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Addressing the pain associated with disbudding and dehorning in cattle

Kevin J. Stafford[a,*], David J. Mellor[b]

[a] Animal Welfare Science and Bioethics Centre, Institute of Veterinary Animal and Biomedical Sciences, Massey University, Palmerston North 4442, New Zealand

[b] Animal Welfare Science and Bioethics Centre, Institute of Food, Nutrition and Human Health, Massey University, Palmerston North 4442, New Zealand

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ABSTRACT

The pain caused by disbudding or dehorning of cattle and its alleviation may be assessed by behavioural, physiological and production responses. Disbudding can be carried out by cautery or the application of a chemical paste. Cautery disbudding and amputation dehorning stimulate definite pain related behaviours during and after the procedure but caustic disbudding causes little response during the procedure though it is followed by behaviours indicative of pain. All three procedures cause definite plasma cortisol responses but the response to amputation dehorning is significantly greater than the response to cautery or chemical disbudding. It has a characteristic format; a rapid increase following dehorning to a maximum concentration within 30 min, then a decline to plateau levels, followed by a return to pretreatment values at 7–8 h. Local anaesthesia administered before disbudding or dehorning eliminates pain-related behaviour and reduces the plasma cortisol response for about 1.5 h. Following amputation dehorning the plasma cortisol concentration then increases for about 6 h before returning to pretreatment levels. When local anaesthesia and a non-steroidal anti-inflammatory drug (NSAID) are given before disbudding or dehorning the cortisol responses to these procedures are virtually eliminated. Chronic pain in the days following disbudding and dehorning is poorly understood. As a general rule, if pain relief is not available, cautery disbudding is preferable to chemical disbudding or amputation dehorning. If possible, local anaesthesia and better still local anaesthesia plus a NSAID should be used to minimise the pain caused by all three procedures.

1. Introduction

The prevention of horn growth (disbudding) or removal of horns (dehorning) are common practices on cattle farms (Stafford and Mellor, 2005) as cattle without horns are easier to manage and cause less injury, especially during transport (Marshall, 1977). In addition, hornless cattle require less trough space (Stookey and Goonewardene, 1996). Disbudding and dehorning are painful procedures and breeding polled, i.e. hornless cattle, eliminates the need to carry out these procedures. Some beef cattle breeds are polled but most dairy breeds and many beef breeds still grow horns. European type cattle (*Bos taurus*) have a simple genetic basis for polledness and could easily be bred as polled, but the genetic basis for polledness in humped cattle (*Bos indicus*) is more complicated and breeding for this phenotype is more difficult (Prayaga, 2007).

As disbudding or dehorning are standard practices on cattle properties a range of tools have been developed either to destroy or remove horn bud tissue (cautery, caustic paste, removal by knife) or cut off horns (saw, embryotomy wire, scoop, shears, electrical saw) (Sylvester et al., 1998a). Speed and safety for cattle and humans are important considerations during the procedure, as is

* Corresponding author.
E-mail address: K.J.Stafford@massey.ac.nz (K.J. Stafford).

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managing the potential post-operative problems of haemorrhage, tissue necrosis, bone fracture, sinusitis and death (Weaver, 1986).

To prevent pain in cattle we can use general anaesthesia, local anaesthesia and/or systemic analgesia. General anaesthesia cannot easily be carried out on large numbers of cattle on farms. Local anaesthetics (usually lignocaine) and analgesic non-steroidal anti-inflammatory agents (NSAIDs) are the drugs used to minimise pain in cattle. The sedative xylazine also has some analgesic effects. At present using the first principles of veterinary analgesia, an analgesic protocol combining xylazine as a sedative/analgesic, local anaesthesia and systemic analgesia should alleviate or eliminate the pain caused by disbudding and dehorning. These drugs are available to veterinarians but may not be available to farmers for regulatory reasons or may be costly. Moreover, the observation that disbudding by caustic paste or the rapid removal of small horns by scoop is not accompanied by pain-related behavioural responses has encouraged the use of these techniques without analgesia.

Setting definite ages for disbudding or dehorning is difficult as (1) the development of horns in some beef breeds occurs much later than in the dairy breeds and (2) some calves born in extensively managed herds are not handled until they are weaned at about 5–6 months of age when horn size makes amputation necessary. Dairy calves are managed intensively from birth and can be disbudded easily in the first few weeks of life. Some cattle are inadequately disbudded and need to have their horns removed by amputation at an older age. In some countries it is illegal to transport long horned cattle so that their horns are tipped before transport. This may or may not be painful depending on the length of horn tip which is cut off. Moreover, some organic farmers insist on leaving horns on cattle and consider the injuries inflicted by horns on other cattle acceptable. These injuries may be quite substantial skin tears. The primary author (KJS) has treated horses with serious abdominal injuries caused by the horns of cows with calves, and bulls.

Animals being disbudded or dehorned experience pain and behave accordingly by attempting to escape. Farmers and veterinarians, who undertake these procedures without analgesia or anaesthesia use restraint that allows the procedure to be carried out safely for the animal and themselves. Thus, they either carry out the procedure on young animals that are easily restrained manually, or restrain larger animals using ropes, head bails, crushes or sedation. The procedures themselves are usually simple, quick and easy.

Disbudding and dehorning without anaesthesia or analgesia cause pain but these practices also involve temporary isolation, restraint, and exposure to novel stimuli (close human contact, smells, blood) which may cause distress as shown by some physiological and behavioural responses. Differentiating between the distress and the pain caused by such procedures is difficult but effective local anaesthesia should eliminate the latter. Frequent and regular handling should reduce the stress caused by isolation and manual restraint and also help to differentiate between the two responses.

The pain caused by disbudding and dehorning and its alleviation has been the subject of research for about two decades and this paper reviews this work. The bulk of this research has been carried out on hand-reared dairy calves which may result in less stress during the process compared to the responses of single suckled beef calves. Pain and the efficacy of pain alleviation have been assessed using behaviour, physiological responses and productivity. In addition, our understanding of the welfare significance of these procedures has been improved by our knowledge of the resultant pathology. Research has concentrated on the acute pain experienced during the procedure itself and in the hour following it, and the inflammatory pain experienced during the subsequent 12 h. Alleviation of these different forms of pain has also been studied. There is much less information on the pain experienced in the days and weeks following disbudding or dehorning. The paper will review the literature pertaining to the three major methods of horn removal, cautery disbudding, caustic disbudding and amputation dehorning. It will review behaviour and physiological studies in which the severity of the pain experienced by calves subjected to these procedures and the success of methods to alleviate this pain were assessed. It will conclude by looking at how this knowledge may be used to improve the welfare of calves in the future worldwide.

2. Cautery disbudding

Cautery disbudding is carried out on calves in the first 4–6 weeks of life. The horn bud and the horn generative tissue are destroyed by searing with a heated bar, usually one with a concave tip which heats the bud and surrounding tissue, for some seconds (Weaver, 1986). The bar may be heated electrically or by gas. During the process calves struggle violently and have to be restrained manually or in a head bail. The behaviours (rearing, falling down, pushing, head jerking and moving) are indicative of severe pain (Taschke and Folsch, 1993; Graf and Senn, 1999; Grondahl-Nielsen et al., 1999). Following cautery disbudding, calves engage in head-shaking for 2 h (Graf and Senn, 1999). The behaviour after disbudding by cautery indicates that the pain lasts for at least 4 h (Hennrich, 2007 cited by Heinrich et al., 2009). Behaviours indicative of pain or distress, which are evident during the first 4 h after cautery, include increases in head shaking, grooming, rubbing, standing up/lying down actions, hind-leg kicks, and fewer head jerks as well as decreased rumination, are markedly reduced or abolished by effective local anaesthesia (Morisse et al., 1995; Grondahl-Nielsen et al., 1999; Graf and Senn, 1999).

Cautery disbudding causes a small total plasma cortisol response which peaks at 30 min and returns to pretreatment values by 2 h (Petrie et al., 1996). This response during the first hour after cautery disbudding is significantly greater than the response in control calves, which supports the suggestion above that during this period cautery disbudding causes some pain or distress (Laden et al., 1985; Petrie et al., 1996). In support of this observation, salivary cortisol levels peak 30 min after cautery disbudding (Taschke and Folsch, 1993) and the heart rate in

calves disbudded by cautery remains higher than in control calves for 213 min following treatment (Grondahl-Nielsen et al., 1999). Heart rate remained above baseline figures for 20 min (Stewart et al., 2008) and 3 h in calves disbudded by cautery and increased 2–3 h after disbudding in calves given a local anaesthetic (Stewart et al., 2009).

These observations suggest that pain and/or wound sensitivity persist for at least 4 h. Pain and wound sensitivity may last for 24 h as significantly higher plasma cortisol concentrations were found 24 h after cautery disbudding by Morisse et al. (1995). However, this pain may not be too intense as the ratios of standing:lying are similar during the 24 h before and after disbudding (Morisse et al., 1995). Some results suggest that pain lasts for up to 24 h. Earflicking in disbudded calves continued at a greater level than in control animals for 24 h (Faulkner and Weary, 2000). Behavioural data from Heinrich (2007 cited by Heinrich et al., 2009) suggests that pain persisted for 44 h but this may be irritation at that time rather than pain *per se*. Clearly more work needs to be done to clarify the duration of pain and whether and when pain becomes irritation.

When calves are given local anaesthetic (lignocaine) in a cornual block (Weaver, 1986) there is a small transient increase in plasma cortisol concentrations which returns to pre-treatment levels 60 min after disbudding (Petrie et al., 1996). This response is not significantly different from the response of calves disbudded without nerve block (Petrie et al., 1996) and Boandl et al. (1989) found no differences in the plasma cortisol response in calves 30 min after disbudding by cautery with or without local anaesthesia. However, local anaesthetic administered as a cornual block plus a ring block virtually abolished the cortisol response to cautery disbudding (Graf and Senn, 1999). On the face of it, the observations by Petrie et al. (1996) and Boandl et al. (1989) suggest that there are no major differences in the pain or distress experienced by calves after cautery disbudding with or without local anaesthesia. This is unlikely and may be explained in several ways. First, the local anaesthetic may not have been effective in all calves; it is important to test for effective anaesthesia by needle prick before disbudding. Second, most of the plasma cortisol response occurs after the local anaesthetic has worn off, so that it is not a useful indicator of the pain experienced during or immediately after a physical insult (Mellor and Stafford, 1997).

There are other physiological indices of pain suggest that cautery disbudding is painful, for example it caused an immediate, large increase in plasma ACTH and vasopressin concentrations which peaked after 5 min and remained elevated for 20 and 60 min, respectively (Graf and Senn, 1999). There were significantly greater plasma noradrenaline and adrenaline concentration in disbudded calves than control calves for up to an hour following treatment (Mellor et al., 2002) and heart rate changes follow a similar pattern (Stewart et al., 2008, 2009).

In any case, the behaviours during cautery disbudding (Taschke and Folsch, 1993; Graf and Senn, 1999; Grondahl-Nielsen et al., 1999), which illustrate severe pain during the process and afterwards, are eliminated by effective local anaesthesia which suggests that giving local anaesthesia before disbudding is beneficial.

The cortisol response of disbudded calves given the NSAID ketoprofen and local anaesthesia was less than the response of calves given local anaesthetic alone, which suggests that following cautery disbudding ketoprofen had some pain-relieving effect in addition to that of local anaesthesia alone (Milligan et al., 2004). Interestingly there were no differences in the behaviour between the calves given ketoprofen and local anaesthetic and those given local alone following disbudding (Milligan et al., 2004) which differs from Faulkner and Weary's (2000) results that head shaking and ear flicks were fewer in calves given ketoprofen. This remains inexplicable. When meloxicam, a longer acting NSAID, was administered along with local anaesthesia the plasma cortisol concentration and the heart and respiratory rates were lower than in calves given only local anaesthetic (Heinrich et al., 2009).

The sedation of calves using xylazine makes the administration of local anaesthetic easier, but xylazine itself does not eliminate the behavioural responses to cautery disbudding and the pain these indicate (Stilwell et al., 2010), although it may reduce them. It is necessary to give local anaesthetic in addition to xylazine to eliminate the physical activity seen during disbudding in calves and the pain the procedure causes (Stilwell et al., 2010).

3. Chemical disbudding

During chemical disbudding a paste or a stick of sodium hydroxide or calcium hydroxide is used to destroy the horn bud (Weaver, 1986). These chemicals burn the tissues and this burn continues as long as the chemical is present. To minimise unnecessary skin damage, the area surrounding the horn should be defatted with surgical spirit. The bud may be scarified to make the caustic paste more effective. The caustic material may spread onto surrounding tissue especially following rain, be licked by and cause damage to other calves or cause damage to the udders of suckling cows. These side-effects are significant in calves kept in groups indoors or outdoors, and in suckling cows.

The application of a caustic paste does not cause much response during application (Stilwell et al., 2009) and this may give a false impression of how it affects calves. However, there was a significant rise in plasma cortisol concentrations within 1 h following application of caustic material (Morisse et al., 1995; Stilwell et al., 2009) and this returned to pre-treatment levels 4–24 h later (Morisse et al., 1995). Following treatment, calves engaged in behaviours suggestive of pain (head shaking, head rubbing) almost immediately (Stilwell et al., 2009) and other behaviours (inert lying, decreased grooming, restlessness) continued for 3 or 4 h (Morisse et al., 1995; Stilwell et al., 2009).

Local anaesthesia alleviates but does not eliminate the pain caused by chemical disbudding. It controlled pain for the first hour in one trial by Stilwell et al. (2009) but not in another by Vickers et al. (2005). Stilwell et al. (2009) used a cornual nerve block and then confirmed local anaesthesia efficacy by needle prick; Vickers et al. (2005) used a ring block without such confirmation so that the local may not have been effective in all the calves in that study. When local anaesthesia was combined with a NSAID

(flunixin-meglumide), the cortisol and behavioural responses were eliminated (Stilwell et al., 2009) but not when a NSAID was used without local anaesthesia (Stilwell et al., 2008).

When calves were disbudded by caustic paste following xylazine, or by cautery following xylazine and local anaesthesia, the latter showed more head shaking suggesting that it is a more painful procedure (Vickers et al., 2005). This finding conflicts with earlier results from Morisse et al. (1995) who found a greater plasma cortisol response to caustic disbudding than cautery disbudding, and more restlessness as well. The use of xylazine may have influenced the results and further work needs to be carried out to compare these two disbudding techniques. Chemical burns unlike cautery burns continue as long as the chemical is in contact with tissue and may cause longer periods of pain than the latter (Stilwell et al., 2009).

4. Dehorning

The acute pain caused by amputation dehorning is significant and animals will struggle to escape during the procedure. The plasma cortisol response of Friesian calves to this procedure has been described and appears similar in a number of trials. The total plasma concentration rises immediately, peaking after about 30 min, and it then decreases to a plateau which persists for 5–6 h before returning to pretreatment levels (Cooper et al., 1995; Petrie et al., 1996; McMeekan et al., 1997, 1998a,b; Sylvester et al., 1998a,b). During the 6–8 h after dehorning, calves engaged in more tail-shaking, head-shaking and ear-flicking, and less rumination (Sylvester et al., 2004) and grazed and ruminated less, lay down more, groomed less and scratched more against pen fittings than calves which were not dehorned (McMeekan et al., 1999; Stafford et al., 2000), suggesting that pain lasts for 8 h. The plasma cortisol responses to dehorning were not significantly affected by different methods (Sylvester et al., 1998a) of amputation, nor by the depth of the wound (McMeekan et al., 1997).

The chronic pain caused by amputation dehorning is less easy to identify and assess. Total plasma cortisol concentrations return to pre-treatment levels 9 h after dehorning and most studies show that they remain there for 24 h (Sutherland et al., 2002a) to 36 h (Sylvester et al., 1998a), but in 4-month-old calves after castration *and* dehorning they were significantly elevated 48 h later (Johnston and Buckland, 1996). Likewise, there are some contradictory reports on behaviour following dehorning. In one study no obvious differences between control and dehorned calves were reported 24 h after dehorning (McMeekan et al., 1999). In another study, dehorned calves grazed and ruminated less between 24 and 48 h after dehorning than they did beforehand or between 48 and 72 h after dehorning (Stafford, unpublished data). Thus there may be chronic pain, but it does not evoke a significant rise in plasma cortisol concentration or influence behaviours associated with the pain of dehorning (head shaking, ear flicking and tail shaking). The wound caused by amputation dehorning may take 6 weeks (Loxton et al., 1982) or even 3 months or more to heal (Kihurani et al., 1989), and dehorning also affects weight gains negatively (Winks et al., 1977), especially during the 2–6 weeks after dehorning (Loxton et al., 1982), but up until approximately 15 weeks (Goonewardene and Hand, 1991). The protracted wound healing and reduced weight gains suggest that dehorned cattle are likely to experience ongoing pain, but long-term analgesic studies are required to elucidate this point.

Effective lignocaine local anaesthesia, usually as a cornual nerve block, virtually eliminates pain-related behaviour in calves during dehorning (Sylvester et al., 2004); it also virtually abolishes any dehorning-induced cortisol response for 90–120 min while the block persists, and then cortisol concentrations increase markedly for about 6 h (Petrie et al., 1996; Sylvester et al., 1998b). This delayed cortisol response probably indicates a period of inflammation-related pain (McMeekan et al., 1998b). This delayed response is seen when local anaesthesia is sustained for 2 (lignocaine), 4 (bupivacaine), 6 (lignocaine followed by bupivacaine) or 8 h (bupivacaine given twice) (Sylvester et al., 1998a; Petrie et al., 1996; McMeekan et al., 1998a,b; Sutherland et al., 2002a). Moreover, while local anaesthesia abolishes pain related behaviour for about 2 h (McMeekan et al., 1999; Stafford et al., 2000), between 2 and 6 h restlessness increases to levels similar to those seen in calves dehorned without local anaesthesia (Sylvester et al., 2004).

Thus, as local anaesthesia alone does not eliminate all of the pain related behaviour or plasma cortisol response following amputation dehorning, leaving largely unaffected the inflammation-related pain (McMeekan et al., 1998b), a systemic analgesic may be needed as well. Administering the NSAID ketoprofen intravenously before horn amputation does not reduce the peak in plasma cortisol concentration, but the plateau is eliminated and plasma cortisol returns to pre-treatment levels at about 2 h rather than 8 h after dehorning (McMeekan et al., 1998b). Moreover the behaviour of calves dehorned without analgesia and those dehorned after ketoprofen injection is similar for about 2 h (McMeekan et al., 1999), which suggests that ketoprofen does not abolish the acute pain experienced immediately after dehorning. However, when both lignocaine and ketoprofen are given before dehorning the cortisol response to dehorning is eliminated (McMeekan et al., 1998b), and calves treated thus may not experience significant acute pain and distress. In addition, their behaviour is similar to that of control animals in the short- and longer-term, supporting the concept that this combination alleviates both acute and inflammatory pain (McMeekan et al., 1999).

Traditionally amputation wounds were cauterised to reduce haemorrhage, but it has been shown that such cauterisation marginally reduces the plasma cortisol response (Sylvester et al., 1998b). Cauterisation of the wound following the administration of local anaesthesia eliminates the plasma cortisol response throughout the first 24 h after dehorning (Sylvester et al., 1998b; Sutherland et al., 2002b). The suggested explanation is that the local anaesthesia blocks the pain of the amputation and cautery, and the cautery probably destroys enough nociceptors in the wound to keep the nociceptor impulse input below the pain threshold when the local anaesthesia wears off.

