

Recommendations for Castration and Dehorning of Cattle

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Abstract

Pain associated with routine husbandry procedures such as dehorning and castration is increasingly being scrutinized by the public. The results of a survey of AABP and AVC members suggest that surgical castration with a scalpel followed by emasculator (>200 lb or 90 kg) or twisting (<200 lb or 90 kg) is the most common castration method used by practitioners in the United States. Risk of injury to the operator, calf size, handling facilities, and experience were the most important considerations in selecting a castration method. Non-surgical castration is perceived to cause more adverse events than surgical castration. One in five veterinarians currently report using anesthesia or analgesia at the time of castration. Ninety percent of veterinarians vaccinate and dehorn at the time of castration. The Barnes dehorning tool appears to be the most common method of dehorning used in the US. Results of studies that use plasma cortisol or weight gain to determine the optimal timing and method of castration and use of analgesia are often equivocal or conflicting. The preliminary findings of a study using electroencephalography to examine the effect of age at the time of castration on brainwave activity show a more prominent shift toward high-frequency, low-amplitude brain activity in older calves compared with six-week-old calves. Meloxicam tablets administered orally at 0.45 mg/lb (1 mg/kg) may provide a convenient and cost-effective means of providing analgesia in cattle. A mean peak plasma concentration (C_{max}) of 3.10 µg/mL (Range: 2.64 – 3.79 µg/mL) was recorded at 11.64 hours (Range: 10 – 12 hours) with a half-life (T_{½ λz}) of 27.54 hours (Range: 19.97 – 43.29 hours) after oral meloxicam administration. In recent studies we found that meloxicam administered prior to dehorning at 0.23 mg/lb (0.5 mg/kg) IV significantly increased average daily weight gain in calves after dehorning. A second study found that calves receiving oral meloxicam 24 hours prior to surgical castration tended to have a lower incidence of bovine respiratory disease.

Résumé

La douleur résultant d'opérations routinières comme l'écornage et la castration retient de plus en plus l'attention du public. Une étude réalisée auprès des

membres de l'American Association of Bovine Practitioners (AABP) et de l'Academy of Veterinary Consultants (AVC) montre que la méthode de castration la plus employée par les vétérinaires américains est la castration chirurgicale, effectuée par incision au scalpel suivie de l'enlèvement des testicules avec l'émasculateur (sur les veaux de plus de 90 kg, ou 200 lb) ou par torsion (veaux de moins de 90 kg, ou 200 lb). Les facteurs les plus considérés dans le choix de la méthode de castration étaient le risque de blessures pour le manipulateur, la taille du veau, les installations et outils disponibles et l'expérience du manipulateur. La castration non chirurgicale est perçue comme une méthode causant davantage d'inconvénients que la castration chirurgicale. Actuellement, un vétérinaire sur cinq dit avoir recours à l'anesthésie ou à l'analgésie lors de la castration. De plus, 90 % des vétérinaires interrogés disent pratiquer la vaccination et l'écornage en même temps que la castration. L'écorneur Barnes semble être l'outil d'écornage le plus utilisé aux États-Unis. Les études visant à déterminer le meilleur moment et la meilleure méthode pour l'écornage et l'analgésie d'après le dosage du cortisol plasmatique du sang ou le gain de poids donnent des résultats souvent équivoques ou contradictoires. Les résultats préliminaires d'une étude par électroencéphalographie de l'effet de l'âge à la castration révèlent que les veaux plus âgés tendent à avoir une activité cérébrale de fréquence plus élevée et d'amplitude plus faible que les veaux âgés de six semaines. La méloxicame, administrée par voie orale sous forme de comprimés à une dose de 1 mg/kg (0,45 mg/lb), semble une méthode d'analgésie pratique et rentable chez les bovins. Dans le plasma sanguin, le sommet de concentration moyen (C_{max}) de la méloxicame était de 3,10 µg/mL (pour une variation de 2,64 à 3,79 µg/mL) et fut observé 11,64 heures (pour une variation de 10 à 12 heures) après l'administration orale de ce médicament, dont la demi-vie moyenne (T_{½ λz}) était de 27,54 heures (pour une variation de 19,97 à 43,29 heures). Dans une étude récente, nous avons observé que les veaux recevant 0,5 mg/kg (0,23 mg/lb) de méloxicame par voie intraveineuse avant l'écornage affichaient, après l'écornage, un gain de poids quotidien moyen significativement supérieur. Une seconde étude a montré que les veaux recevant la méloxicame par voie orale 24 heures avant la castration chirurgicale étaient moins fréquemment affectés par le complexe respiratoire bovin.

Introduction

Castration of male calves is one of the most common livestock management practices performed in the United States, amounting to approximately 15 million procedures per year.¹⁹ Methods of castration are associated with either physical, chemical or hormonal damage to the testicles.¹⁶ In many production settings, physical castration methods are the most common. These are subdivided into procedures involving surgical removal of the testes, or methods that irreparably damage the testicles by interruption of the blood supply using either a castration clamp^a, rubber ring^b, or latex band^c.

Benefits of castration include reduction in aggression and mounting behavior of males, causing fewer injuries in confinement operations and reduced dark-cutting beef.^{9,18} Steers have higher quality meat with increased tenderness and marbling. Carcasses from steers therefore command higher prices at market when compared with bulls.¹ Castration also prevents physically or genetically inferior males from reproducing and prevents pregnancy in commingled pubescent groups.⁹ Although the benefits of castration are widely accepted, all methods of castration produce physiological, neuroendocrine, and behavioral changes indicative of pain and distress.¹⁶

Societal concern about the moral and ethical treatment of animals is becoming more common.¹⁴ In particular, negative public perception of castration and dehorning is increasing, with calls for the development of practices to relieve pain and suffering in livestock. Production agriculture is charged with the challenge of formulating animal welfare policies relating to routine management practices such as castration. To enable the livestock industry to respond to these challenges there is a need for data on management practices that are commonly being used in typical production settings.⁸

We conducted a web-based survey of members of the American Association of Bovine Practitioners (AABP) and Academy of Veterinary Consultants (AVC) who were asked to provide information about castration methods, adverse events, and husbandry procedures conducted at the time of castration. Invitations to participate in the survey were sent to e-mail addresses belonging to 1,669 AABP members and 303 AVC members. After partially completed surveys and missing data were omitted, 189 responses were included in the analysis. Surgical castration with a scalpel followed by testicular removal using manual twisting (cattle < 198 lb [90 kg]) or an emasculator (cattle > 198 lb [90 kg]) were the most common methods of castration. The potential risk of injury to the operator, size of the animal, handling facilities, and experience with the technique were the most important considerations used to determine the castration method. Swelling, stiffness, and increased

lying time were the most prevalent adverse events observed following castration. One in five practitioners reported using an analgesic or local anesthetic at the time of castration. Approximately 90% of respondents said they also vaccinate and dehorn cattle at the time of castration. Equipment disinfection, prophylactic antimicrobials, and tetanus toxoid are commonly used to minimize complications following castration. The results of this survey provide insight into current bovine castration and management practices in the US.

AVMA guidelines suggest that animals should be dehorned and castrated at the “earliest age practicable”. Everyone probably agrees that this is a good idea based on observations that animals castrated younger suffer less performance setback than those castrated at an older age. However, it is interesting to review the science supporting this recommendation. For the most part, this recommendation is based on studies evaluating plasma cortisol concentration and performance effects.

Reviewing the literature highlights several deficiencies. These include that age and method effects are rarely examined under the same set of experimental conditions. This requires extrapolation between studies done in six-week-old calves and studies done in three-month-old calves, which is very risky. Furthermore, the effect of performing dehorning and castration at the same time has not been evaluated until our group studied this fairly recently. The concurrent measurement of multiple novel indicators of pain and distress in the same population of animals is also currently deficient in the literature.

Age Effects

Table 1 shows the Cmax, which is the maximum cortisol concentration in serum, and the Tmax, which is the time after castration when maximum cortisol concentration occurred. When we consider rubber ring castration in six-day-old calves, we see the cortisol concentration was much lower and occurred much earlier than in two to four-month-old animals. However, the opposite is found for surgical castration, where there was a much higher cortisol concentration in six-day-old calves compared to two to four-month-old calves. This does not really fit with the hypothesis that surgical castration should be less stressful in younger calves. The literature suggests those six-day-old calves have a higher cortisol concentration than those older calves. This does not imply that we should wait and castrate them older, instead it illustrates that cortisol responses are an imperfect measure of pain associated with castration.

Table 2 shows the duration of plasma cortisol response elevation above pre-treatment levels. With rubber ring castration in six-day-old calves and two to four-month-old calves, the time above baseline cortisol

Table 1.

Method	Age				
	6 days	21 days	42 days	2-4 months	5.5 months
Rubber ring	60 (36 min)	45 (48 min)	45 (60 min)	76 (90 min)	
Latex band					101 (30-60 min)
Burdizzo	80 (24 min)	50 (24 min)	60 (24 min)	64 (30 min)	87 (30 min)
Surgery (pull)	105 (24 min)	65 (24 min)	110 (24 min)	68 (30 min)	
Surgery (cut)					129 (30 min)

Adapted from: Stafford K, Mellor D: The welfare significance of the castration of cattle: a review. *New Zealand Vet J* 53:271-278, 2005. (Reproduced with permission.)

Table 2.

Method	Age				
	6 days	21 days	42 days	2-4 months	5.5 months
Rubber ring	132 min		96 min	132 min	180 min
Latex Band				180 min	
Burdizzo	60 min	60 min	72 min	90 min	90 min
Surgery (pull)	132 min	84 min	132 min	180 min	
Surgery (cut)					360-600 min

Adapted from: Stafford K, Mellor D: The welfare significance of the castration of cattle: a review. *New Zealand Vet J* 53:271-278, 2005. (Reproduced with permission.)

response is identical. The duration of cortisol response was the same in those two age groups of calves, even though we currently recommend doing them as early as possible. The take home message is that measurement of plasma cortisol is not a perfect measure of pain in animals. Cortisol measurement will not answer the questions we need answered to address animal welfare concerns. In Table 2 we see that surgical castration in six-day-olds produces a much shorter duration of cortisol response than surgical castration in two to four-month-old animals. This is, typically, what we would expect. However, there are also aspects of these data that do not fit with our hypothesis. For example, the AVMA backgrounder^d states that elastrator rubber ring techniques have been associated with chronic pain and should be discouraged, but six-day-old calves had the same duration of cortisol as two to four-month-old calves.

Growth and Performance

Recently, Dr. Dan Thomson, Director of the Beef Cattle Institute at Kansas State University, concluded a study to evaluate the effects of surgical and banding castration on behavioral responses and growth characteristics of postpubertal bulls.¹⁵ Fifty mixed-breed bulls,

weighing 660 to 880 lb (300-400 kg), were randomly assigned to one of five treatment groups as follows: 1) untreated control (CONT); 2) band (BAND); 3) band with local anesthesia (BANDL); 4) surgical castration with twisting of cord utilizing the Henderson tool (SURG); and 5) surgical castration with twisting of cord utilizing the Henderson tool with local anesthesia (SURGL). Behavioral assessment of the cattle was conducted the day before castration, the day of castration, and every day post-castration for 30 days. Bulls were weighed on days 0, 7, 14, 21, and 28 to determine average daily gain (ADG). Data are in the early stages of analysis but initial findings are reported herein. This study found no interactions between local anesthetic treatments and castration methods. Scrotal circumference was similar between treatment groups. Vocalization was higher in the surgically castrated animals than the banded animals ($P = 0.03$). There was no difference in vocalization at the chute with animals treated with local anesthetic prior to castration relative to animals that did not receive local anesthetic ($P = 0.65$). There was no difference in overall feed intake between banded and surgically castrated animals ($P = 0.84$). Cattle that were castrated surgically had lower feed intakes than cattle castrated with bands for the first seven days ($P = 0.02$). However,

at day 14 of the study the intakes were reversed. Cattle that were banded tended to have lower feed intakes than cattle castrated surgically from day 14 to the end of the study ($P = 0.16$). At this point, 50% of the cattle that were banded had lost their scrotum from banding. The other 50% still had their scrotum. There was a marked behavioral pain response noted in animals when necrotic testicles were sloughing after banding.

Castrated cattle had significantly lower rate of gain than control cattle over the course of the study ($P < 0.05$). Cattle castrated surgically had overall higher ADG than cattle that were banded ($P = 0.08$). There was no difference in average daily gain due to castration method during the first week after processing ($P = 0.59$). Cattle surgically castrated had significantly higher ADG during the third week after processing ($P = 0.01$) relative to the banded cattle. This study shows the importance of observing animals for at least two weeks when doing castration studies. These preliminary data suggest that the effect of surgical castration is more pronounced over the first seven days after castration. Banding has a pronounced negative effect on performance during the later part of the feeding period. This coincides with the time when necrotic scrotums are sloughing. Due to the short study duration, the longer term relationship between surgical technique and ADG could not be determined in this study.

Production parameters are often too imprecise to reflect the pain experienced by animals following castration.¹⁶ Furthermore, weight gain following castration may be negatively influenced by a decrease in testosterone following removal of the testes.¹⁶ However, assessment of production parameters is critical if animal well-being research is to have relevance to livestock producers. These assessments may take the form of a cost-benefit analysis or a measure of animal performance. In some studies, Burdizzo or surgical castration had no effect on average daily gain (ADG) over a three-month period following castration.^{5,11} The ADG of seven-week-old calves during the five weeks following castration using rubber rings, clamp or surgery have been reported to be lower than non-castrated calves, but similar between the different castration methods.⁶ Rubber ring and surgical castration were reported to cause a decrease in ADG of 50% and 70%, respectively in cattle aged eight to nine months.²⁰ When eight, nine, and 14-month-old cattle were castrated surgically or using latex bands, cattle castrated later had poorer growth rates than those castrated at weaning. Cattle castrated with latex bands also had lower growth rates than those castrated surgically during the following four to eight weeks.^{7,12} In a study conducted by Oklahoma State University, 162 bull calves were used to determine the effects of latex banding of the scrotum or surgical castration on growth rate. Bulls that were banded at weaning gained less weight than bulls

that were banded or surgically castrated at 2 to 3 mo of age.¹³ In a second study, 368 bull calves were used in two separate experiments to examine the effect of method of castration on receiving health and performance. In the first experiment, latex banding intact males shortly after arrival was found to decrease daily gain by 19% compared with purchasing steers, and by 14.9% compared with surgically castrating intact males shortly after arrival. In the second experiment purchased, castrated males gained 0.58 lb (0.26 kg) more and consumed 1.26 lb (0.57 kg) more feed per day than intact males surgically castrated shortly after arrival.²

Recently, a Canadian group conducted a large, pen-level study to investigate the effect of castration timing, technique and pain management on health and performance of young feedlot bulls in Alberta.³ This study was conducted through close-out when cattle were harvested, therefore providing long-term comparison data between castration techniques are various attempts at pain control. A total of 956 feedlot bulls were assigned to eight castration groups receiving combinations of banding and surgical castration, epidural and systemic analgesia performed either on arrival or 70 days post-arrival. Bulls castrated on arrival tended to have a higher occurrence of undifferentiated fever ($P = 0.086$) and a higher proportion of Canadian yield grade 3 carcasses compared with calves castrated at 70 days. Bulls castrated with a band were found to have a lower occurrence of undifferentiated fever and improved ADG and carcass weight than bulls castrated surgically. There was no significant difference between animals receiving analgesia and anesthesia and those that did not. These findings suggest that band castration is superior to surgical castration and delayed castration is beneficial in bull calves at high risk of developing UF. This study failed to demonstrate any economic benefit to providing analgesia at the time of castration; however, it should be noted that the analgesic drugs used had a relatively short $T_{1/2}$ (< 12 hours).

Provision of Analgesia: Meloxicam

Meloxicam is a NSAID of the oxicam class that is approved in the European Union for adjunctive therapy of acute respiratory disease; diarrhea, and acute mastitis when administered at 0.23 mg/lb (0.5 mg/kg) IV or SC. Meloxicam is considered to bind preferentially to cyclooxygenase-2 (COX-2) inhibiting prostaglandin synthesis although definitive evidence of COX-selectivity in calves is deficient in the published literature. Heinrich *et al*¹⁰ demonstrated that meloxicam IM (0.23 mg/lb) combined with a cornual nerve block reduced serum cortisol response for six hours in six to 12-week-old calves compared with calves receiving only local anesthesia prior to cautery dehorning. Furthermore, calves receiv-

ing meloxicam had lower heart rates and respiratory rates than placebo-treated control calves over 24 hours post-dehorning. Stewart *et al*¹⁷ found that meloxicam administered IV at 0.23 mg/lb mitigated the onset of pain responses associated with hot-iron dehorning in 33 ± 3-day-old calves compared with administration of a cornual nerve block alone, as measured by heart-rate variability and eye temperature. These findings indicate that administration of meloxicam at 0.23 mg/lb IV or IM decreases physiological responses that may be linked to pain and distress associated with cautery dehorning in preweaning calves.

The purpose of this study was to investigate the pharmacokinetics and oral bioavailability of meloxicam in ruminant calves.⁴ Six Holstein calves (319 to 374 lb or 145 to 170 kg) received either meloxicam IV at 0.23 mg/lb or oral meloxicam at 0.45 mg/lb (1 mg/kg) in a randomized cross-over design with a 10-day washout period. Plasma samples collected up to 96 hours post-administration were analyzed by LC-MS followed by noncompartmental pharmacokinetic analysis. A mean peak plasma concentration (C_{max}) of 3.10 ug/mL (range: 2.64 – 3.79 ug/mL) was recorded at 11.64 hours (range: 10 – 12 hours) with a half-life ($T_{1/2\lambda z}$) of 27.54 hours (range: 19.97 – 43.29 hours) after oral meloxicam administration. The bioavailability (F) of oral meloxicam corrected for dose was 1.00 (range: 0.64 – 1.66). These findings indicate that oral meloxicam administration could be an effective and convenient means of providing long-lasting analgesia to ruminant calves.

