Effect of castration and dehorning singularly or combined on the behavior and physiology of Holstein calves

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ABSTRACT: The objectives of this study were to determine i) the effect of castration, dehorning, or both on the physiology and behavior of 3-mo-old Holstein calves, and ii) the effectiveness of pain relief to alleviate the pain caused by castration and/or dehorning. Holstein calves (n = 80) were assigned randomly to 1 of 8 treatments (10 calves/treatment): i) control handling (SHAM); ii) surgical castration (CAS); iii) dehorning (DH); iv) surgical castration and dehorning (CD); v) control handling plus pain relief (ANA); vi) surgical castration plus pain relief (CAS+A); vii) dehorning plus pain relief (DH+A); or viii) surgical castration and dehorning plus pain relief (CD+A). Pain relief consisted of administering local anesthetic and a nonsteroidal anti-inflammatory drug (NSAID) immediately before castration, dehorning, or both. Sequential blood samples were collected to measure leukocyte counts and cortisol concentrations. Behavior was recorded using 5-min scan samples during the first 3 h after application of the treatments. Calves were weighed before and 24 h after treatment application. Calves dehorned spent more time head shaking (P < 0.001) and ear flicking (P < 0.05), and CD calves spent more time ear flicking (P < 0.05) and foot stamping (P < 0.01) than SHAM handled calves. Calves castrated, dehorned, or both spent less (P < 0.01) time eating compared with SHAM handled calves. Giving calves pain relief before castration and/or dehorning increased (P < 0.05) the time spent eating compared with CAS, DH, and CD calves. At 6 h posttreatment, neutrophil to lymphocyte ratio was greater (P < 0.01) in castrated and/or dehorned calves compared with SHAM-handled calves. Castration and/or dehorning also increased (P < 0.05) cortisol concentrations for at least 4 h after these procedures were performed; however, administering pain relief before castration and/or dehorning markedly reduced (P < 0.05) this response. Behavioral and physiological changes caused by castration, dehorning, or both are indicative of calves experiencing pain for at least 4 h after application of these procedures, and these responses were additive when performed together. Therefore, providing calves with pain relief, in the form of local anesthetic and an NSAID, can markedly reduce both the behavioral and physiological response to these procedures.

Key words: behavior, calves, castration, cortisol, dehorning, Holsteins

INTRODUCTION

Cattle are routinely castrated to facilitate handling and prevent unwanted breeding (Stafford and Mellor, 2005b), whereas cattle are dehorned to reduce the risk of injury to people and other animals (Stafford and Mellor, 2005a). However, castration and dehorning cause physiological and behavioral changes in cattle indicative of pain and distress. Surgical castration has been shown to increase cortisol (Robertson et al., 1994; Stafford et al., 2002), acute phase proteins (Earley and Crowe, 2002), and substance-P concentrations (Coetzee et al., 2008), as well as the time spent performing abnormal behaviors (Robertson et al., 1994; Molony et al., 1995). Amputation dehorning has been shown to increase cortisol concentrations (Sylvester et al., 2005b). The authors gratefully acknowledge the financial assistance from the Darden foundation (Orlando, FL), and the technical assistance from Clayton Cobb, Adam Copeland, Amanda Sooter, Cody Lanier, and Katie Haukos (Texas Tech University).

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et al., 1998a), along with increasing the time spent head shaking, ear flicking, and tail wagging (Sylvester et al., 2004; McMeekan et al., 1999). Because it is a common management practice to castrate and dehorn calves concurrently once they arrive at the feedlot, it would be more applicable to the industry to understand the effects of castration and dehorning combined on the physiology and behavior of calves.

The American Veterinary Medical Association recommends the use of procedures and practices that reduce or eliminate pain and discomfort caused by dehorning and castration. Moreover, it has been demonstrated that administration of a local anesthetic and a nonsteroidal anti-inflammatory (NSAID) drug before dehorning (McMeekan et al., 1999; Sutherland et al., 2002) or castration (Stafford et al., 2002) reduces the physiological and behavioral indicators of pain. However, the effect of using pain relief before performing both castration and dehorning is largely unknown in calves. Therefore, the objectives of this research were to determine i) the effect of castration, dehorning, or both on the physiology and behavior of 3-mo-old calves, and ii) the effectiveness of pain relief to alleviate the pain caused by castration and dehorning.

MATERIALS AND METHODS

All animal procedures were approved by the Texas Tech University Animal Care and Use Committee before the initiation of the study.

Calves and Treatment

At 3 mo of age, male Holstein calves (n = 80) weighing 101.5 ± 1.45 kg were allotted to pens measuring 30.8 × 4.9 m (8 calves/pen). All 8 treatments were represented in each pen. Each pen contained a trough feeder and waterer, and pens were designed to allow calves auditory, visual, and olfactory contact with calves in the neighboring pen. All calves were fed once daily at 0800 h a 19.2% CP starter diet (1.79 Mcal/kg NEg) composed of 70% steam flaked corn, 13.3% soybean meal, 11.3% cottonseed meal, and 5.4% molasses (DM basis). Calves had ad libitum access to the diet, with approximately a 10% refusal. On average, calves consumed 3.4% of their BW. The starter diet was formulated to meet, or exceed, NRC (1996) nutrient requirements, and calves had ad libitum access to water. Calves were given 5 d to adapt to the new environment before commencement of the study.

Treatments

Over a 5-d period, 16 calves were treated per day (2 calves · treatment⁻¹ · d⁻¹). Within each pen, calves were randomly assigned to 1 of 8 treatments (10 calves/treatment): i) sham castration and dehorning (SHAM); ii) administration of local anesthetic, an NSAID and sham castration and dehorning (ANA); iii) surgical castration using emasculators (CAS); iv) amputation dehorning using Barnes dehorners (DH); v) surgical castration and amputation dehorning (CD); vi) administration of local anesthetic and an NSAID before surgical castration (CAS+A); vii) administration of local anesthetic and an NSAID before amputation dehorning (DH+A); or viii) administration of local anesthetic and an NSAID before surgical castration and amputation dehorning (CD+A). All calves were restrained in a squeeze chute to perform the 8 treatments. To surgically castrate the calves, the scrotum was grasped, the testicles pushed toward the body wall, and the distal portion of the scrotum removed with a sterile scalpel blade. The testicles were then grasped individually with 1 hand, as the other hand stripped the fat and fascia around the spermatic cord before an emasculator was used to crush and sever the spermatic cords. Any fat or fascia hanging from the scrotum was trimmed and an antiseptic sprayed on the surgical site. Barnes dehorners were used to amputate each horn in a guillotine style. Calves were restrained during the procedure using a rope halter and the hair around each horn was clipped before amputation. Electrocautery was used to control any hemorrhages. Calves in the ANA, CAS+A and CD+A groups received 12 mL of a local anesthetic (2% lidocaine hydrochloride; Hospira Inc., Lake Forest, IL) in the testicular parenchyma and distal scrotum, whereas calves in the ANA, DH+A, and CD+A groups received 12 mL of local anesthetic (2% lidocaine hydrochloride, Hospira Inc.) in a ring block around each horn and a corneal nerve block. The corneal nerve block was performed by injecting lidocaine through the skin at a point midway between the lateral canthus of the eye and the base of the horn. The needle was directed through the frontalis muscle and under the lateral aspect of the temporal portion of the frontal bone. The local anesthetic was injected in a fan-like manner. Furthermore, ANA, CAS+A, DH+A, and CD+A treatment groups were given 2 mg/kg of an NSAID (Banamine, Flunixinmeglumine, