Evaluation of Analgesic Protocol Effect on Calf Behavior after Concurrent Castration and Dehorning

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ABSTRACT

Castration and dehorning are common procedures in the US cattle industry, but the impact of analgesic programs on post-surgical behavior is not well documented. The research objective was to determine the impact of three different analgesic protocols: (sodium salicylate; a combination of xylazine, ketamine and butorphanol; and both treatments together) compared to the absence of analgesia on cattle behavior after concurrent castration and dehorning.

Accelerometers recorded activity on 40 calves for three periods of time: prior to sham surgery, between sham and actual surgery, and 4 days post-surgery. Significant interactions ($P < 0.05$) were found between treatment and time relative to surgery. Cattle treated with a combination of ketamine, butorphanol, xylazine, and sodium salicylate spent more time lying after the procedures compared to cattle receiving only xylazine, ketamine, and butorphanol.

INTRODUCTION

Surgical removal of the horns and testicles are common husbandry practices in the US cattle industry. Recent findings in 2007-2008 by the National Animal Health Monitoring System (NAHMS) stated that 77.1% of bulls are castrated prior to sale.[1] Castration facilitates easier and safer cattle handling through decreased aggression, prevents unwanted pregnancies, and improves carcass characteristics relative to bull calves.[2,3] Dehorning also has management and welfare advantages, including decreased carcass bruising and decreased wounds inflicted by the horns. Cattle without horns also require less room at the feed bunk and during transport.[4] According to the NAHMS, 82.6% of cattle going into the slaughter market came from a feedlot environment, and in this close-proximity environment the advantages for dehorning are pronounced.[1] Although castration and dehorning are known to inflict pain,[4,5] the benefits to the animal and the producer outweigh the adverse effects.[6]

The perceived pain associated with castration and dehorning has led to legislation or recommendations for the use of analgesics during castration and dehorning (depending on age and procedure method) in several countries, including the United Kingdom, Switzerland, and Canada.[6] Currently, the US has no legislation for the use of analgesics, but public awareness of animal welfare issues has increased.[7] Mitigation of pain associated with these procedures is important to animal care providers. However, little research exists documenting the effects of analgesic drug protocols on animal behavior. There is also a paucity of studies examining the combined effect of concurrent dehorning and castration procedures.

Pain assessment in cattle is cumbersome and lacks validity.[8] Perception of animal pain is often subjectively measured using visual parameters to assess changes in behavior associated with pain.[8-10] Validation of video recording using certain scan video collection techniques has been performed.[11] However, video monitoring is labor intensive, expensive, and can be a somewhat subjective observation. Accelerometers have been shown to accurately predict cattle behaviors (standing, lying, walking),[12,13] and have been used in previous research to characterize behavioral differences in cattle following castration.[14]

Research has illustrated cattle display varied lying behavior patterns throughout the day, with differences observed between calves as well.[15] Documenting changes in the lying behaviors of individual calves may prove useful for determining efficacy of treatment following a painful procedure. Castration and dehorning are commonly performed at the same time to reduce veterinary costs, decrease stress on the animals due to chute procedures, and minimize handling times.[16] Published work exists that investigates the pain of castration [4,8,14,16] and dehorning,[9, 10, 16, 17] separately.However, few studies have evaluated both procedures at the same time with the addition of analgesics.

The objective of this trial was to determine the impact of three different analgesic protocols and no analgesia on cattle behavior after castration and dehorning. The four pre-operative treatments were: negative controls (CON, no analgesia); sodium salicylate (SS) free-choice in the drinking water, a combination of xylazine, ketamine, and butorphanol (XKB); and a combination of the last two treatments (XKBSS). Behavioral changes measured in this experiment may be indicative of differences related to pain or stress responses and the ability of the included treatments to mitigate that response. This work is unique as it provides an objective measure of behavior (accelerometers) to evaluate potential changes associated with analgesic protocol when applied to calves dehorned and castrated concurrently.

MATERIALS AND METHODS

Animals and Treatment Allocation

All animals were handled in accordance with a protocol approved by the Kansas State University Institutional Animal Care and Use Committee (IACUC #2694). Calves were weighed upon arrival, and the following measurements were also recorded: horn-base diameter, horn length, and scrotal circumference. The calves were then processed with an eight-way clostridial vaccine (Covexin 8, Schering Plough, Summit, NJ), a modified-live viral vaccine (Bovi-Shield Gold 4, Pfizer, New York, NY), a metaphylactic dose of antibiotic (Draxxin, Pfizer, New York, NY), and given a pour-on anti-parasitic (Dectomax Pour-on, Pfizer, New York, NY). Amprolium (Corid, Merial, Duluth, GA) was added to the drinking water to provide 10 mg/kg per os (PO) for 5 days. Enrolled calves (n=40) had a mean (±SE) body weight of 153.6 ± 11.50 kg and were approximately 16 to 20 weeks old at the time of enrollment in the trial.

