Literature Review on the Welfare Implications of the

Dehorning and Disbudding of Cattle

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HORN ANATOMY AND GROWTH IN CATTLE

Horns are special adaptations of the integument (skin). The corium (the area of cells located at the junction of the horn and skin) is the site of horn production. If the horn but not the corium is removed, horns will resume growing.[1] Horns begin as buds within the skin of the poll. At approximately 2 months of age, the horn buds become attached to the periosteum of the frontal bone overlying the frontal sinus.[2] As the horns grow, the cornual diverticulum of the caudal portion of the frontal sinus extends into the most proximal portion of the horn.[2,3]

The cornual nerve, a branch of the Trigeminal nerve (cranial nerve V), provides sensation to the skin of the horn/horn bud region. Injection of a local anesthetic around the cornual nerve as it traverses the frontal crest desensitizes the area.[1,4]

DISBUDDING

Disbudding involves destroying the horn-producing cells (corium) of the horn bud.[5] Horn buds are removed without opening the frontal sinus. Chemical and hot-iron disbudding methods destroy the horn-producing cells, whereas physical methods of disbudding excise them.[5]

Several methods for disbudding cattle exist, but each method has its advantages and disadvantages. Hot-iron disbudding is commonly performed and is reliable, but is considered to be quite painful.[6] Electrical and butane hot-iron disbudding devices are available. Excessive heat applied during hot-iron disbudding can damage underlying bone.[7] Disbudding via cautery may create less distress than physical dehorning using a scoop because nociceptors are destroyed by heat and pain perception is consequently reduced.[8] Caustic materials (e.g., sodium hydroxide, calcium hydroxide) applied to the horn bud can damage surrounding skin and/or the eyes if runoff occurs; as long as the active chemical is in contact with tissue, damage continues.[5] Injection of calcium chloride under the horn bud results in necrosis of the horn bud, but its administration without prior sedation and/or local anesthesia is not recommended due to the level of discomfort induced by the procedure.[9] Cryosurgical techniques are less reliable than hot-iron disbudding, require additional procedural time, and induce behavioral indicators of pain and distress.[6]

Horn buds can be physically removed, using knives, shears, or dehorning spoons, cups, or tubes. To remove the corium and prevent horn regrowth, a complete ring of hair surrounding the horn bud should also be removed.[2]

DEHORNING

Dehorning is removal of the horns after they have formed from the horn bud. Physical methods of dehorning (gouge dehorning) include the use of embryotomy wire, guillotine shears, or dehorning knives, saws, spoons, cups, tubes, or high tension rubber bands. The Barnes-type scoop dehorner is commonly used for physical dehorning. When cattle have large horns they are sometimes "tipped", a procedure that removes the sharp end of the horn but leaves the base.

The presence of the cornual diverticulum of the frontal sinus causes surgical dehorning of adult cattle to be more invasive.[2,3] Dehorning of adult cattle is associated with increased risks of sinusitis, bleeding, prolonged wound healing, and infection.[2,3,7]

DISBUDDING AND DEHORNING IN THE UNITED STATES AND OTHER COUNTRIES

Disbudding and dehorning of cattle in the United States is not currently regulated. The Canadian Veterinary Medical Association recommends that disbudding be performed within the first week of life.[10] In the United Kingdom, disbudding with a hot iron is preferred to dehorning and it is advised that this should be performed before cattle reach the age of 2 months.[11] Application of caustic paste is acceptable in cattle up to 7 days old,[12] but anesthesia is required if cattle are dehorned after this period.[12,13] Australian and New Zealand authorities recommend disbudding at the youngest age possible, and chemical dehorning is not deemed to be acceptable unless it is performed within the first few days after birth.[14-17] In Australia, dehorning without local anesthesia or analgesia is restricted to animals less than 6 months old.[2,12] The New Zealand Code of Welfare for Painful Husbandry Procedures mandates a 9 month age limit for dehorning without attention to pain relief.[17] The 1992 Animal Rights Law in Sweden requires that dehorning via cautery be performed under anesthesia/sedation.[6,12] In Denmark, calves up to 4 weeks old can be dehorned without application of a local anesthetic.[12]

A survey of dairy farms in in the northeastern provinces of Italy regarding dehorning methods has shown the practice of dehorning is carried out in 80% of the dairies surveyed.[18] In the surveyed group, hot-iron disbudding was the method most commonly used (~91%) with the remaining dairies using caustic paste.[18] Of the farmers surveyed, 10% utilized local anesthetics as part of their dehorning protocol and only 5% administered an analgesic.[18] When questioned about post-procedure pain nearly half of the farmers perceived that pain in calves lasted more than a few minutes.[18]

BENEFITS OF DISBUDDING AND DEHORNING

Dehorning cattle conveys advantages. Horns are the single major cause of carcass wastage due to bruising,[16] and trim associated with bruising for carcasses from horned cattle is approximately twice that for carcasses from hornless cattle.[12] Dehorned cattle require less feeding trough space; are easier and less dangerous to handle and transport; present a lower risk of interference from dominant animals at feeding time; pose a reduced risk of injury to udders, flanks, and eyes of other cattle; present a lower injury risk for handlers, horses, and dogs; exhibit fewer aggressive behaviors associated with individual dominance; and may incur fewer financial penalties on sale.[1,2,8,13,17,19-21]

WELFARE CONCERNS—SCIENCE, RISKS, AND SEVERITY

Physiologic and behavioral indicators have been used to assess acute distress responses to potentially painful husbandry procedures. Tissue damage (e.g., from disbudding and dehorning) results in activation and release of intracellular contents from damaged cells, inflammatory cells, and nerve fibers.[22] Physiologic, neuroendocrine, and behavioral changes indicative of pain and distress are observed following dehorning.[5,23]

***Physiologic indicators*—**Although responses vary slightly according to dehorning method, plasma cortisol concentrations increase rapidly 30 to 60 minutes after dehorning, decline slightly, plateau level for 3 to 4 hours, and then return to baseline values approximately 6 to 8 hours after the procedure.[24-30] Assessment of the catecholamine (fight or flight) response allows evaluation of the acute responses to painful procedures, but this response is short-lived and relevant only to the earliest phases of the distress response.[26] Adrenaline (epinephrine) concentration was increased 5 minutes after scoop dehorning of 10-week-old calves, was not affected by use of local anesthesia, and returned to baseline within 10 minutes.[26] Noradrenaline (norepinephrine) concentrations may also rise due to tissue release of noradrenaline in response to injury; increased noradrenaline concentrations were observed 10 minutes after dehorning, but had returned to baseline levels within 60 minutes.[26] Eye temperature drops either during dehorning or after local anesthesia wore off due to sympathetic activity leading to vasoconstriction and redirection of the blood.[27,28]

Although dehorning using a scoop resulted in slightly higher cortisol concentrations than dehorning via saw, guillotine shear, or embryotomy wire, there was little difference in distress displayed by 5- to 6-month-old calves in response to these methods.[27] Decreasing the depth to which the scoop was applied during dehorning did not reduce the magnitude of the plasma cortisol response in 14- to16-week-old calves.[24] On this basis, the investigators concluded this approach was not effective in reducing associated pain and distress. Another study has shown that cortisol concentrations in the blood were higher in scoop-disbudded calves than in hot-iron or caustic paste disbudded calves up to 6 hours post-disbudding.[31] This study also noted that cortisol concentrations in the blood were significantly higher in caustic paste disbudded calves than hot-iron disbudded (without anesthetic) calves at 1 hour post-disbudding, possibly indicating more intense pain at that time point.[31] It is important to note that the ages of these groups of calves differ as the various techniques have different age windows for utilization.

***Behavioral Indicators*—**Avoidance behaviors observed during dehorning include tail wagging, head movement, tripping, and rearing.[13] Postoperative indicators of pain include head rubbing, head shaking, neck extension, ear flicking, tail flicking, increased numbers of transitions between lying and rising and reduced rumination.[13,31,32] One study has shown that hot-iron disbudded calves that have not been given any anesthetic show more struggling during disbudding and more postoperative indicators of pain after disbudding than scoop and caustic paste disbudded calves.[31] Another study found that hot-iron disbudding (with or without anesthesia and analgesia) led to a reduction in play behavior.[33] Scoop disbudding is thought to be equally painful during the procedure; however, it is very quick so the animal does not have to struggle to get away from the source of pain.[31] Scoop disbudding is comparable to caustic paste and hot-iron disbudding (without anesthetic) with regards to postoperative indicators of pain at 1 and 3 hours post-disbudding.[31] Post-disbudding, caustic paste has been shown to produce more transitions between lying and rising than hot-iron disbudded (without anesthetic) calves.[31] At 6 hours post-disbudding scoop disbudded calves show more postoperative pain behaviors than either caustic paste or hot-iron (without anesthetic) disbudded calves.[31] The use of high tension elastic rubber bands has been shown to cause significant changes in attitude, gait and posture, and increased time spent lying down when compared to mechanically dehorned or tipped cattle.[34] Banded cattle also have decreased appetites and poorer wound healing following the dehorning procedure than cattle that have been mechanically dehorned or tipped.[34] Castration and dehorning of cattle are often combined and a recent study found that pain response to tandem or simultaneous castration and dehorning is additive. Pain responses due to combining these procedures have been shown to last unabated, up to and more than four hours when performed without pain mitigation.[35]

***Disease*—**Tetanus has been reported as affecting cattle after dehorning,[36] and prophylaxis is recommended. Bovine cutaneous papillomas have also developed after dehorning of 3- to 4-month-old calves due to physical transmission of virus particles via equipment.[37]

Physical dehorning has been associated with an increased risk of transmission of the bovine leukosis virus (BLV). Lassauzet et al[38] observed that risk of BLV infection increased from 8% to 77% when cattle were gouge dehorned. Gouge dehorning of 6- to 12-month-old heifers resulted in transmission of BLV via physical transfer of infected blood by the dehorning device; after changing to electrical dehorning of cattle at 8 weeks of age, prevalence of BLV in the herd decreased from 67.7% to 40.3% in 3 years.[39,40]

***Production*—**Although reduced body weight gain was observed during the first 6 weeks after physical dehorning of 4-, 7-, 19-, and 30-month-old calves, final mean body weights of all groups were not significantly different than those of control (naturally polled) calves.[41] No significant difference was observed in weight gain between polled animals, previously dehorned cattle, and recently dehorned stocker cattle.[21] Feed intake and growth rate were not significantly different in electrically dehorned versus control calves at 8 weeks of age.[42]

Refinements

***Sedation*—**Although sedation with xylazine and/or butorphanol reduced the occurrence of avoidance behaviors during disbudding/dehorning, sedation alone was not effective in reducing the cortisol response to hot-iron disbudding.[43] Cortisol may not be a reliable indicator of stress in xylazine-sedated calves and xylazine alone does not effectively control pain from hot-iron disbudding.[44] Calves administered sodium salicylate in conjunction with a xylazine/ketamine/butorphanol (XKB) mixture spent more time lying down post-surgery than those that received only XKB.[45] The addition of ketamine to more traditional chemical restraint formulas ("ketamine stun") can increase patient cooperation, and has been shown to lower stress response to both dehorning and castration in calves. These sedative techniques may be more stably administered via constant-rate or drip infusion than by bolus injection.[46]

***Cauterization* —**Cauterization of the wound following scoop dehorning with a local anesthetic virtually abolished the cortisol response for 24 hours in 3- to 4-month-old calves.[47] In addition, blood loss was minimal and no complications were observed during wound healing. Cauterization after scoop dehorning of 5- to 6-month-old calves produced a transient rise in plasma cortisol concentration associated with the pain of the cautery procedure; however, when combined with local anesthesia, the cortisol response was virtually abolished throughout the 9-hour postoperative observation period.[43]

***Local anesthesia* —**Many sources now recommend that local anesthesia be provided. Anesthesia reduces avoidance behaviors during the disbudding/dehorning procedure.[12,20,48] Investigation of the benefits of local anesthesia (in the form of a preoperative cornual nerve block with lidocaine or bupivicaine) has produced conflicting results. Local administration of lidocaine prior to electric dehorning of 7- to10- and 14- to 16-week-old calves did not significantly reduce plasma cortisol levels, suggesting that the anesthetic did not reduce stress associated with dehorning.[49] McMeekan et al[25] observed that local anesthesia prevented an increase in plasma cortisol concentrations in 3- to 4-month-old calves undergoing dehorning only for the duration of effect of the anesthetic; once the anesthetic wore off, a marked increase in plasma cortisol concentrations was observed. Similar results were observed in 6- to 8-week-old calves,[8] 10-week-old calves,[26] and 3- to 4-month-old calves.[34] Local anesthesia virtually abolished behavioral indicators of pain for the duration of its action; after the anesthetic wore off, however, calves displayed behavioral changes similar to those displayed by calves dehorned without local anesthesia.[20] Overall cortisol response was not significantly reduced, but a rise in plasma cortisol concentrations was delayed by administration of bupivicaine; preoperative administration of bupivicaine attenuated the increase in cortisol concentrations for 4 hours, but a marked rise in plasma cortisol concentration was observed once the effects of the bupivicaine wore off.[37] Administration of bupivicaine locally prior to scoop dehorning, followed by a second dose 4 hours later almost abolished the cortisol response for 8 hours.[50] Application of local anesthetic prior to disbudding/dehorning with caustic paste did not attenuate behavioral indicators of distress, possibly because the basic pH of the caustic paste negatively affected the action of the local anesthetic.[5] Disbudding using caustic paste in 10- to 35-day-old calves resulted in fewer behavioral changes than disbudding using a hot iron.[5] Recently, a preoperative cornual nerve block with 100% ethanol has been shown to provide superior analgesia when compared to a cornual nerve block with 2% lidocaine.[51]

Analgesia—Administration of nonsteroidal anti-inflammatories (NSAIDs) results in prolonged postoperative analgesia.[22] Oral administration of ketoprofen prior to and 7 hours after hot-iron dehorning of 4- to 8-week-old calves significantly reduced head shaking, ear flicking, and head rubbing for at least 24 hours.[13] In addition, the investigators observed a tendency toward greater weight gain on the first day after surgery compared with control calves.[13] Calves administered meloxicam at the time of hot-iron dehorning spent more time on average lying down at five[52] and ten[53] days after surgery when compared with control groups. Intramuscular administration of ketoprofen to 3- to 4-month-old calves prior to scoop dehorning slightly reduced the initial plasma cortisol peak, but abolished the plateau phase.[25] Intramuscular administration of ketoprofen to calves 2 days to 2 weeks old produced a slight, transient reduction in cortisol concentration after disbudding with a butane dehorner.[19] The investigators speculated that ketoprofen may be more effective in older calves and calves disbudded using other devices. Sodium salicylate administered either alone or in conjunction with sedation (intramuscular xylazine, ketamine, butorphanol), also significantly reduced the cortisol response associated with simultaneous castration and dehorning.[54] In addition, sodium salicylate reduced the decrease in ADG from simultaneous castration and dehorning.[54] One study has shown that intravenous tramadol alone is not effective in reducing acute pain from dehorning, but may provide late post-operative analgesia by reducing non-acute pain following dehorning.[55]

The combination of a local anesthetic and ketoprofen administered prior to scoop dehorning of 3-to 4-month-old calves virtually abolished the rise in plasma cortisol concentration routinely observed after dehorning.[25] In studies using local anesthesia in conjunction with NSAIDS other than ketoprofen, Meloxicam was found to effectively alleviate pain following dehorning by cauterization,[28,56,57] but phenylbutazone[31] did not reduce the cortisol response to scoop dehorning. Carprofen combined with local anesthesia can reduce cortisol levels and pain-related behaviors for up to 24 hours after hot-iron disbudding.[58] Another study found that flunixin meglumine administered with a local anesthetic effectively reduced pain behavior associated with caustic paste disbudding.[59]

Availability and use of pharmaceuticals—Although combined use of an anesthetic and analgesic appears to represent the most effective method for controlling pain associated with dehorning, regulatory access and cost remain obstacles to practical application. Studies of pharmaceutical pain management have borne little evidence of increased production yield; however, most of these studies have been too short to permit an adequate assessment. In a survey of producers, the most commonly cited factor for decisions regarding pain mitigation was cost.[60] Ketoprofen is not currently FDA-approved for labeled use in livestock in the United States. The only approved NSAID is flunixin meglumine, which has not been demonstrated to have equivalent analgesic efficacy and is approved only for intravenous delivery for the treatment of respiratory disease, mastitis, or endotoxemia. The use of pharmaceuticals can burden producers in terms of both direct and indirect costs; the latter are associated with time delays and a potential need for more veterinary assistance. Extralabel use of anesthetics and analgesics, while potentially an option, is not ideal. Knowledge of effectiveness for these drugs is not as great as it is for drugs approved for particular species and purposes. Extralabel use can also discourage research and development necessary to approve drugs for specific purposes. Extralabel drug use in the United States is only permitted under certain conditions, among which is that the veterinarian is able to establish a necessary meat and/or milk withdrawal period.[61]

ALTERNATIVES

Selection and breeding of polled stock has been proposed as an alternative because it eliminates both animal pain and production expenses associated with dehorning. Polledness is a dominant autosomal trait.[12,62,63] that appears in all offspring of homozygous polled bulls. In the past it was believed the production characteristics of horned cattle were intrinsically superior to those of polled cattle. More recent reviews, however, acknowledge that polled individuals have existed in cattle populations throughout recorded history,[64] and that polled genes in *Bos taurus* have a simple inheritance and are apparently not linked to production performance or behavioral traits.[65,66] Polled beef bulls already demonstrate behavior,[65] growth,[67] carcass quality[67] and reproductive[68] performance[62,63,69] equivalent to their horned counterparts. Further work is required with dairy bulls where polled sires are rare in many breeds including Holstein (~1%).[70]

When polled bulls are in the minority rapid selection for other desired traits can usually best be achieved using horned bulls;[69,71,72] as a result, polledness continues to be suppressed in the population. Transgenic approaches have been suggested as a means to rapidly insert polled genetics into high-performing reproductive lines.[73,74] However, polledness in other countries and in existing polled herds has generally been introduced gradually through selective breeding to achieve balanced progress, using a range of selection criteria.[65,71,75,76] Recent recommendations for the breeding of Holsteins—such as from the Holstein Association USA's 'Breed of the Future' panel, 2005—have supported broadening the basis for genetic selection, suggesting that: "Increasingly, the emphasis should be on selecting for reduced expenses and improved margin, not just maximum production."[77] Widespread introduction of polled genetics will require active involvement and cooperation of producers, [76] artificial insemination suppliers,[76] researchers,[71] and breed associations.[76]

SUMMARY

Minimizing pain associated with disbudding and dehorning is important to limiting the pain-stress-distress cascade that creates altered behavioral and physiologic states.[22] Pre-emptive analgesia can be accomplished with sedation, general anesthesia, local anesthesia, and pre- and postoperative administration of NSAIDs.[22] A summary of currently available research on pain assessment and management following disbudding and dehorning can be found in a recent edition of Veterinary Clinics of North America: Food Animal Practice.[78] Including polledness in selection indexes and long term breeding strategies has the potential to reduce and eventually eliminate the need to dehorn.

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