.edu/assets/html/g1967/build/g1967.htm. Accessed 12/9/2019.
3. https://www.angus.org/Nce/Heritabilities.aspx. Accessed 12/9/2019.
4. https://www.sites.ext.vt.edu/newsletter-archive/livestock/aps-02_03/aps-074.html (accessed 12/11/2019.
5. https://www.angus.org/Nce/AcrossBreedEpdAdjFactors.aspx. Accessed 12/2/2019.
6. https://www.angus.org/AGI/GenomicEnhancedEPDs.pdf. Accessed 12/2/2019.
7. Knapp B, Baker AL, Clark RT. Crossbred beef cattle for the Northern Great Plains. US Department of Agriculture, 1949.
8. Weaber B. Crossbreeding for commercial beef production. http://www.nbcec.org/producers/sire_selection/chapter5.pdf. Accessed 12/12/2019.

Disease investigations: Review and update

Eugene Janzen, DVM
College of Veterinary Medicine, University of Calgary, Calgary, AB, Canada T2N 4Z6

Abstract

Bovine practise in the 21st century has changed from an emphasis on individual animal diagnosis and treatment to a diagnosis and management of a herd or a cohort of that herd. That change has meant a more comprehensive examination of the animals, environment, and the cattle management on that premises is indicated. A system of diagnostic support in a herd situation is even more important and extensive than on an individual bovine. A necessity for a herd diagnosis is a site visit and the creation of a database that includes a history, individual animal exams and their diagnostic support, necropsies, and environmental scans. A definitive clinical-pathological diagnosis is often not made, but a good clinical or epidemiological diagnosis may lead to improved cattle management that will eliminate or minimize the specific herd problem.

Key words: bovine, herd, population, diagnosis

Résumé

La pratique bovine du 21e siècle s'est éloignée du diagnostic et du traitement d'individus pour passer au diagnostic et à la gestion d'un troupeau ou d'une cohorte de ce troupeau. Ce changement implique qu'un examen plus approfondi des animaux, de l'environnement et de la gestion des bovins sur les lieux est requis. Un système de soutien en matière de diagnostic dans le cas d'un troupeau est encore plus important et plus élaboré que dans le cas d'un simple bovin. Pour le diagnostic au niveau du troupeau, il est nécessaire de faire une visite sur le site et de créer une banque de données incluant les antécédents, les examens individuels et leur soutien en matière de diagnostic, les nécropsies et les analyses de l'environnement. Un diagnostic clinique-pathologique final n'est pas toujours possible mais un bon diagnostic clinique ou épidémiologique peut mener à une meilleure gestion des bovins qui éliminera ou minimisera le problème spécifique du troupeau.

Introduction

Historically, veterinarians working in agriculture were asked to deal with problems on individual cattle or horses. With mechanization of agriculture that included the use of tractors and other self-propelled equipment, agricultural equine practice almost disappeared. Veterinarian practice then changed to more involvement with cattle, both beef and dairy. In Canada, this change was accentuated in the 1970s with the importation of the large European beef breeds. Veterinarians, who could now can be correctly called "Buiatricians", spent most of their time dealing with dystocias and neonatal disease. Veterinary practises in rural areas flourished.

Several events with international trade have changed the daily workload of the buiatricians. Canada synchronized our grading system with our neighbors which meant producers changed their breeding program to meet these new grading specifications. However, in so doing, they significantly reduced the veterinary workload associated with parturition previously seen in western Canadian cow herds. Similarly, the diagnosis of Bovine Spongiform Encephalopathy meant the value of the livestock was drastically reduced. In many situations, there no longer was a cost benefit to use a veterinarian.

Currently producers call a buiatrician to attend to a problem of the group. Examination of the herd, cohort or group on the property not only entails individual bovine examinations, but very quickly resembles an epidemiological investigation. Indeed, the "threshold of concern" that producers have for the cattle in their charge has shifted from individual animals to group of animals. Some of our veterinary textbooks have begun to reflect that change, and describe the examination of the group as well as the examination of the individual.

Herd Examination

It is often said that the first task of a disease investigation is to determine if this is an outbreak or merely random events. A formal examination of the herd is the only way to make the distinction.

A history of the problem should indicate or outline how a herd examination should proceed. Clinical exams of individuals will help to characterize the disease event. If there are dead animals, extract all the information the cadaverous material can provide. Never overlook the importance of a written document that describes the investigative effort.

A site visit is considered a critical imperative. It would allow for an evaluation of the level of biosecurity on the property and facilitate an examination of the environment and an evaluation the management. Such a visit may also show differences in the problem between various classes of cattle on the property, and that alone may help with a diagnosis. Additionally, a farm visit would help with an evaluation of behavior. Cattle seeking shade during a heat wave would increase the livestock density that might facilitate transfer of pathogen (e.g. *Morexella* spp) between individuals. Wild cattle would disguise the degree of lameness.

Herd Examination Protocol

While the examination of an individual cow would basically attempt to look at all body systems, the methodology for examination of the herd is much more extensive. Little has been published on how to examine the herd, so the common protocol followed very closely resembles the rules of journalism.

A description of the problem, with clinical description and number of animals affected, would be the first question, or the journalistic equivalent of "what"! Included in the category could simply be a summary of; e.g. reproductive exams.

"Who" are the affected animals that may need statistical effort to demonstrate that differences between "affected" and "non-affected" groups are actually different and not simply a random effect. Often age of animals can help lead to a more definitive description and how management of an age group is different.

"When" the problem occurs, is critical. Oftentimes a tight cluster of animals clinically affected or even dead can suggest a toxic event. A common practice that arises when a feedlot necropsy is done will be to compare the time of first treatment to the extent and age of the pulmonary pathology.

Cattle struck by lightening are often found under a tree or in a fence line. In these situations the "where" of the problem often provides the only critical component of the diagnosis.

Easily, the most complicated part of a herd examination protocol is in finding a definitive answer to the "why" question.

Then, if an answer to the questions of what, who, when, and where is present, this usually leads to a tentative diagnosis of "why".

Cases with no Definitive Diagnosis

In spite of extensive efforts it may be that no definitive clinical-pathological diagnosis is determined.

Examples of such "unknown" diagnoses are presented in Table 1. Often, even if an etiological diagnosis is not definitive, a clinical or epidemiological diagnosis alone may assist with change in management. If heifers in early spring suffer sudden deaths in a paddock with sloughs, the management change might be to delay grazing that paddock until midsummer.

Table 1. Clinical and epidemiological diagnoses made without a clinical-pathological diagnoses.

Outbreaks of severely traumatized tongues in cattle (2)
Megacolon mortality in "shooter" Elk bulls
Calf-crop loss to congenital joint laxity & dwarfism (2)
Blind neonatal calves, an outbreak over 2 years
Weak calves immediately after birth (2)
Outbreak of mortality in mature bison cows

Reasons for No Diagnosis

The most common reason for "no diagnosis" is the same in many situations. Without sufficient information and material, a result is often that the problem is not described in its entirety.

If the history is incomplete and the site visit is overlooked or compromised, a diagnosis may remain unmade. Additionally, if the material used for diagnostic support is unsuitable, contaminated or insufficient, a diagnosis of the problem is seriously compromised.

Crop agriculture has undergone many recent changes and associated with those changes are many emerging concerns, like mycotoxicoses, that our diagnostic labs may not have the available laboratory capabilities to be definitive.

Commonly the cost of such examinations can become the fundamental issue and often determines whether a diagnosis is made or not.

The problem may have naturally gone away and/or the enthusiasm to make a final diagnosis has waned. A disease investigation is not really defined, and producers who are used to asking their veterinarians to complete a specific task will often consider that seeking a diagnosis on a herd problem to be an almost never-ending task.

References

1. Constable PD, Hinchcliff KW, Done SH, Grunberg W, eds. Veterinary medicine, 11th ed. St. Louis, MO: Elsevier, 2017.
2. Radostits OM, Leslie KE, Jetrow J, eds. Herd health; food animal production medicine. 2nd ed. W.B. Saunders Company, 1994.

Review of respiratory pathology for field clinicians

Eugene Janzen, DVM
College of Veterinary Medicine, University of Calgary, Calgary, AB, Canada T2N 4Z6

Abstract

For all various production methods, bovine respiratory disease has been described as the most common, causing the greatest production loss. With the current increasing scrutiny on the prudent use of antimicrobials, a definitive diagnosis has increased in importance. In commercial cattle operations, buiatricians are rarely called to attend to individual animals with respiratory disease. More often, we are tasked with a problem in a herd or a cohort of that herd. Almost spontaneously part of that task becomes making necropsy diagnoses. Examination of the respiratory tract at necropsy includes dissection of the upper respiratory tract, thorax, and abdomen. Explanations for clinical disease are usually evident with an extensive gross dissection of the aforementioned areas. In many cases the use of diagnostic support like histopathology, microbiology and molecular diagnostics, like immunohistochemistry, may be critical to outline changes to the management of the problem.

Key words: bovine respiratory disease, lungs

Résumé

Pour l'ensemble des méthodes de production, la maladie respiratoire bovine est considérée comme la plus fréquente et celle qui cause les plus lourdes pertes de production. Dans le contexte d'une surveillance accrue pour une utilisation judicieuse des antimicrobiens, un diagnostic final gagne en importance. Dans les exploitations commerciales d'élevage, on demande rarement aux spécialistes en buiatrie de s'occuper d'animaux avec des problèmes respiratoires. Le plus souvent on nous confie des tâches au niveau du troupeau ou d'une cohorte de ce troupeau. Faire un diagnostic suite à une nécropsie devient presque spontanément une partie de cette tâche. L'examen du tractus respiratoire à la nécropsie inclut la dissection des voies respiratoires supérieures, du thorax et de l'abdomen. L'explication de la maladie clinique est souvent évidente suite à une dissection macroscopique poussée des structures précédentes. Dans plusieurs cas, l'utilisation de soutien en matière de diagnostic comme l'histopathologie, la microbiologie et le diagnostic moléculaire peut devenir essentielle pour préciser les changements dans la gestion du problème.

Use of Field Necropsies

In times past, veterinarians were called to examine and treat individual calves or sometimes cows with pneumonia. Currently it is much more likely that we will be called to assist with respiratory disease management in a group. The need to examine clinical cases with pneumonia is still there, but additionally we must examine the dead animals which will contribute to the complete database of the herd problem. This may be especially helpful if the predominant complaint is "poor response to treatment". Currently, as we strive to use antimicrobials more prudently, monitoring those treated animals that die with a necropsy is almost a prerequisite.

Where a large number of cattle are raised, a stock attendant could be trained to conduct necropsies and take a series of images to be submitted to the herd veterinarian. Cadavers are moved to a suitable area to conduct necropsies and to assist with their ultimate removal to the recycling plant. The bovine cadaver should be placed on the left side and when images are taken, an image of the whole animal, along with the identification, are required. Postmortem autolysis can make findings very difficult to interpret, and therefore necropsies should be completed as soon as possible after death. A good external examination of the cadaver can often lead to the definitive pathology. Subsequent to that, a gross examination of the abdominal and thoracic cavity will make 60 to 70% of the final diagnosis.

Pathogens of Respiratory Tract Spread via Bloodstream

Pathogens are commonly spread to the lungs by 2 mechanisms, via the bloodstream and via the bronchial tree. There are 2 common pneumonias spread via emboli in the bloodstream that buiatricians will encounter. Subsequent to subclinical acidosis, liver abscesses often develop and some of these may leak infectious debris into the vena cava and thereby cause abscession in the lung. In a similar fashion, a septic osteomyelitis in the hoof may cause a septicemia that spreads and localizes in the internal organs, the most obvious being the lung.

A more complicated example may be the disease associated with *Histophilus somni*. The pathogenic hypothesis is that the organism spreads to the lower respiratory tract, occasionally causing a bronchopneumonia. The lung is then considered to be the source of a septicemia, often called Histophilosis, that may manifest as encephalitis, nephritis or myocarditis.

Pathogens spread via Bronchial Tree

Common bacteria that are spread via the bronchi include *Mannhaemia hemolytica*, *Mycoplasma* spp, *Pasteurella multocida,* and *Histophilus somni*. Viruses like the bovine herpes 1, bovine respiratory syncytial virus, parainfluenza 3, bovine coronavirus and various species of adenoviruses may find their way into the respiratory tract via the bronchial tree.

Verminous pneumonias, whether *Dictocaulus* spp finding their way to the lung via the lymphatic system or migrating ascarid larvae from the digestive tract occasionally occur. Without a definitive diagnosis to direct treatment, the pneumonia may be mostly intractable.

Tracheal Disease

In feedlot cattle, probably the most common condition of the upper respiratory tract is a diphtheritic membrane caused by the bovine herpes virus 1. Clinically, the animal is coughing, hyperventilating with little exercise tolerance. A clinical exam reveals the presence of a serous nasal discharge that would become purulent in 24 to 36 hours. At this time, a visual inspection of the external nares would reveal the presence of a fibrinous lining. At necropsy, the diphtheritic fibrinous membrane would extend from the nose into the deep bronchial tree. Associated with this tracheal lesion, a bronchopneumonia is often present.

In unweaned calves on range, an infectious laryngitis means the calf can often be heard to be breathing very loud before it can be visually identified. Even with extensive treatment, some calves succumb and a necropsy is indicated to confirm the diagnosis. The relative lack of tracheal and pulmonary pathology makes the diagnosis of a laryngitis definitive.

Unusual Respiratory Disease

Bovine Honkers

After a pen of resident feedlot cattle have been presented to the facility for reprocessing, a random animal may be found extremely exercise intolerant or dead. A necropsy examination may reveal a trachea that is 75% blocked with edema. Commonly called a "honker" by the stock attendants, the cause of the condition has never been completely elucidated.

Monensin Toxicosis

Cases of monensin toxicosis are usually associated with an inadvertent mix-up in the delivery of the ration supplement to the feedlot or to the cattle. Typically, sudden death, without any observed clinical evidence, is the first indication of a feeding error. Prior to that, the only warning would be that the feed intake of an entire pen would have been reduced. Within the pen, affected cattle have extreme exercise intolerance. Blood samples from these animals show a high level of troponin 1, indicative of myocardial damage. At necropsy, the pathology is all referable to heart failure, either acute or chronic. When the mortality is acute, the predominant lesion usually is excess fluid in the thorax and abdomen. If the case in the live animal has progressed and is not considered acute, hepatomegaly, mesenteric edema, and cardiomyopathy all become grossly visible.

Neoplasia of the Respiratory Tract

Bovine lymphoma may come in a variety of manifestations. Careful scrutiny of the cadaver usually exhibits more than 1 organ affected. The lung may have local necrotic lesions that were likely initiated by metastatic emboli. Some lymphatic locations may be more affected than others. A thymic lymphoma can often mimic other forms of respiratory disease or congestive heart failure. Stock attendants will often report the presence of very visible jugular pulse in these animals.

Extreme dyspnea may be caused by a neoplastic lesion in the upper respiratory tract. To make a specific clinical diagnosis would require the use of an endoscopic exam. A squamous cell carcinoma of the soft palate has been a surprising observation when such an examination is made.

Interstitial Pneumonias

Interstitial pneumonias may be caused by 3-methylindole, other pneumotoxins, an unknown hypersensitivity or exposure to lungworm larvae. One of the most common respiratory diseases in feedlots is usually called bronchointerstitial pneumonia, usually coded as "BIP" in feedlot databases. The bronchopneumonia component characteristically has some chronicity and exists in the dependant portions of the lung. The diaphragmatic lobes are enlarged, often with rib impressions on the lung's surface. The etiology of this condition has not been well established.

Verminous pneumonia is often obvious grossly, especially if the bronchial tree has been well opened and examined. Lungworms in the bronchial tree give us the diagnosis. An interstitial pneumonia caused by migrant ascarid larvae would be a histological diagnosis, even with ample circumstantial evidence of exposure.

Other Pulmonary Pathology

Under any circumstances, if examination of the thoracic cavity reveals a grossly enlarged lung with visible widening of the spaces between the lobules, a careful dissection of the pericardium and heart are indicated. Classical left sided heart failure (LSHF) can be confused with respiratory disease, if a careful examination of liver, mesentery and abdomen has not been completed. A change in the proportional size of the ventricles may help to rule in congestive heart failure even if no other overt lesions in the heart exist. If histological examination reveals a pulmonary fibrosis that, if severe and extensive, can overwhelm cardiac function and result in heart failure. While there is limited agreement in the exact cause of pulmonary fibrosis, it is usually associated with an incomplete recovery from a pneumonia.

References

Buergelt C, Clark EG, Del Piero F, eds. *Bovine pathology. A text and color atlas.* 2017.

Constuble PD, Hinchclift KW, Dane SH, Gruberg W, eds. Diseases of bovine respiratory tract. *Vet Med* 2017;11:901-965.

Jubb, Kennedy, Palmers. Respiratory system. *Pathology of domestic animals* 2017.

St. Jean G, Vestweber J, eds. Update on bovine respiratory disease. *Vet Clin North Am Food Anim Pract* 1997.

Cow-calf vaccination programs: Vaccines and beyond

Christine B. Navarre, DVM, MS, DACVIM-LA
School of Animal Sciences, Louisiana State University, Baton Rouge, LA 70803

Abstract

The term "herd health" means different things to different people, both producers and veterinarians. Many times producers equate a herd health program with a vaccination program. However, much more goes into preventive herd health programs than just a good vaccination program. To truly immunize cattle, they must have a working immune system at the time of vaccination. That means that we need to minimize all of the stressors that negatively impact the immune system.

Herd health programs can be divided into 6 parts: nutrition; parasite control; biosecurity; vaccinations; genetics; and stress management. A good analogy is a 6-strand barbed wire fence. You need all the strands intact to keep cattle in. The more strands that are broken, the higher the risk of cattle escaping. All 6 parts of a herd health program are important. We can't pick only the ones that are easy or cheap.

It is most cost-effective to personalize each herd health/vaccination program. Many ranches don't need every vaccine available, and in some cases recommendations don't fit the business model of the ranch. "Cookbook" programs are a good place to start, but should be tailored to each ranch.

Key words: beef cattle, herd health, vaccination

Résumé

Le terme 'santé du troupeau' signifie différentes choses pour différentes personnes autant pour les producteurs que pour les vétérinaires. Les producteurs vont souvent assimiler un programme de santé du troupeau à un programme de vaccination. Toutefois, un programme de santé du troupeau est bien plus qu'un bon programme de vaccination. Pour que les bovins soient vraiment immunisés, ils doivent avoir un système immunitaire fonctionnel au moment de la vaccination. Ceci implique que nous devons minimiser tous les facteurs de stress qui ont un impact négatif sur le système immunitaire.

Les programmes de santé du troupeau peuvent être divisés en six parties : l'alimentation, le contrôle des parasites, la biosécurité, la vaccination, la génétique et la gestion du stress. Une clôture de barbelés avec six brins est une bonne analogie. Vous avez besoin que tous les brins soient intacts pour garder les bovins à l'intérieur. Plus il y a de brins brisés et plus le risque que les bovins s'échappent augmente. Les six composantes dans un programme de santé sont toutes importantes. Nous ne pouvons pas choisir seulement celles qui sont faciles ou peu dispendieuses.

Il est plus rentable de personnaliser les programmes de santé/vaccination à chaque troupeau. Plusieurs élevages ne requièrent pas tous les vaccins disponibles et dans certains cas les recommandations ne correspondent pas au modèle d'affaires de l'élevage. Les programmes clés en main sont un bon départ mais ils devraient être ajustés à chaque élevage.

Nutrition

The single biggest herd health threat to cow-calf operations is inadequate nutrition. If nutrition is optimized, health and production will be also. If it is not optimized, diseases and production losses will be a problem. Poor nutrition (protein, energy, vitamins, and minerals) depresses immunity to diseases and interferes with response to vaccination.

Nutrition in the brood cow has a major impact on calf health and performance, and ultimately the profitability of the ranch. One year of poor nutrition can have impacts for multiple years. When cows cannot maintain adequate body condition, dystocia problems increase. Thin cows have trouble pushing with enough force to have calves in a timely manner. This leads to more stillborn and weak calves. Weak calves are more likely to die of cold stress and have poor colostrum intake. Cows that cannot maintain their body condition also produce poor quality colostrum, further compounding failure of passive transfer problems. Failure of passive transfer leads to more disease and death in calves. Any calf that gets sick, even if it recovers, will not ever perform to its genetic potential. Calves that have failure of passive transfer but remain healthy still have decreased lifetime performance. Cows that calve thin will either not rebreed or will breed late. And heifers born to thin cows, even when managed with appropriate nutrition, will have decreased reproductive performance when compared to heifers born to cows in good condition. This all adds up to fewer pounds of calf weaned per cow for multiple years, and decreased productivity of feeder calves and heifers beyond weaning.

Parasite Control

Good parasite control is essential for good health and productivity, especially in young animals. Controlling parasites increases weaning weights, milk production, and conception rates. Parasites are also immunosuppressive, so overall disease resistance and response to vaccines is decreased in parasitized animals.

With the emergence of serious anthelmintic resistance, parasite control programs need to be overhauled. The con-

cept of "routine deworming' needs to be abolished. Parasite control programs need to be tailored to individual operations based on diagnostics and a clear understanding of cattle and grass management on the ranch.

Biosecurity

I do not know who to credit with this quote, but it is a favorite: "Most disease is bought and paid for". A good biosecurity program will protect a herd from diseases in which there is not a good vaccine available or what's available is very expensive. It is futile to try to eliminate a disease problem if you are not going to prevent it from coming back into the herd. Biosecurity plans can be challenging and time consuming to develop initially, but they are the cheapest and most effective means of disease control. No disease prevention program will work without biosecurity. There are different levels of risk, and therefore biosecurity needs, with different management/business models. It is up to the veterinarian to discuss the risks of certain management practices and business models, and help producers develop practical biosecurity plans that fit each ranch.

Biosecurity plans do not have to be complicated. Since beef breeding animals are usually housed outdoors, the elements help with disease control. Some simple biosecurity recommendations are a good start: test purchased animals for diseases of concern (BVD, Johne's, etc.); quarantine new arrivals and any animals that are returning from shows or sales; avoid fence line contact with neighboring herds; and purchase breeding stock and embryo recipients from as few sources as possible.

Vaccinations

As mentioned before, there is no generic/cookbook vaccination program. Many programs are similar, but each should be tailored to the ranch. Management issues such as disease risk, breeding season, disease history, locale, etc. must all be taken into consideration. A "generic" vaccination program would have to cover all known diseases and be safe to recommend for all herds. The result would be a more costly but less effective vaccination program. Timing of vaccinations relative to ranch issues is also as important as selecting the right products.

Genetics

Genetically selecting animals that are more resistant to diseases is a growing field of research, and some important breakthroughs have occurred recently. Recent work by Bonnie Mallard at the Ontario Veterinary College showed that cattle can be tested and categorized into high, medium or low immune responders. High immune responders are less likely to have many disease issues. Dr. Alison Van Eenennaam and others across the United States have done pivotal work trying to better understand the genetics of animal resistance to respiratory disease.

Fetal programming and epigenetics are also areas of ongoing research. Fetal (or developmental) programming is the concept that a maternal stimulus or insult at a critical period in fetal development has long term impacts on offspring. For example, nutritional stress in the 1st and 2nd trimesters of pregnancy can lead to problems with fetal organ development and vascularization/placental development. Epigenetics is the study of heritable changes in gene expression or cellular phenotype caused by mechanisms other than changes in the underlying DNA sequence. The resulting adverse long-term effects reflect a mismatch between fetal environmental conditions and the conditions that the individual will confront later in life. For example, when calves are born to thin cows, they may later have health and performance issues when placed on full feed in the feedyard. Knowing the implications of our management practices could lead to recommendations on matching cows to their ideal environment and managing feeder and breeding cattle for better performance.

Stress Management

Other stressors such as castration, dehorning, weaning, commingling, handling, heat, cold, etc., depress the immune system, making animals more susceptible to disease. They also interfere with vaccine response. We can't eliminate all stressors, but we can manage them to minimize the impacts.

References

Available on request.

Neonatal distended abdomen

Sarah M. Depenbrock, DVM, MS, DACVIM (LAIM)
Assistant Professor of Livestock Medicine, UC Davis School of Veterinary Medicine

Abstract

The case of the neonatal distended abdomen is often referred to as "bloat". Despite the common name, there are many different possible underlying etiologies for a distended abdomen in calves. This session discusses differential diagnoses, clinical reasoning, and diagnostic tools for investigation of common causes of bloat in calves.

Key words: bloat, calf

Résumé

La distension abdominale néonatale est communément appelée le ballonnement. En dépit de ce nom commun, l'étiologie peut révéler plusieurs causes sous-jacentes à la distension abdominale chez les veaux. Cette session va discuter du diagnostic différentiel, du raisonnement clinique et de outils de diagnostic pour l'analyse des causes fréquentes du ballonnement chez les veaux.

A distended abdomen, commonly referred to as 'bloat', is a relatively common problem in calves; however, it can sometimes be challenging to diagnose the underlying cause. Although the disease is commonly referred to as 'bloat', a true ruminal bloat is relatively uncommon in young calves due to minimal ruminal development, until after about 5 weeks of age.[8]

There are many possible underlying causes of abdominal distension in calves. To simplify the process of working up such a case, the basic causes can be broken down to the anatomic structures contained in the abdomen. Working roughly from oral to aboral, distension could result from the rumen, abomasum, intestines, free abdominal fluid, or rarely other organ or mass enlargement. Once the clinician has determined which basic structures are involved, they can start investigating problems likely to occur at that site. A non-exhaustive list of diagnoses by structure is provided in Table 1.

We have a number of tools at our disposal to sort out the source of abdominal distension. These tools commonly include the following: history and signalment, physical examination, passage of an orogastric or nasogastric tube, imaging such as ultrasound or radiographs, bloodwork, abdominocentesis, exploratory laparotomy, and necropsy.

The value of a thorough history should not be underestimated. Feeding history is of particular importance because many causes of abdominal distension are due to GI disease, with indigestion and associated ruminal or abomasal disease occurring frequently. Examples of causes of abdominal distension grouped by some very basic historical findings is provided in Table 2.

When bloat (or deaths due to bloat) are reported, a thorough history of feeding practices and milk/feed preparation processes is indicated. For example, when abomasal bloat has been diagnosed in a calf-rearing operation, particularly if it is a herd problem, it is advised to investigate many possible causes of abomasal dysmotility to identify control points that can be corrected. This history will likely include an investigation into colostrum quality control practices, possibility of feeding or mixing errors with milk replacer or addition of other components to milk preparation, water quality, bucket vs nipple feeding, nipple condition, feeding frequency, concurrent disease problems such as diarrhea or ulcers, and evidence or monitoring for nutritional deficiencies.

A thorough physical exam is arguably the most valuable diagnostic tool at your fingertips. Take note of perfusion (heart rate, capillary refill, extremity temperature, jugular fill, peripheral pulses); many of the causes of distended abdomen such as acute abomasal bloat or intestinal accidents are accompanied by severe systemic compromise and require IV fluid therapy. In pre-weaned calves, a lack of an appropriate suckle can indicate severe systemic compromise such as a concurrent acidosis or sepsis, or may be a clue that the animal is a rumen drinker. Examination of the abdomen may reveal left or right-sided abdominal distension, pings or splashes that can provide clues to the location of the problem, or presence of a hernia that may contain entrapped bowel. Generally, left-sided distension is indicative of ruminal disease, although left displaced abomasum can rarely occur in calves, and right-sided distension suggests abomasal disease, although the distended abomasum in young calves may result in roughly symmetric-appearing abdominal distension. Ruminal distension may result in ventral right-sided distension in addition to the left-sided distension with marked feed or fluid accumulation. Examples of causes of symmetric abdominal distension include intestinal accidents and obstructions, and conditions that result in free fluid in the abdomen (ex: uroabdomen, peritonitis). Examination of the thorax may reveal concurrent pneumonia, which would increase the suspicion of ruminal disease such as vagal indigestion. Examination of fecal output can provide clues ranging from lack of an anus in atresia ani, to decreased or absent fecal output consistent with an obstruction, to poorly digested feed in feces indicative of inappropriate rumen digestion in older calves. Palpation of the ventrum and extremities may reveal edema, which might increase clinician suspicion for causes of ascites and associated abdominal distension. The clinical

Table 1. Possible causes of a distended abdomen in calves broken down by anatomic site.

Anatomic site	Diagnoses
Rumen	Rumen drinking
	Grain overload
	Rumen impaction or obstruction
	Vagal indigestion
Abomasum	Clostridial abomasitis
	Indigestion/other bacterial overgrowth
	Abomasal impaction/obstruction
	Ulcers
	Displaced abomasum (rare in calves)
Intestines	Obstruction Intestinal accident (Ex: intussusception, mesenteric torsion, intestinal entrapment in a mesenteric rent/hernia/umbilical remnant) Foreign body Atresia
	Ileus Secondary to systemic disease (Ex: sepsis) Secondary to enteritis/ enterocolitis Peritonitis
Free fluid	Blood (hemoabdomen)
	Pus (peritonitis)
	Water (ascites, uroabdomen)
Other organ enlargement/mass	Uncommon in calves

Table 2. Examples of causes of abdominal distension in calves broken down by history and signalment.

Historical factor	Animal group	Diagnoses
Age	Neonate	Atresia ani/coli (other intestinal segments less common)
	Pre-weaned calves	Acute abomasal bloat
	Weaned calves with a history of pneumonia	Chronic, ruminal bloat
	Anytime	Intestinal accidents Free fluid ('blood, pus, water')
Feeding history	Bucket or bottle feeding	Abomasal bloat Ruminal drinking
Clinical progression	Chronic	Ruminal causes

picture for some common causes of abdominal distension using the history and PE are described in Table 3.

When the diagnosis is not obvious, or to prognosticate or plan treatment, further diagnostics may be warranted.

Passage of an orogastric tube is an inexpensive, relatively non-invasive intervention and can be helpful to confirm suspicion of proximal GI disease based on abnormal smell, volume or appearance of rumen contents. Lavage of abnormal rumen contents at the time of tube passage, when possible, can be beneficial in cases of ruminal drinking and grain overload or when abomasal reflux into the rumen is suspected in neonates.

Ultrasound has gained increasing utility as a diagnostic tool for investigation of abdominal conditions of cattle in both field and hospital settings. Some useful reviews of abdominal ultrasound in calves and in surgical decision making are referenced below.[2,3] Even under less than ideal imaging conditions, a basic differentiation can usually be made between causes of abdominal distension in calves using ultrasound. Ultrasound can easily be used to identify free fluid, and occasionally make preliminary determinations between hemorrhage (cellular, swirling), fibrinous peritonitis (strands/pockets of fibrin), and anechoic fluid representing possible ascites or uroabdomen. Distended loops of bowel in the case of an obstructive lesion are usually not challenging to identify in the right caudal region. Lack of bowel motility can be visualized in cases of ileus. A ruminal drinker can be confirmed by imaging the rumen and visualizing milk entering the rumen while feeding the calf.[4] A complete abdominal ultrasound using an abdominal probe, standard techniques, and appropriate restraint and lighting is ideal; however, even a field scan using the rectal probe trans-abdominally can provide useful basic information to differentiate basic causes of abdominal distension in calves as listed above. Quick and easy actions

Table 3. Common clinical pictures associated with causes of bloat in calves.

Common cause of 'bloat'	Common clinical picture
Abomasal bloat	Milk fed Acute colic Abnormal perfusion parameters Abdominal distension – R side prominent or bilateral May be found dead
Ruminal drinker	Milk fed, maybe bucket fed Poor suckle Poor BCS Abdominal distension- more obvious on L, to symmetrically pendulous
Ruminal bloat	Weaned calf Chronic poor doer- thin BCS Concurrent pneumonia Abdominal distension- L side prominent
Intestinal accident	Any age Severe, acute disease May follow other disease: enteritis, hernia etc. Signs of poor perfusion

to increase the quality of the image in field setting include clipping of the hair, application of plenty of coupling agent (alcohol or gel), and shade from direct sunlight on the screen.

Abdominocentesis and fluid analysis can be a useful tool in working up the acute abdomen, or in cases with abdominal effusion. Reference ranges for calf abdominal fluid have been published.[1] A specific diagnosis may be reached when abdominocentesis reveals specific obvious changes. For example, in septic peritonitis fluid is cloudy and may be foul smelling. In cases of uroabdomen, urine is retrieved from abdominocentesis; the presence of urine can be confirmed by using a BUN reagent strip, or by heating up the sample and assessing for the smell of urine. If abdominal fluid is hemorrhagic and has a high lactate, these changes indicate possible serious bowel compromise; if systemic signs suggest an obstruction or intestinal accident is possible, surgery is likely indicated rapidly. Changes in cell count, protein concentration, and lactate can be used to investigate inflammation, infection, and gut perfusion.

When available, blood work can be useful for working up cases of distended abdomen in calves. Even a simple electrolyte panel can be useful in initial diagnosis or emergency treatment plan. Increases in lactate suggest poor perfusion or serious compromise of cellular metabolism. Decreased chloride with concurrent signs of forestomach or intestinal disease may indicate a proximal GI obstruction. Marked hyperglycemia, beyond that expected for a stress response, may occur with clostridial enteritis. The results of a simple electrolyte panel can aid not only in diagnosing the cause of the distended abdomen, but can also be helpful for planning emergency fluid therapy as needed with acidosis, electrolyte imbalances, or cases with associated poor perfusion or shock. More extensive bloodwork, including a CBC and chemistry, can be more useful in working up cases with ambiguous underlying disease or to investigate comorbidities.

An exploratory laparotomy can be a very valuable diagnostic and potentially therapeutic tool when indicated. An exploratory laparotomy is indicated when obstructions or intestinal accidents are suspected, or when a diagnosis cannot be made using less invasive diagnostic tools and the animal fails to improve. The approach to laparotomy will depend on the ranking of differential diagnoses. If a rumen impaction or ruminal foreign body is suspected, a left-sided laparotomy and rumenotomy or rumenostomy are appropriate. If intestinal or abomasal surgical conditions are suspected, a right-sided or ventral midline approach are desired and surgeon preference will dictate between ventral midline and right-sided approaches. If a ruptured bladder or problem necessitating resection of umbilical structures is suspected, a ventral midline approach is indicated. A useful reference for surgical decision making in cattle is provided below.[5]

Of course, we can't forget about the value of a necropsy. It may be too late for the calf under your necropsy knife, but what you learn from necropsied animals you may use to prevent disease in others. Necropsy of freshly deceased animals is always preferable; this is *particularly* true when investigating abdominal distension cases, because GI lesions may be difficult to interpret after autolysis and other post mortem changes advance. Pay attention to gross findings as well as sample collection for ancillary testing such as histology or specific pathogen testing. A nice reference for necropsy findings of the GI tract is listed below.[6] Consider saving liver and kidney for trace mineral, vitamin E, and selenium testing. This monitoring is useful for herd monitoring in general (don't waste a dead), and may also be important for working up a variety of herd problems that may present with signs referable to the GI tract.[7,8]

Conclusions

There are many potential causes of abdominal distension in calves. Some causes are extremely common, such as abomasal and ruminal 'bloat'. When these disease are diagnosed, it usually warrants clinician investigation into herd management to help producers identify control points for these diseases and make recommendations for changes or improvements to *specific* aspects of feeding or health management. Close investigation of feeding practices can reveal useful information relating to bloat in calves. Observation of milk preparation, feeding, and bottle hygiene can all reveal clues that may identify control points for indigestion that have been missed. Anything that affects abomasal motility has the potential to result in abomasal bloat. As the rumen develops, a closer investigation into the solid ration is imperative for investigation of ruminal bloats. If ruminal bloats are associated with respiratory disease, practices for minimizing respiratory disease should be re-evaluated. For more detail on specific conditions, the reader is referred to the excellent references.

References

1. Anderson DE, Cornwell D, Anderson LS, St-Jean G, Desrochers A. Comparative analyses of peritoneal fluid from calves and adult cattle. *Am J Vet Res* 1995;56:973-976.
2. Braun U. Ultrasonographic examination of the reticulum, rumen, omasum, abomasum, and liver in calves. *Vet Clin North Am Food Anim Pract* 2016;32:85-107. doi:10.1016/j.cvfa.2015.09.011
3. Braun U. Ultrasound as a decision-making tool in abdominal surgery in cows. *Vet Clin North Am Food Anim Pract* 2005;21:33-53. doi:10.1016/j.cvfa.2004.11.001
4. Braun U, Gautschi A. Ultrasonographic examination of the forestomachs and the abomasum in ruminal drinker calves. *Acta Vet Scand* 2013;55:1. doi:10.1186/1751-0147-55-1
5. Fecteau G, Desrochers A, Francoz D, Nichols S. Diagnostic approach to the acute abdomen. *Vet Clin North Am Food Anim Pract* 2018;34:19-33. doi:10.1016/j.cvfa.2017.10.001
6. Helman RG. Interpretation of basic gross pathologic changes of the digestive tract. *Vet Clin North Am Food Anim Pract* 2000;16:1-22. doi:10.1016/S0749-0720(15)30134-1
7. Marshall TS. Abomasal ulceration and tympany of calves. *Vet Clin North Am Food Anim Pract* 2009;25:209-220. doi:10.1016/j.cvfa.2008.10.010
8. Smith BP, Van Metre D, Pusterla N. *Large Animal Internal Medicine.*

Joints, ears, and navels!

Sarah M. Depenbrock, DVM, MS, DACVIM (LAIM)
Assistant Professor or Livestock Medicine, UC Davis School of Veterinary Medicine

Abstract

Infectious diseases of the joints, ears, and umbilicus are common diseases of the calf. Many different infectious agents can play a role in disease at these different anatomic sites. Combinations of these diseases often present in the same population of calves, and the problem can often be traced back to inappropriate colostrum management practices. This review provides an overview of septic arthritis, otitis, and navel ill in calves as well as a brief discussion on colostrum management practices.

Key words: septic arthritis, otitis, omphalitis, omphalophlebitis, omphaloarteritis, urachitis

Résumé

Les maladies infectieuses des articulations, des oreilles et de l'ombilic sont communes chez le veau. Plusieurs agents infectieux peuvent jouer un rôle dans la maladie à ces différents sites anatomiques. Différentes combinaisons de ces maladies se présentent souvent dans la même population de veaux. Des pratiques de gestion inappropriées du colostrum sont souvent à l'origine de ces problèmes. Cet article donne un aperçu de l'arthrite septique, de l'otite et des affections de l'ombilic chez les veaux de même qu'une brève discussion des pratiques de gestion du colostrum.

Introduction

Why talk about joints, ears and navels all together? They all represent very common sites for infection in calves, share several underlying infectious etiologies, and may result from similar management problems.

Septic arthritis

Septic arthritis is a common cause for lameness in calves. Often, septic arthritis is accompanied by severe lameness, however, this is *not always* the case. Cases can be missed, or only found when chronic, if careful examination is not performed. Reasons that lameness may be masked include systemic illness such that the calf is depressed, slow moving, weak or unwilling to rise, or multiple-limb lameness that obscures the severity of lameness in each specific limb. It can occasionally be difficult to detect pain or lameness in young calves, and thus the expected severe lameness associated with septic arthritis may be less obvious in some cases. Other clinical signs that alert the clinician to possible septic arthritis are joint effusion, enlargement of the draining lymph node, heat or pain on palpation, and changes in range of motion. History or evidence of infections such as pneumonia, enteritis, or omphalophlebitis should raise the concern for possible septic arthritis secondary to a bacteremia or septic event.

Septic arthritis in calves typically results from hematogenous spread of infectious agents.[13] Although external trauma or extension from digital infections can certainly result in septic arthritis in calves, these are less common routes compared to adult cattle who typically acquire septic arthritis as an extension from disease in the digit. Bacteria commonly isolated from cases of septic arthritis in calves include: *Streptococcus* (coag negative), *Trueperella pyogenes,* Pasteurellaceae, Enterobacteriaceae, and *Mycoplasma bovis.*[4,5,8]

A presumptive diagnosis of septic arthritis can be made on the basis of physical exam findings in some cases; confirmatory testing usually includes arthrocentesis and diagnostic imaging. Arthrocentesis is an extremely useful tool for the diagnosis of septic arthritis in calves. In suspected cases, joint effusion usually allows for relatively easy access for joint fluid aspiration. After aseptic preparation of the site and appropriate restraint of the animal, a sample is obtained with a needle and syringe and is examined grossly for evidence of decreased viscosity, cloudiness or foul odor, any of which are suggestive of septic arthritis. The diagnosis can be further supported by laboratory evaluation including cytology and biochemical analysis. Cytology predominated by neutrophils or presence of bacteria in neutrophils, or increased protein concentration are all consistent with septic arthritis. Ranges for cytologic and chemical evaluation of bovine synovial fluid have been published.[14] Culture and sensitivity can be useful for prognosticating and planning treatment. *Mycoplasma* must be cultured using different techniques than standard culture and sensitivity, so the clinician usually must request *Mycoplasma* testing in addition to standard culture and sensitivity. *Mycoplasma bovis* PCR is available at some laboratories and may be a more rapid way to investigate cases of *Mycoplasma bovis*. If joint infection is suspected, empiric treatment should begin without delay, before results of culture/ sensitivity are complete. Treatment recommendations can change after receiving results if indicated. Unfortunately, culture and sensitivity testing do not always yield positive results despite clinical evidence of sepsis in a synovial structure. The absence of bacteria on culture should not be taken as a sign that the joint is not septic. The clinical picture, gross and microscopic appearance of joint fluid, and biochemical analysis of joint fluid can all be used to determine if the joint is likely septic or not.

Radiographs can also be helpful in cases of suspected septic arthritis, particularly when differentiating between

other causes of severe lameness such as a fracture. Radiographic changes associated with joint sepsis may include increases or decreases in joint space, lytic lesions of the subchondral bone, articular destruction, osteomyelitis, or boney/periosteal proliferation. Boney changes and joint space reduction are more supportive of chronic severe infection, while soft tissue swelling and increased joint space may be less chronic. In cases where joint effusion or increase in joint space are the sole radiographic abnormality, it is wise to keep septic arthritis on the differential list and strongly consider arthrocentesis to confirm, despite lack of boney changes. Radiographic changes lag behind the pathology occurring in these cases.

Ultrasound is another useful imaging technique for investigation of joint disease. This tool may be more practical for the ambulatory food animal practitioner who may not carry a portable radiograph machine. The linear rectal probe can be a useful tool examine the fluid character of an effusive joint. The best image is obtained after clipping, cleaning, and application of a coupling agent such as ultrasound gel or isopropyl alcohol (or obstetric lube in a pinch). Joint effusion with echogenic strands or mixed echogenicity may indicate fibrin or cellular debris in the joint and should increase the clinician's suspicion of joint sepsis. Ultrasound can also be helpful in locating the most effusive or abnormal joint pouches for arthrocentesis.

There are many options for the treatment of joint infections in cattle. A detailed discussion on this topic is beyond the scope of this proceedings; an excellent reference has previously been published.[5,13] The basic principles of treatment include managing infection and provision of pain control. Treatment with systemic and local antibiotics is usually necessary. The proceedings for regional limb perfusion from this conference discuss the provision of local antibiotics in cattle in more detail. Removal of infected debris from the joint is also imperative. In acute cases, through and through lavage of the joint using needles and sterile isotonic crystalloids may be effective. However, cattle are excellent makers of fibrin and joint sepsis is often accompanied by significant fibrin deposition in the joint. This feature makes simple through and through lavage less than rewarding in many cases, especially chronic cases. More aggressive debridement of the joint can be accomplished via arthrotomy or arthroscopy. Further surgical debridement or other intervention may be necessary depending on the location, extent, and severity of the infection. The reader is referred to previously published review articles for an excellent discussion of the surgical options for joint sepsis treatment in cattle.[13]

Any confirmed case of joint sepsis in a calf warrants investigation into the systemic health of the animal and concurrently addressing any ongoing sites of bacterial shedding such as pneumonia, navel ill or enteritis. Concurrent pneumonia or otitis in this animal or its cohorts warrants serious consideration of *Mycoplasma bovis* as a possible causative agent. The original illness that resulted in bacterial spread to the joint may have progressed beyond the acute phase or may have resolved by the time of diagnosis of the septic joint. Additionally, if there is 1 septic joint that appears to have resulted from the hematogenous route, the clinician should carefully examine all palpable joints to ensure no other joints are affected. The prognosis for return to soundness decreases as the number of affected joints increases. The location, severity, and extent of infection can all influence the prognosis for return to function.

Otitis

Otitis in calves can result from multiple routes; it can occur via the Eustachian tube as may occur with an extension of respiratory disease, via hematogenous spread from another infected site, or more rarely from the external ear inward as occurs in combination with ear parasites. Otitis occurring from extension of respiratory disease is common in calves, and the same pathogens have been found in both cases of otitis and respiratory disease including: *Mycoplasma bovis*, *Mannheimia haemolytica, Pasteurella multocida, Histophilus somni*.[3,15]

Clinical signs of otitis include ear droop, head tilt, aural discharge and may also include signs of facial nerve dysfunction (such as facial paralysis or signs of a corneal ulcer from lack of blink or decreased tear production), additional vestibular signs, head shaking, or signs of systemic illness such as fever and lack of appetite. When disease is bilateral, head tilt or ear droop may not be obvious because both sides are affected.

Diagnosis of otitis can be challenging if clinical signs are vague or discharge is not apparent. An otoscopic exam can be performed in calves and may reveal an opaque or ruptured tympanic membrane; appropriate restraint greatly improves the ability to visualize the canal to the tympanic membrane. The author prefers to restrain calves in lateral recumbency to perform an otoscopic exam; this usually requires sedation. Otoscopic exam is not always practical in larger or older calves, and the sensitivity of this technique for diagnosing otitis media/interna is not known. Ultrasound for diagnosis of otitis in calves has recently been described.[2] This technique can be useful to confirm cases of otitis media/interna and can be performed in the field using a linear rectal probe.[10] Radiographs may also be helpful in diagnosing and evaluating the extent of boney involvement of otitis in calves. However, obtaining diagnostic skull radiographs can be challenging in the field, and overlapping structures can make interpretation of plain films for the evaluation of otitis challenging. For animals whose individual value warrants investment in diagnostics, advanced imaging such as CT can provide more information on extent of disease associated with otitis[6] and may be useful for surgical planning if surgery is indicated.

Treatment of otitis in calves primarily relies on administration of appropriate antibiotics. Early cases are more likely to respond to medical management alone. Myringotomy may be necessary to establish drainage and has been described

in calves.[12] Due to the predilection for *Mycoplasma bovis* to cause otitis in calves, the antibiotics selected should have empiric efficacy against *Mycoplasma*. No drugs are labeled specifically for otitis in cattle, so off-label drug use due to an off-label indication must be considered. When copious debris or exudate is present, lavage may be helpful to improve drainage. Gentle lavage with sterile solution, such as sterile saline, can be used. Comorbidities should be investigated and treated; respiratory disease is commonly present with otitis in calves.

Navel ill

Omphalitis/omphalophlebitis/omphaloarteritis/urachitis result when the umbilical remnant structures become infected. These infections can present with a variety of clinical signs depending on which structures are infected and the extent of infection. Most umbilical infections result in some degree of external swelling and pain on palpation of the base of the umbilicus (omphalitis). Other disease processes or herniation can result in umbilical swellings; umbilical swellings in general are discussed in another session of these proceedings.

The umbilical remnant structures include the umbilical arteries, umbilical vein, and urachus. The internal portion of the umbilical arteries coarse caudally, around the urinary bladder, and become the lateral ligaments of the bladder. Infection of the umbilical arteries is called omphaloarteritis. The urachus likewise runs caudally and attaches to the apex of the urinary bladder. Infection of the urachus is called urachitis. The umbilical vein runs cranially, passes through the liver, and travels to the ductus venosus. Infection of the umbilical vein is omphalophlebitis. Infection can extend from external to the internal umbilical remnants and any associated tissue. Any combination of the umbilical structures can be affected.

Diagnosis of external infection, or navel ill, is usually not challenging and is typically based on clinical appearance and palpation of the navel. Swelling, pain on palpation of the base of the umbilicus, or wetness of umbilical tissue lasting beyond the first day of life are suggestive of infection. Calves may be dysuric with urachal remnant infection; they may display prolonged posturing to urinate, or frequent incomplete urinations. This is presumably due to the abnormal persistent attachment of an abnormal urachus between the apex of the bladder and the body wall. Additionally, infection may extend into the urinary bladder and cause cystitis. A patent urachus is relatively rare in cattle. The more common abnormality of the urachus is infection or abscessation; often there are very firm to ropey attachments to the bladder, but it is usually not patent. Internal infections of the umbilical arteries or vein may not be as obvious. Signs may be vague and include fever, ADR or failure to grow as expected, or simply the external signs of navel ill. Internal umbilical structure involvement can occasionally be determined with abdominal palpation, although this can be more carefully assessed by ultrasound when available. Descriptions of umbilical remnant ultrasound in calves have been published and provide useful references.[1,11]

Determination of internal structure involvement is important for planning treatment and prognosis. Involvement of internal umbilical structures typically requires surgical resection of abscessed structures, whereas external infection alone is commonly treated medically or by lancing external abscesses if present.

Treatment of umbilical remnant infection relies on drainage and removal of any infected structures that extend internal to the body wall. External navel ill is typically treated medically and involves maintaining a clean dry umbilicus and administration of antibiotics in moderate to severe cases. Drying agents such as iodine or isopropyl alcohol are sometimes used for this purpose. When an abscess is present, lancing the abscess and allowing external drainage allows for healing. Systemic antibiotic therapy is warranted in moderate to severe cases to prevent spread of infection and treat cellulitis of the base of the umbilicus. When internal umbilical structure involvement is present, resection of the umbilicus and the infected structure(s) via ventral midline laparotomy is ideal. This technique allows the surgeon to remove the umbilicus en bloc with the infected internal structures. When umbilical vein infections extends to the liver, the surgeon may elect to marsupialize the umbilical vein to allow it to drain externally. A more complete discussion of surgical procedures of the umbilicus in the calf has been published.[1]

Prevention of navel ill requires proper hygiene in the calving area, dipping of navels, and maximizing immunity through proper colostrum management. A variety of navel dipping solutions have been used in calves, with no strong evidence to favor 1 specific treatment.[7,16]

Unifying features and disease prevention

Probably the biggest unifying feature of septic arthritis, otitis, and navel ill in calves is a lack of effective immunity. A cornerstone of maximizing immunity of the calf crop is ensuring **adequate**, **timely** intake of **high quality colostrum**. When investigating herd problems with the diseases discussed in this session, a break in colostrum management should be considered. A full discussion of colostrum management practices is beyond the scope of these proceedings; however, a nice summary of colostrum management practices in dairy calves has been published recently.[9] Some basic control points in colostrum management to consider include donor cows (appropriate immunity, disease status such as *Mycoplasma* shedding, etc.), colostrum milking equipment, colostrum quality testing (IgG concentration, bacterial contamination testing), storage methods, heat treatment or other method of colostrum treatment, volume fed to calves, timing of colostrum feeding to calves, hygiene of bottles/nipples/tubes, and calf factors that may decrease absorption (hypothermia, previous ingestion of other things, hypoglycemia, etc.).

Another unifying feature, specifically of otitis and arthritis, is common underlying infectious etiology. Both diseases are common manifestations of *Mycoplasma bovis*

infection. Calf exposure is primarily through contaminated colostrum or milk. Other sources of calf exposure include exposure of naive calves to infected calves or adult cattle shedding disease. Preventative methods are aimed at minimizing contamination of colostrum and milk through appropriate screening (bulk tank monitoring or monitoring of pooled colostrum or hospital milk sources), heat treatment of colostrum, and pasteurization of milk fed to calves. Treatment of calves affected with disease due to *Mycoplasma* (commonly pneumonia, otitis, and arthritis) should be started early in the course of disease to limit morbidity and mortality from the disease. It is important to note that once an animal has been infected with *Mycoplasma*, shedding may occur after clinical signs have resolved and the animal may never be completely free of the organism.

References

1. Baird AN. Surgery of the umbilicus and related structures. *Vet Clin North Am Food Anim Pract* 2016;32:673-685. doi:10.1016/j.cvfa.2016.05.008
2. Bernier Gosselin V, Babkine M, Gains MJ, Nichols S, Arsenault J, Francoz D. Validation of an ultrasound imaging technique of the tympanic bullae for the diagnosis of otitis media in calves. *J Vet Intern Med* 2014;28:1594-1601. doi:10.1111/jvim.12398.
3. Bertone I, Bellino C, Alborali GL, et al. Clinical-pathological findings of otitis media and media-interna in calves and (clinical) evaluation of a standardized therapeutic protocol. *BMC Vet Res* 2015;11:297. doi:10.1186/s12917-015-0606-3.
4. Constant C, Nichols S, Desrochers A, et al. Clinical findings and diagnostic test results for calves with septic arthritis: 64 cases (2009-2014). *J Am Vet Med Assoc* 2018;252:995-1005. doi:10.2460/javma.252.8.995
5. Desrochers A, Francoz D. Clinical management of septic arthritis in cattle. *Vet Clin North Am Food Anim Pract* 2014;30:177-203. http://www.sciencedirect.com/science/article/pii/S0749072013000911. Accessed March 9, 2015.
6. Finnen A, Blond L, Francoz D, Parent J. Comparison of computed tomography and routine radiography of the tympanic bullae in the diagnosis of otitis media in the calf. *J Vet Intern Med* 2011;25:143-147. doi:10.1111/j.1939-1676.2010.0659.x
7. Fordyce AL, Timms LL, Stalder KJ, Tyler HD. Short communication: The effect of novel antiseptic compounds on umbilical cord healing and incidence of infection in dairy calves. *J Dairy Sci* 2018;101:5444-5448. doi:10.3168/jds.2017-13181
8. Francoz D, Desrochers A, Fecteau G. A retrospective study of joint bacterial culture in 172 cases of septic arthritis in cattle. In: *20th ACVIM Forum*, Dallas, May 29-June 1; 2002.
9. Godden SM, Lombard JE, Woolums AR. Colostrum management for dairy calves. *Vet Clin North Am Food Anim Pract* 2019;35:535-556. doi:10.1016/j.cvfa.2019.07.005
10. Gosselin VB, Babkine M, Francoz D. Ultrasonography of the tympanic bullae and larynx in cattle. *Vet Clin North Am Food Anim Pract* 2016;32:119-131. doi:10.1016/j.cvfa.2015.09.010
11. Guerri G, Vignoli M, Palombi C, Monaci M, Petrizzi L. Ultrasonographic evaluation of umbilical structures in Holstein calves: A comparison between healthy calves and calves affected by umbilical disorders. *J Dairy Sci* 2019. doi:10.3168/jds.2019-16737
12. Heller MC, Lane VM. *Imaging study of myringotomy in dairy calves*, 2006. www.CutePDF.com. Accessed January 27, 2020.
13. Mulon P-Y, Desrochers A, Francoz D. Surgical management of septic arthritis. 2016. doi:10.1016/j.cvfa.2016.05.014
14. Rohde C, Anderson DE, Desrochers A, St-Jean G, Hull BL, Rings DM. Synovial fluid analysis in cattle: A review of 130 cases. *Vet Surg* 2000;29:341-346. doi:10.1053/jvet.2000.5605
15. Smith BP. *Large animal internal medicine*. 4th ed. St. Louis, Mo.: Mosby Elsevier; 2009.
16. Wieland M, Mann S, Guard CL, Nydam DV. The influence of 3 different navel dips on calf health, growth performance, and umbilical infection assessed by clinical and ultrasonographic examination. *J Dairy Sci* 2017;100:513-524. doi:10.3168/jds.2016-11654

Understanding the economic impact of mastitis therapy – the role of duration and drug selection

Pamela L. Ruegg, DVM, MPVM
Department of Animal Science, Michigan State University, 474 S. Shaw Lane, E. Lansing MI 48864

Abstract

Mastitis occurs on all dairy farms, and veterinarians can help producers reduce losses and promote more judicious antimicrobial usage. In the US, 7 intramammary (IMM) antibiotics are approved for treatment of mastitis, but no antibiotics are approved for systemic treatment of mastitis. Most cases of clinical mastitis present with mild or moderate clinical signs and there is no evidence that use of systemic antimicrobials is of benefit. Farmers typically underestimate costs associated with treatment of clinical mastitis, and about 75% of costs are associated with milk discard. Selection of drugs and duration of treatment are both areas that can have significant impact on economic losses associated with mastitis therapy. The distribution of etiologies is associated with the value of antimicrobial therapy, and use of intramammary antibiotics should be determined based on knowledge of etiology. Clinical outcomes of most mastitis cases that are culture-negative or caused by *E. coli* are not improved by use of antimicrobials, and considerable losses can be incurred when longer-duration therapy is used as the standard protocol. When etiology of non-severe clinical mastitis is unknown, use of narrow-spectrum IMM antimicrobials for short duration results in optimal economic outcomes.

Key words: dairy, mastitis, treatment, economics

Résumé

La mammite est présente dans toutes les fermes laitières et les vétérinaires peuvent aider les producteurs à réduire leurs pertes et à promouvoir une utilisation plus judicieuse des antimicrobiens. Aux États-Unis, il existe sept antibiotiques intramammaires approuvés pour le traitement de la mammite bien qu'aucun antibiotique ne soit approuvé pour le traitement systémique de la mammite. La plupart des cas de mammite se présente avec des signes cliniques de légers à modérés et il n'y a pas d'évidence que l'utilisation d'antimicrobiens systémiques soit bénéfique. Les producteurs sous-estiment habituellement les coûts associés au traitement de la mammite clinique et près de 75% des coûts sont associés au lait jeté. Le choix des drogues et la durée du traitement sont deux éléments qui peuvent avoir un impact significatif sur les pertes économiques associées à la thérapie de la mammite clinique. La distribution des étiologies est associée à la valeur de la thérapie antimicrobienne et l'utilisation des antibiotiques intramammaires devrait être basée sur la connaissance de l'étiologie. Le résultat clinique de la plupart des cas de mammite négatifs à la culture ou causés par *E. coli* ne s'améliore pas avec l'utilisation d'antimicrobiens et des pertes considérables peuvent s'ensuivre si la thérapie à long-terme est utilisée comme protocole de routine. Lorsque l'étiologie de la mammite clinique non-sévère n'est pas connue, l'utilisation d'antimicrobiens intramammaires à spectre d'activité étroit pour une courte durée produit des résultats économiques optimaux.

Introduction

Mastitis treatment protocols were initially developed when the majority of cows were affected with *Streptococcus agalactiae* and/or *Staphylococcus aureus*, and the principles developed during that era continue to influence current treatments.[22] Spontaneous cure of *Str agalactiae* and *Sta aureus* is rare, and without effective antimicrobial therapy many cows develop chronic subclinical infections which may infect other animals. Widespread adoption of effective preventive management practices have essentially eradicated *Str. agalactiae* and greatly reduced the prevalence of mastitis caused by *Sta. aureus*,[22] and principles of treatment need to be aligned with the distribution of current pathogens. Treatment protocols should be designed to use antimicrobials responsibly, maintain well-being of cows, and limit economic losses. On most modern farms, the majority of clinical mastitis cases are non-severe and caused by opportunistic environmental pathogens, many of which are effectively cleared by the cow's immune response.[7,15,26] While prevalent etiologies may vary among farms, microbiological results of milk samples obtained from cases of clinical mastitis are usually distributed as no growth (25-30%), gram-negative (25-30%), gram-positive (25%), and 10-15% other non-responsive etiologies (such *as Staph aureus*, *Prototheca* spp, *Serratia* spp, yeasts, etc.). Most cases of clinical mastitis are treated using antibiotics[30] but many cases do not benefit and unnecessary use of antimicrobials is not cost effective. The purpose of this paper is to review the economic impact of antimicrobial usage for treatment of non-severe clinical mastitis with emphasis on drug selection and duration of treatment.

Antimicrobial Usage for Treatment of Clinical Mastitis

Recommendations for mastitis therapy should promote responsible antimicrobial usage, and veterinarians can refer to AABP guidelines for judicious antimicrobial usage

(www.AABP.org/Resources). Those guidelines include the following statements (italics added for emphasis):

"The veterinarian should select an antimicrobial drug, product and regimen that is likely to be effective *given strong clinical evidence of the identity of the pathogen causing disease* and based on clinical signs, history, necropsy examination, laboratory data and clinical experience."

"Regimens for antimicrobial use should be optimized using current pharmacological and microbiological information and principles. This includes *using antimicrobials at an appropriate dosage, for the shortest appropriate period,* and in the smallest number of animals reasonable."

"Whenever possible, label instructions should be followed to include using antimicrobials labeled for the condition diagnosed *following the labeled, dose, route, frequency, duration and withholding period.*"

There is considerable opportunity for veterinarians to help producers use antimicrobials more responsibly. Many mastitis treatments are given solely based on observation of clinical signs, and lack evidence of active bacterial infection. The duration of treatment often exceeds label recommendations, and broader-spectrum compounds are often used when narrower-spectrum drugs would be effective. In the US, dairy farmers have access to 7 intramammary (IMM) products that are approved for treatment of bovine mastitis and in most states, 5 require a veterinary prescription (Table 1). Approved IMM antibiotics have been tested to ensure that the parent compound (or active metabolite) reaches a sufficient concentration in milk during the approved dosing interval to kill or inhibit growth of organisms listed on the product label. Several approved IMM antibiotics are in classes that have been ranked by the World Health Organization based on their importance in treating human disease (Table 1).[1] Aminopenicillins and 3rd generation cephalosporins are considered to be critically important to human health and when efficacy is expected to be equivalent, veterinarians should recommend use of less critically important products.

In a nationally representative study,[30] all farmers reported occurrence of mastitis, with 25% of cows affected and 90% of farmers reported using antibiotics for treatment. Almost all treated cows (88%) received IMM antibiotics. Approved IMM products containing ceftiofur and cephapirin were most common and were used on 34% and 32% of farms, respectively.[30] While no antibiotics are approved for systemic treatment of mastitis, extralabel systemic usage of antibiotics for treatment of clinical mastitis was reported by 48% of farmers. While there is some evidence that systemic therapy is beneficial for cows experiencing severe clinical mastitis,[4,32] one researcher demonstrated that systemic therapy using ceftiofur did not improve outcomes of cows with non-severe mastitis,[33] and this route cannot be recommended for routine treatment of non-severe clinical mastitis.

We previously reported detailed treatment data for 589 cases of clinical mastitis occurring on 51 Wisconsin dairy farms.[16] In our study, 66% of cases received only IMM antibiotics, 1% received a single systemic antibiotic, 2% received 2 concurrent systemic antibiotics, 16% received both IMM & systemic antibiotics, 14% were given a second antibiotic treatment (due to perceived treatment failure), and 18% received non-antibiotic supportive therapies. Of enrolled cases, milk samples collected at case detection were later cultured from 558 cases (Figure 1). Of total IMM treatments, 32% were given to cases that were bacteriologically negative when detected and 19% were given to cases caused by *E. coli*. Researchers have shown that clinical outcomes of non-severe mastitis that are culture-negative or caused by *E. coli* are not improved by use of 5-d of IMM ceftiofur.[8,9] While severe cases may benefit from antimicrobial therapy, this data illustrates the importance of determining etiology of non-severe cases of mastitis before administering antibiot-

Table 1. All antibiotics approved for intramammary use in the US. All products are classified as beta-lactams except pirlimycin (lincosamide).

Product name active compound	Label dosing no. & interval	Label claims for efficacy	WHO classification[6]	Prescription status*
Amoxi-Mast™ 62.5 mg amoxicillin	3 tubes @ 12 h	*Str. agalactiae, Sta. aureus*	Critically important	Prescription
DariClox™ 200 mg cloxacillin	3 tubes @ 12 h	*Str. agalactiae, Sta. aureus*	Highly important	Prescription
Masti-Clear™ 100,000 IU PenicillinG	3 tubes @ 12 h	*Str. agalactiae, Str. Dysgalactiae, Str. uberis*	Highly important	OTC
Pirsue™ 50 mg pirlimycin	2-8 tubes @ 24 h	*Sta. aureus, Str. Dysgalactiae, Str. uberis*	Highly important	Prescription
Polymast™ 62.5 mg ampicillin	3 tubes @ 24 h	*Str. agalactiae, Str. Dysgalactiae, Sta. aureus, E. coli*	Critically important	Prescription
SpectramastLC™ 125 mg ceftiofur	2-8 tubes @ 24 h	*CNS, Str. dysgalactiae E. coli*	Critically important	Prescription
Today™ 200 mg cephapirin	2 tubes @ 12 h	*Str. agalactiae, Sta. aureus*	Highly important	OTC

*All antimicrobials require a prescription in California

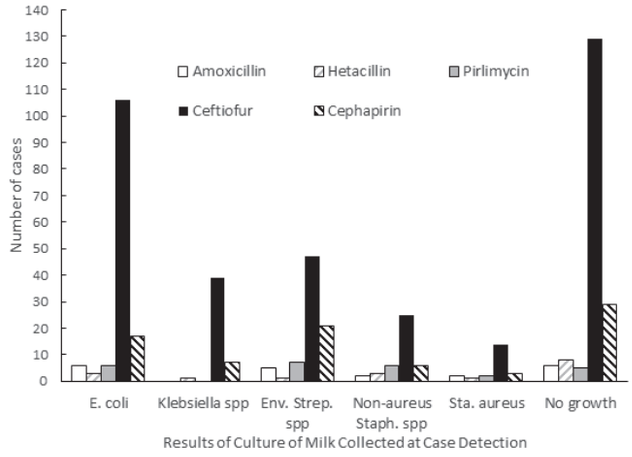

Figure 1. Treatments administered to 558 cases of clinical mastitis occurring on 51 Wisconsin dairy farms in 2010. Etiology was determined after treatment was completed using milk samples collected at detection of the case. From Oliveira and Ruegg, 2014.

ics, as almost 50% of IMM usage could have been eliminated if etiology had been known.

In 2017, as part of a broader study, we collected extensive animal health and treatment data on 40 large dairy farms in Wisconsin.[12] The overall incidence of clinical mastitis was 34% and the incidence and use of antimicrobials varied among farms (Figure 2). Of 26,007 cases of clinical mastitis, 31% received no IMM antimicrobial, 53% received commercial products containing IMM ceftiofur, 10% received IMM cephapirin, 3% each were treated with IMM hetacillin or pirlimycin, and about 1% received IMM amoxicillin. Systemic antibiotics were given to 14% of cases on 29 farms (11 farms did not report use of systemic treatments for mastitis). The wide variation in antimicrobial usage for treatment of mastitis is related to the lack of evidence-based guidelines for mastitis treatment and indicates an opportunity to improve therapy and reduce costs.

Selection and Evaluation of Antimicrobials for treating non-severe clinical mastitis

Clinical mastitis is detected based on observation of non-specific signs of inflammation and is usually treated empirically without knowledge of etiology.[11,16] Producers often evaluate efficacy based on time until milk returns to a normal appearance, but this outcome has almost no variation and is not a good indicator of longer-term outcomes.[21] There is very little evidence that drug selection has a significant impact on clinical outcomes. Of 7 recent studies evaluating IMM mastitis treatments, days to normal milk varied little among protocols (Table 2).[8,9,14,26,28,29,31] In 5 studies, cases were enrolled based on observation of inflammation without regard of pathogen and included cases that would not be expected to benefit from IMM therapy (no growth, *E. coli* and *Sta aureus* and other intrinsically resistant pathogens).[14,26,28,29,31]

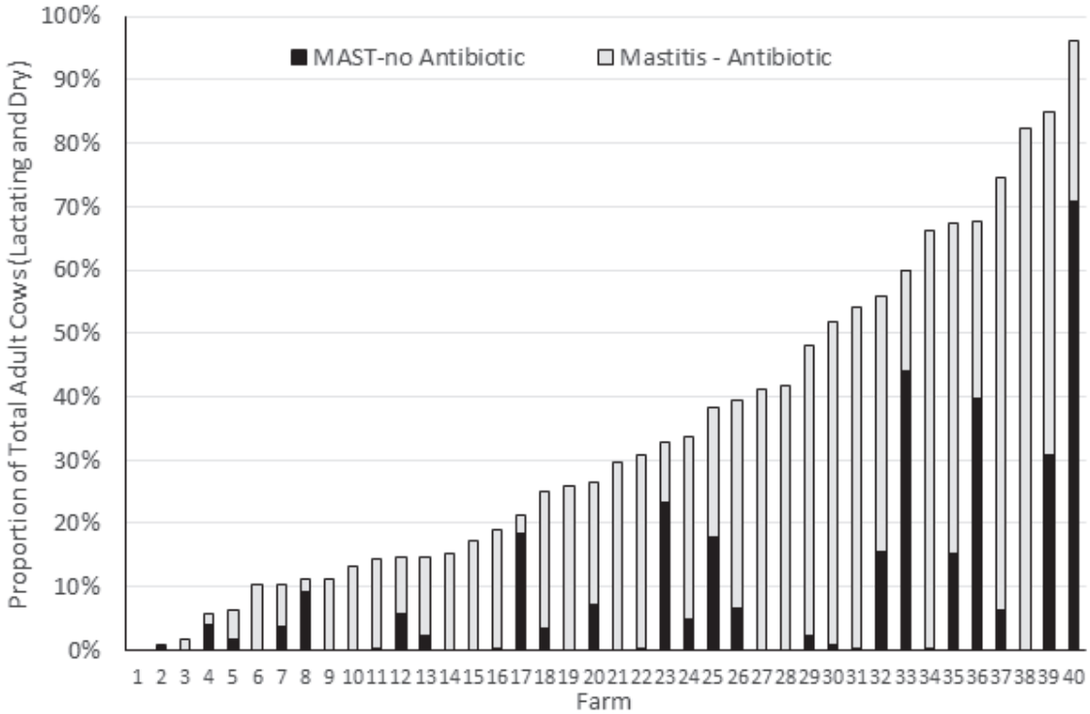

Figure 2. Use of antimicrobials to treat 26,007 cases of clinical mastitis occurring on 40 large Wisconsin dairy farms in 2017. The herds contained about 52,000 cows. From unpublished data, Leite de Campos and Ruegg.