Calves were blocked by arrival weight,

scrotal circumference, horn base diameter, and horn length, then randomly assigned to one of four treatment groups: negative controls (CON); sodium salicylate in the drinking water (Sodium Salicylate, Fisher Scientific, Fair Lawn, NY) (SS); a combination of xylazine (AnaSed ,Lloyd Laboratories, Shenandoah, IA), ketamine (Ketaset, Fort Dodge, Fort Dodge, IA) and butorphanol (Torbugesic, Fort Dodge, Fort Dodge, IA) (XKB); and a combination of the last two treatments (XKBSS). Negative controls received no analgesic treatments at any time point during the study, but did receive an isotonic saline given IM 1 minute before the procedure. As the study objective was to evaluate analgesic protocols and not differences between specific agents, each protocol was administered in a manner consistent with potential field application of that analgesic protocol. The cattle in the SS group were administered sodium salicylate via the drinking water 24 hrs at 2.5 to 5 mg/mL and continued to receive this dose ad libitum until 48 hrs after the actual procedure. Cattle in the XKB group received 0.05 mg/kg xylazine, 0.1 mg/kg ketamine, 0.025 mg/kg butorphanol via IM injection one minute before both sham and actual castration and dehorning. The final treatment group (XKBSS) received both SS and XKB treatments in the administered in the same manner and at the same dosages as described above.

Experimental Procedures

The trial was completed in five replicates consisting of eight animals (n= 2 per treatment) in each replicate. The trial consisted of three basic phases: before the sham (mock) surgery (day 0 to day 3, PRE); between the sham and actual surgery (day 4 to day 5, SHAM); and post-surgery (day 6 to day 9, POST). On day 0, 4 days prior to sham, castration cattle were individually housed in randomly allocated pens (3.5m x 3.5m) within a completely roofed facility with side doors that could be opened to regulate temperature. Throughout the study all calves were fed the same grain diet with free choice prairie hay. A concurrent project was conducted evaluating pharmacokinetics of selected analgesic protocols. Therefore, blood sampling occurred on individual calves periodically during the trial phase with the majority of samples occurring during daytime hours. A catheter was placed in the jugular vein to facilitate frequent sample collection.

All calves went through the same sham and surgical procedures with the same experienced individual performing all procedures. For the sham procedure, the calves were restrained by a halter in a squeeze chute along with the administration of tail elevation when the scrotum was approached and manipulated. The sham procedure consisted of palpating the scrotum with a rag soaked in dilute chlorhexidine solution (Chlorhexidine Solution, MWI, Meridian, ID). The horn bases were stimulated by removing the hair around the horn bud with electronic clippers (Oster Golden A5 Single Speed Vet Clipper, Jarden Corp., Rye, NY). The sham procedure was performed 2 days before the actual castration and dehorning, allowing for a washout period for the xylazine, ketamine, and butorphanol.18,19 Sodium salicylate was continuously administered 24 hours before the sham to 48 hours after the actual procedure.

For the castration procedure, calves were restrained in the same manner as described for the sham castration. The calves were castrated by removal of the bottom third of the scrotum with a #21 scalpel blade and the removal of testicles by gloved hand using traction in accordance with standard industry practices. The removal of horns was accomplished with a Barnes-type dehorner (Stone Precision Barnes Dehorner, Stone Mfg., Kansas City, MO) and cauterization of the horn base after horn removal was done with an electronic hot-iron (Stone Electric Dehorner Model 24210, Stone Mfg., Kansas City, MO). Blood stop powder (Blood Stop Powder, Agri Laboratories Ltd., St. Joseph, MO) was then applied to the horn base to help ensure clotting. The lesions of the horns and scrotum were sprayed with a fly insecticide (Prozap Screw Worm Aerosol, Chem Tech Ltd., Pleasantville, IA). Calves were monitored four times daily for illness or potential sequealea from the surgical procedures.

Behavioral Monitoring

Each calf was outfitted with a tri-axial capacitive accelerometer (Sensr GP1 Programmable Accelerometer, Reference LLC., Elkader, IA) attached to the right rear leg just proximal the fetlock at initiation of each trial phase (day 0.) The accelerometers were placed inside a padded waterproof case before attachment to the calf's leg. The sham castration was performed on day 4, followed by castration and dehorning on day 6. Calves were monitored for a total of 10 days for each phase of the trial.

***Table 1**. Model adjusted[1] proportion (SE) of time lying and walking by analgesic treatment group[2] through the three study periods.[3]*

Activity	Analgesic Treatment	Time Period PRE		SHAM		POST	
Lying down							
	CON	58.0 (3.7)	c	68.4 (3.9)	b	77 (3.6)	a
	SS	59.5 (3.6)	c	66.2 (4.1)	b	76.7 (3.7)	a
	XKB	61.6 (3.6)	c	69.3 (3.9)	b	74.5 (3.9)	a
	XKBSS	68.5 (3.3)	a	71.3 (3.7)	a	77.8 (3.6)	b
Walking							
	CON	0.5 (0.1)	a	0.3 (0.1)	b	0.10 (0.0)	c
	SS	0.5 (0.1)	a	0.5 (0.1)	a	0.2 (0.0)	b
	XKB	0.4 (0.0)	a	0.4 (0.1)	a	0.1 (0.0)	b
	XKBSS	0.3 (0.0)	a	0.3 (0.1)	a	0.1 (0.0)	b

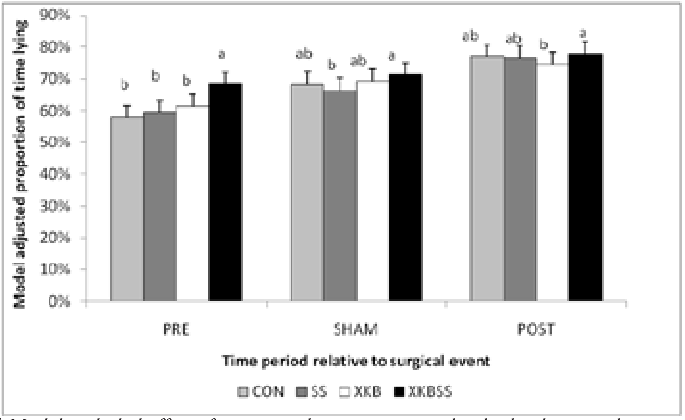
[1] Model included effects for repeated measures on individual calves, trial replicate and hour of the day data was collected. Differences ($P < 0.05$) between time periods within analgesic treatment group are represented by differing superscripts within rows.
[2] The four pre-operative treatments were: negative controls (CON, no analgesia), sodium salicylate (SS), a combination of xylazine, ketamine and butorphanol (XKB), and a combination of the last two treatments (XKBSS).
[3] Time periods relative to surgical event are defined as: PRE = trial days 0-4 (trial initiation to sham surgery); SHAM = trial days 5-6 (sham to actual surgery); POST = trial days 6-10 (surgery to trial end).

Accelerometers were downloaded chute-side three times for each trial: at sham surgery, at the actual surgery, and at the end of the trial. During each download, the accelerometer was removed from the case, connected to a laptop by USB for downloading, disconnected, put back in the case and reattached the calf's leg. Accelerometers were set to record five variables including average acceleration in each of the three axes (X, Y, Z) and the average and maximum vector magnitude. Each variable was aggregated over a 5 second epoch as previously described.12 Data were processed through a previously described classification system12 to categorize the activity of the animal at each time point into standing, lying, or walking.

Statistics

Classified accelerometer data was summarized to calculate the percent of time each calf spent lying for each hour in the trial. Calves participated in a concurrent study where blood samples were procured during the daytime hours. To remove potential bias of human interaction, only the hours between 6 pm and 6 am were included in the statistical analysis. The accelerometer data were exported to a statistical software program (SAS 9.1, SAS Institute Inc., Cary, NC) for analysis. Logistic regression was used to determine potential associations between the amount of time spent lying and walking with analgesic treatment (CON, SS, XKB, XKBSS), time relative to surgical procedure (PRE, SHAM, POST), and the interaction between analgesic treatment and time relative to surgery. The unit of analysis was the percent of each hour a calf spent lying during each trial phase with calf identification included as a random effect in the models to account for repeated measures on individuals. Trial replicate and hour of the study were included as random effects in all models to account for the lack of independence between animals within each replicate and each hour relative to treatment application.

Figure 1. *Model adjusted[1] proportion of time lying by analgesic treatment group[2] and study period.[3]*



[1] Model included effects for repeated measures on individual calves, trial replicate and hour of the day data was collected. Differences (P < 0.05) between analgesic treatments within each time point are represented by differing superscripts.
[2] The four pre-operative treatments were: negative controls (CON, no analgesia), sodium salicylate (SS), a combination of xylazine, ketamine and butorphanol (XKB), and a combination of the last two treatments (XKBSS).
[3] Time periods relative to surgical event are defined as: PRE = trial days 0-4 (trial initiation to sham surgery); SHAM = trial days 5-6 (sham to actual surgery); POST = trial days 6-10 (surgery to trial end).

RESULTS

Forty Holstein bull calves were enrolled in the trial (mean weight 153.6 kg / SE 11.50 kg) that had scrotal circumference (mean 16.76cm / SE 1.10cm), horn base diameter (mean 34.73mm / SE 2.56mm), and horn length (mean 42.12 mm / SE 4.93mm) measurements recorded. No cattle were removed in any replicate during the trial phase. After the trial period, some calves acquired phlebitis at the catheter site and required antibiotic treatment. All accelerometer data points recorded during the time between 6pm and 6am were analyzed, with none being discarded. Analgesic treatment group, time relative to surgery, and the interaction between treatment group and time period were all significantly ($P < 0.02$) associated with the proportion of time calves spent lying down. As the interaction between time and treatment group was significant, only the interactive estimates are discussed. Calves in all treatment groups spent more time lying POST when compared to PRE. Cattle in all analgesic treatments, except XKBSS, spent more time lying in the POST period compared to MID (Table 1). When comparing within a time period, XKBSS calves spent more time lying PRE compared to all other treatment groups (Figure 1). In the POST period, XKBSS calves spent more time lying relative to XKB calves, yet CON or SS did not differ from either group.

Evaluation of the proportion of time walking also identified a significant interaction ($P < 0.01$) between analgesic treatment and time relative to surgery. Therefore, only interactive model results are described. Calves in all treatment groups spent less time walking POST compared to PRE readings (Table 1). Only the CON calves spent less time walking in the SHAM period compared to the PRE time frame. Comparing within study time frames, CON and SS calves spent more time walking compared to XKB and XKBSS calves in PRE time frame.

However, CON calves spent less time walking post-surgery compared to SS and XKB calves in POST (Figure 2).

DISCUSSION

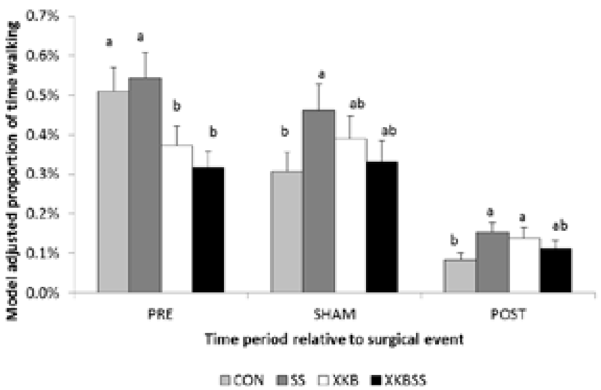
The experimental model of castration and dehorning concurrently performed induced a behavioral change exhibited by the control group that walked less and spent more time lying compared to the previous time frame following both sham and actual surgical procedures. The measurable change in behavior may be indicative of stress in the SHAM period and stress with the addition of pain in the POST period. Cattle in each of the analgesic groups also followed the same behavioral trends as control cattle when comparing the PRE to POST time frames. Therefore, administration of the analgesic protocols selected for this research did not mitigate the behavioral changes associated with castration and dehorning at the same time.

Our finding of increased lying behavior post-surgery (in all treatment groups) contradicts previous research indicating cattle spend higher percent of time standing immediately following castration.[8,14] These differences may be due to procedures performed and both the timing and length of behavioral measurements. In the aforementioned studies, calves were only castrated, while in the current study both castration and dehorning were performed concurrently. The increase in standing behavior has been noted at 38 and 2414 hours following castration.However, our current study had only limited data available for evaluation during this time period due to exclusion of hours between 6 am and 6 pm related to intensive cattle handling. Our data also covered a longer observational period of time post-surgery as measurements were recorded for four evenings after the surgery. The difference noted in the 4- day post-operative period may be meaningful, and indicate that the recovery period to return to normal behavior is longer than the time period we monitored.

The potential sedative effect of analgesic agents utilized may have influenced lying behaviors after procedures.However, previous work illustrates that more calves treated with xylazine and ketamine exhibit unchanged attitude following castration compared to non-treated controls.[19] In the current study, calves treated with analgesic protocols with potential sedative effects (XKB, XKBSS) did not differ from CON calves at any time point. These findings indicate that although the analgesic agents may have transient sedative properties, the method and length of behavioral analysis did not elucidate these differences.