The sedative xylazine reduces the usual cortisol response to dehorning for about 3 h, and when combined with lignocaine it eliminates the response for the first 3 h (Stafford et al., 2003). After both treatments, there is a delayed cortisol response which begins 3 h after dehorning and continues for about 5 h (Stafford et al., 2003). This delayed response suggests that calves experience pain during this period.

5. Comparison between methods

The cortisol response in the hours following cautery disbudding without anaesthesia or analgesia is lower than the response to chemical disbudding and amputation dehorning, which suggests that the former technique is less painful, acutely, than the latter techniques. The differences in the pathology caused by the three techniques probably explain the different cortisol responses. Cautery damages the skin around the horn buds with reasonable superficial injuries whereas amputation removes skin and also bone, sometimes penetrating into the frontal sinuses, wounds which are much deeper and more extensive. Cautery ends with the removal of the heated bar, but chemical damage continues as long as there are chemical in contact with tissue, thus the chemical burns may be ongoing and deeper than the burns caused by cautery. More research needs to be carried out to compare these two methods of disbudding.

The chronic pain that is the pain experienced in the days and possibly weeks following disbudding or dehorning is poorly understood, but may be significant. Long term analgesia studies are required to further develop our understanding of this difficult subject.

6. Implications and conclusions

Veterinary protocols and regulations for disbudding or dehorning calves vary between countries and usually reflect the availability of veterinarians, veterinary drugs and cattle management practices. In some countries it is now mandatory to provide pain relief during painful procedures. On some farms in the wealthy world, where veterinarians or veterinary technicians carry out the disbudding or dehorning, the cattle may be sedated, receive local anaesthesia and systemic analgesia, which will virtually eliminate acute pain regardless of technique if local anaesthesia is administered effectively. On other farms xylazine will be combined with local anaesthesia, or local anaesthesia with systemic analgesia and physical restraint, or local anaesthesia will be used alone with the calf restrained in a head bail. When farmers carry out disbudding or dehorning, usually no pain relief is used. The availability of drugs for farmer use is regulated differently in different countries, so that farmers may or may not have access to local anaesthetics, NSAIDS or sedatives.

Although the scientific knowledge exists to minimise acute pain, the use of the necessary pharmaceuticals is dependent on the economics of farm management and other factors including the cost of drugs, veterinary costs and market demands. On dairy farms, it is convenient to disbud calves as they are reared in sheds or close to the farmstead during their first two months of life. However, beef calves on extensive properties may not be mustered until they are weaned at 5 or 6 months of age when they are marked (branded and/or ear notched and/or ear tagged), castrated and dehorned at one time. There is little work looking at pain relief during this process, but a combination of sedation, local anaesthesia and systemic analgesia using a long lasting NSAID should reduce, perhaps even eliminate, the pain caused by these combined procedures. Many beef cattle are polled and breeding for polled cattle should be encouraged to eliminate the need to disbud or dehorn and the pain those procedures cause. Meanwhile it is to be hoped that local anaesthetics and NSAIDs become more freely available to farmers worldwide to reduce the acute pain caused by these procedures. The administration of a corneal block is a simple procedure as is the administration of a NSAID. On larger properties animal health technicians are often employed to do this type of work and in communities of smaller farmers a local veterinary technician can easily be trained to do it. The use of expensively trained veterinarians to disbud and dehorn cattle is generally not economically feasible (Stafford et al., 2005). As countries make the provision of pain relief mandatory for such procedures legislators and regulators have to make the other regulatory adjustments to allow non-veterinarians to use such drugs and carry out such procedures.

Conflict of Interest

We have no financial, personal or other relationships with people or organisations within three years of submitting this work that could inappropriately influence or be perceived to influence the work.

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