Table 2. Clinical outcomes of recent studies evaluating treatment of non-severe clinical mastitis.

		Criteria to enroll	Comparison – all IMM treatments		Days to normal milk		Bacteriological cure		Other outcomes	
Study	Cases		Rx1	Rx2/Rx3	Rx1	Rx2	Rx1	Rx	Rx1	Rx2
Truchetti 2014	197	Clinical signs	2 @ 24 h Ceftiofur	8 @24 h Ceftiofur	2.8*	3.7**	32%[1*]	61%**	NIMI 13%	NIMI 8%
McDougall 2019[2]	304	Clinical signs	3 @ 12 h Combo[3]	5 @ 12 h Combo[3]	--	--	73%	72%	Recur21 28%[a]	Recur21 13%[b]
Tomazi 2018	236	Clinical signs	4 @ 12 h combo1[4]	4 @ 12 h combo2[5]	@4d 36%	@4d 36%	68%	73%	SCC 29%	SCC 28%
Schukken 2013	296	Clinical signs	2 @ 12 h cephapirin	5 @ 24 h ceftiofur	62%[6]	62%	61%	73%	Culling 21%	Culling 12%
Vasquez[7] 2016	596	Clinical signs	3 @ 24 h hetacillin	5 @ 24 h ceftiofur	@4d 70%	4@d 59%	68%	73%	Culling 7.8%	Culling 10.0%
Fuenzalida[8] 2019	121	No growth	No treat	5 @ 24 h ceftiofur	4.0	4.2	--	--	Recur 5%	Recur 8%
Fuenzalida[9] 2019	168	*E. coli* & *Klebsiella*	No treat	2 @ 24 h 5 @ 24 h ceftiofur	4.2	4.8 4.5	[10]67%*	84%** 89%**	Recur 32%	Recur 34% 32%

*signifies statistically significant differences; [1]calculated only for *Strep.* spp and *S. aureus*; [2]reported no difference in NIMI (15%; 14%), postRX SCC at 21(6.8,6.6) or 28 d (6.4,6.3); [3]Amoxicillin-clavulanic acid and prednisolone; [4]cephapirin and prednisolone; [5]tetracycline, neomycin, bacitracin and prednisolone; [6]determined at 10 and 17 days post-enrollment; [7]no difference in post-treatment milk yield (37, 38.2 kg) or SCC (3.4, 3.1); [8]no difference in IMI @ 14 or 28 d (25%, 13%); post-treatment culling (<5% both groups), ¼ SCC (5.4 and 5.5), or milk yield (43 kg for both groups); [10]signficant interaction with pathogen, BC was (no treatment – 97% for *E. coli,* 18% for *Klebsiella* spp; Combined IMM Rx – 99% for *E. coli,* 74% *Klebsiella* spp); [9]no difference in post-treatment probability of voluntary quarter dry-off, culling, quarter SCC, daily milk yield (37.1, 36.3, 37.6 kg)

Regardless of enrollment criteria, IMM antibiotic or duration of treatment, few important differences were noted in clinical outcomes (Table 2). Thus, choice of IMM product should be based on other characteristics, such as dosing schedule, price, and social responsibility.

Of approved IMM products, all except pirlimycin (lincosamide) are classified as beta-lactams and all are expected to have some efficacy against gram-positive pathogens (Table 1). Almost all approved IMM antibiotics are labeled for treatment of *Streptococci* and *Staphylococci,* and 2 include label claims for efficacy against *E. coli* (Table 1). No products have explicit label claims for treatment of mastitis caused by *Klebsiella* spp and this organism is considered intrinsically resistant to aminopenicillins (ampicillin, amoxicillin, and hetacillin). Little to no research exists to support efficacy claims of any IMM product for other organisms, and the lack of efficacy data makes it very difficult to justify use of antibiotics for treatment of mastitis caused by many opportunistic pathogens.

Except for mastitis caused by *Staph aureus*, there is little evidence that mastitis pathogens in North American dairy herds have acquired resistance to most commonly used IMM antimicrobials.[5,13,24,25] However, intrinsic resistance should be considered when selecting appropriate therapies. Use of sensitivity results to select antimicrobials is not cost effective nor predictive of clinical outcomes.[2,3,10] Knowledge of etiology is strongly associated with results of *in vitro* sensitivity tests and culture is a critical aspect for selection of appropriate antimicrobials (Table 3). Except for pirlimycin and cloxacillin, few streptococci demonstrate *in vitro* resistance to most IMM products, and very little *in vitro* resistance is demonstrated by gram-positive organisms for 1st or 3rd generation cephalosporins nor by *E. coli* for ceftiofur.

In general, selection of antimicrobials should be based on knowledge of the etiology and producers should be encouraged to culture milk samples to determine the need for use of IMM antibiotics. Infections caused by gram-positive organisms should be treated using a relatively narrow-spectrum IMM antimicrobial, while broad-spectrum products should be reserved for cases that will not respond to narrow-spectrum compounds. In immunologically healthy cows, the spontaneous cure rate is very high for non-severe mastitis caused by *E. coli* and most cases will not benefit from IMM antimicrobials.[8] However, when veterinarians prescribe antimicrobials for cases caused by gram-negative pathogens, they should use a broader-spectrum compound. When cases are treated empirically, without knowledge of etiology, a narrow-spectrum drug should be used for the shortest labeled duration, because only a small proportion of cases will benefit.

Costs of Clinical Mastitis Treatment

Producers typically underestimate costs of clinical mastitis and it was estimated that direct costs (without milk

Table 3. Prevalence of reported in-vitro resistance of antibiotics approved for IMM treatment of mastitis.

Pathogen	Study year	Ampicillin	Cloxacillin	Procaine Penicillin	Pirlimycin	Ceftiofur	Cephapirin
Staph aureus	2002[21]	50%	1%	50%	2%	--	<1%
	2003[20]	35%	2%	35%	5%	--	<1%
	2015[32]	23%	0%	20%	23%	0%	0%
Staph spp	2003[20]	30%	7%	33%	14%	--	<1%
	2015[32]	8%	2%	10%	25%	0%	0%
Strep spp	2002[21]	2%	42%	5%	20%	--	<1%
	2003[20]	2%	42%	5%	21%	--	3%
	2015[32]	3%	0%	8%	19%	0%	0%
E. coli	2002[21]	15%	NT[a]	NT	NT	5%	26%
	2003[20]	22%	99%	NT	NT	--	28%
	2018[33]	4%	100%	98%	100%	2%	13%
Klebsiella	2002[21]	16%	NT[c]	NT[c]	NT	14%	4%
	2003[20]	NT	99%	100%	NT	--	12%
	2018[33]	98%	100%	100%	100%	32%	32%

*not tested due to expected intrinsic resistance

discard) were about $43 per case, which were distributed as $14 (IMM antibiotics), $9 (systemic antibiotics), $5 (supportive drugs), $8 (farm labor), and $7 (veterinary services).[30] In our recent 40-herd study, the average cost (not including labor) of treating a case of mastitis was $147 (95% CI = $130-165) which was distributed as $15 for systemic antibiotics ($1-$29), $24 for IMM products ($21-$26), and $109 for milk discard ($100-$117) (Figure 3). Across all 40 herds, the distribution of direct expenses was 10% (ranging from 0 – 65%) for cost of systemic treatments, 74% (58-100%) for cost of milk discard, and 16% (0-22%) for cost of IMM products. The cost of clinical mastitis varied widely among farms, indicating that treatment decisions can have strong economic consequences (Figure 3).

In a previous study, we used decision tree analysis to model losses (negative expected monetary values, EMV) attributable to treatment of a first case of mastitis occurring in a single quarter of a cow that was 30 DIM.[20] Expected monetary values are calculated as the sum of the products of the probabilities of each outcome multiplied by the estimated cost of each outcome. We included costs of diagnosis, initial treatment, recurrence, labor, discarded milk, post-treatment milk loss due to clinical and subclinical mastitis, culling, and transmission of infection to other cows (only for CM caused by *S. aureus*). Overall, losses due to treatment of mastitis ranged from -$262 (high prevalence of coliforms) to -$363 (high prevalence of *Staph aureus*). Duration of antimicrobial treatment had a strong impact on overall costs because milk discard comprises the greatest proportion of overall economic losses.

Determining Duration of Treatment

Dutch researchers have demonstrated that farmers are insecure about appropriateness of mastitis treatments and will often extend antibiotic therapy simply based on meeting perceived social norms of being a "good farmer."[27] Mastitis is detected based on observation of abnormal milk, and it seems logical to evaluate treatments based on improved appearance of milk, but this outcome is misleading. With or without treatment, return to normal milk is expected to occur within 4 to 6 days because immunologically competent cows will often successfully reduce the number of bacteria infecting the gland, allowing inflammation to subside.[8,9,15,16,21] With the exception of pirlimycin and ceftiofur, the label for approved IMM treatments ranges from 1 to 3 days (Table 1). However, farmers typically extend therapy and regardless of product, average durations of treatment used by WI farmers ranged from 3.3 to 5.7 days (Table 4). These durations correspond with the expected duration of inflammation, suggesting that farmers are extending therapy based on appearance of abnormal milk. While some studies have indicated that extended treatment of mastitis caused by some gram-positive pathogens results in faster bacteriological clearance,[17,18,19] there is no evidence that extended therapy improves important clinical outcomes (Table 2). Costs of treatment are strongly associated with duration of milk discard, and the use of extended durations increased costs from $14 to $87 per case as compared to label usage (Table 4).

For routine treatment protocols, duration of IMM treatment should be as short as possible to reduce unnecessary

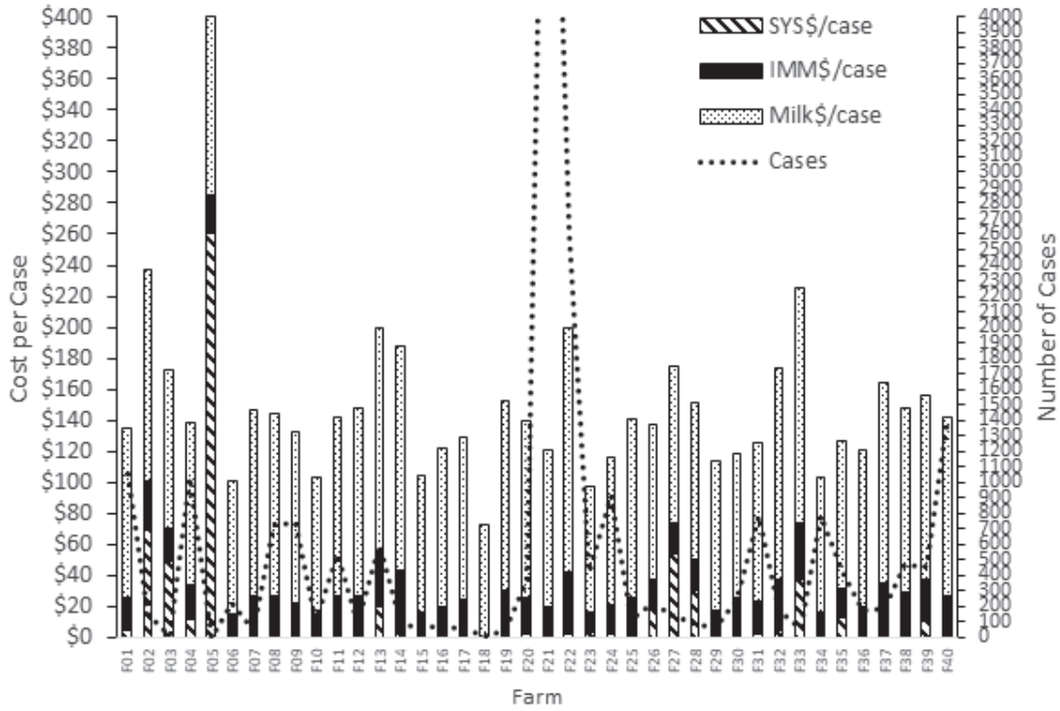

Figure 3. Cost of clinical mastitis treatment per case on 40 Wisconsin dairy farms in 2017. From unpublished data, Leite de Campos and Ruegg.

Table 4. Estimated cost of antimicrobial therapy and milk discard based on products used in 40 large Wisconsin dairy herds in 2017 (Leite de Campos and Ruegg, unpublished)

	Today™	Amoximast™	Polymast™	Pirsue™	SpectramastLC™
WI 2017 herds using (maximum = 40)	14	6	10	16	36
Tubes given per day	2	2	1	1	1
Cost per tube	$3.50	$3.08	$4.20	$5.00	$5.00
Milk discard after Rx (days)	4.0	2.5	3.0	1.5	3.0
Label duration of Rx (days)	1.0	1.5	3.0	2-8[a]	2-8[a]
Total milk discard when used on label (days)	5.0	4.0	6.0	6.5	8.0
WI 2017 herds duration of Rx (days)	3.3	5.7	3.9	4.8	5.7
Total milk discard as used by WI 2017 herds (days)	7.3	8.2	6.9	6.3	8.7
Cost of drug used on label	$7.00	$9.24	$12.60	$25.00	$25.00
Cost of drug WI 2017 herds	$23.10	$35.11	$16.38	$24.00	$28.50
Cost of discard – label use	$72.00	$57.60	$86.40	$93.60	$115.20
Cost of discard – WI 2017	$105.12	$118.08	$99.36	$118.60	$140.20
Total cost Rx label use	$79.00	$66.84	$99.00	$118.60	$140.20
Total cost Rx – WI 2017	$128.22	$153.19	$115.74	$114.72	$153.78
Difference in cost per case (Label vs WI 2017)	$49.22	$86.35	$16.74	-$3.88	$13.58
Annual projected herd difference in cost: label vs WI 2017 usage[c]	$11,075	$19,429	$3,767	----	$3,056

[a]5-day duration was used for economic calculations;
[c]$18/cwt milk, 80 lb per cow, 1000-cow herd with 30% IR; 75% cases treated 25% not treated

use of antimicrobials and minimize economic losses associated with milk discard.[20] Routine use of extended duration IMM treatment increases costs without improving economic outcomes.[20] An additional consideration is the ability of farm personnel to adequately perform IMM treatments without inducing new infections. When longer-duration therapy is recommended, veterinarians should assess the ability of farm workers to perform aseptic infusions, as extended intramammary treatment is associated with an increased risk of infection from opportunistic pathogens and herds

with poor infusion techniques are not good candidates for multiple doses of intramammary tubes.

Our decision tree analysis demonstrated that the optimal economic outcome occurred when mastitis caused by gram-positive pathogens was treated for 2 days and antimicrobials were not used when CM was caused by gram-negative pathogens or when no pathogen was recovered.[20] When mastitis is treated without knowing the etiology, duration of therapy had a considerable impact on differences in economic losses. In a herd with a typical distribution of etiologies (35% gram-positive, 30% gram-negative, 35% no growth) EMV were -$266 (no treatment and 2-d IMM), -$317 (5-d IMM) and -$371 (8-d IMM).

We also evaluated economic consequences of using on-farm culture (OFC) to guide therapy. When short-duration therapy (or no treatment) was primary treatment strategy, our model indicated that use of on-farm culture (OFC) did not reduce costs. In contrast, herds routinely using extended-duration therapy (without knowledge of etiology) could incur considerable savings by adopting OFC. For example, a 1000-cow dairy with a 40% incidence of CM and a typical distribution of pathogens would experience 400 first cases of mastitis per year. If standard treatment was 5 d of IMM antimicrobial, the EMV (loss) for each case in primiparous cows would be approximately $369, or $147,600 per year (for 400 cases). In contrast, the overall EMV for each case treated using a strategy of OFC would be $325, or $130,000 per year. In this instance, the use of OFC would result in approximately $18,000 in annual savings.

Conclusions

Mastitis is caused by a diverse group of bacterial pathogens with differing distributions among farms. Costs of treatment are strongly associated with duration of milk discard. Most cases of clinical mastitis are currently treated using IMM antibiotics, but many cases that are culture-negative at detection or caused by *E. coli* will not benefit from use of antimicrobials. To use antibiotics responsibly and minimize losses associated with treatment, veterinarians should encourage use of narrow-spectrum, short-duration IMM products when appropriate. Based on antibiotics that are approved for systemic use in US dairy cows, there is no evidence to support routine use of systemic antibiotics for treatment of non-severe clinical mastitis. Survey data demonstrate variation in mastitis treatments among farms, and there is considerable opportunity for veterinary involvement in reducing losses associated with treatment and encouraging improved antimicrobial stewardship.

References

1. Anonymous. Critically important antimcrobials for human health, 6th Rev. World Health Organization, ed. Switzerland: WHO, 2019.
2. Apparao D, Oliveira L, Ruegg PL. Relationship between results of *in vitro* susceptibility tests and outcomes following treatment with pirlimycin hydrochloride in cows with subclinical mastitis associated with gram-positive pathogens. *J Am Vet Med Assoc* 2009;234:1437-1446.
3. Apparao MD, Ruegg PL, Lago A, et al. Relationship between *in vitro* susceptibility test results and treatment outcomes for gram-positive mastitis pathogens following treatment with cephapirin sodium. *J Dairy Sci* 2009;92:2589-2597.
4. Erskine RJ, Bartlett PC, VanLente JL, et al. Efficacy of systemic ceftiofur as a therapy for severe clinical mastitis in dairy cattle. *J Dairy Sci* 2002;85:2571-2575.
5. Erskine RJ, Walker RD, Bolin CA, et al. Trends in antibacterial susceptibility of mastitis pathogens during a seven-year period. *J Dairy Sci* 2002;85:1111-1118.
6. Fuenzalida MJ. Improving treatment of clinical mastitis in dairy farms in Wisconsin. *Dairy Science*. Madison WI: University of Wisconsin, 2018;224.
7. Fuenzalida MJ, Fricke PM, Ruegg PL. The association between occurrence and severity of subclinical and clinical mastitis on pregnancies per artificial insemination at first service of Holstein cows. *J Dairy Sci* 2015;98:3791-3805.
8. Fuenzalida MJ, Ruegg PL. Negatively controlled, randomized clinical trial to evaluate intramammary treatment of nonsevere, gram-negative clinical mastitis. *J Dairy Sci* 2019;102:5438-5457.
9. Fuenzalida MJ, Ruegg PL. Negatively controlled, randomized clinical trial to evaluate use of intramammary ceftiofur for treatment of nonsevere culture-negative clinical mastitis. *J Dairy Sci* 2019;102:3321-3338.
10. Hoe FG, Ruegg PL. Relationship between antimicrobial susceptibility of clinical mastitis pathogens and treatment outcome in cows. *J Am Vet Med Assoc* 2005;227:1461-1468.
11. Kayitsinga J, Schewe RL, Contreras GA, et al. Antimicrobial treatment of clinical mastitis in the eastern United States: The influence of dairy farmers' mastitis management and treatment behavior and attitudes. *J Dairy Sci* 2017;100:1388-1407.
12. Leite de Campos J, Steinberger A, Goldberg TS, et al. Frequency of antimicrobial usage on treatment for bacterial diseases occurring in cows on large dairy farms. . *J Dairy Sci* 2019;101:135.
13. Makovec JA, Ruegg PL. Antimicrobial resistance of bacteria isolated from dairy cow milk samples submitted for bacterial culture: 8,905 samples (1994-2001). *J Am Vet Med Assoc* 2003;222:1582-1589.
14. McDougall S, Clausen L, Hintukainen J, et al. Randomized, controlled, superiority study of extended duration of therapy with an intramammary antibiotic for treatment of clinical mastitis. *J Dairy Sci* 2019;102:4376-4386.
15. Oliveira L, Hulland C, Ruegg PL. Characterization of clinical mastitis occurring in cows on 50 large dairy herds in Wisconsin. *J Dairy Sci* 2013;96:7538-7549.
16. Oliveira L, Ruegg PL. Treatments of clinical mastitis occurring in cows on 51 large dairy herds in Wisconsin. *J Dairy Sci* 2014;97:5426-5436.
17. Oliver SP, Almeida RA, Gillespie BE, et al. Extended ceftiofur therapy for treatment of experimentally-induced *Streptococcus uberis* mastitis in lactating dairy cattle. *J Dairy Sci* 2004;87:3322-3329.
18. Oliver SP, Gillespie BE, Headrick SJ, et al. Efficacy of extended ceftiofur intramammary therapy for treatment of subclinical mastitis in lactating dairy cows. *J Dairy Sci* 2004;87:2393-2400.
19. Oliver SP, Almeida RA, Gillespie BE, et al. Efficacy of extended pirlimycin therapy for treatment of experimentally induced *Streptococcus uberis* intramammary infections in lactating dairy cattle. *Vet Ther* 2003;4:299-308.
20. Pinzon-Sanchez C, Cabrera VE, Ruegg PL. Decision tree analysis of treatment strategies for mild and moderate cases of clinical mastitis occurring in early lactation. *J Dairy Sci* 2011;94:1873-1892.
21. Pinzon-Sanchez C, Ruegg PL. Risk factors associated with short-term post-treatment outcomes of clinical mastitis. *J Dairy Sci* 2011;94:3397-3410.
22. Ruegg PL. A 100-year review: Mastitis detection, management, and prevention. *J Dairy Sci* 2017;100:10381-10397.
23. Ruegg PL, Oliveira L, Jin W, et al. Phenotypic antimicrobial susceptibility and occurrence of selected resistance genes in gram-positive mastitis pathogens isolated from Wisconsin dairy cows. *J Dairy Sci* 2015;98:4521-4534.
24. Saini V, McClure JT, Léger D, et al. Antimicrobial resistance profiles of common mastitis pathogens on Canadian dairy farms. *J Dairy Sci* 2012;95:4319-4332.

25. Saini V, McClure JT, Scholl DT, et al. Herd-level relationship between antimicrobial use and presence or absence of antimicrobial resistance in gram-negative bovine mastitis pathogens on Canadian dairy farms. *J Dairy Sci* 2013;96:4965-4976.
26. Schukken YH, Zurakowski MJ, Rauch BJ, et al. Noninferiority trial comparing a first-generation cephalosporin with a third-generation cephalosporin in the treatment of nonsevere clinical mastitis in dairy cows. *J Dairy Sci* 2013;96:6763-6774.
27. Swinkels JM, Hilkens A, Zoche-Golob V, et al. Social influences on the duration of antibiotic treatment of clinical mastitis in dairy cows. *J Dairy Sci* 2015;98:2369-2380.
28. Tomazi T, Lopes TAF, Masson V, et al. Randomized noninferiority field trial evaluating cephapirin sodium for treatment of nonsevere clinical mastitis. *J Dairy Sci* 2018;101:7334-7347.
29. Truchetti G, Bouchard E, Descôteaux L, et al. Efficacy of extended intramammary ceftiofur therapy against mild to moderate clinical mastitis in Holstein dairy cows: A randomized clinical trial. *Can J Vet Res* 2014;78:31-37.
30. USDA. Dairy 2014, Milk quality, milking procedures and mastitis in the United States, 2014 In: USDA–APHIS–VS–CEAH–NAHMS, ed. Fort Collins, CO, 2016.
31. Vasquez AK, Nydam DV, Capel MB, et al. Randomized noninferiority trial comparing 2 commercial intramammary antibiotics for the treatment of nonsevere clinical mastitis in dairy cows. *J Dairy Sci* 2016;99:8267-8281.
32. Wenz JR, Barrington GM, Garry FB, et al. Bacteremia associated with naturally occuring acute coliform mastitis in dairy cows. *J Am Vet Med Assoc* 2001;219:976-981.
33. Wenz JR, Garry FB, Lombard JE, et al. Short communication: Efficacy of parenteral ceftiofur for treatment of systemically mild clinical mastitis in dairy cattle. *J Dairy Sci* 2005;88:3496-3499.

Rational treatments for mineral disorders in fresh cows

Garrett R. Oetzel, DVM, MS; Diplomate, ACVN (Honorary)
Professor, Food Animal Production Medicine Section, Department of Medical Sciences, School of Veterinary Medicine, University of Wisconsin, 2015 Linden Drive, Madison, WI 53706

Abstract

Hypocalcemia, hypophosphatemia, hypomagnesemia, and hypokalemia are important metabolic diseases of fresh dairy cows. Many dairy practitioners and dairy producers may need to update their approaches to these diseases based on current scientific information. Hypocalcemia in standing cows is best treated orally; intravenous calcium should be reserved for recumbent cases of milk fever because it may cause cardiac toxicity and rebound hypocalcemia. Glucose or additional electrolytes should not be included in intravenous solutions administered to cows with hypocalcemia. Hypophosphatemia is a less common mineral disorder that is usually secondary to hypocalcemia. Mild to moderate cases of hypophosphatemia are best treated with oral phosphorus; intravenous phosphorus should be reserved for severe cases. Hypomagnesemia may be a clinical problem in grazing herds or a subclinical problem in confinement dairies with cows fed stored feeds. Clinical hypomagnesemia may be treated intravenously or via rectal enema; subclinical cases are best managed by oral magnesium supplementation. Hypokalemia may follow prolonged periods of anorexia in early lactation cows and typically presents as severe, flaccid paralysis. Oral potassium supplementation is the preferred means for treating and preventing hypokalemia.

Key words: fresh cow mineral disorders, hypocalcemia, hypophosphatemia, hypomagnesemia, hypokalemia

Résumé

L'hypocalcémie, l'hypophosphatémie, l'hypomagnésémie et l'hypokaliémie sont des désordres métaboliques importants chez les vaches récemment vêlées. En se basant sur l'état actuel des connaissances, plusieurs praticiens et producteurs laitiers pourraient avoir besoin de mettre à jour leurs approches concernant ces maladies. L'hypocalcémie chez les vaches debout se traite le mieux oralement. Le calcium intraveineux devrait être réservé pour les cas de fièvre vitulaire chez les vaches à terre car il y un risque de toxicité cardiaque et ce calcium peut causer un rebond de l'hypocalcémie. Le glucose ou d'autres électrolytes ne devraient pas être inclus dans la solution intraveineuse administrée à des vaches en hypocalcémie. L'hypophosphatémie est un désordre minéral moins commun qui fait souvent suite à l'hypocalcémie. Les cas légers ou modérés d'hypophosphatémie se traitent le mieux avec du phosphore administré oralement tandis que le phosphore intraveineux devrait être réservé aux cas plus sévères. L'hypomagnésémie peut être un problème clinique dans les troupeaux au pâturage ou un problème subclinique dans les troupeaux confinés nourris avec des aliments entreposés. L'hypomagnésémie clinique peut se traiter par voie intraveineuse ou par lavement du rectum tandis que les cas subcliniques se traitent le mieux par la supplémentation orale en magnésium. L'hypokaliémie peut faire suite à une longue période d'anorexie chez les vaches en début de lactation et se présente le plus souvent sous forme de paralysie flasque sévère. La supplémentation orale en potassium est la façon désignée de traiter et de prévenir l'hypokaliémie.

Introduction

Despite the shift from veterinary to lay diagnosis and treatment of most mineral disorders on dairy farms, dairy practitioners still have a unique role in guiding the diagnostic and treatment protocols used by dairy producers. This makes it doubly important that dairy practitioners be aware of the best available science and clinical observations about these disorders. Unfortunately, some of the treatments for metabolic diseases recommended by veterinarians are less than optimal. My main concerns are the excessive use of intravenous (IV) mineral treatments that interfere with the cow's own attempts at homeostasis, the use of IV multiple electrolyte solutions that contain ineffective ingredients, and disregard for oral treatments that may be more effective than IV treatments.

New graduates may face opposition from older veterinarians regarding new or different methods of diagnosing and treating mineral disorders in fresh cows. My suggestions for those in this dilemma are: 1) it is fair to expect to be given the freedom to diagnose and treat fresh cows as you were trained to do; 2) be professional as you deal with situations in which there are differences; and 3) respect the long experience that older practitioners have with less than optimal treatments. There are more important issues than these for you, your colleagues, and your clients.

The purpose of this paper is to provide an overview of the current science and clinical reasoning for appropriate diagnostic and treatment protocols for hypocalcemia, hypophosphatemia, hypomagnesemia, and hypokalemia in fresh dairy cows.

Diagnosis and Treatment for Hypocalcemia

Pathophysiology of hypocalcemia. Dairy cows excrete very large amounts of colostrum into milk after calving.

Calcium outflow increases from about 10 grams per day into the fetal skeleton prior to calving[18] to excreting about 30 grams of daily calcium into colostrum.[39] On the day before calving, the cow must meet the demand for both fetal and colostral calcium. Colostrum is about twice as calcium-dense as milk (1.7 to 2.3 g calcium per kg of colostrum vs 1.1 g/kg calcium in milk).[11,39]

Because of the large increase in calcium outflow that occurs after calving, about half or more of all second and greater lactation cows develop subclinical hypocalcemia (SCH) following calving and about 2 to 6% of second and greater lactation cows develop clinical milk fever.[34] Producers surveyed by the 2002 dairy study of the US National Animal Health Monitoring System (NAHMS)[43] reported that 5.2% of their cows had clinical milk fever. The incidence of clinical milk fever appears to be declining; producers surveyed in 2007 reported 4.9% clinical milk fever[44] and those surveyed in 2014 reported 3.7% clinical milk fever.[45] Average risk for clinical milk fever is not the goal; herds can continue to improve and do better than average. A reasonable goal for clinical milk fever cases is <2% of calvings from second and greater lactation cows.[30]

The 2002 NAHMS dairy study reported that 47% of second and greater lactation cows had SCH, which was defined as serum total calcium <8.0 mg/dL (<2.0 mmol/L) measured within 48 hours of calving but without clinical signs of milk fever.[34] The risk for SCH increased substantially as parity increased.

The overall risk for SCH in dairy herds does not appear to be declining over time; this is the opposite of the trend for clinical milk fever. Recent studies that measured SCH [5,23,35] have reported higher rates of SCH – as high as 88% of cows tested. Unfortunately, it is not possible to compare risks for SCH across studies because of differences in herd selection criteria, parities of cows sampled, and cutpoints used for SCH.

Standing vs recumbent cases of hypocalcemia. Keen dairy producers may recognize very early signs of clinical milk fever in standing cows; this is Stage 1 clinical milk fever. Clinical signs of Stage 1 milk fever may include wobbliness, weight-shifting, dull appearance, cold extremities, hypothermia, reduced ruminal contractions, and mild tachycardia.[29]

Oral calcium is the preferred supplementation choice for Stage 1 clinical milk fever. Oral calcium supplementation causes a very rapid spike in blood calcium concentrations that peak within about 30 minutes of administration.[14] The increase in blood calcium concentration following oral calcium chloride administration is equivalent to IV administration of about 4 grams of calcium.[14] This is the equivalent of about half of a bottle of IV calcium and should provide more than enough calcium to help the cow overcome her Stage 1 milk fever.

Intravenous calcium is not recommended for standing cows, even if they are exhibiting clinical signs of Stage 1 milk fever. Oral calcium supplementation alone is recommended because it is much safer for the cow. Intravenous calcium infusion increases blood calcium to extremely high and potentially dangerous concentrations.[13] Hypercalcemia may induce a fatal arrhythmia starting at blood concentrations of about 28 to 32 mg/dL (7.0 to 8.0 mmol/L).[22] The routine administration of a single dose of IV calcium increases average blood calcium to about 19 mg/dL (4.8 mmol/L), with individual cows exceeding 22 mg/dL (5.5 mmol/L).[4] It is useful to remember that any IV calcium infusion puts cows dangerously close to a fatal arrhythmia. This precludes the use of IV calcium in standing cows, because they do not require immediate correction of their hypocalcemia and can be effectively treated with oral calcium instead.

Another complication associated with IV calcium infusion is a secondary hypocalcemia. Hypercalcemia quickly and directly impairs parathyroid hormone (PTH) secretion. This in an unfortunate metabolic consequence, because increased PTH secretion is the cow's primary response to hypocalcemia. Increased PTH enhances renal reabsorption of calcium from proximal renal tubular fluids, enhances osteoclastic bone resorption, and stimulates the production of the hormonal form of vitamin D.[11] These adaptations to hypocalcemia are necessary for the cow to survive the period of negative calcium balance that occurs during early lactation. Interrupting them has negative consequences.

Blood concentrations of PTH are very high in cows suffering from clinical milk fever (about 2,000 pg/mL).[4] However, blood PTH decreases to about 100 pg/mL within 10 minutes of IV calcium administration.[4] This effectively ends the cow's own efforts to mobilize calcium at the time she most needs it.

Hypercalcemia caused by IV calcium also stimulates the release of calcitonin (CT). This may be even more detrimental to the cow than impaired PTH secretion, because CT actively inhibits renal calcium resorption and bone resorption. This can be measured (at least in part) by urinary calcium loss, which is substantial (about 1 to 2 grams of calcium within 30 minutes of IV calcium treatment).[13]

A rebound hypocalcemia following IV calcium administration is caused by the combined effects of impaired PTH secretion and increased CT secretion. Cows given IV calcium typically return to hypocalcemia within about 8 hours and remain hypocalcemic until 24 to 48 hours after IV treatment.[4,13] About 25% to 38%[9,26] of cows treated successfully with IV calcium will suffer a hypocalcemic relapse and become recumbent again. Preventive measures (described later in the paper) can greatly reduce the risk. Relapses into recumbency typically occur about 12 to 18 hours after the initial IV treatment.[9]

Intravenous calcium is clearly necessary for cows with Stage 2 or Stage 3 milk fever because recumbent cows can quickly suffer irreversible musculoskeletal damage. About 4 to 30% of cows with clinical milk fever become alert downer cows, and about 20 to 67% of alert downer cows die.[41] The critical need for a recumbent cow is to get up; this need overshadows potential complications from IV calcium

administration.

Proper intravenous dose of IV calcium. The goal of IV calcium treatment should be to provide as little calcium as possible in order to get the cow up. Any IV calcium beyond the minimum required exposes the cow to additional risk for fatal cardiac complications, inhibits the cow's own attempts at calcium homeostasis, and increases the risk for a hypocalcemic relapse.

It is not possible to precisely determine the optimal dose of IV calcium for recumbent cases of milk fever. Nonetheless, physiological calculations provide a useful starting point. A dairy cow's entire extracellular pool of calcium is about 11 grams (3.5 grams dissolved in the bloodstream and 7.5 grams in the interstitial fluid).[11] A cow in Stage 2 clinical hypocalcemia typically has a blood calcium concentration around 4.5 mg/dL (about half of the normal blood calcium concentration). The total calcium deficit for this cow is 6.5 grams (making the reasonable assumption that blood and interstitial fluid have equal calcium concentrations). Blood calcium is typically lower (about 2.0 mg/dL) in severe cases of Stage 3 milk fever. This represents a loss of about 88% of the extracellular calcium – about 9.7 grams. A single bottle of calcium for IV infusion provides about 8 to 11 grams of calcium – an amount that replaces more than the cow's entire body deficit of calcium in almost all scenarios. Providing some calcium beyond the deficit is reasonable because calcium will continue to be lost in the colostrum. However, IV infusions of 2 or more 500 mL bottles of calcium provides 16 to 22 grams of calcium, which is an unreasonably high amount.

Some empirical studies help us to define an optimal dose of IV calcium. A low dose of IV Ca (6.2 grams) was not as effective as 8.0 grams in treating clinical cases of milk fever.[27] Another field study reported that a high dose of IV calcium (12.4 grams of calcium) was no more effective in correcting clinical milk fever than a lower dose (7.4 grams of calcium).[10] Thus, a reasonable inference is that the optimal IV calcium dose is between about 7 and 10 grams of calcium.

The most commonly used IV calcium solution in the US is provided in a 500 mL bottle and contains 23% calcium gluconate. One bottle provides 10.7 grams of elemental calcium; this is sufficient to restore the entire calcium deficit of any hypocalcemic cow. Unfortunately, many veterinarians and producers routinely administer 2 or more bottles of IV calcium to cows with clinical milk fever. For example, a published field study used 2 bottles (1000 mL total) of calcium-containing solutions for all cases of clinical milk fever.[24] This equals as much as 21.6 grams of calcium per IV treatment, depending on the products used. This is physiologically unwarranted and potentially harmful. High doses of IV calcium could result in higher risks for iatrogenic death, hypocalcemic relapse, and alert downer cows.

Another potential complication of high doses of intravenous calcium is excessive systemic acidification. Intravenous calcium solutions are acidic because boric acid is added to calcium gluconate preparations to solubilize the calcium gluconate and stabilize the solution.[13] Intravenous calcium solutions in the US are typically labeled as containing calcium gluconate; however, boric acid has been added and the solution is technically calcium borogluconate. Calcium gluconate would precipitate at room temperature if the solution contained no boric acid and was more than about 10% calcium gluconate.[2] The actual concentration of calcium gluconate is typically 23% – much greater than 10%. In countries other than the US, IV calcium solutions are correctly labeled as calcium borogluconate and provide between about 8 and 12 grams of elemental calcium per standard dose of 400 to 500 mL. The standard US formulation of 500 mL of 23% calcium gluconate includes 17.5 grams of boric acid. One bottle of this solution lowers urinary pH substantially (from about 6.6 to 5.8 at 1 hour post-treatment).[3] The acid load from administering 2 bottles of 23% calcium gluconate has not been evaluated. It could be substantial and contribute to clinically relevant acidemia.

The amount of calcium required to restore depleted stores of intracellular calcium is not significant in determining the appropriate dose of intravenous calcium. Intracellular calcium concentrations are extremely low in dairy cows (about 0.004 mg/dL) and the total intracellular calcium pool is numerically insignificant (about 0.01 grams).[13]

Providing multiple electrolytes in addition to calcium for IV treatment. Many products marketed for treatment of hypocalcemia include phosphorus, magnesium, glucose, or potassium in addition to calcium. None of these additional electrolytes are necessary, and some could be harmful. Cows suffering from clinical milk fever typically have low blood phosphorus, high blood magnesium, high blood glucose, and normal to slightly low blood potassium.[21] This information alone indicates that including additional magnesium, glucose, and potassium is irrational. Low blood phosphorus during hypocalcemia suggests that treatment with additional phosphorus might be helpful. It is true that hypophosphatemia typically follows hypocalcemia; however, it does not require treatment unless it persists following the correction of the hypocalcemia. Another problem is that hypophosphites are commonly used as the phosphorus source in multiple electrolyte solutions; however, this form of phosphorus is not biologically available to the cow.

Hypermagnesemia often accompanies hypocalcemia because of the effect of PTH on the renal tubules. Administering additional magnesium to hypocalcemic cows is not necessary; however, there is no evidence of physiological basis for it to be harmful. One field trial reported that treating cases of clinical milk fever with either IV calcium alone (10.5 grams from calcium borogluconate) or an IV solution containing calcium (12.4 grams from calcium borogluconate) plus phosphorus (1.5 grams from glycerophosphate) and magnesium (2.6 grams from magnesium chloride) resulted in no difference in treatment response.[36] The addition of phosphorus or magnesium to IV calcium solutions for the treatment of hypocalcemia appears to be unnecessary.

Hyperglycemia accompanies hypocalcemia because calcium is required for glucose to simulate insulin secretion from the pancreas. Administering additional glucose IV to hypocalcemic cows that are already hyperglycemic is not necessary and could prolong the cow's period of hyperglycemia if her hypocalcemia is not corrected and her insulin secretion restored. The effect of a bolus dose of IV glucose on a cow that is already hyperglycemic has not been formally evaluated to my knowledge. Prolonged hyperglycemia from continuous glucose infusions lowers GI motility and may increase the risk for displaced abomasum.[17]

The amount of potassium contained in multiple electrolyte products marketed to treat milk fever is quite small (1 to 2 grams) relative to the extracellular pool of potassium (19 to 20 grams). Even if hypokalemia were present along with hypocalcemia (which it usually is not), providing enough potassium in an IV solution to correct a clinically significant hypokalemia is nearly impossible. Administering more than about 2 grams of potassium as an IV bolus causes very high risk for cardiac side effects and sudden death.[13]

The addition of a small amount of potassium to an IV solution for the treatment of clinical milk fever may reduce the risk for cardiac problems secondary to hypercalcemia. Potassium is known to counteract the toxic effects of calcium on the electrical potential of cardiac muscle.[13] However, there is no empirical evidence that the addition of potassium to IV solutions to treat clinical milk fever is actually safer or improves the clinical response to treatment.[13] It is quite likely that the very small dose of potassium found in multiple electrolyte solutions marketed for IV milk fever treatment at least does no harm.

The use of multiple electrolyte solutions containing additional phosphorus, magnesium and glucose for the treatment of clinical milk fever is irrational. Veterinarians should actively discourage dairy producers from using such products. Additionally, dairy practitioners should push against the notion that adding more ingredients to an IV solution makes it better. Stage 2 and Stage 3 cases of milk fever should be treated with a single bottle of a solution that provides 7 to 10 grams of calcium from calcium borogluconate. Nothing else is needed and anything else could be detrimental.

Preventing hypocalcemic relapses following successful IV treatment. About 25%[26] to 38%[9] of cows successfully treated with IV calcium will become recumbent again within about 12 to 24 hours. It is likely that an even higher percentage will return to biochemical hypocalcemia but remain standing.

Oral calcium supplementation is the preferred method of preventing hypocalcemic relapses following successful IV calcium treatment. The efficacy of oral calcium drenches in preventing relapses in cows successfully treated for clinical milk fever is about 50 to 60%.[42] Bolus formulations of oral calcium, which are safer to administer, were developed later and have not been directly evaluated for the prevention of hypocalcemic relapses. In theory, they should be just as effective in reducing the risk for hypocalcemic relapses. A reasonable recommendation is to administer one oral bolus after the cow is standing, alert and able to swallow, followed by a second bolus about 12 hours later.[28,42]

Subcutaneous calcium administration is a second-choice approach to preventing hypocalcemic relapses following successful IV treatment of cases of clinical milk fever. It reduces the risk for a clinical relapse by about half compared to cows not given any source of slower-release calcium after IV calcium administration.[9] Important practical limitations of subcutaneous calcium administration are tissue irritation and abscessation. High amounts of extracellular calcium may overwhelm the ability of cells to maintain low intracellular calcium concentrations and lead to cell death.[13] The amount of solution per injection site should be limited to 1.0 to 1.5 grams of calcium, which equals about 50 to 70 mL per site for a typical IV calcium preparation.[13] Solutions that contain glucose should never be given subcutaneously due to the high risk for swelling, tissue irritation, and abscessation. Glucose requires active uptake by cells; however, there is not much cellular activity in the subcutaneous space. This leads to poor absorption of the glucose, prolonged high osmolarity in the subcutaneous space,[13] swelling, and tissue irritation. Glucose also supports bacterial growth in the subcutaneous space, which increases the risk for abscessation.

Managing subclinical hypocalcemia in early lactation. Individual treatment of cows for SCH is not possible, because cows with SCH (by definition) do not exhibit clinical signs and thus cannot be diagnosed. This leaves either blanket or strategic supplementation as the only options. Oral calcium is the most commonly used form of calcium supplementation for mitigating the effects of SCH on fresh cows.[28] Blanket oral calcium supplementation for second and greater lactation cows reduced the risk for health events in lame cows and increased milk yield in cows with higher previous lactation milk production.[31] The herds that participated in this large field study were fed supplemental anions and had an extremely low incidence of clinical milk fever. Nonetheless, they still had positive results in subgroups of cows. In this study, it is also notable that neither the age of the cow at calving nor her blood calcium concentration at calving had any effect on her response to oral calcium supplementation.[31]

Blanket use of IV calcium for the management of SCH is clearly contraindicated due to the risk for cardiac complications and rebound hypocalcemia. This concept is well illustrated by a field trial in which cows that were given a blanket, single-dose treatment of IV calcium at calving had lower blood calcium concentrations by 48 hours after calving than cows given no supplemental calcium at all.[3]

Treating secondary hypocalcemia in early lactation cows. Transient hypocalcemia may occur whenever a dairy cow goes off feed or has periods of decreased intestinal motility. This principle is illustrated by the results of a study in which cows were induced to have hypocalcemia. This resulted in severe ruminal stasis.[20] Gastrointestinal stasis

from other causes could lead to hypocalcemia, or at least make it worse. Whatever the underlying cause, oral calcium supplementation is indicated for any off-feed cows in early lactation. Most oral fresh cow drench products (or recipes) contain an effective dose of oral calcium. Sick cows that are still standing should not be exposed to the risks of IV calcium administration.

Diagnosis and Treatment for Hypophosphatemia

Overview of hypophosphatemia. Primary hypophosphatemia in dairy cattle is extremely unusual; almost all dairy cows are fed diets that provide excessive amounts of dietary phosphorus. Phosphorus is an important environmental pollutant, and dairy nutritionists have appropriately focused on reducing dietary phosphorus intakes. Even with reductions, dairy cattle diets are well over minimum phosphorus requirements.

Hypophosphatemia can occur in early lactation cows for metabolic reasons rather than overt phosphorus deficiency. Milk production requires a significant phosphorus outflow, and colostrum is higher in phosphorus than milk.[15] Thus, the greatest challenges to phosphorus homeostasis occur in early lactation.

Most hypophosphatemia is secondary to hypocalcemia. Blood calcium and phosphorus concentrations are highly correlated; 90 to 100% of cows with clinical milk fever will be hypophosphatemic.[4] The known physiology of calcium and phosphorus metabolism explains this relationship. The first principle is that PTH, which increases during hypocalcemia, causes renal excretion of phosphorus in order to retain calcium. The second principle is that salivary phosphorus, in the form of phosphate buffers, pools in the rumen during periods of hypomotility caused by hypocalcemia. The amount of ruminal phosphorus that is transiently unavailable may be substantial. Saliva contains about twice the concentration of phosphorus as blood, and salivary production of phosphorus is between 25 and 100 grams per day.[13] Phosphorus that is pooled in the rumen cannot be absorbed across the rumen wall; it must pass on to the small intestine before it can be absorbed back into circulation.

Hypophosphatemia secondary to hypocalcemia almost always self-corrects once the hypocalcemia is corrected. Restored blood calcium improves ruminal motility and allows pooled salivary phosphorus to exit the rumen and be absorbed back into the bloodstream at the small intestine. Correcting the hypocalcemia also lowers blood PTH, which decreases renal phosphorus excretion. These theoretical assertions have been supported by field study results. For example, adding IV sodium phosphate to IV calcium for the treatment of cows with clinical milk fever did not improve response to treatment, despite the finding of hypophosphatemia in almost all of the affected cows.[4]

A small proportion of cows with secondary hypophosphatemia remain hypophosphatemic following correction of the hypocalcemia. Blood phosphorus concentrations in these cows are quite low - typically about 0.5 to 0.9 mg/dL (0.15 to 0.30 mmol/L).[3] This is well below the normal range of about 4.0 to 8.0 mg/dL (1.3 to 2.6 mmol/L). Some cows with persistent hypophosphatemia may remain recumbent but alert. The exact causes for persistent hypophosphatemia are unknown, and the role that hypophosphatemia might play in the continued recumbency of these cows is unclear and controversial. There is no empirical evidence that hypophosphatemia actually causes prolonged recumbency.[15] Persistent recumbency may be secondary to hypocalcemia-related musculoskeletal damage, gastrointestinal stasis, and inappetance.

Hypophosphatemia may also be secondary to IV administration of glucose. A bolus dose of IV glucose lowers blood phosphorus concentrations quickly and dramatically.[16] This effect is mediated by insulin, which moves phosphorus from the extracellular space into the cells.[15] Insulin increases dramatically following IV glucose administration.

Several unique features of phosphorus metabolism complicate our ability to diagnose it. For example, blood collected from the jugular vein contains less phosphorus than blood collected from the coccygeal vein.[25,46] This happens because the salivary glands, located just above the jugular vein, harvest large amounts of phosphorus to buffer the rumen. Therefore, jugular blood samples may cause a false positive diagnosis of hypophosphatemia. Blood samples collected to diagnose recumbency in parturient dairy cows should always be collected from the coccygeal vein. Blood samples should also be collected prior to any treatment. If the cow was recently given IV glucose, her blood phosphorus will be depressed (as described above).

It is reasonable to attempt to correct hypophosphatemia whenever it is diagnosed, whether hypophosphatemia directly contributes to prolonged recumbency or not.[13,15] Treating the primary cause of the hypophosphatemia (hypocalcemia or hyperglycemia) is always the first consideration. There are no empirical data to support the value of phosphorus therapy for recumbent cows with hypophosphatemia.[15] Phosphorus therapy likely does no harm if it does not interfere with correction of the cow's primary condition and if it is not seen as a replacement for excellent management of downer cows (humane handling, prompt flotation, and excellent nursing care).

Intravenous treatment for hypophosphatemia. Intravenous treatment for hypophosphatemia is controversial. One author suggests reserving it for unusual cases, such as when severe intravascular hemolysis may be resulting from the hypophosphatemia.[15] Another author is more open to wider use.[13]

A precise dose of phosphorus needed for IV treatment cannot be known.[15] Nonetheless, a reasonable dose can be estimated from the calculated phosphorus deficit in the cow. The entire extracellular pool of inorganic phosphorus for a dairy cow is about 6 grams.[13] Using the reasonable assump-

tions that blood phosphorus is a valid surrogate for extracellular phosphorus[15] and that the phosphorus concentration in extracellular fluid decreases from about 5 mg/dL to 1 mg/dL (1.6 to 0.3 mmol/L) during hypophosphatemia, the calculated extracellular phosphorus deficit in a hypophosphatemic cow is about 4.8 grams. It would also be reasonable to provide a modest amount of additional phosphorus to help cover for continued phosphorus loss in the milk. Therefore, a reasonable dose for IV phosphorus therapy is about 5 to 7 grams of phosphorus.[13] Intracellular phosphorus is unlikely to be depleted during short periods of hypophosphatemia and is not considered in the dosage calculations.[13]

No commercial products are available in the US that can be recommended for the IV correction of hypophosphatemia. The only recommended IV treatment for hypophosphatemia is 30 grams of sodium phosphate (monobasic, monohydrate, reagent grade) mixed in 300 mL sterile water.[13] This formulation provides 6.7 grams of phosphorus. It should be infused slowly, over a 10 minute or longer period of time. Intravenous phosphorus supports blood phosphorus concentrations for only 3 to 4 hours.[13] Therefore, oral supplementation of phosphorus should follow IV phosphorus treatment for most cases. An exception could be made for cows that are able to get up and begin eating well on their own.

Intravenous infusions of phosphorus should not be regarded as innocuous. Blood phosphorus concentrations rise well above the normal range soon after IV infusion. This apparently does not cause overt clinical signs or problems with rebound hypophosphatemia, because phosphorus is a poorly regulated mineral. However, hyperphosphatemia is associated with transient reductions in blood calcium. The formation of insoluble calcium phosphate crystals in the bloodstream could explain the secondary hypocalcemia.[15] The value of IV phosphorus infusions must be weighed against risks associated with subsequent hypocalcemia.

Sodium phosphate cannot be mixed with calcium salts prior to IV administration, as the phosphates immediately form insoluble calcium phosphate crystals in the bottle. The same phenomena may occur in the bloodstream of the cow; giving IV phosphorus concurrent with or soon after IV calcium will simply favor the formation of insoluble calcium phosphate crystals and not correct either the calcium or phosphorus deficit. Wait at least 2 hours after giving IV calcium before administering IV phosphorus.[13]

Some saline enemas that are available over the counter for human use contain a reasonable dose of phosphorus (6 to 7 grams) that comes from reasonable sources (monobasic and dibasic sodium phosphate). These have been used for IV treatment of hypophosphatemia in dairy cattle. The use of these formulations in dairy cattle involves some risk. First, the enema solution should first be diluted with water to 1000 mL in order to reduce the tonicity of the IV infusion.[13] Second, the amounts and effects of other ingredients in these human enema solutions (benzalkonium chloride and disodium EDTA, for example) are unknown.

Infusing more than about 8 grams of phosphorus IV will cause severe and unnecessary hyperphosphatemia. High blood phosphorus by itself is apparently not a clinical problem; however, it could trigger a profound, secondary hypocalcemia.[15]

Ineffective sources of parenteral phosphorus. Hypophosphites (PO_2) such as calcium hypophosphite may be added to commercially-available multiple electrolyte solutions labeled for the correction of hypocalcemia or hypophosphatemia. Hypophosphites are chosen as the source of supplemental phosphorus because they do not precipitate with calcium, as phosphates would. Unfortunately, phosphites are biologically unavailable to the cow.[6] Phosphates (PO_4) are the dominant form of phosphorus in the body and are biologically available.[13] Phosphite forms of phosphorus are not biologically available, are not metabolized, and are simply excreted in the urine. They do no apparent harm, but have no value whatsoever in correcting hypophosphatemia. It is unfortunate and misleading that hypophosphites are added to multiple electrolyte IV solutions. Any label indication for these products indicating that they may be used to treat phosphorus deficiency is false.

Organic phosphorus compounds may be included in products that are labeled for parenteral use to correct phosphorus deficiencies. Examples of organic phosphorus sources include sodium glycerophosphate, butafosfan, toldimfos, and aminoethyl dihydrogen phosphate. This category of products is not recommended for correcting hypophosphatemia. They either use a metabolically useless form of phosphorus, or they provide much less phosphorus than is needed to be metabolically useful in hypophosphatemic cows.[15]

Oral treatment for hypophosphatemia. Oral supplementation of phosphorus is the preferred approach to correcting and sustaining blood phosphorus in mild to moderate cases of hypophosphatemia.[15] An example recipe for oral phosphorus supplementation is 200 to 300 grams of feed grade monosodium phosphate (NaH_2PO_4) mixed with about 1.5 L warm water.[13,16] This solution can be administered by pumping it through an oro-gastric tube or as a drench. Pumping is preferred, as oral drenching results in about a 13% loss of product due to spillage.[19] Extreme care must be used to prevent pharyngeal trauma or regurgitation with aspiration when administering oral supplements to recumbent cows.

Oral administration of 200 to 300 grams of monosodium phosphate provides 45 to 67 grams of elemental phosphorus. This dose appears adequate to support blood phosphorus concentrations for about 12 to 24 hours and does not cause hyperphosphatemia.[13,19] Monopotassium phosphate (KH_2PO_4) is similarly effective in supporting blood phosphorus when administered at a similar dose (263 grams, which provides 60 grams of phosphorus).[19] Monopotassium phosphate provides an effective dose of available potassium as well as phosphorus; this could be useful for cows with anorexia in early lactation. Monocalcium phosphate ($Ca(H_2PO_4)_2$) does raise blood phosphorus concentrations,

but not as much as monosodium or monopotassium phosphate.[19] Dicalcium phosphate ($CaHPO_4$) has little to no effect on blood phosphorus concentrations. It is not considered an effective oral phosphorus supplement.[19,40]

Oral monosodium phosphate or monopotassium phosphate may be administered to cows in gelatin capsules.[13] A number 7 gelatin capsule (1.5-ounce size) has a 24 mL capacity and should hold about 49 grams of monosodium phosphate (assuming 2.03 grams per cubic centimeter) or about 56 grams of monopotassium phosphate (assuming 2.34 grams per cubic centimeter). Thus, about 4 to 6 capsules per cow would be a reasonable dose for either compound.

This author is not aware of any commercially available paste, gel, or bolus formulations in the US that provide a reasonable amount of supplemental phosphorus from monosodium phosphate. Oral products in the US that contain phosphorus are typically combined with other nutrients and provide relatively small amounts of phosphorus from less available sources. The labels for these products may create the false impression that they are useful for correcting hypophosphatemias.

Subcutaneous treatment for hypophosphatemia. There are no commercially available phosphorus supplements in the US that are labeled for subcutaneous administration. The subcutaneous administration of monosodium phosphate solutions is strongly discouraged. Unbuffered preparations of monosodium phosphate have a very low pH (< 3.5); this would be expected to cause severe tissue irritation if given subcutaneously.[15] Buffering a monosodium phosphate solution to a reasonable pH (above about 5.8) would unfortunately impair its solubility.[13]

Diagnosis and Treatment for Hypomagnesemia

Clinical hypomagnesemia. Clinical hypomagnesemia (grass tetany) is mostly a disease of pastured animals; it is uncommon in dairy cattle housed in confinement and fed stored feeds. Grazing dairies do encounter hypomagnesemia during the spring months, when pasture is relatively high in potassium and low in magnesium. Potassium, as for all monovalent ions, is highly soluble in water and is readily taken up by plant tissue during the wet, early spring months. Grass tetany may be seen year-round in the southern US, when dairy cattle may be grazed on cool-season pasture grasses during periods of high moisture.

Potassium unfortunately competes with magnesium for plant uptake from the soil and for ruminal absorption. Thus, hypomagnesemia may develop when pastures are low in magnesium, high in potassium, or both.

Cows have minimal ability to regulate blood magnesium. They also have no readily available body stores of magnesium. Thus, they must consume adequate amounts of available magnesium from the diet each day.

The clinical signs of grass tetany are easily recognized in grazing cows. Affected cows initially have mild anorexia. They soon develop hyperexcitability and may separate from the rest of the herd. If observed closely, they may display ear twitching, muscle fasciculations and hyperesthesia around the head. Some cows become maniacal and aggressive. Clinical signs then often progress to more severe whole-body tremors, ataxia, and recumbency with seizure activity. Low magnesium concentrations in the cerebrospinal fluid (CSF) are regarded as the primary cause for the clinical signs of grass tetany.[1,32] A clinical diagnosis of hypomagnesemia can be confirmed by pre-treatment blood magnesium below 1.1 mg/dL (0.5 mmol/L), or preferably by CSF magnesium below 1.0 mg/dL (0.4 mmol/L).[13] Blood magnesium concentrations may occasionally be falsely elevated (and thereby considered normal) because severe tetany may damage muscle cells enough to cause leakage of magnesium from the cells into circulation. Note that cells have relatively high magnesium concentrations compared to extracellular fluid. Magnesium concentration in the CSF is not affected by muscle damage and is therefore the preferred sample for diagnosing hypomagnesemia. Magnesium concentrations in CSF are low during episodes of tetany and for up to 12 hours after death.[13]

Hypomagnesemic cows that exhibit signs of tetany will almost certainly have concurrent hypocalcemia. Clinical manifestations of tetany may not even be possible unless the cow is also hypocalcemic.[11]

Treatment of clinical hypomagnesemia. Cows with clinical hypomagnesemia require immediate treatment with parenteral magnesium and calcium. Calcium is included in the treatment for 2 reasons: 1) affected cows are also hypocalcemic, and 2) IV calcium reduces the severity of side effects associated with IV magnesium, such as respiratory paralysis and cardiac arrest. An appropriate magnesium dose is between 1.5 and 2.25 grams of elemental magnesium. This allows for 50 to 75% replacement of all of the cow's extracellular magnesium.[13] Multiple electrolyte preparations available in the US typically contain about 1.6 grams of magnesium from magnesium borogluconate; this is a reasonable dose.

Multiple electrolyte preparations are often the only practical IV treatment for hypomagnesemia. Other components of some multiple electrolyte solutions may be unnecessary (phosphorus and potassium) or potentially harmful (glucose – since cows with clinical hypomagnesemia are most likely already hyperglycemic). Nonetheless, a multiple electrolyte solution that contains both magnesium and calcium may be the most practical choice for the initial correction of severe hypomagnesemia.

Intracellular magnesium represents about 29% of total body magnesium, and intracellular magnesium concentrations are very high relative to extracellular magnesium.[38] Fortunately, intracellular magnesium does not appear to be depleted during hypomagnesemia.[13] Correction of the extracellular magnesium deficit should be sufficient.

Cows with clinical grass tetany need immediate magnesium supplementation and should be treated IV whenever practical.[13] Once IV treatment is started, the infusion should

be given as slowly as possible, with careful monitoring of heart and respiratory rates.

Some cows affected with clinical grass tetany are too aggressive to be restrained for IV treatment. In these cases, supplemental magnesium may be administered by safer routes. Magnesium sulfate (about 200 to 400 mL of a 25% solution of $MgSO_4 \cdot 7\ H_2O$) can be given subcutaneously (50 to 100 mL per injection site).[13] This provides 4.9 to 9.9 grams of magnesium, which is reasonable to correct the cow's magnesium deficit. However, subcutaneous absorption will obviously be slow compared to IV magnesium administration. Cows with cold extremities may have poor peripheral perfusion and are not good candidates for subcutaneous magnesium.[13] There are no commercially available magnesium solutions for subcutaneous injection marketed in the US; therefore, the magnesium sulfate solution described above must be made up and sterilized by the veterinarian.

Expect the response to IV or subcutaneous treatment to be slower for cows with clinical grass tetany compared to cows with clinical milk fever. Additional time is required for magnesium to cross into the CSF; cows cannot recover until CSF magnesium is restored. Treated animals should not be stimulated to rise during or soon after treatment; this could trigger fatal convulsions. Instead, cows should be left in a quiet location after treatment and allowed at least 30 minutes to respond on their own without any stimulation to rise.[13]

Rectal administration is the route of choice for delivering supplemental magnesium to hypomagnesemic cows with severe convulsions and/or poor peripheral perfusion.[13] This route is safer both for the cow and for the person administering the treatment. Example magnesium-containing enema formulations are 60 grams of magnesium chloride or 60 grams of magnesium sulfate dissolved in 200 mL warm water. Administer the solution into the descending colon via a short tube.[3] Rectal absorption of magnesium is very good; blood magnesium concentrations increase within 10 minutes and CSF magnesium concentrations increase in about 30 minutes.[24] Cows should be observed for premature evacuation of the magnesium enema. Do not overdose the rectum with magnesium solutions, as this could cause severe rectal mucosal sloughing.[13]

Preventive measures are needed to prevent hypomagnesemic relapses following initial treatment of clinical grass tetany. Options include subcutaneous administration of magnesium sulfate (200 mL of a 50% solution, which provides 9.9 grams magnesium) or oral administration of 400 mL of a 50% magnesium sulfate solution (200 grams of magnesium sulfate in 400 mL of water, which provides 19.7 grams of magnesium).[13] Extreme caution should be exercised if any oral supplement is given to a recumbent cow; the best approach is to defer oral magnesium administration until the cow is standing, alert, able to swallow, and not aggressive. This could be 30 to 90 minutes after the initial treatment.[13]

Commercial oral gel preparations containing magnesium (typically packaged in 300-mL tubes) are available in the US. Most of these preparations source their magnesium primarily from magnesium chloride, which is a very available source of magnesium. Some products provide about 6 grams of magnesium per tube; 2 or 3 tubes would provide a reasonable dose for prevention of hypomagnesemic relapses. Some multiple nutrient oral tubes provide only about 3 grams of magnesium per tube; it would require too many of these tubes to reach an effective dose of magnesium. The other nutrients present in these tubes may be helpful, depending on the clinical situation.

Another reasonable source of oral magnesium is a fresh cow drench formulation. These typically provide about 200 grams of magnesium sulfate (19.7 grams of magnesium), along with other nutrients such as calcium, a glucose precursor, phosphorus, or potassium. These drench formulations are appropriate for preventing hypomagnesemic relapses.

Subclinical hypomagnesemia. Dairy cattle managed in confinement rarely develop clinical hypomagnesemia, but may have its subclinical form. Subclinical hypomagnesemia may be diagnosed at the herd level by evaluating blood magnesium concentrations in apparently healthy cows. The cutpoint that defines subclinical hypomagnesemia has not been formally characterized but appears to be around 1.8 mg/dL (0.74 mmol/L). Unfortunately, there has been no formal evaluation of the highest risk period for subclinical hypocalcemia and no formal evaluation of appropriate alarm levels for herd-level diagnosis of subclinical hypomagnesemia. The author's limited clinical experience suggests that the highest risk period for subclinical hypomagnesemia in confinement dairies may be about 4 to 14 days-in-milk, and that a reasonable alarm level may be over about 15% of the herd affected with subclinical hypomagnesemia.

Blanket supplementation with oral magnesium could be used to mitigate subclinical hypomagnesemia in dairy herds shown to be at high risk. There is no cowside test for diagnosing subclinical hypomagnesemia, so blanket treatment strategies are the only option available. Unfortunately, no studies have evaluated the effectiveness of blanket oral magnesium supplementation strategies. An oral drench that provides about 200 grams of magnesium sulfate (19.7 grams of elemental magnesium) would be a reasonable supplement to mitigate the impact of subclinical hypomagnesemia.[13] Magnesium sulfate at this dose, which is well below a cathartic dose, is very appropriately included in many fresh cow drench products.

Diagnosis and Treatment for Hypokalemia

Hypokalemia overview. Hypokalemia may occur in early lactation dairy cows due to prolonged anorexia. It is often associated with chronic ketosis or another primary condition that impairs appetite. Additional risk factors for hypokalemia include repeated administration of isoflupredone acetate, IV glucose, or insulin.[12] Depletion of total body potassium leads to severe muscle weakness and flaccid pa-

ralysis.[37] The flaccid paralysis associated with hypokalemia can be so severe that cows have a complete inability to keep their head in a straight position and cannot eat unless their head in placed into a feed bucket.[37]

Hypokalemia is confirmed by low serum or plasma potassium concentration. Samples must be separated from the red blood cells within about an hour after calving; otherwise, potassium from the red blood cells (which concentrate potassium about 30 times greater than serum or plasma[12]) could falsely elevate the measured potassium concentration and cause the diagnosis to be missed. Hypokalemia starts whenever blood potassium falls below the normal range (<3.9 mEq/L); however, most cows with clinical signs of hypokalemia have blood potassium concentrations below about 2.5 mEq/L.[7,37] There is no consensus on the exact cut point for blood potassium concentration that should be used to define hypokalemia.[37]

About 25 to 40% of cases of hypokalemia also have low blood phosphorus.[37] These conditions may both be related to prolonged anorexia.

Intravenous treatment of hypokalemia. Intravenous correction of hypokalemia requires slow infusion, due the risk for sudden cardiac death, and daily monitoring of blood potassium.[37] This is rarely practical in the field. An IV infusion should not provide more than 0.5 mEq of potassium per kg bodyweight per hour.

Oral treatment of hypokalemia. Oral potassium chloride is the treatment of choice for clinical cases of hypokalemia. Potassium is needed to correct the whole-body potassium depletion, and chloride is needed for cows that may be alkalemic and have a pH-induced compartmental shift of potassium into the intracellular space.[7]

The current recommendations for oral potassium chloride supplementation for clinical cases of hypokalemia is 0.4 g/kg body weight, which equals 300 grams of potassium chloride for a 1650 lb (750 kg) cow. This dose should be divided into 2 or more treatments during a 24-hour period.[8] In practice, this translates to an initial treatment of about 150 grams of potassium chloride (79 grams of potassium and 71 grams of chloride) that is repeated 12 hours later. There is no advantage to dividing this dose into 8 smaller doses administered every 3 hours.[8] Higher doses of oral potassium chloride are dangerous due to the risk for diarrhea, convulsions, or death; they should be reserved for cows with severe hypokalemia. Oral supplementation with potassium chloride is often necessary for 3 to 5 days.[8,33]

Prevention of hypokalemia. Essentially all cases of hypokalemia are preventable. This can be accomplished by: 1) avoid repeated administration of isoflupredone acetate, IV glucose, or insulin; and 2) supplement all early lactation cows that are anorectic more than 3 days with oral potassium chloride. The suggested preventive dose of oral potassium chloride is 100 grams per day; this dose appears to be safe and effective.[37] Oral potassium chloride may be pumped as part of a fresh cow drench package (100 grams of potassium chloride is a standard dose of potassium chloride in fresh cow drench packages marketed in the US) or administered orally in gelatin capsules. A number 7 gelatin capsule (1.5-ounce size) has a 24 mL capacity and thus should hold about 48 grams of potassium chloride (assuming 1.98 grams per cubic centimeter). Thus, a reasonable dose is 2 capsules of this size per cow per day.

Conclusions

Prevention of mineral disorders in fresh dairy cows is obviously superior to treating them. Nonetheless, clinical and subclinical cases of mineral disorders will still occur, even with the best of transition cow management. Dairy practitioners can work with dairy producers to implement the most effective programs for early detection and optimal treatment of mineral disorders.

Acknowledgments

Dr. Oetzel has served as a consultant and speaker for Boehringer Ingelheim Animal Health and Zoetis Animal Health. He has conducted research projects sponsored by AgSource, Boehringer Ingelheim Animal Health, and Zoetis Animal Health.

References

1. Allsop T, Pauli J. Magnesium concentrations in the ventricular and lumbar cerebrospinal fluid of hypomagnesaemic cows. *Res Vet Sci* 1985; 38:61-64.
2. Austin J. Process for stabilization of calcium gluconate solutions. US Patent Office No. 2,007,786, 1935.
3. Blanc CD, Van der List M, Aly SS, Rossow HA, Silva-del-Río N. Blood calcium dynamics after prophylactic treatment of subclinical hypocalcemia with oral or intravenous calcium. *J Dairy Sci* 2014; 97:6901-6906.
4. Braun U, Zulliger P, Liesegang A, Bleut U, Hässig M. Effect of intravenous calcium borogluconate and sodium phosphate in cows with parturient paresis. *Vet Rec* 2009; 164:296-299.
5. Caixeta LS, Ospina PA, Capel MB, Nydam DV. Association between subclinical hypocalcemia in the first 3 days of lactation and reproductive performance of dairy cows. *Theriogenology* 2017; 94:1-7.
6. Cheng YH, Goff JP, Horst RL. Restoring normal blood phosphorus concentrations in hypophosphatemic cattle with sodium phosphate. *Vet Med* 1998; 93:383-388.
7. Constable P, Grünberg W, Staufenbiel R, Stämpfli HR. Clinicopathologic variables associated with hypokalemia in lactating dairy cows with abomasal displacement or volvulus. *J Am Vet Med Assoc* 2013; 242:826-835.
8. Constable PD, Hiew MWH, Tinkler S, Townsend J. Efficacy of oral potassium chloride administration in treating lactating dairy cows with experimentally induced hypokalemia, hypochloremia, and alkalemia. *J Dairy Sci* 2014; 97:1413-1426.
9. Curtis RA, Cote JF, McLennan MC, Smart JF, Rowe RC. Relationship of methods of treatment of relapse rate and serum levels of calcium and phosphorous in parturient hypocalcaemia. *Can Vet J* 1978; 19:155-158.
10. Doze JG, Donders R, van der Kolk JH. Effects of intravenous administration of two volumes of calcium solution on plasma ionized calcium concentration and recovery from naturally occurring hypocalcemia in lactating dairy cows. *Am J Vet Res* 2008; 69:1346-1350.
11. Goff JP. Calcium and magnesium disorders. *Vet Clin North Am Food Anim Pract* 2014; 30:359-381.
12. Goff JP. Macromineral disorders of the transition cow. *Vet Clin North Am Food Anim Pract* 2004; 20:471-494.

13. Goff JP. Treatment of calcium, phosphorus, and magnesium balance disorders. *Vet Clin North Am Food Anim Pract* 1999; 15:619-639.
14. Goff JP, Horst RL. Oral administration of calcium salts for treatment of hypocalcemia in cattle. *J Dairy Sci* 1993; 76:101-108.
15. Grünberg W. Treatment of phosphorus balance disorders. *Vet Clin North Am Food Anim Pract* 2014; 30:383-408.
16. Grünberg W, Morin DE, Drackley JK, Barger AM, Constable PD. Effect of continuous intravenous administration of a 50% dextrose solution on phosphorus homeostasis in dairy cows. *J Am Vet Med Assoc* 2006; 229:413-420.
17. Holtenius K, Sternbauer K, Holtenius P. The effect of the plasma glucose level on the abomasal function in dairy cows. *J Anim Sci* 2000; 78:1930-1935.
18. House WA, Bell AW. Mineral accretion in the fetus and adnexa during late gestation in Holstein cows. *J Dairy Sci* 1993; 76:2999-3010.
19. Idink MJ, Grünberg W. Paper: Enteral administration of monosodium phosphate, monopotassium phosphate and monocalcium phosphate for the treatment of hypophosphataemia in lactating dairy cattle. *Vet Rec* 2015; 176:494.
20. Jørgensen RJ, Nyengaard NR, Hara S, Enemark JM, Andersen PH. Rumen motility during induced hyper- and hypocalcaemia. *Acta Vet Scand* 1998; 39:331-338.
21. Larsen T, Møller G, Bellio R. Evaluation of clinical and clinical chemical parameters in periparturient cows. *J Dairy Sci* 2001; 84:1749-1758.
22. Littledike ET, Glazier D, Cook HM. Electrocardiographic changes after induced hypercalcemia and hypocalcemia in cattle: reversal of the induced arrhythmia with atropine. *Am J Vet Res* 1976; 37:383-388.
23. Martinez N, Risco CA, Lima FS, Bisinotto RS, Greco LF, Ribeiro ES, Maunsell F, Galvao K, Santos JE. Evaluation of peripartal calcium status, energetic profile, and neutrophil function in dairy cows at low or high risk of developing uterine disease. *J Dairy Sci* 2012; 95:7158-7172.
24. Ménard L, Thompson A. Milk fever and alert downer cows: Does hypophosphatemia affect the treatment response? *Can Vet J* 2007; 48:487-491.
25. Montiel L, Tremblay A, Girard V, Chorfi Y. Preanalytical factors affecting blood inorganic phosphate concentration in dairy cows. *Vet Clincal Pathol* 2007; 36:278-280.
26. Mullen PA. Clinical and biochemical responses to the treatment of milk fever. *Vet Rec* 1975; 97:87-92.
27. Mullen PA. Milk fever: A case against polypharmacy solutions. *Vet Rec* 1977; 101:405-407.
28. Oetzel GR. Oral calcium supplementation in peripartum dairy cows. *Vet Clin North Am Food Anim Pract* 2013; 29:447-455.
29. Oetzel GR. Parturient paresis and hypocalcemia in ruminant livestock. *Vet Clin North Am Food Anim Pract* 1988; 4:351-364.
30. Oetzel GR. Undertaking nutritional diagnostic investigations. *Vet Clin North Am Food Anim Pract* 2014; 30:765-788.
31. Oetzel GR, Miller BE. Effect of oral calcium bolus supplementation on early-lactation health and milk yield in commercial dairy herds. *J Dairy Sci* 2012; 95:7051-7065.
32. Pauli JV, Allsop TF. Plasma and cerebrospinal fluid magnesium, calcium and potassium concentrations in dairy cows with hypomagnesaemic tetany. *NZ Vet J* 1974; 22:227-231.
33. Peek SF, Divers TJ, Rebhun WC. Hypokalemia in dairy cattle. *Compend Contin Educ Pract Vet* 2002; 24:S18-S24.
34. Reinhardt TA, Lippolis JD, McCluskey BJ, Goff JP, Horst RL. Prevalence of subclinical hypocalcemia in dairy herds. *Vet J* 2011; 188:122-124.
35. Rodríguez EM, Arís A, Bach A. Associations between subclinical hypocalcemia and postparturient diseases in dairy cows. *J Dairy Sci* 2017; 100:7427-7434.
36. Sasaki K, Sasaki K, Sato Y, Devkota B, Furuhama K, Yamagishi N. Response of Holstein cows with milk fever to first treatment using two calcium regimens: A retrospective clinical study. *J Vet Med Sci* 2013; 75:373-376.
37. Sattler N, Fecteau G. Hypokalemia syndrome in cattle. *Vet Clin North Am Food Anim Pract* 2014; 30:351-357.
38. Schonewille JT. Magnesium in dairy cow nutrition: An overview. *Plant and Soil* 2013; 368:167-178.
39. Shappell NW, Herbein JH, Deftos LJ, Aiello RJ. Effects of dietary calcium and age on parathyroid hormone, calcitonin and serum and milk minerals in the periparturient dairy cow. *J Nutr* 1987; 117:201-207.
40. Shu S, Bai Y, Wang G, Xiao X, Fan Z, Zhang J, Zhao C, Zhao Y, Xia C, Zhang H. Differentially expressed serum proteins associated with calcium regulation and hypocalcemia in dairy cows. *Asian-Australasian J Anim Sci* 2017; 30:893-901.
41. Smith BP, George LW, Angelos S, House JK. Down cows: Causes and treatments. *Proceedings.* 30th Annu Conf Am Assoc Bov Pract 1997; 43-45.
42. Thilsing-Hansen T, Jørgensen RJ, Østergaard S. Milk fever control principles: A review. *Acta Vet Scand* 2002; 43:1-19.
43. USDA National Animal Health Monitoring System. Dairy 2002 Part I: Reference of dairy health and management in the United States, 2002. Available at: https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy02/Dairy02_dr_PartI_1.pdf. Accessed Feb 7, 2020.
44. USDA National Animal Health Monitoring System. Dairy 2007 Part I: Reference of dairy cattle health and management practices in the United States, 2007. Available at: https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy07/Dairy07_dr_PartI_1.pdf. Accessed Feb 7, 2020.
45. USDA National Animal Health Monitoring System. Dairy 2014: Health and management practices on U.S. dairy operations, 2014. Available at: https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy14/Dairy14_dr_PartIII.pdf. Accessed Feb 7, 2020.
46. Wagner SA, Schimek DE. Evaluation of the effect of bolus administration of 50% dextrose solution on measures of electrolyte and energy balance in postpartum dairy cows. *Am J Vet Res* 2010; 71:1074-1080.

What every practitioner should know about calf barn ventilation

Gabe Middleton, DVM, DABVP (Dairy)
Orrville Veterinary Clinic, Orrville, OH 44667

Abstract

Bovine respiratory disease (BRD) is financially significant to a dairy operation due to treatment costs, veterinary costs, loss of replacements, and reduced future production potential. High air bacterial counts have been shown to increase incidence of respiratory disease. Positive pressure tube ventilation systems aim to reduce air bacterial counts and noxious agents by driving fresh, outside air to the microenvironment of the calf. It is important for dairy practitioners to understand the basics of these systems so that they can make recommendations or troubleshoot problems.

Key words: BRD, tube, ventilation, calves

Résumé

Le syndrome respiratoire bovin a un impact économique important dans une ferme laitière en raison des coûts de traitement, des dépenses pour les soins vétérinaires, des pertes de remplacement et d'un potentiel moindre de production future. Un nombre élevé de bactéries dans l'air a été associé à une augmentation de l'incidence des maladies respiratoires. Les systèmes de ventilation en pression positive ont comme but de réduire le nombre de bactéries et de produits nocifs dans l'air en poussant l'air frais de l'extérieur vers le microenvironnement du veau. Il est important que le praticien dans une ferme laitière comprenne les rudiments de ces systèmes de ventilation afin de pouvoir faire des recommandations ou de résoudre les problèmes.

Introduction

Bovine respiratory disease is a common cause of financial loss on a dairy operation. BRD incidence can change, depending on management and environmental factors. Veterinary practitioners focus tremendous effort on improving immune function through vaccination programs and effective colostrum management. While these efforts are critically important, ventilation in calf and heifer facilities deserves evaluation to determine if air quality is causing either clinical BRD or subclinical lung lesions.

BRD causes increases in direct costs (treatment costs, veterinary costs, death), but it also causes increases in indirect costs such as reduced future performance. It is well established that calves treated for respiratory disease tend to produce less first-lactation milk and have an increased age at first calving.[2]

High air bacterial counts have been shown to increase incidence of respiratory disease.[2] Positive pressure tube ventilation (PPTV) systems aim to reduce air bacterial counts and noxious gases, thereby decreasing respiratory disease. These systems are designed to maintain 4 air exchanges per hour to remove moisture and airborne bacteria and contaminants.[1] When properly designed, PPTV systems aim to provide a uniform distribution of air throughout the barn, without creating a draft on the calf.[3,4] Mathematical formulas factoring in several variables were used to develop a spreadsheet for designing and analyzing PPTV systems in calf facilities. This Excel spreadsheet was developed by the University of Wisconsin Dairyland Initiative and is available for use by trained consultants. The spreadsheet ensures that the fan's static pressure and tube's discharge coefficient and aperture ratio are at the desired levels to ensure that air volume and velocity are similar at every hole on the tube and the fan is performing as expected while under the load of the tube.[3]

Veterinary practitioners need to be aware that housing calves and heifers in a barn, particularly in larger groups, is a risk factor for BRD at least partially due to an increase in bacterial air counts and other noxious agents. Even if the practitioner is not proficient in designing PPTV systems, they need to be able to recommend in what situations a system will improve respiratory health and to identify when existing systems are not functioning properly.

Most indoor calf and heifer facilities benefit from the installation of a PPTV system. Producers need to be convinced of the economic benefit. Practitioners provide the expertise to examine the direct and indirect costs of BRD based on the morbidity and mortality and convince the producer of the benefit. Practitioners also need to steer the producer in the right direction in regards to design of the system. The University of Wisconsin Dairyland Initiative spreadsheet for trained consultants is used to design a PPTV system for each individual barn. Producers may choose to save money by purchasing a "cookie cutter" system that is not designed specifically for their facility. This situation invariably leads to disappointment in the performance of the system.

Lastly, practitioners need to be able to evaluate current PPTV systems that are in place to determine if they are effective at reducing air bacterial counts. While not all practitioners have access to equipment to directly test air bacterial counts, simple observations are often very helpful

to determine the effectiveness of the system. Evaluate the fan to determine if dust build-up or other objects are impeding air output. Check the tube for tears or ripped holes. Tears most commonly occur as the tube exits the fan shroud. Location of the fan and holes is also a simple observation that practitioners can make. If the tube is not located over the pens where calves are located or the hole location appears to be directing air to walkways, walls, etc., the system deserves some further analysis.

Conclusion

Veterinary practitioners can make recommendations on the installation or troubleshooting of PPTV systems and can have a significant positive impact on the reduction of BRD in calf and heifer facilities. These recommendations also help the producer realize that the practitioner is genuinely concerned about calf health and not only interested in selling drugs or vaccines.

References

1. Bates DW, Anderson JF. Calculation of ventilation needs for confined cattle. *J Am Vet Med Assoc* 1979;174:581-589.
2. Soberon F, Raffrenato E, Everett RW, et al. Preweaning milk replacer intake and effects on long term productivity of dairy calves. *J Dairy Sci* 2012;95:783-793.
3. Wells MW, Amos ND. Design of air distribution systems for closed greenhouses, in *Proceedings*. Acta Horticulture 361, 1994;93-104.
4. Wilson JD, Walker JN, Albright LD. Ventilation air distribution. In: Hellickson, Walker, eds. *Ventilation of agricultural structures*. St. Joseph, Michigan: Amer Soc Agre Engineers, 1983;25-43.

The evolution of fertility programs for lactating dairy cows

P. M. Fricke, PhD
Department of Dairy Science, University of Wisconsin - Madison, 1675 Observatory Drive, Madison, WI 53706,
Email: pmfricke@wisc.edu

Introduction

Synchronization protocols have been incorporated widely into reproductive management programs by most dairy farms in the US.[12,48] At first glance, it may seem that the newly released Reproductive Management Strategies for Dairy Cows protocol published by the Dairy Cattle Reproduction Council (DCRC) offers many options. In reality, reproductive management strategies have generally consolidated into a few management options depending on the extent to which farms want to use artificial insemination (**AI**) to a detected estrus versus timed artificial insemination (**TAI**). It is important to clarify that there is not one "right way" to approach reproductive management on all dairy farms. Many strategies can be implemented to achieve excellent 21-day pregnancy rates by increasing the AI service rate alone.[22] Newer fertility programs increase both service rate as well as pregnancies per artificial insemination (**P/AI**).[15] Each individual farm must implement a plan to submit cows for first AI and to identify non-pregnant cows and return them to AI service to maximize their 21-day pregnancy rate.

Dairy farmers, dairy veterinarians, and dairy consultants are continually challenged to stay current on the latest recommendations for synchronization protocols. An excellent and up-to-date source of information on synchronization protocols can be found at the DCRC web site: http://www.dcrcouncil.org/. Protocols recommended by the DCRC are reviewed and updated by researchers who develop and test these protocols, and are based on the latest peer-reviewed research published in the scientific literature. The purpose of this paper is to overview the key research underlying development of fertility programs for lactating dairy cows.

Detection of Estrus Followed by Timed AI

Artificial insemination (**AI**) to a detected estrus continues to play an important role in the overall reproductive management program on almost all dairy farms.[12] Use of detection of estrus alone for submitting lactating dairy cows for first AI, however, generally results in poor reproductive performance because of 2 broad limitations associated with detection of estrus. The first limitation is with the human element (i.e., visual observation of estrus) in which dairy personnel must visually observe estrous behavior. Many technologies have been developed and introduced throughout the years to help overcome problems with the human element of detection of estrus. These technologies include pressure-activated heat mount devices and androgenized females,[32] tail chalking, pedometry,[49] and radiotelemetry.[20,69] Dogs have even been trained to detect estrus-related odors in dairy cows.[36] More recently, activity monitoring systems that use accelerometer technology to detect increased physical activity associated with behavioral estrus have been widely adopted by dairy farms. A second limitation of detection of estrus pertains to the biology of the high-producing dairy cow. Cow-related biological factors that limit detection of estrus include the effect of high milk production on the duration of estrus,[39] ovulation failure after expression of estrus and ovulation without accompanying estrous behavior,[41,67] and anovular conditions in dairy cows.[72] Taken together, these human-related and cow-related issues substantially limit AI service rates and 21-d pregnancy rates in dairy herds that rely on detection of estrus alone for submitting cows for AI.

A long-standing goal of reproductive biologists was to develop a hormonal synchronization protocol that would allow for TAI, thereby increasing the AI service rate. This goal was realized in 1995 with publication of the Ovsynch protocol, a synchronization protocol in which 3 sequential hormonal treatments are used to control ovarian function.[51] In the first field trial that evaluated the Ovsynch protocol for reproductive management,[52] lactating dairy cows managed using only TAI without detection of estrus had fewer median days to first AI (54 vs 83) and fewer days open (99 vs 118) than cows inseminated to estrus, whereas P/AI to first AI was similar (37% vs 39% for TAI vs estrus, respectively) even though cows managed using TAI were inseminated earlier postpartum. To deal with cows failing to be detected in estrus, some farms submit cows for first AI from the end of the voluntary waiting period to 80 DIM based on a detected estrus followed by submission of cows failing to be detected in estrus to an Ovsynch protocol and TAI. Because of the human-related and cow-related limitations to detection of estrus, all farms can increase reproductive performance by combining detection of estrus with use of Ovsynch and TAI for cows failing to be detected in estrus.

Presynchronization Methods Used Before TAI

Presynchronization strategies were initially developed when it was reported that initiation of an Ovsynch protocol between days 5 to 12 of the estrous cycle resulted in more P/AI than initiation of the protocol earlier or later during the

estrous cycle.[13,44,68] There are 2 broad categories of presynchronization strategies: 1) presynchronization using $PGF_{2\alpha}$, and 2) presynchronization that combines GnRH and $PGF_{2\alpha}$.

Presynchronization using $PGF_{2\alpha}$

The first presynchronization strategy tested used 2 $PGF_{2\alpha}$ treatments administered 14 d apart, with the second $PGF_{2\alpha}$ treatment preceding the first GnRH treatment of an Ovsynch protocol by 12 d[45] (**Presynch-Ovsynch**). When only cycling cows were included in the statistical analysis, P/AI to TAI increased from 29% for cows submitted to an Ovsynch protocol to 43% for cows submitted to a Presynch-Ovsynch protocol. Two things need to be clarified regarding this presynchronization strategy. First, the authors never intended that cows be inseminated to estrus during the protocol as is now commonly practiced. In fact, a recent meta-analysis of 3 randomized controlled studies including 1,689 cows concluded that inseminating cows that show estrus after the second $PGF_{2\alpha}$ treatment of a Presynch-Ovsynch protocol decreased P/AI compared to when all cows were allowed to complete the protocol and receive TAI.[6] This decrease in P/AI occurs because cycling cows that are presynchronized so that the Ovsynch protocol is initiated at an optimal stage of the estrous cycle are removed from the TAI protocol, thereby negating the presynchronization effect. Second, the 2 $PGF_{2\alpha}$ treatments preceding the Ovsynch protocol were never intended to "clean the uterus", although this effect could certainly be beneficial. An updated meta-analysis on the effect of $PGF_{2\alpha}$ therapy on bovine endometritis that included 9 experiments in 8 eligible studies and a total of 5,563 cows concluded that a positive effect on reproductive outcomes could not be shown.[33] Indeed, administration of either 1 or 2 $PGF_{2\alpha}$ treatments before initiation of a Double-Ovsynch protocol had no effect on uterine health, P/AI, or maintenance of pregnancy in lactating Holstein cows.[37]

Even though the Presynch-Ovsynch protocol was originally developed to increase P/AI of cows submitted to TAI, many farms inseminate cows to a detected estrus after the second $PGF_{2\alpha}$ treatment of a Presynch-Ovsynch protocol, a practice commonly referred to as "cherry picking heats", followed by submission of cows not detected in estrus to an Ovsynch protocol. Decreasing the interval between the second $PGF_{2\alpha}$ treatment of Presynch to initiation of the Ovsynch protocol from 14 to 11 d, however, increased ovulatory response to the first GnRH treatment and increased P/AI by approximately 7 percentage points when all cows were submitted to TAI.[26] Thus, if a Presynch-Ovsynch protocol is used for 100% TAI for first service, a shorter interval (i.e., 10 to 12 d) between the second $PGF_{2\alpha}$ treatment and initiation of the Ovsynch protocol is better. When cows were inseminated to estrus after the second $PGF_{2\alpha}$ treatment of a Presynch-Ovsynch protocol, no difference in P/AI was reported when a 12 d vs a 14 d interval was compared[30] supporting the idea that inseminating cows to estrus during a Presynch-Ovsynch protocol negates the effect of presynchronization.[25] Further, anovular cows submitted to a Presynch-Ovsynch protocol have fewer P/AI than their cycling herd mates. Because anovular cows lack a CL and therefore do not respond to the first 2 $PGF_{2\alpha}$ treatments of a Presynch-Ovsynch protocol, the Ovsynch protocol is initiated in a low progesterone (**P4**) environment resulting in fewer P/AI to TAI.[15] Because anovular cows represent 20% to 30% of cows submitted for first TAI,[1,56] presynchronization strategies using $PGF_{2\alpha}$ alone with or without inclusion of detection of estrus do not yield high P/AI to Timed AI.

Presynchronization that Combines GnRH and $PGF_{2\alpha}$

Two limitations of a presynchronization strategy that uses $PGF_{2\alpha}$ alone are that 1) $PGF_{2\alpha}$ does not affect anovular cows or resolve the anovular condition before initiation of the Ovsynch protocol, and 2) follicular growth is not tightly synchronized after 2 sequential $PGF_{2\alpha}$ treatments administered 14 d apart. Newer presynchronization strategies that combine GnRH and $PGF_{2\alpha}$ overcome both of these limitations, thereby increasing P/AI to TAI. Cows that were presynchronized using an Ovsynch protocol (i.e., a **Double-Ovsynch** protocol) had more P/AI than cows submitted to a Presynch-Ovsynch protocol (50% vs 42%).[60] In a subsequent study, there was a treatment by parity interaction in which the Double-Ovsynch protocol increased P/AI for primiparous but not multiparous cows.[35] We now know this parity effect is due to incomplete luteal regression, particularly for multiparous cows.[73]

Presynchronization strategies have used a combination of GnRH and $PGF_{2\alpha}$ 6 to 7 d before G1 (i.e., **G6G** and **PG-3-G**.[3,63] Presynchronization using a PG-3-G protocol yielded more P/AI than inseminating cows at estrus during cooler weather and was superior to a Presynch-Ovsynch 10 protocol during the summer.[63] Inclusion of GnRH into a presynchronization strategy increases P/AI to TAI by resolving the anovular condition before initiation of the Ovsynch protocol, by more tightly controlling follicular development and luteal regression, and by presynchronizing cows so that the Ovsynch protocol is initiated on either day 6 or 7 of the estrous cycle in a high proportion of cows, thereby optimizing the response of cows to each sequential treatment of the Ovsynch protocol.[15,64]

Synchronization Methods for TAI

Over time, there have been several variations of timing of treatments during an Ovsynch protocol that have been compared and used on dairy farms. For the purposes of this discussion, the first GnRH treatment of the Ovsynch protocol will be referred to as **G1**, and the last GnRH treatment will be referred to as **G2**. A number of experiments have compared various timings of the treatments within the Ovsynch protocol as well as timing of AI relative to the last GnRH treatment of the protocol. These variations can lead to differences in P/AI, and a review of several key studies can

help farms to determine which of the 4 variations may work best for a given situation.

In the first published experiment using Ovsynch to hormonally synchronize ovulation,[57] lactating cows were submitted to TAI approximately 24 h after the last GnRH treatment of the protocol. All cows (n=20) ovulated to the last GnRH treatment of the Ovsynch protocol within 24 to 32 h, which is similar to the interval from the first standing event of estrus to ovulation of 27.6 h.[69] Thus, from a physiologic perspective, timing of ovulation is similar when comparing the interval from the first standing event of estrus or the last GnRH treatment of an Ovsynch protocol to ovulation.

To assess the effect of timing of AI relative to a synchronized ovulation, lactating dairy cows (n = 732) were randomly assigned to 5 treatments by stage of lactation and parity.[53] Ovulation was synchronized using an Ovsynch 48 protocol, and TAI was varied from 0, 8, 16, 24, or 32 h relative to G2. In this study, the 24 h treatment is equivalent to the **Ovsynch 48** protocol. Overall, cows in the 0, 8, 16, and 24 h treatments had more P/AI than cows in the 32 h treatment (Table 1). Thus, although no statistical difference in fertility was detected when TAI occurred from 0 to 24 h after the last GnRH treatment of the Ovsynch protocol, inseminating too late (i.e., at 32 hours) resulted in fewer P/AI.[53] Although this study included more than 700 cows, the number of experimental units in each treatment was less than 150 cows, thereby decreasing the statistical power necessary to detect differences among these treatments that may be physiologically relevant.

To further evaluate timing of AI relative to G2, a field trial was conducted to compare 2 variations of a Cosynch protocol (i.e., Cosynch 48 and Cosynch 72 compared in 2 earlier experiments),[50,61] in which TAI occurred concomitant to G2, with a variation of the Ovsynch protocol in which TAI occurred 16 h after G2.[10] This third treatment is now referred to as an **Ovsynch 56** protocol. Timing of AI in an Ovsynch 56 protocol is supported by the data in Table 1 in which the 16 h interval from the last GnRH treatment to TAI resulted in numerically (but not statistically) greater fertility than the other treatments, as well as data reporting that optimal fertility should occur when cows are inseminated around 15 to 24 h before ovulation.[20,69] Because timing of ovulation is similar when comparing the interval to ovulation from the first standing event of estrus or G2, timing of AI based on a Cosynch protocol will not optimize timing of AI relative to an induced ovulation.

Most farms using an Ovsynch 56 protocol administer G1, the $PGF_{2\alpha}$ treatment, and TAI in the morning, whereas G2 is administered in the afternoon to achieve a 56 h interval from the $PGF_{2\alpha}$ treatment to the last GnRH treatment of the Ovsynch protocol and a 16 h interval from the last GnRH treatment to TAI. Despite the data in Table 2 supporting that an Ovsynch 56 protocol yields more P/AI, it is difficult for some farms to implement this timing of treatments due to the inconvenience or inability to handle cows in the afternoon. Most of these farms prefer the timing of the **Ovsynch 48** protocol or a **Cosynch 72** protocol. Thus, these Ovsynch variations are based on ease of implementation on farms rather than biology. Because of the extended interval between the last GnRH treatment of the Ovsynch protocol and TAI in a Cosynch 72 protocol, many cows will display estrus more than 12 h before scheduled TAI, thereby decreasing fertility to TAI.[10] Detection of estrus and AI from the $PGF_{2\alpha}$ treatment to the last GnRH treatment of a Cosynch 72 protocol can help to mitigate the decreased fertility to TAI when using this protocol variation.

The last option is a **5-day Cosynch** protocol in which the interval between G2 and the $PGF_{2\alpha}$ treatment is decreased from 7 (7-d protocol) to 5 (5-d protocol) d. The 5-day Cosynch

Table 1. Effect of timing of AI relative to the last GnRH treatment of an Ovsynch 48 protocol on pregnancies per artificial insemination (P/AI) in lactating Holstein cows.[1]

	Hours from second GnRH injection of Ovsynch to TAI					
Item	0	8	16	24	32	Total
n	149	148	149	143	143	732
P/AI (%)	37	41	45	41	32[a]	39

[1]Adapted from Pursley et al, 1998.

[a]Differs from other treatments within a row (P<0.10).

Table 2. Effect of treatment on pregnancies per artificial insemination (P/AI) and pregnancy loss in lactating Holstein cows.[1]

Item	Cosynch 48	Ovsynch 56	Cosynch 72
P/AI 31-33 d, % (n)	27 (494)	36 (457)	27 (517)
Least squares estimate	29[a]	39[b]	25[a]
P/AI 52-54 d, % (n)	25 (493)	33 (450)	25 (513)
Least squares estimate	27[a]	36[b]	23[a]
Pregnancy loss, % (n)	5 (131)	5 (158)	7 (137)

[1]Adapted from Brusveen et al, 2008.

[a,b]Proportions with different superscripts differ (P < 0.0).

protocol was first reported in a series of experiments in beef cows.[8] Although timing of AI after the $PGF_{2\alpha}$ treatment differed between cows in the 7-d protocol than in the 5-d protocol, cows submitted to the 5-d protocol has more P/AI than cows submitted to the 7-d protocol in 2 experiments (80% vs 67%, respectively and 65% vs 56%, respectively). In 2010, the 5-d Ovsynch protocol was compared to a 7-d Cosynch 72 protocol in lactating Holstein cows.[57] In that study, cows submitted to the 5-d protocol received 2 $PGF_{2\alpha}$ treatments, whereas cows submitted to the 7-d protocol received a single $PGF_{2\alpha}$ treatment. Overall, cows in the 5-d protocol had more P/AI than cows in the 7-d protocol (38% vs 31%). The authors conducted an analysis to control for a difference in luteal regression rates between cows receiving 1 vs 2 $PGF_{2\alpha}$ treatments by analyzing only cows with P4 < 1 ng/mL on the day of TAI, and cows submitted to the 5-d protocol had more P/AI than cows submitted to the 7-d protocol (39% vs 34%). The authors attributed this treatment effect to the decreased period of follicle dominance for cows in the 5-d Cosynch protocol. Colazo and Ambrose[18] also compared a 5-d Cosynch protocol with 2 $PGF_{2\alpha}$ treatments to a 7-d Ovsynch protocol with 1 $PGF_{2\alpha}$ treatment; however, P/AI did not differ between treatments in that study (39% vs 34%).

A recent experiment directly tested the effect of addition of a second $PGF_{2\alpha}$ treatment and the effect of decreasing the duration of the Ovsynch protocol from 7 to 5 d in a Resynch protocol.[58] Lactating Holstein cows (n = 821) were randomly assigned at a nonpregnancy diagnosis (d 0 = 32 d after AI) to 1 of 3 Resynch protocols: 1) 7D1PGF (GnRH, d 0; $PGF_{2\alpha}$, d 7; GnRH, d 9.5); 2) 7D2PGF (GnRH, d 0; $PGF_{2\alpha}$, d 7; $PGF_{2\alpha}$, d 8; GnRH, d 9.5); and 3) 5D2PGF (GnRH, d 2; $PGF_{2\alpha}$, d 7; $PGF_{2\alpha}$, d 8; GnRH, d 9.5). All cows received an intravaginal P4 insert[a] at G1, which was removed at the first $PGF_{2\alpha}$ treatment, and all cows received a TAI approximately 16 hours after G2. Overall, there was no effect of treatment on P/AI (Table 3). When these data were analyzed based on the presence or absence of a CL at G1, cows lacking a CL and receiving 2 $PGF_{2\alpha}$ treatments had more (P=0.03) P/AI than cows receiving 1 $PGF_{2\alpha}$ treatment regardless of protocol duration (i.e., 5 vs 7 d), whereas there was no effect of treatment for cows that had a CL at G1 (Table 3). We concluded that addition of a second $PGF_{2\alpha}$ treatment to a Resynch protocol increased the proportion of cows undergoing complete luteal regression thereby increasing P/AI, particularly for cows that have low P4 at G1, whereas decreasing the duration of the Ovsynch protocol did not affect P/AI. Nonetheless, the 5-d Cosynch protocol is a good option for dairy farms that want to administer all protocol treatments and TAI in the morning, thereby simplifying implementation of this protocol.

Inclusion of a Second $PGF_{2\alpha}$ Treatment 24 h after the First in Ovsynch Protocols

A major modification to Ovsynch protocols is the recommendation to include a second $PGF_{2\alpha}$ treatment 24 h after the first in the 7 d Ovsynch protocol. Inclusion of a second $PGF_{2\alpha}$ treatment is absolutely necessary for the 5-day Cosynch protocol due to a younger CL at the $PGF_{2\alpha}$ treatment that fails to regress after a single $PGF_{2\alpha}$ treatment.[46,65] Addition of a second $PGF_{2\alpha}$ treatment is highly recommended for all of the 7-day protocols, particularly when used for first TAI after a presynchronization strategy that incorporates both GnRH and $PGF_{2\alpha}$. The lack of complete luteal regression, particularly for multiparous cows which is addressed by the addition of the second $PGF_{2\alpha}$ treatment, was in fact the rate limiting factor for fertility to TAI.[73] Indeed, submission of lactating Holstein cows to a Double-Ovsynch protocol and TAI for first insemination increased the percentage of cows inseminated within 7 d after the end of the voluntary waiting period and increased P/AI at 33 and 63 d after first insemination, resulting in 64% and 58% more pregnant cows, respectively, than submission of cows for first AI after detection of estrus at a similar day-in-milk range.[59]

Several experiments have been conducted to assess the addition of a second $PGF_{2\alpha}$ treatment on luteal regression and P/AI.[2,11,66,73] A recent meta-analysis of data from these experiments was conducted with the primary objective to evaluate the effect of an additional $PGF_{2\alpha}$ treatment during the Ovsynch protocol on luteal regression and P/AI.[7] The meta-analysis included 7 randomized controlled experiments from 6 published manuscripts including 5,356 cows, and information regarding luteal regression at the end of the Ovsynch protocol was available for 1,856 cows. Includ-

Table 3. Effect of presence of a corpus luteum (CL) at Day 0 on pregnancies per AI (P/AI) in Holstein dairy cows 32 days after TAI[1].

	Treatment			*P*-value[2]		
P/AI	**7D1PGF**	**7D2PGF**	**5D2PGF**	**T**	**C1**	**C2**
	---------- % (n) ----------					
Overall	36 (266)	41 (268)	44 (265)	0.14	0.05	0.56
Cows with a CL at G1	38 (196)	40 (191)	43 (189)	0.51	0.35	0.49
Cows lacking a CL at G1	30 (70)	46 (77)	45 (76)	0.11	0.03	0.98

[1]Adapted from Santos et al., 2016.

[2]C1: preplanned contrast between 7D1PGF (one $PGF_{2\alpha}$) and 7D2PGF + 5D2PGF (two $PGF_{2\alpha}$) treatments; C2: preplanned contrast between 7D2PGF (7-d protocol) and 5D2PGF (5-d protocol) treatments.

ing a second $PGF_{2\alpha}$ treatment 24 h after the first during the Ovsynch protocol increased the relative risk (RR) of complete luteal regression at the end of the Ovsynch protocol (RR = 1.14; 95% confidence interval = 1.10 to 1.17) using a fixed effects model and the RR for pregnancy (RR = 1.14; 95% confidence interval = 1.06 to 1.22) 32 d after TAI using a fixed effects model. No heterogeneity was observed among the 6 manuscripts regarding complete luteal regression and P/AI. The authors concluded that there was a clear benefit of including an additional $PGF_{2\alpha}$ treatment during the Ovsynch protocol on luteal regression (+11.6 percentage units) and on P/AI (+4.6 percentage units). Inclusion of a second $PGF_{2\alpha}$ treatment in 7-d Ovsynch protocols is now recommended to increase fertility to TAI.

Although addition of a second $PGF_{2\alpha}$ treatment to Ovsynch protocols dramatically increases luteolysis and P/AI, it also increases the number of times cows have to be handled. A common question is whether increasing the dose of $PGF_{2\alpha}$ at a single time can achieve a similar rate of luteolysis and/or P/AI as including a second $PGF_{2\alpha}$ treatment. Two prostaglandin products are available and approved for use in dairy cows in the US: dinoprost (i.e., native $PGF_{2\alpha}$) and cloprostenol (a $PGF_{2\alpha}$ analog). Doubling the dose of dinoprost from 25 to 50 mg does not appear to perform as well as 2 25 mg dinoprost treatments administered 24 h apart for first[66] or Resynch[2] TAI. Increasing the dose of cloprostenol from 500 to 750 µg increased the rate of luteal regression primarily in multiparous cows, but tended to increase fertility (P=0.05) only at the pregnancy diagnosis 39 days after TAI.[28] Finally, delaying a single dinoprost treatment by 24 h (i.e., from day 7 to day 8 of the protocol) without adjusting G2 and TAI decreased luteal regression and P/AI.[47] Because of the complexity of much of the data generated thus far, more studies are needed to definitively answer this question using both prostaglandin products. At the present time, the new DCRC recommendation of adding a second $PGF_{2\alpha}$ treatment 24 h after the first to both 7 d and 5 d Ovsynch protocols should be followed.

Resynchronization Programs

There are now 2 major options for Resynchronization programs based on timing of nonpregnancy diagnosis and initiation of the Resynch protocol. Although both options include detection of estrus and AI after an initial AI, some farms choose to minimize use of AI to estrus and submit nearly all cows to TAI. In this management scenario, the AI service rate is fixed based on the interval between inseminations which is set by the timing of pregnancy diagnosis, and the primary emphasis is focused on compliance to the protocols, a key element to their success. Nonetheless, including detection of estrus after an initial AI can increase 21-d pregnancy rates by increasing the AI service rate. Farm managers should keep in mind that they must manage 2 reproductive management systems in this scenario; 1 for the TAI protocol, and the other for the daily chore of detection of estrus and AI. Nonetheless, most of the DCRC award-winning dairy herds in 2017, which all had annualized 21-day pregnancy rates between 30% and 40%, submitted all cows to TAI after a fertility program, inseminated any cows detected in estrus after first TAI, and then submitted cows not detected in estrus and diagnosed not pregnant to a Resynch protocol.

Return to Estrus after AI

Accurate detection of cows failing to conceive to AI and returning to estrus from 18 to 32 d after AI is the earliest method for identifying and re-inseminating cows failing to conceive after AI. There are, however, several challenges for detection of estrus after AI. First, only, 52% of the eligible cows were detected in estrus and re-inseminated between AI and pregnancy diagnosis when detection of estrus was performed through continuous monitoring of activity after a previous AI until pregnancy diagnosis 32 d after AI.[29] Second, estrous cycle duration varies widely with a high degree of variability among individual cows.[54] Finally, the high rate of early pregnancy losses in dairy cows increases the interval from insemination to return to estrus for cows that establish pregnancy early then undergo pregnancy loss.[55] Because of these issues with nonpregnant cows returning to estrus, implementation of a Resynch strategy is critical for achieving high 21-d pregnancy rates.

Timing of Pregnancy Diagnosis and Initiation of Resynch

In the first strategy for Resynch, nonpregnancy diagnosis is conducted before initiation of the Resynch protocol, whereas in the second strategy, the first GnRH treatment of a Resynch protocol is initiated 7 d before nonpregnancy diagnosis. Choosing between these 2 Resynch variations depends on the reproductive management goals of the dairy farm. The advantage of delaying G1 until the pregnancy diagnosis is that more time is allowed for cows to show estrus for submission to AI, thereby decreasing the total number of cows submitted to a Resynch protocol.[9] For herds focused on detecting cows in estrus and minimizing cows submitted to TAI, this is a good option. The disadvantage of this approach is that the Resynch protocol is delayed by 1 week due to the need to identify nonpregnant cows before G1. The obvious disadvantage of administering G1 before pregnancy diagnosis is that all cows are treated with GnRH regardless of their pregnancy status which is unknown at the time of treatment. Herds that have excellent detection of estrus after an AI have a high proportion of cows diagnosed pregnant at the herd check, and these cows are unnecessarily treated with GnRH. By contrast, an advantage of administering G1 before pregnancy diagnosis is that TAI occurs 1 week earlier. Overall, P/AI did not differ between cows submitted to a Resynch protocol 32 or 39 d after AI,[38] so the earlier Resynch protocol decreases the interval between TAI services, thereby increasing the AI service rate. A second advantage of administering G1 before pregnancy diagnosis is that management decisions can be made based

on the presence or absence of a CL at the $PGF_{2\alpha}$ treatment of the Ovsynch protocol (see the next section).

Presence or Absence of a CL at Initiation of the Ovsynch Protocol and Fertility to Resynch

Based on P4 profiles at each treatment during the Ovsynch protocol, the best indicator of poor fertility to TAI is low P4 (i.e., cows lacking a CL) at the $PGF_{2\alpha}$ treatment of the Ovsynch protocol.[15] One of the first strategies to increase P/AI to a Resynch protocol attempted to determine the optimal interval after an initial TAI to initiate G1 based on the physiology of the estrous cycle.[24] Assuming an estrous cycle duration of 21 to 23 d, administering G1 32 d after AI should correspond to initiating the Resynch protocol around day 6 to 14 of the estrous cycle, a stage of the estrous cycle when a dominant follicle and a CL with mid-level P4 concentrations should be present. Cows identified not pregnant 32 d after AI with a CL at G1 have more P/AI than cows without a CL.[27,38] In several studies however, 16%, 22%, and 35% of cows diagnosed not pregnant 32 d after TAI and that were not presynchronized with GnRH 7 d before pregnancy diagnosis lacked a CL at G1.[24,29] When cows were synchronized for first TAI and P4 profiles and CL diameter was measured until a pregnancy diagnosis 32 d later, 19% of cows diagnosed not pregnant lacked a CL > 10 mm in diameter.[55] Thus, Resynch protocols are initiated in a low-P4 environment in up to one-third of nonpregnant cows which leads to a lack of complete luteal regression after treatment with $PGF_{2\alpha}$ 7 d later, resulting in fewer P/AI. Inclusion of a second $PGF_{2\alpha}$ treatment 24 h after the first into a Resynch protocol increases P/AI for cows initiating Resynch in a low-P4 environment.[14]

One strategy to treat nonpregnant cows without a CL at G1 is to supplement with exogenous P4 during the Resynch protocol. Cows without a CL at G1 and treated with a CIDR insert for 7 d had more P/AI at first as well as Resynch TAI.[4,5,17] Many veterinarians now use the presence or absence of a CL at a nonpregnancy diagnosis to implement a strategy to increase fertility to Resynch protocols or to increase the proportion of cows inseminated to a detected estrus after AI. Based on this idea, a recent study assigned cows diagnosed not pregnant to various Resynch strategies based on ovarian structures.[70] The control treatment was a standard Resynch protocol in which G1 was administered 32 d after AI and including a single $PGF_{2\alpha}$ treatment. Alternatively, cows diagnosed not pregnant 32 d after AI were assigned to a Resynch strategy based on the presence or absence of a CL >15 mm in diameter. Nonpregnant cows with a CL received 2 $PGF_{2\alpha}$ treatments 24 h apart followed by GnRH and TAI (i.e., a Resynch protocol without G1), whereas nonpregnant cows without a CL were submitted to a Resynch protocol that included a second $PGF_{2\alpha}$ treatment and a CIDR insert. It is important to note that cows were detected in estrus and inseminated from the initial AI to initiation of each of the 3 Resynch treatments. The authors concluded that the shorter Resynch program decreased time to pregnancy because of a decrease of the interval between AI services for nonpregnant cows with a CL and more P/AI in nonpregnant cows lacking a CL.[70] This Resynch strategy is a good option for herds that combine detection of estrus after first TAI with a Resynch strategy.

Herds that do not incorporate detection of estrus after an initial TAI can implement a Resynch strategy based on ovarian structures as described by Carvalho et al.[15] In this strategy, all cows are treated with GnRH 25 d after TAI. Pregnancy diagnosis is conducted using transrectal ultrasonography 32 d after TAI, and cows diagnosed not pregnant are classified as having or lacking a CL. Nonpregnant cows with a CL continue an Ovsynch 56 protocol by receiving a $PGF_{2\alpha}$ treatment 32 d after TAI with the addition of a second $PGF_{2\alpha}$ treatment 24 h after the first. Nonpregnant cows lacking a CL restart an Ovsynch 56 protocol that includes a second $PGF_{2\alpha}$ treatment 24 h after the first (i.e., GGPPG) as described by Carvalho et al.[14] Intravaginal P4 inserts (1 per cow) are included within the Ovsynch protocol for cows without a CL based on studies in which treatment with exogenous P4 increased P/AI for cows lacking a CL at initiation of an Ovsynch protocol to that of cows with a CL at initiation of an Ovsynch protocol.[4,5]

Low Progesterone, Double-Ovulations, and Twinning: A New Problem

Low P4 during growth of an ovulatory follicle is associated an increased incidence of double ovulation.[71] Cows in which the preovulatory follicle develops in the absence of P4 from a CL have a greater incidence of co-dominant follicles resulting in double ovulations.[34,62] All dairy cows experience a low P4 environment during the postpartum anovular period from calving to first ovulation. Double ovulation rate after a spontaneous estrus was greater for anovular cows (i.e., low P4) than for cycling cows.[40] Incidence of double ovulation to G1 was greater for anovular than for ovular cows; however, incidence of double ovulation to G2 was similar between ovular and anovular cows.[31] Thus, the first postpartum ovulation results in a high double ovulation rate due to the lack of P4 during growth of the preovulatory follicle, and the first exposure to P4 during the postpartum anovular period decreases the incidence of double ovulation.

To test the effect of P4 during growth of the ovulatory follicle on the incidence of double ovulation, Holstein cows were randomly assigned to 2 presynchronization protocols that manipulated cows into either a high or a low P4 environment during an Ovsynch protocol (Table 4).[19] Cows in the high P4 treatment were submitted to a Double-Ovsynch protocol[60] and had more P4 at the first GnRH treatment of the Ovsynch protocol and at the $PGF_{2\alpha}$ treatment of the Ovsynch protocol than cows in the low P4 treatment. Ovulatory response to the last GnRH treatment of the Ovsynch protocol was similar between treatments; however, cows in the low P4 treatment, had more double ovulations than cows in the high P4 treatment. Furthermore, fertility was greater and pregnancy loss was less for cows in the high vs the low P4 treatment. Thus,

Table 4. Effect of progesterone (P4) during growth of the preovulatory follicle on incidence of double ovulation in Holstein dairy cows.*

Item	Low P4 (n = 259)	High P4 (n = 255)	*P*-value
P4 at 1st GnRH (ng/mL)	0.28	1.84	-
P4 at $PGF_{2\alpha}$ (ng/mL)	2.23	4.40	-
Ovulation to G2 (%)	95	95	NS
Double Ovulation (%)	21	7	<0.05
P/AI at 29 d (%)	33	48	<0.01
Pregnancy loss 29 to 57 d (%)	16	4	<0.05

*Adapted from Cunha et al, 2008.

Table 5. Effect of progesterone (P4) during growth of the preovulatory follicle on follicle size, incidence of double ovulation, pregnancies per artificial insemination (P/AI), and twin pregnancies in Holstein dairy cows.*

Item	Low P4 (n = 40)	High P4 (n = 40)	*P*-value
Follicle size at G2 (mm)	16.4 ± 0.5	14.8 ± 0.3	<0.01
Double ovulations (%)	33 (13/40)	10 (4/40)	<0.01
P/AI at 32 d (%)	53 (21/40)	45 (18/40)	0.97
Twins at 32 d (%)	29 (6/21)	0 (0/18)	<0.01

*Carvalho et al, 2019.

cows with high P4 during growth of the ovulatory follicle had fewer double ovulations, more P/AI, and fewer pregnancy losses than cows with low P4.

It is important to note that the study by Cunha et al was conducted before the second $PGF_{2\alpha}$ treatment was included in the Ovsynch protocol.[19] Therefore, we must now interpret these data based on a current understating of the physiology associated with these protocols in which a lack of complete luteal regression decreases P/AI. Thus, in the study by Cunha et al, cows in the low P4 treatment had high double ovulation rates but low conception rates due to incomplete luteal regression.[19] For cows that initiate an Ovsynch protocol in a low-P4 environment, if you fix the luteal regression problem by adding a second $PGF_{2\alpha}$ treatment, P/AI could increase dramatically due to increased double ovulations[23] followed by increased pregnancy losses for cows that conceive unilateral twins,[42] followed by an increase in twins for cows that maintain the twin pregnancy. Thus, a new problem has arisen concurrent with the recommendation to add the second $PGF_{2\alpha}$ treatment to Ovsynch protocols, particularly when cows initiate the protocol in a low P4 environment.

To further evaluate the effect of manipulating P4 before TAI, lactating Holstein cows (n=80) were synchronized for first TAI using a Double-Ovsynch protocol that included a second $PGF_{2\alpha}$ treatment 24 h after the first, and were randomly assigned to receive 25 mg $PGF_{2\alpha}$ 1 d after the first GnRH treatment of the breeding Ovsynch protocol that included a used CIDR insert (Low P4) or to receive 2 new CIDR inserts during the breeding Ovsynch protocol (High P4). Results of this experiment are shown in Table 5.[16] Incidence of double ovulation was three-fold greater for Low P4 than for High P4 cows. Overall, P/AI at 32 d did not differ between treatments; however, Low P4 cows had more twin pregnancies than High P4 cows. We concluded that low P4 concentrations before TAI increased the incidence of double ovulations and twin pregnancies. The data in Table 5 agree with a larger study in which cows were manipulated into high vs low P4 environments during growth of the ovulatory follicle.[43] In that study, cows that were maintained in a low P4 environment during growth of the ovulatory follicle had a double ovulation rate of 49%, P/AI of 66.4%, and pregnancy loss from 23 to calving of 33%.[43]

To summarize, the problem with the increased risk of double ovulation and twinning occurs when cows are submitted to an Ovsynch protocol that includes a second $PGF_{2\alpha}$ treatment and initiates the protocol in a low-P4 environment. This scenario also leads to increased pregnancy losses due to bilateral twins,[43] and may explain a significant proportion of pregnancy losses that occur in dairy herds). There are 2 primary management scenarios under which this scenario arises. The first scenario is when herds that use a Presynch-Ovsynch protocol for first AI include detection of estrus after the second $PGF_{2\alpha}$ treatment of the protocol. When an activity-monitoring system was used, approximately 70% of cows were inseminated to increased activity after the second $PGF_{2\alpha}$ treatment of a Presynch-Ovsynch protocol, and about half of the cows not detected with increased activity had low-P4 at the first GnRH treatment of the Ovsynch protocol.[25] This scenario can be avoided by using a presynchronization strategy that combines both GnRH and $PGF_{2\alpha}$, because these presynchronization strategies set up a high proportion of cows to have a CL at G1. A second scenario arises when herds submit cows without a CL either knowingly or unknowingly to a Resynch protocol that includes a second $PGF_{2\alpha}$ treatment. This scenario can be avoided by submitting cows to the Resynch protocol based on ovarian structures, with the nonpregnant cows lacking a CL treated with a CIDR insert which should increase P4 during the protocol and decrease the double ovulation rate.

Conclusion

Development and optimization of fertility programs for first and resynch TAI remains an active area of research that has advanced dramatically over the past 20 years and will most certainly change in the future. It takes time for researchers to sift and winnow ideas and data to reach a consensus on protocols to recommend for use on commercial dairy farms, and scientific progress holds the potential to change longstanding recommendations. An excellent and up-to-date source of information on synchronization protocols can be found at the Dairy Cattle Reproduction Council (DCRC) web site: http://www.dcrcouncil.org/.

Endnotes

[a] PRID Delta; Ceva Santé Animale, Libourne, France

References

1. Bamber RL, Shook GE, Wiltbank MC, et al. Genetic parameters for anovulation and pregnancy loss in dairy cattle. *J Dairy Sci* 2009;92:5739-5753.
2. Barletta RV, Carvalho PD, Santos VG, et al. Effect of dose and timing of prostaglandin $F_{2\alpha}$ treatments during a Resynch protocol on luteal regression and fertility in lactating Holstein cows. *J Dairy Sci* 2018;101:1730-1736.
3. Bello NM, Steibel JP, Pursley JR. Optimizing ovulation to first GnRH improved outcomes to each hormonal injection of Ovsynch in lactating dairy cows. *J Dairy Sci* 2006;89:3413-3424.
4. Bilby TR, Bruno RGS, Lager KJ, et al. Supplemental progesterone and timing of resynchronization on pregnancy outcomes in lactating dairy cows. *J Dairy Sci* 2013; 96:7032-7042.
5. Bisinotto, RS, Castro LO, Pansani MB, et al. Progesterone supplementation to lactating dairy cows without a corpus luteum at initiation of the Ovsynch protocol *J Dairy Sci* 2015;98:2515-2528.
6. Borchardt S, Haimerl P, Heuwieser W. Effect of insemination after estrous detection on pregnancy per artificial insemination and pregnancy loss in a Presynch-Ovsynch protocol: A meta-analysis. *J Dairy Sci* 2016;99:2248-2256.
7. Borchardt S, Pohl A, Carvalho PD, et al. Short communication: Effect of adding a second prostaglandin $F_{2\alpha}$ injection during the Ovsynch protocol on luteal regression and fertility in lactating dairy cows: A meta-analysis. *J Dairy Sci* 2018;101:8566-8571.
8. Bridges GA, Helser LA, Grum DE, et al. Decreasing the interval between GnRH and $PGF_{2\alpha}$ from 7 to 5 days and lengthening proestrus increases timed-AI pregnancy rates in beef cows. *Theriogenology* 2008;69:843-851.
9. Bruno RGS, Moraes JGN, Hernández-Rivera JAH, et al. Effect of an Ovsynch56 protocol initiated at different intervals after insemination with or without a presynchronizing injection of gonadotropin-releasing hormone on fertility in lactating dairy cows. *J Dairy Sci* 2014;97:185-194.
10. Brusveen D J, Cunha AP, Silva CD, et al. Altering the time of the second gonadotropin-releasing hormone injection and artificial insemination (AI) during Ovsynch affects pregnancies per AI in lactating dairy cows. *J Dairy Sci* 2008;91:1044-1052.
11. Brusveen DJ, Souza AH, Wiltbank MC. Effects of additional prostaglandin $F_{2\alpha}$ and estradiol-17β during Ovsynch in lactating dairy cows. *J Dairy Sci* 2009;92:1412-1422.
12. Caraviello DZ, Weigel KA, Fricke PM, et al. Survey of management practices on reproductive performance of dairy cattle on large US commercial farms. *J Dairy Sci* 2006;89:4723-4735.
13. Cartmill JA, El-Zarkouny SZ, Hensley BA, et al. Stage of cycle, incidence and timing of ovulation, and pregnancy rates in dairy cattle after three timed breeding protocols. *J Dairy Sci* 2001;84:1051-1059.
14. Carvalho PD, Fuenzalida MJ, Ricci A, et al. Modifications to Ovsynch improve fertility during resynchronization: Evaluation of presynchronization with GnRH 6 days before Ovsynch and addition of a second prostaglandin $F_{2\alpha}$ treatment. *J Dairy Sci* 2015;98:8741-8752.
15. Carvalho PD, Santos VG, Giordano JO, et al. Development of fertility programs to achieve high 21-day pregnancy rates in high-producing dairy cows. *Theriogenology* 2018;114:165-172.
16. Carvalho PD, Santos VG, Fricke HP, et al. Effect of manipulating progesterone before timed artificial insemination on reproductive and endocrine outcomes in high-producing multiparous Holstein cows. *J Dairy Sci* 2019;102:(in press).
17. Chebel RC, Al-Hassan MJ, Fricke PM, et al. Supplementation of progesterone via internal drug release inserts during ovulation synchronization protocols in lactating dairy cows. *J Dairy Sci* 2010;93:922-931.
18. Colazo MG, Ambrose DJ. Effect of initial GnRH and duration of progesterone insert treatment on the fertility of lactating dairy cows. *Reprod Domest Anim* 2015;50:497-504.
19. Cunha AP, Guenther JN, Maroney MJ, et al. Effects of high vs. low progesterone concentrations during Ovsynch on double ovulation rate and pregnancies per AI in high producing dairy cows. *J Dairy Sci* 2008;91(E-Suppl 1):246 (abstr).
20. Dransfield MBG, Nebel RL, Pearson RE, et al. Timing of insemination for dairy cows identified in estrus by a radiotelemetric estrus detection system. *J Dairy Sci* 1998;81:1874-1882.
21. El-Zarkouny SZ, Cartmill JA, Hensley BA, et al. Pregnancy in dairy cows after synchronized ovulation regimens with or without presynchronization and progesterone. *J Dairy Sci* 2004;83:1024-1037.
22. Ferguson JD, Skidmore A. Reproductive performance in a select sample of dairy herds. *J Dairy Sci* 2013;96:1269-1289.
23. Fricke PM, Wiltbank MC. Effect of milk production on the incidence of double ovulation in dairy cows. *Theriogenology* 1999;52:1133-1143.
24. Fricke PM, Caraviello DZ, Weigel KA, et al. Fertility of dairy cows after resynchronization of ovulation at three intervals after first timed insemination. *J Dairy Sci* 2003;86:3941-3950.
25. Fricke PM, Giordano JO, Valenza A, et al. Reproductive performance of lactating dairy cows managed for first service using timed artificial insemination with or without detection of estrus using an activity monitoring system. *J Dairy Sci* 2014;97:2771-2781.
26. Galvão KN, Sá Filho MF, Santos JEP. Reducing the interval from presynchronization to initiation of timed artificial insemination improves fertility in dairy cows. *J Dairy Sci* 2007;90:4212-4218.
27. Giordano JO, Wiltbank MC, Guenther JN, et al. Increased fertility in lactating dairy cows resynchronized with Double-Ovsynch when compared to Ovsynch initiated 32 d after timed artificial insemination. *J Dairy Sci* 2012;95:639-653.
28. Giordano JO, Fricke PM, Bas S, et al. Effect of increasing GnRH and $PGF_{2\alpha}$ dose during Double-Ovsynch on ovulatory response, luteal regression, and fertility of lactating dairy cows. *Theriogenology* 2013;80:773-783.
29. Giordano JO, Stangaferro ML, Wijma R, et al. Reproductive performance of dairy cows managed with a program aimed at increasing insemination of cows in estrus based on increased physical activity and fertility of timed artificial inseminations. *J Dairy Sci* 2015;98:2488-2501.
30. Giordano JO, Thomas MJ, Catucuamba G, et al. Effect of extending the interval from Presynch to initiation of Ovsynch in a Presynch-Ovsynch protocol on fertility of timed artificial insemination services in lactating dairy cows. *J Dairy Sci* 2016;99:746-757.
31. Gümen A, Guenther JN, Wiltbank MC. Follicular size and response to Ovsynch versus detection of estrus in anovular and ovular lactating dairy cows. *J Dairy Sci* 2003;86:3184-3194.
32. Gwazdauskas FC, Nebel RL, Sprecher DJ, et al. Effectiveness of rump-mounted devices and androgenized females for detection of estrus in dairy cattle. *J Dairy Sci* 1990;73:2965-2970.
33. Haimerl P, Heuwiueser W, Arlt S. Short communication: Meta-analysis on therapy of bovine endometritis with prostaglandin $F_{2\alpha}$ – an update. *J Dairy Sci* 2018;101:10557-10564.
34. Hayashi KG, Matsui M, Shimizu T, et al. The absence of corpus luteum formation alters the endocrine profile and affects follicular development during the first follicular wave in cattle. *Reproduction* 2008;136:787-797.
35. Herlihy MM, Giordano JO, Souza AH, et al. Presynchronization with Double-Ovsynch improves fertility at first postpartum artificial insemination in lactating dairy cows. *J Dairy Sci* 2012;95:7003-7014.
36. Kiddy CA, Mitchell DS, Bolt DJ, et al. Detection of estrus-related odors in cows by trained dogs. *Biol Reprod* 1978;19:389-395.
37. Lima FS, Bisinotto RS, Ribeiro ES, et al. Effects of 1 or 2 treatments with prostaglandin $F_{2\alpha}$ on subclinical endometritis and fertility in lactating dairy cows inseminated by timed artificial insemination. *J Dairy Sci* 2013;96:6480–6488.
38. Lopes G Jr, Giordano JO, Valenza A, et al. Effect of timing of initiation of resynchronization and presynchronization with gonadotropin-releasing hormone on fertility of resynchronized inseminations in lactating dairy cows. *J Dairy Sci* 2013;96:3788-3798.
39. Lopez H, Satter LD, Wiltbank MC. Relationship between level of milk production and estrous behavior of lactating dairy cows. *Anim Reprod Sci* 2004;81:209-223.
40. Lopez H, Caraviello DZ, Satter LD, et al. Relationship between level of milk production and multiple ovulations in lactating dairy cows. *J Dairy Sci* 2005;88:2783-93.
41. López-Gatius F, Lopez-Bejar M, Fenech M, et al. Ovulation failure and double ovulation in dairy cattle: Risk factors and effects. *Theriogenology* 2005;63:1298–1307.

42. López-Gatius F, Hunter RHF. Spontaneous reduction of advanced twin embryos: Its occurrence and clinical relevance in dairy cattle. *Theriogenology* 2005;63:118-125.
43. Martins JPN, Wang D, Mu N, et al. Level of circulating concentrations of progesterone during ovulatory follicle development affects timing of pregnancy loss in lactating dairy cows. *J Dairy Sci* 2018;101:10505-10525.
44. Moreira F, de la Sota RL, Diaz T, et al. Effect of day of the estrous cycle at the initiation of a timed artificial insemination protocol on reproductive responses in dairy heifers. *J Anim Sci* 2000;78:1568-1576.
45. Moreira F, Orlandi C, Risco CA, et al. Effects of presynchronization and bovine somatotropin on pregnancy rates to a timed artificial insemination protocol in lactating dairy cows. *J Dairy Sci* 2001;84:1646-1659.
46. Nascimento AB, Souza AH, Keskin A, et al. Lack of complete regression of the Day 5 corpus luteum after one or two doses of $PGF_{2\alpha}$ in nonlactating Holstein cows. *Theriogenology* 2014;81:389-395.
47. Niles AM, Jones AE, Carvalho PD, et al. Delaying administration of prostaglandin $F_{2\alpha}$ by 24 hours during a Double-Ovsynch protocol decreased fertility of lactating Holstein cows to timed artificial insemination. *J Dairy Sci* 2017;100(Suppl 2):284 (abstr).
48. Norman HD, Wright JR, Hubbard SM, et al. Reproductive status of Holstein and Jersey cows in the United States. *J Dairy Sci* 2009;92:3517-3528.
49. Peralta OA, Pearson RE, Nebel RL. Comparison of three estrus detection systems during summer in a large commercial dairy herd. *Anim Reprod Sci* 2005;87:59-72.
50. Portaluppi MA, Stevenson JS. Pregnancy rates in lactating dairy cows after presynchronization of estrous cycles and variations of the Ovsynch protocol. *J Dairy Sci* 2005;88:914-921.
51. Pursley JR, Mee MO, Wiltbank MC. Synchronization of ovulation in dairy cows using $PGF_{2\alpha}$ and GnRH. *Theriogenology* 1995;44:915-923.
52. Pursley JR, Kosorok MR, Wiltbank MC. Reproductive management of lactating dairy cows using synchronization of ovulation. *J Dairy Sci* 1997;80:301-306.
53. Pursley JR, Silcox RW, Wiltbank MC. Effect of time of artificial insemination on pregnancy rates, calving rates, pregnancy loss, and gender ratio after synchronization of ovulation in lactating dairy cows. *J Dairy Sci* 1998;81:2139-2144.
54. Remnant JG, Green MJ, Huxley JN, et al. Variation in the interservice intervals of dairy cows in the United Kingdom. *J Dairy Sci* 2015;98:889-897.
55. Ricci A, Carvalho PD, Amundson MC, et al. Characterization of luteal dynamics in lactating Holstein cows for 32 days after synchronization of ovulation and timed artificial insemination. *J Dairy Sci* 2017;100:9851-9860.
56. Santos JEP, Rutigliano HM, Sa Filho MF. Risk factors for resumption of postpartum estrous cycles and embryonic survival in lactating dairy cows. *Anim Reprod Sci* 2009;110:207-221.
57. Santos JEP, Narciso CD, Rivera F, et al. Effect of reducing the period of follicle dominance in a timed artificial insemination protocol on reproduction of dairy cows. *J Dairy Sci* 2010;93:2976-2988.
58. Santos VG, Carvalho PD, Maia C, et al. Adding a second prostaglandin $F_{2\alpha}$ treatment to but not reducing the duration of a PRID-Synch protocol increases fertility after resynchronization of ovulation in lactating Holstein cows. *J Dairy Sci* 2016;99:3869-3879.
59. Santos VG, Carvalho PD, Maia C, et al. Fertility of lactating Holstein cows submitted to a Double-Ovsynch protocol and timed artificial insemination versus artificial insemination after synchronization of estrus at a similar day in milk range. *J Dairy Sci* 2017;100:8507-8517.
60. Souza AH, Ayres H, Ferreira RM, et al. A new presynchronization system (Double-Ovsynch) increases fertility at first postpartum timed AI in lactating dairy cows. *Theriogenology* 2008;70:208-215.
61. Sterry RA, Jardon PW, Fricke PM. Effect of timing of Cosynch on fertility of lactating Holstein cows after first postpartum and Resynch timed AI services. *Theriogenology* 2007;67:1211-1216.
62. Stevenson JS, Portaluppi MA, Tenhouse DE. Factors influencing upfront single- and multiple-ovulation incidence, progesterone, and luteolysis before a timed insemination resynchronization protocol. *J Dairy Sci* 2007;90:5542-5551.
63. Stevenson JS, Pulley SL. Pregnancy per artificial insemination after presynchronizing estrous cycles with the Presynch-10 protocol or prostaglandin $F_{2\alpha}$ injection followed by gonadotropin-releasing hormone before Ovsynch-56 in 4 dairy herds of lactating dairy cows. *J Dairy Sci* 2012;95:6513-6522.
64. Stevenson JS, Pulley SL, Mellieon Jr, HI. Prostaglandin $F_{2\alpha}$ and gonadotropin-releasing hormone administration improve progesterone status, luteal number, and proportion of ovular and anovular dairy cows with corpora lutea before a timed artificial insemination program. *J Dairy Sci* 2012;95:1831-1844.
65. Stevenson JS, Pulley SL, Hill SL. Pregnancy outcomes after change in dose delivery of prostaglandin $F_{2\alpha}$ and time of gonadotropin-releasing hormone injection in a 5-day timed artificial insemination program in lactating dairy cows. *J Dairy Sci* 2014;97:7586-7594.
66. Stevenson JS, Sauls JA, Mendonca LGD, et al. Dose frequency of prostaglandin $F_{2\alpha}$ administration to dairy cows exposed to presynchronization and either 5- or 7-day Ovsynch program durations: Ovulatory and luteolytic risks. *J Dairy Sci* 2018;101:9575-9590.
67. Valenza A, Giordano JO, Lopes Jr. G, et al. Assessment of an accelerometer system for detection of estrus and for treatment with gonadotropin-releasing hormone at the time of insemination in lactating dairy cows. *J Dairy Sci* 2012;95:7115-7127.
68. Vasconcelos JLM, Silcox RW, Rosa GJ, et al. Synchronization rate, size of the ovulatory follicle, and pregnancy rate after synchronization of ovulation beginning on different days of the estrous cycle in lactating dairy cows. *Theriogenology* 1999;52:1067-1078.
69. Walker WL, Nebel RL, McGilliard ML. Time of ovulation relative to mounting activity in dairy cattle. *J Dairy Sci* 1996;79.1555-1561.
70. Wijma, R, Perez MM, Masello M, et al. A resynchronization of ovulation program based on ovarian structures present at nonpregnancy diagnosis reduced time to pregnancy in lactating dairy cows. *J Dairy Sci* 2018;101:1697-1707.
71. Wiltbank MC, Fricke PM, Sangritasvong S, et al. Mechanisms that prevent and produce double ovulations in dairy cattle. *J Dairy Sci* 2000;83:2998-3007.
72. Wiltbank MC, Gumen A, Sartori R. Physiological classification of anovulatory conditions in dairy cattle. *Theriogenology* 2002:57:21-52.
73. Wiltbank MC, Baez GM, Cochrane F, et al. Effect of a second treatment with prostaglanding $F_{2\alpha}$ during the Ovsynch protocol on luteolysis and pregnancy in dairy cows. *J Dairy Sci* 2015;98:8644-8654.

Uterine health problems – Risk factors and effects on herd performance

Mark J. Thomas, DVM, DABVP; **Matias L. Stangaferro,** DVM, MS, PhD; **Rita Couto Serrenho,** DVM, MSc
Dairy Health and Management Services, Lowville, NY 13367

Abstract

A successful calving event and the following transition period are critically important to the future reproductive performance and productivity of the dairy cow. Although the diagnosis and treatment of uterine diseases are generally considered straightforward by most veterinarians, there are many misconceptions and a lack of data to support many of the recommended treatments. Other metabolic disorders such as hypocalcemia and hyperketonemia can further complicate the diagnosis and treatment plan.

Not only is an understanding of reproductive physiology and normal uterine involution important, but also the economic outcomes of uterine disease. The effects on milk production, fertility, risk to other diseases, and exit from the herd need to be recognized by both the dairy herd managers and veterinarians alike.

This article will review the definitions, risk factors, treatment options and economics of uterine diseases: retained placenta (RP), metritis, and endometritis.

Key words: uterine health, metritis, transition cow disease

Résumé

Un vêlage réussi et la période de transition suivante sont très importants pour les performances reproductives et la productivité futures de la vache laitière. Bien que le diagnostic et le traitement des maladies utérines soient généralement considérés simples par la plupart des vétérinaires, il existe plusieurs idées fausses et un manque de données pour supporter plusieurs des traitements recommandés. D'autres troubles métaboliques comme l'hypocalcémie et l'acétonémie tendent à compliquer davantage le diagnostic et le plan de traitement.

La connaissance de la physiologie de la reproduction et de l'involution utérine normale importe autant que la reconnaissance des résultats économiques de la maladie utérine. Les effets sur la production laitière, la fertilité, le risque de développer d'autres maladies et le retrait du troupeau doivent être reconnus autant par les gestionnaires de la ferme laitière que par les vétérinaires.

Cet article fait le point sur les définitions, les facteurs de risque, les options de traitement et les retombées économiques des maladies utérines : rétention placentaire, métrite et endométrite.

Introduction

High milk yield and reduced involuntary culling have been shown to improve overall herd profitability.[4,18] Uterine disease decreases milk yield,[a,20] fertility,[5] and herd survival.[12,14] Thus, it is expected that RP and metritis can have a major impact on the economics of a dairy operation. Understanding the risk factors and the prevention of uterine disease, along with proper diagnosis and treatment choices, is therefore important.

The transition period is generally defined as 3 weeks prior to 3 weeks following calving. This period has the greatest risk of metabolic disease, with some herds having 30 to 50% of transition cows affected by 1 or more diseases.[19] There are many risk factors for RP, metritis, and endometritis,[24] which, in turn, are risk factors for other metabolic diseases such as hypercalcemia, hyperketonemia, and displaced abomasum (DA).[7] Uterine damage from dystocia and more importantly, nutritional issues during the pre-calving close-up period, are major areas of focus for the prevention of disease.

Risk Factors

One important aspect in the discussion of uterine disease is the difference between contamination and infection of the uterus. Uterine contamination does not always lead to metritis or endometritis.[30] Uterine infections are generally considered non-specific in nature and are caused by environmental bacteria.[1]

Delayed uterine involution is the factor most commonly associated with uterine infection. Any disruption of normal calving such as dystocia, twins and stillbirth, increase the risk of delayed involution[15] and therefore can lead to infection.

Metabolic diseases such as hypocalcemia, hyperketonemia, and DA are also are associated with an increased risk of uterine disease. The exact mechanism underlying this association has not been determined, but a failure of the immune system is believed to play a part in this increased risk.[3]

Diagnosis

The diagnostic definition of RP is straightforward; visible fetal membranes greater than 24 hours after calving. The diagnosis of clinical metritis can be more challenging and is a current topic of discussion, but is defined as a fetid,

watery uterine discharge often accompanied by fever and/or systemic signs of disease.[30] Clinical endometritis is defined as the presence of pus in the vagina > 21 days post-calving. Clinical endometritis must be differentiated from cases of vaginitis that can also present with a purulent discharge. This distinction can be difficult given that common methods of diagnosis (e.g. Metricheck device or gloved hand) cannot differentiate between vaginitis and endometritis.[26]

Treatment

Treatment protocols need to be based on an accurate diagnosis of the uterine disease along with any concurrent metabolic disorders. A quote from Frazer provides the current thinking on various treatment modalities: "This postpartum metritis-delayed uterine involution syndrome is extremely frustrating for a veterinary clinician to manage since there is no scientifically proven protocol that will enhance uterine contraction and promote evacuation of the fetid uterine contents. Supportive measures (anti-inflammatory medication and systemic antibiotics) may help to maintain the cow's appetite and rumen motility, but this author remains unconvinced that any current hormonal therapy actually works."[8]

A detailed review of the treatment of RP, metritis, and endometritis can be found in the literature.[5] The current data does not support the use of prostaglandins for the treatment of RP or metritis.[6,11,21] Additionally, infusions of intrauterine disinfectants and/or antibiotics have not shown a benefit in terms of future fertility and may in fact be detrimental.[9] These treatments are also extra-label in the USA and present the risk for antibiotic residues.[13] Non-traditional treatments such as intra-uterine infusion of mannose or bacteriophage[23] or dextrose[2,23] have not been shown to be effective for the treatment of uterine infections.

For severe, acute toxic metritis, systemic antibiotics, non-steroidal anti-inflammatory drugs (NSAIDS), supportive care, and treatment of concurrent metabolic disease represent the accepted treatment regimen. The antibiotic choice should be based on spectrum of activity, withholding times and economics with the knowledge that *E coli*, *T. pyogenes*, and *F. necrophorum* are the most common isolates from metritic cows.[30] NSAIDS are generally used based on first-principle concepts for treatment of pyrexia, as literature support for such use appears to be lacking[5,16,22,27] and the routine use of flunixin meglumine in peri-parturient cows has been shown to increase the prevalence of RP and metritis.[25]

Prevention

Given the multifactorial pathophysiology of uterine diseases, prevention of uterine contamination and infection needs to be focused on overall transition cow management to minimize predisposing factors.[31] The role of nutrition in preventing metabolic disorders such as hyperketonemia, hypocalcemia, and DA is of major importance. Attention to maternity area hygiene is another important area for the reduction of uterine contamination at calving.[28] Training of maternity pen caregivers to ensure proper assistance at birthing, dystocia management and hygiene are other important considerations.[17,28,29]

The use of vaccines targeting uterine infection pathogens has been investigated[23] and holds potential promise for future commercial use. Immune modulators such as pegbovigrastim have not been shown to be beneficial for the prevention of uterine disease.[32]

Economics

There are a number of economic models that have been used to calculate the cost of transition cow diseases.[a,10,14,20] It is interesting to note that these models all calculate a very similar economic loss from uterine disease with an average cost per case for RP/metritis combined of $322 and $576 per case for primiparous and multiparous cows, respectively. Milk loss represents the largest component of the cost of metritis, with choice of treatment having a minimal effect on overall cost per case.[20]

Although these costs represent real economic losses, the overall low incidence of these diseases in most well-managed herds does not represent a significant economic return in the reduction of incidence. The goal is to always prevent disease, but the savings from reducing RP/metritis by 1% in a 1000-cow herd is less than $3000/year.[a] Therefore, prioritization of disease prevention strategies must be considered individually for each dairy and each disease.

Conclusions

High milk production and cow longevity are important factors for overall dairy farm profitability. Management of the nutritional and environmental needs of the dairy cow along with proper training of employees in maternity care are critically important to reduce the risk of postpartum disease and ensure a successful transition period. Transition cow diseases are multifactorial and interrelated. Attention to the prevention, correct diagnosis and effective treatment of uterine diseases can result in positive economic returns, but this must be prioritized with other management and prevention strategies that can perhaps yield greater returns.

Endnote

[a] Thomas MJ, Stangaferro ML. Unpublished data, 2019.

References

1. Bicalho RC, Machado VS, Bicalho MLS, Gilbert RO, Teixeira AGV, Caixeta LS, Pereira RVV. Molecular and epidemiological characterization of bovine intrauterine *Escherichia coli*. *J Dairy Sci* 2010;93:5818-5830.

2. Brick TA, Schuenemann GM, Bas S, Daniels JB, Pinto CR, Rings DM, Rajala-Schultz PJ. Effect of intrauterine dextrose or antibiotic therapy on reproductive performance of lactating dairy cows diagnosed with clinical endometritis. *J Dairy Sci* 2012;95:1894-1905.
3. Correa MT, Erb H, Scarlett J. Path analysis for seven postpartum disorders of Holstein cows. *J Dairy Sci* 1993;76:1305-1312.
4. De Vries A. Reproduction: Economics of reproductive efficiency. *Revista Colombiana de Ciencias Pecuarias* 2017;30:218-221.
5. Drillich M, Beetz O, Pfutzner A, Sabin M, Sabin HJ, Kutzer P, Nattermann H, Heuwieser W. Evaluation of a systemic antibiotic treatment of toxic puerperal metritis in dairy cows. *J Dairy Sci* 2001;84:2010-2017.
6. Dubuc J, Duffield TF, Leslie KE, Walton JS, LeBlanc SJ. Randomized clinical trial of antibiotic and prostaglandin treatments for uterine health and reproductive performance in dairy cows. *J Dairy Sci* 2011;94:1325-1338.
7. Erb HN, Martin SW, Ison N, Swaminathan S. Interrelationships between production and reproductive diseases in Holstein cows. Path analysis. *J Dairy Sci* 1981;64:282-289.
8. Frazer GS. A rational basis for therapy in the sick postpartum cow. *Vet Clin North Am Food Anim Pract* 2005;21:523-568.
9. Fuquay JW, Harris RA, McGee WH, Beatty JF, Arnold BL. Routine postpartum treatment of dairy cattle with intrauterine neomycin sulfate boluses. *J Dairy Sci* 1975;58:1367-1369.
10. Galligan D. Economic assessment of animal health performance. *Vet Clin North Am Food Anim Pract* 2006;22:207-227.
11. Galvao KN, Frajblat M, Brittin SB, Butler WR, Guard CL, Gilbert RO. Effect of prostaglandin F2α on subclinical endometritis and fertility in dairy cows. *J Dairy Sci* 2009;92:4906-4913.
12. Gilbert RO, Shin ST, Guard CL, Erb HN, Frajblat M. Incidence of endometritis and its effects on reproductive performance of dairy cows. *Theriogenology* 2005;64:1879-1888.
13. Gorden PJ, Ydstie JA, Kleinhenz MD, Wulf LW, Gehring R, Lee CJ, Wang C, Coetzee JF. A study to examine the relationship between metritis severity and depletion of oxytetracycline in plasma and milk after intrauterine infusion. *J Dairy Sci* 2016;99:8314-8322.
14. Guard D. The costs of common diseases of dairy cattle, in *Proceedings*. CVC in San Diego, 2008.
15. Hussain AM, Daniel RCW, O'Boyle D. Postpartum uterine flora following normal and abnormal puerperium in cows. *Theriogenology* 1990;34:291-302.
16. Jeremejeva J, Orro T, Waldmann A. Treatment of dairy cows with PGF2α or NSAID, in combination with antibiotics, in cases of postpartum uterine inflammation. *Acta Vet Scand* 2012;54:45.
17. Kristula MA, Smith BI. Care report—Veterinary specific training to manage dairy cows at calving time. *Bov Pract* 2011;45:78-86.
18. Krpálková L, Cabrera VE, Kvapilík J, Burdych J, Crump P. Associations between age at first calving, rearing average daily weight gain, herd milk yield and dairy herd production, reproduction, and profitability. *J Dairy Sci* 2014;97:6573-6582.
19. LeBlanc SJ, Duffield TF, Leslie KE, Bateman KG, Keefe GP, Walton JS, Johnson WH. Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. *J Dairy Sci* 2002;85:2223-2236.
20. Liang D, Arnold LM, Stowe CJ, Harmon RJ, Bewley JM. Estimating US dairy clinical disease costs with a stochastic simulation model. *J Dairy Sci* 2017;1001472-1486.
21. Lima FS, Vieira-Neto A, Vasconcellos GSFM, Mingoti RD, Karakaya E, Solé E, Bisinotto RS, Martinez N, Risco CA, Galvao KN, Santos JEP. Efficacy of ampicillin trihydrate or ceftiofur hydrochloride for treatment of metritis and subsequent fertility in dairy cows. *J Dairy Sci* 2014;97:5401-5414.
22. Lomb J, Neave HW, Weary DM, LeBlanc SJ, Huzzey JM, Von Keyserlingk MAG. Changes in feeding, social, and lying behaviors in dairy cows with metritis following treatment with a nonsteroidal anti-inflammatory drug as adjunctive treatment to an antimicrobial. *J Dairy Sci* 2018;101:4400-4411.
23. Machado VS, Bicalho MLdS, Meira Jr EBdS, Rossi R, Ribeiro BL, Lima S, Santos T, Kussler A, Foditsch C, Ganda EK, Oikonomou G, Cheong SH, Gilbert RO, Bicalho RC. Subcutaneous immunization with inactivated bacterial components and purified protein of *Escherichia coli*, *Fusobacterium necrophorum* and *Trueperella pyogenes* prevents puerperal metritis in Holstein dairy cows. *PLoS ONE* 2014;9:e1734.
24. McNaughton AP, Murray RD. Structure and function of the bovine fetomaternal unit in relation to the causes of retained fetal membranes. *Vet Rec* 2009;165:615-622.
25. Newby NC, Leslie KE, Dingwell HP, Kelton DF, Weary DM, Neuder L, Duffield TF. The effects of periparturient administration of flunixin meglumine on the health and production of dairy cattle. *J Dairy Sci* 2017;100:582-587.
26. Pleticha S, Drillich M, Heuwieser W. Evaluation of the Metricheck device and the gloved hand for the diagnosis of clinical endometritis in dairy cows. *J Dairy Sci* 2009;92:5429-5435.
27. Pohl A, Bertulat S, Borchardt S, Burfeind O, Heuwieser W. Randomized, controlled clinical trial on the efficacy of nonsteroidal antiinflammatory drugs for the treatment of acute puerperal metritis in dairy cows. *J Dairy Sci* 2016;99:8241-8249.
28. Schuenemann GM, Nieto I, Bas S, Galvao KN, Workman J. Dairy calving management: Effect of perineal hygiene scores on metritis. *J Dairy Sci* 2011;94(E-Suppl. 1):744.
29. Schuenemann GM, Bas S, Workman JD, Rajala-Schultz R. Dairy reproductive management: Assessing a comprehensive continuing education program for veterinary practitioners. *J Vet Med Educ* 2010;37:289-298.
30. Sheldon IM, Williams EJ, Miller AN, Nash DM, Herath S. Uterine diseases in cattle after parturition. *Vet J* 2008;176:115-121.
31. Stevenson JS, Call EP. Reproductive disorders in the periparturient dairy cow. *J Dairy Sci* 1988;71:2572-2583.
32. Zinicola M, Korzec H, Teixeira AGV, Ganda EK, Bringhenti L, Tomazi ACCH, Gilbert RO, Bicalho RC. Effects of pegbovigrastim administration on periparturient diseases, milk production, and reproductive performance of Holstein cows. *J Dairy Sci* 2018;101:11199-11217.

Dairy benchmarks: Using data to add value to dairy farms

Gabe Middleton, DVM, DABVP (Dairy)
Orrville Veterinary Clinic, Orrville, OH 44667

Abstract

Dairy farms have a tremendous amount of data available for consultants to evaluate and interpret. Veterinarians are in a unique position on most dairy farms to be trusted consultants because of their observational skills, frequent exposure to the cows, and knowledge surrounding many different biological processes on the farm. Benchmarking means to evaluate something compared to a standard. Benchmarking data on farms can be both helpful and dangerous at the same time due to several factors. Dairy managers should be encouraged to set goals, monitor trends, suggest changes, and evaluate results. Again, the herd veterinarian is in the position to be able to consult with the farm on all of these items. If veterinarians do not get involved in the analysis, other consultants will likely fill that void.

Key words: benchmarking, data, records analysis

Résumé

Les fermes laitières génèrent un volume considérable de données que les consultants peuvent évaluer et interpréter. Les vétérinaires dans la plupart des fermes laitières sont des consultants de confiance dans une unique position en raison de leur pouvoir d'observation, de leur exposition fréquente aux vaches et de leurs connaissances sur plusieurs processus biologiques à la ferme. L'étalonnage consiste à évaluer quelque chose par rapport à une référence. Les données d'étalonnage dans une ferme peuvent être pratiques mais dangereuses en même temps en raison de plusieurs facteurs. Les gestionnaires d'une ferme laitière devraient être encouragés à déterminer des objectifs, surveiller les tendances, suggérer des changements et évaluer les résultats. Encore une fois, le vétérinaire du troupeau est dans une position qui lui permet de conseiller la ferme sur tous ces aspects. Si les vétérinaires ne s'impliquent pas dans cette analyse, d'autres consultants vont probablement combler ce vide.

Introduction

Dairy veterinarians need to be involved in several different aspects of the operation, not just reproductive ultrasound or palpation. One value-added service that the veterinarian is in a unique position to perform is analysis of data and Dairy Herd Improvement Association (DHIA) test day records. These records are typically analyzed via PCDART or DairyComp305 dairy records software. Other helpful programs exist, such as TMR Tracker, that veterinarians can use to analyze data to evaluate dry-matter intake between groups.

Benchmarking is a common term that is used to compare something to a standard. However, veterinarians might be better served setting goals on dairy farms rather than comparing data to an industry-wide benchmark. After attainable and smart goals are set, trends can be monitored over time to determine if action items have produced positive results. Developing a consistent method to evaluate and interpret data is critically important to ensuring that the producer finds value in the analysis. The veterinarian may struggle to break through into analysis of data on the farm due to insecurity on whether the producer is willing to pay for the service as well as their own level of comfort interpreting the data. Finding a mentor to help instill confidence and starting with simple data points may be helpful for the practitioner to break through into records analysis.

Veterinarians should develop a list of data points from test day data that they review every month with the producer or farm manager. These data points may involve several aspects of the operation, such as reproduction, culling, disease monitoring, milk quality, and heifer inventory just to name a few. Interpretation of data points should be monitored for trends over time. The veterinarian should also understand how factors within the data affect the final number. For example, if the herd does not have solid parameters in which to identify and record different transition cow diseases, the analysis of disease incidence may be flawed. This is an excellent opportunity for the veterinarian to help the producer understand the importance of quality data in regards to transition cow disease identification.

Veterinarians should also have an understanding that test day data is only 1 part of the equation when it comes to analysis of dairy farm records. Reproductive data can be analyzed more frequently, as those numbers are typically updated in real time. Bulk tank somatic cell count and milk component data should be analyzed daily along with test day data to identify any changes that are occurring in real time. This can be accomplished more frequently by observing information provided by federal milk marketing order testing.

Many veterinarians provide services to dairy farms with very little data available for analysis due to multiple factors. Perhaps the herd does not perform DHIA testing and there is no herd management software. Veterinarians

are once again in a unique position to help manage data on these herds. Microsoft Excel is an excellent option to track data points such as transition cow disease data, culling and death, production trends, milk components, and other reproductive parameters.

Veterinarians can also provide tremendous value to producers by analyzing data points such as heifer growth rates, lung ultrasound scoring, colostrum management data collection, and calf serum total proteins. Producers are often more than willing to pay for collection and analysis of this data if the results are meaningful and appropriately interpreted.

Conclusion

Veterinarians need to step into the realm of data analysis help secure their position on the farm as 1 of the most trusted consultants. Others will fill the void if veterinarians do not show interest or take the time to analyze records. Young veterinarians are in a particularly appropriate position to analyze data on farms because they are more likely to be able to take the time to perform the analysis due to potentially less daily workload relative to the seasoned veterinarians. This provides an excellent opportunity to begin to gain confidence and build rapport with dairy clients.

A toolbox for troubleshooting dairy nutrition problems

Garrett R. Oetzel, DVM, MS; Diplomate, ACVN (Honorary)
Professor, Food Animal Production Medicine Section, Department of Medical Sciences, University of Wisconsin, School of Veterinary Medicine, 2015 Linden Drive, Madison, WI 53706

Abstract

Nutrition is a crucial determinant of dairy cow health and productivity. Veterinarians can leverage their regular access to cows and feed bunks to provide herd owners with regular evaluation and monitoring of nutritional management. The 5 areas in which dairy veterinarians can have the most impact on nutritional management are particle length of total mixed rations, sorting of total mixed rations, adequacy of eating space, adequacy of feed refusals, and appropriate timing of feed deliveries. The pre- and post-fresh groups are the highest priority pens for evaluation and monitoring. The most common problems that may be encountered are inappropriate proportion of long particles in the total mixed rations, excessive sorting of the total mixed rations, insufficient bunk space for all of the cows to eat at the same time, insufficient targeted feed refusals such that cows do not have full access to feed throughout the day, and lack of fresh feed in the bunk when cows return from the parlor after the first milking of the day.

Key words: dairy cows, nutrition diagnostic investigations, nutrition troubleshooting, diet evaluation

Résumé

L'alimentation est un élément essentiel de la santé et de la productivité des vaches laitières. Les vétérinaires peuvent miser sur leur accès fréquent aux vaches et aux mangeoires pour fournir aux propriétaires de troupeau une surveillance et des évaluations régulières de la régie de l'alimentation. Les vétérinaires peuvent avoir le plus grand impact sur la régie de l'alimentation dans cinq grands domaines : la longueur des particules dans la ration totale mélangée, le triage de la ration totale mélangée, la suffisance d'espace pour l'alimentation, la suffisance des refus d'alimentation et le moment propice pour la distribution d'aliments. Les groupes avant ou après le vêlage sont les enclos avec la plus haute priorité pour l'évaluation et la surveillance. Parmi les problèmes les plus courants qu'on puisse rencontrer on retrouve une proportion inadéquate de particules longues dans la ration totale mélangée, un triage excessif de la ration totale mélangée, le manque d'espace dans la mangeoire faisant en sorte que les vaches ne peuvent pas toutes manger en même temps, un mauvais calcul de refus de sorte que les vaches n'ont pas pleinement accès à la nourriture toute la journée et le manque d'aliments frais dans la mangeoire lorsque les vaches retournent de la salle de traite après la première traite de la journée.

Introduction

Veterinarians serving dairy clients can provide comprehensive investigations of nutritional management on a dairy herd. The process for doing this has been described in detail elsewhere.[2]

Because the dairy industry has consolidated so much, the need for veterinarians to conduct comprehensive nutritional investigations has declined. Dairy nutritionists are more than able to provide comprehensive investigations to a shrinking number of dairy producers. However, several areas of nutritional management are often overlooked. Dairy veterinarians, who regularly visit herds and already spend much time around the cows and the feed bunks, are well-positioned to monitor and evaluate these areas. These are 1) particle length of total mixed rations (TMR); 2) TMR sorting; 3) eating space; 4) feed refusals; and 5) timing of feed deliveries relative to milking and pen lock-ups. These are the most useful dairy nutrition tools to have in your toolbox.

Particle Length of Total Mixed Rations

Forage particle length is a critical determinant of dairy cow health and productivity. Long forage particles constitute the ruminal mat layer, determine rumination time, and determine how much endogenous buffer is secreted into the rumen via saliva. The general importance of adequate forage particle length in dairy cattle diets has been reviewed in detail.[1]

The most critical TMR on any dairy are those for the pre- and post-fresh cows. Your time is best spent evaluating these diets. Other diets can be evaluated if the dairy producer first finds value in monitoring the pre- and post-fresh groups.

Visual appraisal of the length of forage particles in a TMR is generally unreliable, unless the TMR is on the extremes of particle size. The Penn State Particle Separator (PSPS) is a practical on-farm tool for evaluating forage particle length. Some forage laboratories also offer forage particle length evaluations; however, the PSPS is not difficult to use and can be operated either on-farm or at the veterinary clinic.

A dairy practitioner interested in providing some form of nutritional services would be well-served to invest in a PSPS, watch the Penn State videos showing how to use it, and then gather experience applying it. For routine herd monitoring, the basic PSPS with 2 sieves (19 mm upper sieve and 8 mm middle sieve) plus the pan is sufficient. A 4-mm sieve is also available but is not essential for our purposes. The main value of the 4-mm sieve is to fine-tune the physically effec-

tive neutral detergent content of the diet. A digital platform scale (capacity of about 400 grams and 0.1-gram readability) plus 3 tubs (usually plastic or aluminum) for collecting and weighing the forage from each sieve are also needed.

Forage particle length determination first requires that a representative sample of the TMR be obtained. Grabbing a few handfuls of the TMR from the top of the bunk is not sufficient. It is important that the TMR bunk sample be as representative as possible of the entire load. The best time to sample a TMR for particle size analysis is immediately after it is fed - before the cows have a chance to sort it. Collect about 12 handfuls of TMR from the start to the end of the bunk. Place these handfuls into a 5-gallon bucket (or similar) as you collect them. The bucket will be full by the last handful. Collect the handfuls by scooping upwards and placing 1 hand above the TMR sample and 1 hand below it. Grabbing a TMR sample with 1 hand from the top of the bunk and pulling it away could result in the selective loss of finer particles from the sample.

After collecting the TMR, empty the TMR in the bucket onto a flat, smooth surface (I use a folding table for this purpose) and then mix the TMR gently in several directions. Next, separate the TMR into 4 distinct quarters. Make sure that the quarters are completely separated, with no loose feed between them. Randomly select 2 of the quarters and discard them. Re-mix the remaining 2 quarters of TMR, quarter them, and randomly discard 2 quarters. Continue mixing, quartering, and discarding until you have reduced the sample to a volume of 6 cups. If you wish to run the PSPS sample in duplicate (a good idea as you are learning to use it), then collect another 6-cup sample at this time.

It is crucial to add the correct volume of feed to the PSPS. A common mistake is to add more than 6 cups of TMR; this could result in incomplete separation of the sample on the sieves.

My goals for the particle size distribution of a TMR are 2 to 8% above the top sieve, 30 to 50% above the middle sieve, and 40 to 60% in the pan. These goals apply to any TMR on the farm; there are no separate goals for dry cow vs milking cow diets.

The main outcome of interest from the PSPS is the percentage of the sample above the top sieve. Less than about 2% above the top sieve results in inadequate ruminal mat layer, which will lead to reduced cud chewing and higher risk for ruminal acidosis. Dairy nutritionists can partially compensate for inadequate long particles by increasing the chemical fiber in the diet formulation. A TMR with over about 8% above the top sieve is at increased risk for sorting.

Analysis of Total Mixed Rations for Sorting

Evaluating TMR for sorting is an especially useful application of forage particle length determination. Sorting is evaluated by comparing the particle length of the TMR offered to the cows to the particle length of the refusals. This requires collecting a representative sample of the TMR offered and the TMR refused. Refusal samples should be collected with the same care as described above. It is typically necessary to be at the farm very early in the morning in order to collect the TMR refusal sample. On-farm personnel can be trained to collect these samples for you.

As mentioned earlier, the pre- and post-fresh diets are the most critical ones to evaluate carefully. Sorting is often a problem in these 2 diets.

Refusals of TMR should have the same visual appearance and particle length distribution as the TMR that was originally offered. The main problem with a sortable TMR is that cows will sort away from the long particles (usually long or coarse forage particles) and selectively consume only the finer ones (often concentrates, which are more ruminally fermentable and could cause ruminal acidosis). Modest increases in the proportion of long particles in the refusals (up to 5 percentage points) appear to cause no problem. For example, if the TMR offered contained 7% long particles, it would be acceptable for the refusal sample to contain up to 12% long particles. An increase of 5 to 10% long particles from the TMR offered to the TMR refused is considered to be moderate TMR sorting. More than a 10% increase in long particles represents a severe sorting problem and requires immediate correction.

Excessive TMR sorting is often caused by dry forage particles (especially coarse dry hay or straw) that are longer than about 2.5 inches (6.35 cm) in length. Straw is particularly prone to sorting if it is not chopped prior to adding it to the mixer. Sorting is also increased if the TMR is too dry (>50% dry matter).

Whenever a TMR is sortable, high rank cows and cows with the ability to sort can select diets that are too low in effective fiber, while low rank cows are left with diets that are too high in fiber. Both groups suffer as a result. Cows that sort may get ruminal acidosis, and the cows that do not sort may be left with inadequate soluble carbohydrates to support optimal ruminal fermentation.

Mitigating TMR sortability depends upon the underlying factors that caused it. The most common solution for a sortable TMR is to more finely pre-process any dry hay or straw before adding it to the mixer. There should be no dry hay or straw particles in the diet over 2.5 inches (6.35 cm) long. This typically requires running the hay or straw through a tub grinder before adding it to the mixer.

If the TMR is too dry, add adding extra water or wet by-product feed(s) may solve the problem. The target dry-matter percentage for a TMR is 40 to 50%. Liquid molasses is particularly useful for this purpose; it adds extra water and helps the TMR particles stick together.

Dairy herds often cannot fully remedy the problems that made the TMR sortable. In these situations, providing ample bunk space so that all cows can eat at the same time is critically important. It also helps to feed the TMR twice rather than once daily.

Dairy producers may be quick to point out that adding water or molasses to TMR mixes shortens their bunk life during hot weather. The extra moisture and sugar, combined with summer heat, allows spoilage bacteria and yeasts to proliferate faster. This could create a difficult trade-off between reducing sortability and preventing over-heating of the TMR in the bunk. The best solution is to feed the TMR more frequently; this reduces the risk for TMR heating and simultaneously decreases sortability.

Evaluating and Monitoring Eating Space

Dairy cows are about 30 inches (76 cm) wide. Therefore, their eating space must provide at least 30 inches (76 cm) per cow so that all cows may eat at the same time.

Housing and bunk space for dairy cows is very expensive in colder climates. Thus, dairy producers in these regions are very much tempted to overstock their pens and provide less than 30 inches (76 cm) of eating space per cow. However, this can be disastrous for the herd. The pre- and post-fresh cows are particularly sensitive to the effects of insufficient eating space.

Cows eat larger and fewer meals per day when they cannot all eat together at the same time. This increases the risk for ruminal acidosis and magnifies the influence of TMR sorting. Lower rank cows eat less total feed than they are capable of consuming when eating space is limiting. There is no way to fully avoid the negative impacts of inadequate eating space. Feeding twice daily, eliminating TMR sorting, and feeding for very generous feed refusals helps some.

Dairy producers may become defensive when confronted about the lack of eating space they provide for their cows. There are complex economic and business reasons that may pressure them into overstocking their facilities. It likely does no good to repeatedly express dismay with the lack of eating space provided on a dairy. Nonetheless, dairy veterinarians can be ready to provide input about overstocking when teachable moments do arise on the farm.

Dairy practitioners are also in a good position to keep an eye on the availability of eating space, especially in the pre- and post-fresh pens. Cow flow through these pens is very dynamic, and dairy producers may simply be unaware of that these pens are overstocked.

Pre-fresh overstocking can be difficult to avoid during transient periods of heavy calving. Moving cows into the pre-fresh pen closer to calving is not recommended, because it leads to very short stays in the pre-fresh pen for cows that calve early. The only solution to this problem is to design pre-fresh pens with access to flexible eating space via movable gates. Creating some flexible pen space that is shared with late-lactation cows is often the most practical approach. This allows pre-fresh pen capacity to be expanded when needed. It is unusual for season shifts in calving patterns to simultaneously affect cow density in both the late lactation and pre-fresh pens.

Post-fresh pen overstocking during transient periods of heavy calving is not as difficult to manage as for the pre-fresh cows. Healthy cows can simply be moved out of the post-fresh pens whenever eating space falls below 30 inches (76 cm) per cow. For this to work, however, there must be enough capacity in the post-fresh pen to assure that all cows can spend at least 10 days there. Moving cows out of the post-fresh pen less than 10 days after calving is not recommended.

Evaluating and Monitoring Feed Refusals

Someone on the dairy must decide each day how much feed to mix for each group of cows. Feeding the ideal amount keeps cows from becoming too hungry (and potentially overeating when new feed is offered) with the smallest possible amount of feed refusal.

The amount of feed mixed each day should be based on the appearance of the bunk at the end of the previous feeding day. A typical target is a 5% daily feed refusal; however, the tendency is to lower feed refusals when milk prices are low or feed costs are high.

A 5% daily feed refusal is inadequate for pens with very dynamic populations, such as the pre- and post-fresh groups. Mid- and late-lactation pens can be fed to lower feed refusal because their populations are more stable.

Some dairy herds consistently feed to zero daily feed refusals. This usually compromises dry-matter intakes, increases meal sizes, magnifies the impact of TMR sortability, and increases the risk for ruminal acidosis. The impact of low feed refusals is somewhat lessened if feeding management is very consistent, the bunks are empty for only a few hours each day, the TMR is not sortable, and the cows have adequate eating space. Cows may be able to self-regulate intakes and ruminal pH if they can consistently have access to feed at the same time each day. Most dairies cannot manage their feed bunks this well and should target at least 5% daily refusals.

How much daily TMR refusal a dairy producer will target is in part dependent on how much value the farm gets from its TMR refusals. The ideal destination for dairy TMR refusals is to beef feedlot animals. Some dairies have this option within their own farm enterprise. Other dairies are able to sell TMR refusals to beef feedlot producers. Farms with methane digesters may add TMR refusals directly to the digester and realize value from the extra electricity generated. If these options do not exist, the best approach is to feed TMR refusals to pregnant heifers on the farm. Varying amounts of TMR refusal can be added to the TMR mix for pregnant heifers, as long as the amounts are known and the other ingredients added to the mix are adjusted accordingly. Pregnant heifers may become too fat if they consume too much of their diet as TMR refusal or if their TMR is not properly adjusted for the amount of TMR refusal that it contains.

Dairy producers should be encouraged to record the amount of feed offered and feed refused for each pen. Refusals do not have to be weighed daily; an estimation of the

amount refused (usually as a fraction of a loader bucket) is usually sufficient. This does require the occasional weighing of a bucket of TMR refusal to make sure that the estimated weight is accurate.

Because veterinarians regularly visit dairies and spend much of their time there around the feed bunks, it makes sense that they be aware of the amount of feed available to the cows. Veterinarians can make themselves more valuable to a dairy simply by monitoring feed in the bunks and communicating this information to farm management. One approach is to take pictures when the bunks are empty and send them to person in charge.

Monitoring the Timing of Feed Deliveries

The timing of feed deliveries on a dairy should be fanatically consistent. If feed is always available at the same time, cows have considerable ability to learn to control their meal patterns (meal frequency and meal size) in order to self-regulate ruminal pH. However, if the delivery of feed to the bunks is erratic, the cow's self-regulation will fail.

It is particularly harmful if cows receive their TMR later than usual; hungry cows may over-eat when feed is finally offered. Problems with an inconsistent feeding schedule are magnified by inadequate eating space, inadequate resting space (cows may be more concerned about securing a place to lie down rather than regulating their ruminal pH), or inadequate availability of feed or water immediately after milking.

The post-fresh pen is usually locked up once daily to allow for diagnosis and treatment of the fresh cows. It is particularly helpful if feed delivery is consistently synchronized with return from the parlor after the first milking of the day. This is the biggest and most important meal of the day for most cows. Cows also lock up better when they return from the parlor to fresh feed.

Conclusions

Dairy veterinarians, even though usually not involved with the day-to-day details of diet formulation, can still provide important nutritional assistance to their dairy clients. The key areas for involvement are in forage particle length, TMR sorting, feed refusals, eating space, and timing of feed deliveries. Veterinarians working regularly on dairies can leverage their access to cows and feed bunks by providing their clients with highly useful information in these areas.

Acknowledgments

Dr. Oetzel has served as a consultant and speaker for Boehringer Ingelheim Animal Health and Zoetis Animal Health. He has conducted research projects sponsored by AgSource, Boehringer Ingelheim Animal Health, and Zoetis Animal Health.

References

1. Oetzel GR. Application of forage particle length determination in dairy practice. *Compend Contin Educ Pract Vet* 2001; 23:S30-S37.
2. Oetzel GR. Undertaking nutritional diagnostic investigations. *Vet Clin North Am Food Anim Pract* 2014; 30:765-788.

Rational treatments for ketosis in fresh cows

Garrett R. Oetzel, DVM, MS; Diplomate, ACVN (Honorary)
Professor, Food Animal Production Medicine Section, Department of Medical Sciences,
School of Veterinary Medicine, University of Wisconsin, 2015 Linden Drive, Madison, WI 53706

Abstract

Hyperketonemia affects over 40% of dairy cows in early lactation. The prevalence of hyperketonemia (determined by spot checks within herds) is about 20%. Negative impacts of hyperketonemia most notably include decreased milk yield, increased risk for displaced abomasum, and increased risk for early lactation herd removal. Cowside blood beta-hydroxybutyrate tests are now available for rapid and accurate diagnosis of hyperketonemia. Urine and milk tests can also be used, but have substantial disadvantages. Accurate and early diagnosis of hyperketonemia after calving allows early and effective treatment. This mitigates about half of the negative impacts of hyperketonemia such as decreased milk yield, increased risk for displaced abomasum, and increased risk for herd removal. Mild to moderate cases of hyperketonemia in individual cows are best treated with an oral glucose precursor such as propylene glycol. Intravenous glucose should be reserved for severe cases and followed with oral glucose precursors.