Previous research by Morisse (1995) showed there were no differences in the time spent lying down after young calves

Figure 2. *Model adjusted[1] proportion of time walking by analgesic treatment group[2] and study period.[3]*



1 Model included effects for repeated measures on individual calves, trial replicate and hour of the day data was collected. Differences ($P < 0.05$) between analgesic treatments within each time point are represented by differing superscripts.
2 The four pre-operative treatments were: negative controls (CON, no analgesia), sodium salicylate (SS), a combination of xylazine, ketamine and butorphanol (XKB), and a combination of the last two treatments (XKBSS).
3 Time periods relative to surgical event are defined as: PRE = trial days 0-4 (trial initiation to sham surgery); SHAM = trial days 5-6 (sham to actual surgery); POST = trial days 6-10 (surgery to trial end).

were dehorned chemically or by cauterization with and without anesthesia when compared 24 hours before and after dehorning. Morisse (1995) used a video sampling technique in which a 1 minute video recording was taken every 15 minutes for 24 hours resulting in 96 observations per calf for which results were interpreted. The lack of a behavioral difference post-dehorning was also displayed by Doherty (2007) in calves dehorned by hot-iron and followed 72 hours afterward using a video scan sampling technique. During our experiment, the calves were larger and dehorned by scoop dehorning so comparisons between our results and these must take this into consideration along with the use of different analgesics and a different behavioral monitoring technique.

Cattle spent less time walking after the castration and dehorning than in pre-treatment measurement period. The percent of time cattle spent walking in our study was very low, and this is likely due to study constraints that restricted our data to nighttime hours when cattle normally spend most time resting.[15] The fact that the calves were in smaller pens with water and feed readily available also might have contributed to reduced walking behavior. Other studies document that cattle under similar husbandry conditions spend less time walking than standing or lying.[11,14] Although walking as a percent of the total time period was very low, the finding of decreased walking behavior post-surgery may be an indicator of calf attitude or responsiveness to the environment. One interesting note was that the CON calves decreased walking behavior after the sham procedure.However, none of the treated calves (SS, XKB, XKBSS) displayed different walking behavior in the SHAM period. This finding may indicate that the pharmaceutical agents decreased animal stress during this time period, but walking behavior of these treated cattle decreased POST in a similar fashion as the CON group.

In this study, the experimental model induced a behavioral change in CON cattle. However, the analgesic agents selected did not mitigate these changes in the treated groups. The total analgesic protocol was evaluated. Therefore, agents (SS and XKB) were not administered at the same time relative to the surgical procedure. The advantage of this design is external validity of findings relative to how the protocols would be applied in field settings. Yet, the disadvantage is the inability to directly compare analgesic properties of the pharmaceutical agents used in this project. The only behaviors analyzed in this study were time spent lying down and walking. This is because time spent lying down is very close to the inverse of standing due to the low percentage of time walking throughout the time periods and also because similar behaviors have been recorded in previous research allowing comparisons.8,10,14 Control cattle spent less time walking and more time lying following the procedures. However the level of association between these measurements and pain in cattle should be explored with further research.

Potential limitations of this work include the sole use of accelerometers to monitor behavior, the evaluation of only nighttime hours, and the length of time cattle were monitored after the procedures. Other work has utilized subjective observations of animal behavior (eg, tail movement, ear twitches) to evaluate potential changes in animal attitude. Our work relied on accelerometer measures of calf activity, and the correlation between subjective and objective measures of animal behavior is unknown at this time and should be an area of further research. Due to participation in a concurrent trial and high level of human interaction during the daytime hours, our study focused on behavioral changes during the nighttime hours. Previous work[14] illustrates differences in lying behavior occurring immediately following castration during the night time hours. Further, our objective was to evaluate potential differences between treatment groups and the same hours of the day were used to compare behavior between analgesic protocol groups. Our study only monitored cattle for less than a week after the procedure, and behavioral changes may have been present beyond the trial period. However, our hypothesis was that the analgesic protocols utilized in this project would have the most profound behavioral effects relatively soon following the surgical procedures. Further work should be done to evaluate the long-term implications of analgesic protocol administration at the time of dehorning and castration.

CONCLUSION

This research describes behavioral trends following the concurrent procedures of castration and dehorning. Although the analgesic treatments may have contributed to changes in other parameters following castration and dehorning they did not mitigate the post-surgical lying and walking behavior changes when compared to controls. This research illustrates the use of objective behavioral measures to evaluate the ability of analgesic agents to minimize behavioral changes after a painful procedure.

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