In the United States, meloxicam administered to cattle by any route constitutes extra-label drug use (ELDU). Under the Animal Medicinal Drug Use Clarification Act (AMDUCA), ELDU is permitted for relief of suffering in cattle provided specific conditions are met. These conditions include that 1) ELDU is permitted only by or under the supervision of a veterinarian, 2) ELDU is allowed only for FDA-approved animal and human drugs, 3) ELDU is only permitted when the health of the animal is threatened and not for production purposes, 4) ELDU in feed is prohibited, and 5) ELDU is not permitted if it results in a violative food residue. Therefore, use of oral meloxicam to alleviate suffering associated with dehorning and castration in calves in the United States would be required by law to comply with these regulations. Currently, the only NSAID approved for use in cattle in the United States is flunixin meglumine. The plasma elimination half-life of flunixin is reported to be three to eight hours, therefore requiring once-daily administration. Although this drug class is recognized as having analgesic properties, flunixin is only indicated for control of fever associated with respiratory disease or mastitis, and fever and inflammation associated with endotoxemia, rather than for control of pain. Studies demonstrating the analgesic effects of flunixin at the

approved dose of 1.0 mg/lb (2.2 mg/kg) are deficient in the published literature. Use of flunixin meglumine is further complicated by the requirement for intravenous administration, which is more stressful on the animal and involves more skill and training on the part of the operator. Several reports have suggested that the IM administration of flunixin may result in significant myonecrosis and tissue residues. In the absence of data demonstrating that flunixin reduces signs of pain and distress associated with dehorning and castration in calves, it could be argued that use of oral meloxicam for this purpose can be justified under AMDUCA. Meloxicam (20 mg/mL) is approved for use in cattle in several European countries with a 15-day meat withdrawal time and a five-day milk withdrawal time following administration of 0.23 mg/lb IM or SC. An oral meloxicam suspension (1.5 mg/mL) and injectable formulation (5 mg/mL) are approved in the United States for the control of pain and inflammation associated with osteoarthritis in dogs. Furthermore, an injectable formulation (5 mg/mL) is approved for the control of post-operative pain and inflammation in cats. Several generic tablet formulations containing meloxicam (7.5 and 15 mg) have recently been approved for relief of signs and symptoms of osteoarthritis in human medicine. The cost of administering IV meloxicam to calves in the present study was approximately US \$58.00/220 lb (100 kg) bodyweight and the cost of administering oral meloxicam was US \$0.30/220 lb bodyweight.

Conclusions

Pain associated with routine husbandry procedures such as dehorning and castration is increasingly being scrutinized by the public. The results of a survey of AABP and AVC members suggest that surgical castration with a scalpel followed by emasculator (>200 lb or 90 kg) or twisting (<200 lb or 90 kg) is the most common castration method used by practitioners in the United States. One in five veterinarians currently report using anesthesia or analgesia at the time of castration. Results of studies that use plasma cortisol or weight gain to determine the optimal timing and method of castration and use of analgesia are often equivocal or conflicting. The preliminary findings of a study using electroencephalography to examine the effect of age at the time of castration on brainwave activity show a more prominent shift toward high-frequency, low-amplitude brain activity in older calves compared with six-week-old calves. Meloxicam tablets administered orally at 0.45 mg/lb (1 mg/kg) may provide a convenient and cost-effective means of providing analgesia in cattle. A mean peak plasma concentration (C_{max}) of 3.10 ug/mL (Range: 2.64 – 3.79 ug/mL) was recorded at 11.64 hours (Range: 10 – 12 hours) with a half-life ($T_{1/2\lambda z}$) of 27.54

hours (Range: 19.97 – 43.29 hours) after oral meloxicam administration. In recent studies we found that meloxicam administered prior to dehorning at 0.23 mg/lb (0.5 mg/kg) IV significantly increased average daily weight gain in calves after dehorning. A second study found that calves receiving oral meloxicam 24 hours prior to surgical castration tended to have a lower incidence of bovine respiratory disease.

Endnotes

^aBurdizzo castration

^bElastrator rubber ring

^cCallicrate Bander, No Bull Enterprises LLC, St. Francis, KS

^dAVMA Policy, 2008: "Elastrator rubber banding techniques have been associated with increased chronic pain and should be discouraged."

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