Key words: fresh cow metabolic disease, ketosis, hyperketonemia

Résumé

L'acétonémie affecte plus de 40% des vaches laitières en début de lactation. La prévalence d'acétonémie (déterminée par des vérifications ponctuelles dans les troupeaux) est d'environ 20%. Les impacts négatifs les plus fréquents de l'acétonémie incluent une baisse de production laitière, un risque plus élevé de déplacement de caillette et un risque plus élevé de retrait du troupeau tôt en lactation. Des tests du bêta-hydroxybutyrate sanguin sont maintenant disponibles à la ferme pour le diagnostic rapide et précis de l'acétonémie. Des tests d'urine et de lait peuvent aussi être utilisés mais ont de sérieux désavantages. Le diagnostic précis et précoce de l'acétonémie après le vêlage permet un traitement efficace et hâtif. Cela permet d'éviter près de la moitié des impacts négatifs de l'acétonémie comme la baisse de production laitière, le risque plus élevé de déplacement de caillette et le risque plus élevé de retrait du troupeau. Les cas légers à modérés d'acétonémie chez des vaches particulières se traitent le mieux avec l'ajout d'un précurseur du glucose par voie orale comme le propylène glycol. L'administration intraveineuse de glucose devrait être réservée pour les cas sévères et suivie de l'ajout de précurseurs du glucose par voie orale.

Introduction

Hyperketonemia (HYK) is one of the most crucial problems faced by early lactation dairy cattle. Older and higher producing cattle are at the highest risk to develop HYK. The overall risk for HYK is unlikely to abate as genetic progress pushes individual cow milk production higher.

Our ability to understand and to mitigate hyperketonemia has been greatly aided by the availability of cowside blood testing. As a result, we have learned much about this metabolic disorder that can be practically applied on dairies. This paper will review the current science and clinical reasoning for appropriate diagnostic and treatment protocols for HYK in fresh dairy cows.

Overview of Hyperketonemia (Ketosis)

Hyperketonemia occurs in early lactation dairy cows when 2 conditions are met: 1) energy demands (dominantly from milk production) exceed dietary energy intake, resulting in negative energy balance and 2) negative energy balance is sufficient to cause excessive mobilization of body adipose tissue relative to carbohydrate supply. The end result is incomplete oxidation of fatty acids, production of ketone bodies, and HYK.

Ketosis is best described as HYK, which in turn is defined as defined as blood beta-hydroxybutyric acid (BHBA) concentrations ≥1.2 mmol/L. Ketosis technically describes a clinical condition; however, the clinical signs of ketosis are vague and largely determined by the subjective skill of the fresh cow observer. We now have a blood BHBA test that allows for rapid and inexpensive blood BHBA determination cowside. This makes it practical to discuss the precisely-defined condition of HYK instead of the vaguely-defined condition of ketosis.

Incidence vs Prevalence of Hyperketonemia

The incidence and prevalence of HYK are often confused. Incidence is the number of new cases of HYK that occurred during the risk period (early lactation) divided by the number of cows who completed the risk period. Most new cases of HYK occur within the first week after calving in intensively managed herds.[17] Cows that are housed in individual stalls and component-fed may develop HYK later (3 to 6 weeks after calving). A specific time period over which the incidence of HYK is measured must be specified (e.g., a week, a month, or a year).

Repeated testing of cows throughout the entire risk period is required to determine the incidence of HYK.

Sampling for HYK must occur twice or more weekly to assess the incidence of SCK, because the median time for the resolution of HYK is about 5 days.[17] A cow might potentially develop and resolve her HYK between test intervals if she was tested only once weekly.[17] Research trials are usually required for the determination of the incidence of HYK. Testing for HYK twice or more weekly throughout early lactation is very costly for a commercial dairy herd.

One large field study (1,756 cows from 4 dairy herds in 2 states) reported a 44% incidence of HYK.[19] Cows were tested 3 times weekly between 3 and 16 days-in-milk (DIM). Hyperketonemia cases were divided into 2 categories: 1) subclinical ketosis (SCK), defined as blood BHBA 1.2 to 2.9 mmol/L at first diagnosis of HYK; and 2) clinical ketosis, defined as blood BHBA ≥3.0 mmol/L at first diagnosis of HYK. The incidence of clinical ketosis was 2% and the incidence of SCK was 42%. Some cows (3%) were initially categorized as SCK and developed clinical ketosis on later tests; including these cows as clinical ketosis increased the overall risk for clinical ketosis to 5%.[19] Another large-scale study reported a similar incidence of HYK.[7]

Prevalence is a 'snapshot' measure of the current HYK status of a group of cows. It is defined as the proportion of cows with blood BHBA concentrations ≥1.2 mmol/L at a given point in time. Prevalence testing is much more practical than incidence testing because it does not require repeated testing of individual cows. The prevalence of HYK is typically determined for a subset of the early lactation cows within a herd. Herds can be repeatedly tested for HYK and the results pooled into a cumulative prevalence; this increases the reliability of the estimate of the herd's true prevalence of HYK. For practical reasons, almost all herd-level evaluations for HYK are conducted as prevalence testing.

Knowing the incidence of HYK in a herd is far more useful than knowing the herd's prevalence. For example, any economic estimate of the cost of HYK must be based on its incidence (not prevalence). Fortunately, the incidence of HYK can be estimated by multiplying the prevalence by about 2.25. This factor was derived from a large field study in which the measured incidence of HYK was 2.25 X the prevalence (45% incidence and 20% prevalence).[7]

Effects of Hyperketonemia on Production and Health

Hyperketonemia and milk production. Many studies report reduced milk yield (about 3 to 7% less) in cows experiencing HYK.[4,19,21] These studies compared milk yield in cows with spontaneous HYK to cows with normal blood BHBA concentrations. Because higher producing cows have inherently higher risk for HYK, this approach probably underestimates the reduction in milk yield associated with it.

One large field study reported that the negative impact of HYK on first test milk yield was linear; each additional 0.1 mmol/L increase in BHBA (beyond the 1.2 mmol/L threshold) was associated with 1.1 lb (0.5 kg) reduced milk yield.[19] For example, the difference between modest (1.2 mmol/L) and moderate HYK (2.4 mmol/L) was 13.2 lb (6.0 kg) less milk yield at first test.

Days-in-milk at the first onset of HYK has also been reported to affect the severity of milk yield loss associated with HYK. Cows first diagnosed with SCK between 3 and 7 DIM produced 4.6 lb (2.1 kg or about 6.0%) less milk at first test compared to cows first diagnosed with SCK between 8 and 16 DIM.[19]

Some studies report higher milk yield in cows affected with HYK.[14,23] These may represent milder cases of HYK, or HYK that was promptly detected and treated.

Hyperketonemia and displaced abomasum. Numerous studies have reported that HYK substantially increases the risk for displaced abomasum (DA).[6,16,22] Cows with more severe HYK at the onset of their SCK had even greater risk for DA; each 0.1 mmol/L increase in BHBA at the first SCK-positive test increased the risk for subsequent DA by a factor of 1.1.[16] Thus, a cow with an initial blood BHBA of 2.4 mmol/L at the onset of her HYK had a 3.1-fold increased risk for a subsequent DA compared to a cow with an initial BHBA concentration of 1.2 mmol/L. Earlier onset of SCK also increased the risk for DA; cows who first developed SCK between 3 and 5 DIM were 6.1 X more likely to develop a DA compared to cows first testing positive for SCK between 6 and 16 DIM.[17]

Hyperketonemia and metritis. Hyperketonemia and metritis occur in nearly the exact same window of DIM. This makes it difficult to determine which condition is primary and which is secondary. One study reported that HYK in the first week after calving increased the odds for metritis by 3.4 X.[6]

Hyperketonemia and herd removal. Early lactation HYK appears to increase the risk for early lactation herd removal (sold or died). In one report, cows with SCK were 3.0 X more likely to be removed from the herd in the first 30 DIM compared to cows with normal blood BHBA.[17] Each 0.1 mmol/L increase in BHBA increased the risk for herd removal 1.4 times. For example, cows with a blood BHBA of 2.4 mmol/L at the onset of SCK would (remarkably) be at 57 times higher risk for herd removal by 30 DIM than a cow with a blood BHBA of 1.2 mmol/L at her onset of SCK.[17]

Hyperketonemia and reproduction. Associations between SCK and fertility have been inconsistent. Several studies have reported negative associations of SCK with reproductive outcomes.[21,24,29] Other studies have reported no effect of SCK on subsequent fertility.[2,16] It is possible that ovulation synchronization programs limit the negative impacts of HYK on reproductive performance.

On-Farm Detection of Hyperketonemia

Early detection of HYK followed by early treatment of HYK is very beneficial in terms of both clinical outcomes and economic returns.[16,19] This becomes particularly important

in light of the fact that about 40% or more cows develop HYK sometime in early lactation. Cowside testing is necessary to diagnose these cows as soon as possible so that treatment can be initiated.

Cowside blood BHBA tests. A blood BHBA test is the preferred cowside test for HYK because of its excellent test accuracy. The Precision Xtra® blood ketone monitoring system[a] has been extensively evaluated for use as a cowside blood BHBA test in early lactation dairy cows. A meta-analysis reported that it has very high summary sensitivity (94.8%) and very high summary specificity (97.5%) at the 1.2 mmol/L cutpoint. The price of the Precision Xtra® test increased dramatically in the US about 5 years ago, which greatly limited its use as a cowside BHBA test. A similar cowside BHBA test (BHBCheck™ blood ketone test system[b]) based on the same test principle is now available in the US market. It had nearly identical test performance to Precision Xtra® when tested under field conditions[25] and is reasonably priced (about $2.00 USD per strip and $25 USD for the meter).

Cowside urine ketone tests. The traditional cowside test for HYK in the US is a semi-quantitative urine strip that measures urine acetoacetate. A meta-analysis of published studies using KetoStix® reagent strips for urinalysis[c] reported 87.6% summary sensitivity and 89.2% summary specificity for predicting HYK using the trace (0.5 mmol/L) threshold on the urine test stip.[26] However, the threshold most commonly used is the field is the "small" reading (1.5 mmol/L). The sensitivity of the KetoStix® dropped to 70.5% using this threshold.[26] The main practical limitation of using urine as the test medium for HYK is the difficulty in collecting a urine sample.

Cowside milk ketone tests. Milk-based tests can be used to diagnose HYK in dairy cows; however, they have reduced sensitivity and specificity compared to blood tests. Milk-based tests for HYK are fundamentally limited because the udder has different options for handling the ketones bodies it takes up from the bloodstream. It may either utilize the ketones or excrete them in the milk. The proportion of ketones either utilized or excreted by the udder varies by week after calving and by HYK status.[20]

Keto-Test® milk ketone body test strips[d] are a cowside HYK test that measures milk BHBA. A meta-analysis of published studies using this test compared to the gold standard of laboratory blood BHBA reported a summary sensitivity of 81.5% and a summary specificity of 81.9% using weak positive (0.1 mmol/L) as the milk test threshold.[26] A similar milk BHBA test (PortaBHB® milk ketosis test[e]) has also been evaluated and produced similar results.[3]

Milk acetoacetate tests (usually test powders) are also available for cowside HYK testing. However, they have very low sensitivity and are not recommended.[26]

Automated milk ketone tests from herd monthly milk samples. Milk samples collected as part of routine herd production monitoring are often tested for milk ketones. These approaches have minimal utility at the cow level because cows are typically tested only once per month. Their best use is for herd-level inference and not for cow-level treatment decisions.[27]

Milk BHBA can be determined in samples from routine herd testing by using automated milk testing equipment; however, milk BHBA alone is only moderately associated with blood BHBA.[27] A more robust approach, available commercially as the KetoMonitor® test day option[f], predicts blood BHBA using automated milk ketone measures plus other test day variables.[1] The accuracy of the prediction of blood BHBA using KetoMonitor® was also enhanced by developing different models by breed (Holsteins vs. Jerseys), by parity groups, and by DIM groups.[1]

Milk fat to protein ratios. Hyperketonemia is associated with increased milk fat percentage with simultaneously decreased milk protein percentage. Thus, the ratio of milk fat to protein (usually evaluated only at the first monthly DHIA test) often increases to above 1.4 during HYK. Milk fat to protein ratios are readily available and involve minimal extra expense beyond normal monthly herd tests. They have some (although limited) value in characterizing herd-level ketosis. In-line milk testing equipment can estimate milk fat to protein ratios at each milking, in real time. However, increased milk fat to protein ratios are not considered accurate enough to diagnose HYK in individual cows.[5,13]

Benefits of Early Detection and Early Treatment of Hyperketonemia

Early detection of HYK followed by early treatment is exceptionally beneficial in terms of both clinical outcomes and economic returns.[16,18,19] Early detection of SCK using a cowside blood BHBA test and early treatment of SCK with propylene glycol (300 ml orally once daily until the HYK resolved) improved milk production by about 3.3 lb (1.5 kg) of daily milk compared to cows whose SCK was left untreated.[19] Early detection and treatment of SCK also reduced the risk for early lactation removal by 2.1X, reduced the risk for DA by 1.6X, and increased first service conception.[16]

The prevention of HYK is obviously of paramount importance to dairy producers. Nonetheless, dairy producers neglect an exceptionally rewarding opportunity if they fail to use current technologies for early detection and early treatment of HYK.

Intravenous Treatment of Hyperketonemia

The traditional approach for individual cows with HYK has been to administer IV glucose. A typical dose has been 500 mL of a 50% solution, infused rapidly. However, the effectiveness of IV glucose for treating HYK (especially mild to moderate cases) is uncertain, and information regarding the effectiveness of IV glucose from controlled clinical studies is surprisingly lacking.[8]

It is very possible that our current dosing of IV glucose

is excessive. A 50% glucose solution is 10 times its isotonic concentration and provides 250 grams of glucose – enough to support about 7% of a cow's daily glucose needed to produce about 110 lb (50 kg) of milk. Unfortunately, there could be complications from giving this much glucose as an IV bolus. Hypertonic glucose given IV acts as an osmotic diuretic with the potential to increase urinary excretion of electrolytes. In addition, IV infusion of glucose rapidly increases blood glucose to very high concentrations. One study reported peak blood glucose concentrations of about 170 mg/dL following a 500 mL infusion of 50% glucose and 310 mg/dL for a single 1000 mL infusion of 50% glucose.[28] These concentrations exceed the renal threshold for glucose, which is about 100 to 140 mg/dL, and may cause glucosuria with electrolyte loss.

Not surprisingly, hyperglycemia is short-lived following IV glucose administration. Blood glucose concentrations return to baseline about 1.5 hours after IV administration.[11]

Hyperglycemia also has the potential to interfere with the normal process of hepatic gluconeogenesis and cause a rebound hypoglycemia. However, this does not appear in short-term studies, and has not been definitively demonstrated in longer-term studies.

Hypophosphatemia can be expected to follow IV administration of 500 mL of 50% glucose.[10,28] Caution should be used when administering glucose intravenously to cows already at risk for hypophosphatemia. Unfortunately, there are no clear criteria for defining cows at high risk for hypophosphatemia. Cows in early lactation with anorexia, high milk yield , and persistent subclinical hypocalcemia are probably at high risk for hypophosphatemia; however, these are not very specific considerations and are quite commonplace.

It seems prudent to reserve the administration of IV glucose for cows with more severe HYK (for example >3.0 mmol/L BHBA) and to always follow IV glucose with at least several days of an oral glucose precursor. One study reported that IV glucose (500 mL of a 50% solution once daily for 3 days) in combination with oral propylene glycol (300 mL once daily for 3 days) was more effective in lowering blood BHBA than either treatment alone.[15]

Using a lower dose of IV glucose (e.g., 250 mL of 50% glucose, which provides 125 grams of glucose) has been suggested. This is based on adverse clinical experiences in herds giving high and repeated doses of IV glucose, plus the theoretical evidence that 250 grams of intravenous glucose is a very large dose relative to metabolic needs.

Long-term hyperglycemia reduces GI motility and increases the risk for displaced abomasum (DA).[12] However, no studies have evaluated the effects of a single dose of IV glucose on GI motility or risk for DA.

Intravenous glucose does reduce blood BHBA concentrations; however, the duration of suppression of HYK is short (<12 hours).[28] This bolsters the recommendation that an oral glucose precursor should always follow IV glucose infusion.

Oral Treatment of Hyperketonemia

Oral glucose precursors are the preferred treatment for mild to moderate cases of HYK (i.e., blood BHBA between 1.2 and 2.9 mmol/L). The effectiveness of 300 mL propylene glycol for this purpose has been clearly demonstrated in a large, randomized, and controlled study.[16,19] Cows with blood BHBA between 1.2 and 2.9 mmol/L that were given propylene glycol were 1.50 times more likely to resolve their HYK by 16 DIM, 1.85 times less likely to develop severe HYK (blood BHBA ≥3.0 mmol/L), and gave about 3.3 lb (1.5 kg) more daily milk (for 2 of the 4 farms enrolled in the study). Cows with SCK who were treated with oral propylene glycol were also 1.6 times less likely to develop a displaced abomasum (DA), 2.1 times less likely to be removed from the herd by 30 DIM, and 1.3 times more likely to conceive at first service (in 3 of the 4 study herds) compared to untreated cows.[16,19] The economic benefits of aggressive early diagnosis and early treatment of HYK have been modeled and are impressive.[18] The best economic return for dairy herds with a typical prevalence of HYK comes from testing each cow twice, between 2 and 9 DIM, followed by appropriate oral treatment.

Cows with low blood glucose (<about 40 mg/dL or 2.2 mmol/L) along with HYK responded better to oral propylene glycol treatment than cows with higher blood glucose.[9] Low blood glucose was noted in 37% of the cows with HYK. This is an interesting finding and suggests that there may be lingering insulin resistance in some cows that carries a poorer prognosis. However, it is difficult to apply this treatment concept under field conditions. Cowside blood glucose testing is possible, but is not as accurate as cowside BHBA testing. There is no alternative treatment at this time for cows with normal to high blood glucose along with their HYK.

Conclusions

Hyperketonemia is one of the most crucial problems faced by higher-producing dairy cows in early lactation. New advances in cowside diagnosis of HYK have substantially increased our ability to diagnose it quickly and treat it effectively. Dairy practitioners can assist dairy clients in implementing programs to promptly detect and properly treat HYK. We can now mitigate about half of the negative impacts of HYK in the herd.

Acknowledgments

Dr. Oetzel has served as a consultant and speaker for Boehringer Ingelheim Animal Health and Zoetis Animal Health. He has conducted research projects sponsored by AgSource, Boehringer Ingelheim Animal Health, and Zoetis Animal Health.

Footnotes

[a] Precision Xtra® Blood Glucose and Ketone Monitoring System, Abbott Diabetes Care, Alameda, CA
[b] BHBCheck™ Blood Ketone and Glucose Test System, PortaCheck Inc., Moorestown, NJ
[c] KetoStix® Reagent Strips for Urinalysis, Bayer AG, Leverkusen, Germany
[d] Keto-Test® Milk Ketone Body Test Strips, Elanco Animal Health, Greenfield, IN
[e] PortaBHB® Milk Ketone Test, PortaCheck, Moorestown, NJ
[f] KetoMonitor®, AgSource, Verona, WI

References

1. Chandler TL, Pralle RS, Dórea JRR, Poock SE, Oetzel GR, Fourdraine RH, White HM. Predicting hyperketonemia by logistic and linear regression using test-day milk and performance variables in early-lactation Holstein and Jersey cows. *J Dairy Sci* 2018; 101:2476-2491.
2. Chapinal N, Carson ME, LeBlanc SJ, Leslie KE, Godden S, Capel M, Santos JEP, Overton MW, Duffield TF. The association of serum metabolites in the transition period with milk production and early-lactation reproductive performance. *J Dairy Sci* 2012; 95:1301-1309.
3. Denis-Robichaud J, Descôteaux L, Dubuc J. Accuracy of a new milk strip cow-side test for diagnosis of hyperketonemia. *Bov Pract* 2011; 45:97-100.
4. Dohoo IR, Martin SW. Subclinical ketosis: Prevalence and associations with production and disease. *Can J Comp Med* 1984; 48:1-5.
5. Duffield TF, Kelton DF, Leslie KE, Lissemore KD, Lumsden JH. Use of test day milk fat and milk protein to detect subclinical ketosis in dairy cattle in Ontario. *Can Vet J* 1997; 38:713-718.
6. Duffield TF, Lissemore KD, McBride BW, Leslie KE. Impact of hyperketonemia in early lactation dairy cows on health and production. *J Dairy Sci* 2009; 92:571-580.
7. Duffield TF, Sandals D, Leslie KE, Lissemore K, McBride BW, Lumsden JH, Dick P, Bagg R. Efficacy of monensin for the prevention of subclinical ketosis in lactating dairy cows. *J Dairy Sci* 1998; 81:2866-2873.
8. Gordon JL, LeBlanc SJ, Duffield TF. Ketosis treatment in lactating dairy cattle. *Vet Clin North Am Food Anim Pract* 2013; 29:433-445.
9. Gordon JL, LeBlanc SJ, Kelton DF, Herdt TH, Neuder L, Duffield TF. Randomized clinical field trial on the effects of butaphosphan-cyanocobalamin and propylene glycol on ketosis resolution and milk production. *J Dairy Sci* 2017; 100:3912-3921.
10. Grünberg W, Morin DE, Drackley JK, Barger AM, Constable PD. Effect of continuous intravenous administration of a 50% dextrose solution on phosphorus homeostasis in dairy cows. *J Am Vet Med Assoc* 2006; 229:413-420.
11. Grünberg W, Morin DE, Drackley JK, Constable PD. Effect of rapid intravenous administration of 50% dextrose solution on phosphorus homeostasis in postparturient dairy cows. *J Vet Intern Med* 2006; 20:1471-1478.
12. Holtenius K, Sternbauer K, Holtenius P. The effect of the plasma glucose level on the abomasal function in dairy cows. *J Anim Sci* 2000; 78:1930-1935.
13. Jenkins NT, Peña G, Risco C, Barbosa CC, Vieira-Neto A, Galvão KN. Utility of inline milk fat and protein ratio to diagnose subclinical ketosis and to assign propylene glycol treatment in lactating dairy cows. *Can Vet J* 2015; 56:850-854.
14. Kauppinen K. Annual milk yield and reproductive performance of ketotic and non-ketotic dairy cows. *Zentralbl Vet A* 1984; 31:694-704.
15. Mann S, Yepes FAL, Behling-Kelly E, McArt JAA. The effect of different treatments for early-lactation hyperketonemia on blood β-hydroxybutyrate, plasma nonesterified fatty acids, glucose, insulin, and glucagon in dairy cattle. *J Dairy Sci* 2017; 100:6470-6482.
16. McArt JAA, Nydam DV, Oetzel GR. A field trial on the effect of propylene glycol on displaced abomasum, removal from herd, and reproduction in fresh cows diagnosed with subclinical ketosis. *J Dairy Sci* 2012; 95:2505-2512.
17. McArt JAA, Nydam DV, Oetzel GR. Epidemiology of subclinical ketosis in early lactation dairy cattle. *J Dairy Sci* 2012; 95:5056-5066.
18. McArt JAA, Nydam DV, Oetzel GR, Guard CL. An economic analysis of hyperketonemia testing and propylene glycol treatment strategies in early lactation dairy cattle. *Prev Vet Med* 2014; 117:170-179.
19. McArt JAA, Nydam DV, Ospina PA, Oetzel GR. A field trial on the effect of propylene glycol on milk yield and resolution of ketosis in fresh cows diagnosed with subclinical ketosis. *J Dairy Sci* 2011; 94:6011-6020.
20. Oliveira SJ, Pralle RS, Chandler TL, Sailer SJ, Mack TN, Weld KA, White HM. Mammary utilization and secretion of ß-hydroxybutyrate differs in cows with hyperketonemia. *J Dairy Sci* 2017; 100 (Suppl 1):287 (abstract).
21. Ospina PA, Nydam DV, Stokol T, Overton TR. Associations of elevated nonesterified fatty acids and beta-hydroxybutyrate concentrations with early lactation reproductive performance and milk production in transition dairy cattle in the northeastern United States. *J Dairy Sci* 2010; 93:1596-1603.
22. Ospina PA, Nydam DV, Stokol T, Overton TR. Evaluation of nonesterified fatty acids and beta-hydroxybutyrate in transition dairy cattle in the northeastern United States: Critical thresholds for prediction of clinical diseases. *J Dairy Sci* 2010; 93:546-554.
23. Ruoff J, Borchardt S, Heuwieser W. Short communication: Associations between blood glucose concentration, onset of hyperketonemia, and milk production in early lactation dairy cows. *J Dairy Sci* 2017; 100:5462-5467.
24. Rutherford AJ, Oikonomou G, Smith RF. The effect of subclinical ketosis on activity at estrus and reproductive performance in dairy cattle. *J Dairy Sci* 2016; 99:4808-4815.
25. Sailer KJ, Pralle RS, Oliveira RC, Erb SJ, Oetzel GR, White HM. Technical note: Validation of the BHBCheck blood β-hydroxybutyrate meter as a diagnostic tool for hyperketonemia in dairy cows. *J Dairy Sci* 2018; 101:1524-1529.
26. Tatone EH, Gordon JL, Hubbs J, LeBlanc SJ, DeVries TJ, Duffield TF. A systematic review and meta-analysis of the diagnostic accuracy of point-of-care tests for the detection of hyperketonemia in dairy cows. *Prev Vet Med* 2016; 130:18-32.
27. van der Drift SGA, Jorritsma R, Schonewille JT, Knijn HM, Stegeman JA. Routine detection of hyperketonemia in dairy cows using Fourier transform infrared spectroscopy analysis of β-hydroxybutyrate and acetone in milk in combination with test-day information. *J Dairy Sci* 2012; 95:4886-4898.
28. Wagner SA, Schimek DE. Evaluation of the effect of bolus administration of 50% dextrose solution on measures of electrolyte and energy balance in postpartum dairy cows. *Am J Vet Res* 2010; 71:1074-1080.
29. Walsh RB, Walton JS, Kelton DF, LeBlanc SJ, Leslie KE, Duffield TF. The effect of subclinical ketosis in early lactation on reproductive performance of postpartum dairy cows. *J Dairy Sci* 2007; 90:2788-2796.

Protecting our social license to operate – consumers, social media, and modern agriculture

Marissa A. Hake, DVM, MPH
600 Strauss-Provini Rd 8611, North Manchester, IN 46962

Abstract

As members of the food animal community, we are given a "social license to operate" from our consumers, a license that can easily be taken away if they feel we have not lived up to our obligations. Agriculture's social license is rooted in the beliefs, perceptions, and opinions held by consumers. Our consumers are the ones granting our social license, which is often intangible, and our status can change quickly as new information is learned. In a world that wants to know how its food is being produced, we must embrace transparency and understand how to communicate effectively with our consumers. Veterinarians are a valuable resource to help farms establish care-focused cultures and proactive, auditable protocols in order to keep our "social licenses to operate".

Key words: social media, protocols, consumers

Résumé

En tant que membres de la communauté travaillant avec des animaux de consommation, les consommateurs nous donnent un 'droit social d'opérer', un droit qui peut être facilement retiré si les consommateurs sentent que nous ne respectons pas nos obligations. Le droit social en agriculture est issu des convictions, des perceptions et des opinions que forment les consommateurs. Nos consommateurs sont ceux qui nous octroient un droit social souvent intangible et notre statut peut changer rapidement avec l'acquisition de nouvelles informations. Dans un monde qui exige de savoir comment la nourriture est produite, nous devons être disposés à l'ouverture et savoir comment communiquer efficacement avec nos consommateurs. Les vétérinaires sont une ressource précieuse pour aider les fermes à établir une culture centrée sur les soins et sur des protocoles proactifs et vérifiables dans le but de sauvegarder nos 'droits sociaux d'opérer'.

Introduction

Protecting our ability to operate in the future will involve 3 key areas: building consumer trust, care-focused farm cultures, and effective protocol development. Agriculture's "social license" is rooted in the beliefs, perceptions and opinions held by consumers. This is given and taken away by consumers based on the information they receive.[7]

To keep our social license, we must focus on building consumer trust, which is a 2-way street. Trust building starts with understanding who our consumers are and what drives their purchasing decisions, but also involves agriculture openly sharing its story and exhibiting transparency.[5] Social media is an important tool to achieve transparency because the Millennial, Z, and Alpha consumers are getting most of their food information online.[4] We have to meet our consumers where they are at and on the platforms they demand, ie, 88% of Millennials are on the Facebook platform. Furthermore, 95% of this generation find friends as the most creditable source of information and 62% say that when a brand engages them on social networks they are more likely to be a loyal customer. Generation Z, the largest population in US history, believe that having an online presence reflects a brand's value and not being social media makes a brand irrelevant and outdated.[4] Knowing who and what our consumers trust also helps us build communication strategies that will be meaningful. For example, 66% of consumers polled said they don't trust the government to look out for consumer interests.[6] This helps us understand that communicating about stringent regulations might not be as impactful as talking about what we do on-farm to keep our products safe. A study by McKinsey and Co. looked at the top 5 views and behaviors consumers have towards dairy and they found:

1. Health considerations are increasingly more important.
2. Transparency is expected.
3. Openness to trying new brands and products is expanding.
4. Plant-based dairy alternatives continue to grow.
5. Channel and value preferences vary by age.[1]

We have an opportunity to engage consumers on social media to discuss many of these key concerns and drive purchasing decisions, as well as bolster our social license.

Developing and maintaining a positive farm culture is critical for keeping a social license to operate, as our farms are only as good as our worst employee. Our consumers are assuming that we are showing compassion towards our animals while providing them with the best care. If they believe we are not living up to that obligation, they quickly lose trust in that specific product or brand. Care-focused farm culture starts at the top and you must have buy-in from all key decision makers. By developing a strong culture that puts the care of employees and animals first, we can mitigate the risk of unwanted exposure. We must learn to develop a "culture of care" over a "culture of production". The first step is making sure every farm has an "Animal Care Commitment" that explicitly defines what the farm's policy is on animal care

and steps they take to uphold it.[12] This should be signed by every employee and posted throughout the farm, especially in areas of human-cow interactions. We ultimately rely upon our employees, aka "animal care technicians", and we should be investing in them. Through continued education we have a huge opportunity to help instill animal ethics and attitudes towards animals into our workers. The investment into trained labor will continue to be a huge necessity as farms consolidate. From 2003 to 2016 we have increased hired labor in agriculture by almost 16%.[10] We need to help make our farm employees less of a liability and more of an insurance policy for our farms. This can be accomplished through prolonged employee acclimation, clearly defined roles, and investment into continuing education.[10]

Veterinarians have always been instrumental in the development of farm protocols, but now more than ever protocols are necessary to help protect farmers—think insurance policy.

Protocols should be farm-specific, bilingual, and auditable. Our farm protocols are living documents, therefore should be updated and revisited frequently. When developing protocols for our farms, we should always start with "discovery". Discovery involves assessing the unique needs and gaps in care on the farm. Farm protocols must cover some of the most critical and sensitive areas of food animal production—non-ambulatory animals, transportation, painful procedures, cow-calf separation, deadstock, hiring, and crisis plans.[2] Once discovery is complete, protocols can be written that involve detailed procedures, measurement tools, goals, and reasons. After the protocols are written, employees must be fully-trained and mentored. This is critical because our goal is to have auditable protocols, but you can't audit what you don't train. Our industry is moving more towards second- and third-party audits in order to help consumers and brands feel comfortable with what is happening within the supply chain. Second party audits are a great opportunity for veterinarians or veterinary technicians to bring a value-added service to our farms.

Conclusion

Our farms are becoming increasingly aware of how consumer pressure can impact how we manage our farms. Helping our farmers adopt policies and cultures that embrace sound animal husbandry, exceptional animal welfare and sustainable farming practices, balanced with consumer demands, will help us to keep our social license to operate.

Acknowledgement

I have a financial interest, agreement or affiliation with Fairlife, LLC.

References

1. Adams C, et al. Five insights into the views and behaviors of the US dairy consumer. *McKinsey and Company* Sept. 2019. www.mckinsey.com/industries/consumer-packaged-goods/our-insights/five-insights-into-the-views-and-behaviors-of-the-us-dairy-consumer.
2. Animal Agriculture Alliance. Resource Center. *Animal Agriculture Alliance* 1 Jan. 2020, animalagalliance.org/resource-center/.
3. Bailey S. 1 in 2 millennials admit to avoiding dairy because of social media influence. *Sporteluxe* 2020. Available at: https://sporteluxe.com/1-in-5-millennials-now-avoid-dairy-but-without-a-clear-reason-why-according-to-new-research/.
4. Business Insider. Generation Z latest characteristics, research, and facts. *Business Insider* Apr. 2019, www.businessinsider.com/generation-z.
5. Center for Food Integrity. A dangerous food disconnect . *Center for Food Integrity* 2018. www.foodintegrity.org/wp-content/uploads/2018/01/CFI_Research_8pg_010918_final_web_REV2-1.pdf.
6. Consumer Reports. As Trump takes office, what's top of consumers' minds? 19 Jan. 2017. www.consumerreports.org/consumer-protection/as-trump-takes-office-what-is-top-of-consumers-minds/. Accessed 10 Feb. 2020.
7. Definition of Social License. socialicense.com/definition.html. 2018. Accessed 13 Feb. 2020.
8. Farm Journal MILK Magazine. Animal rights activists change tactics. *The Fence Post* 21 Aug. 2017. www.thefencepost.com/news/animal-rights-activists-change-tactics/.
9. Gallup News Service. Public rates nursing as most honest and ethical profession. *Gallup News Service* 1 Dec. 2003. news.gallup.com/poll/9823/public-rates-nursing-most-honest-ethical-profession.aspx.
10. Leach T. 3 ways to keep farm employees around longer. *Dairy Herd Management* 2020. Available at: https://www.dairyherd.com/article/3-ways-keep-farm-employees-around-longer.
11. Minthrush N. Five reasons social media is a powerful tool in your marketing strategy. *Forbes* 17 July 2018. www.forbes.com/sites/forbescommunicationscouncil/2018/07/17/five-reasons-social-media-is-a-powerful-tool-in-your-marketing-strategy/#746c5c347300.
12. National Dairy Farm. Farmers Assuring Responsible Management - FARM. *National Dairy Farm - FARM Program* Sept. 2019. nationaldairyfarm.com/training-resources/.
13. See It, Stop It Overview. *See It, Stop It* 1 Jan. 2020, www.seeitstopit.org/.
14. USDA. USDA ERS - farm labor. *United States Department of Agriculture Economic Research Service* 21 Jan. 2020.www.ers.usda.gov/topics/farm-economy/farm-labor/.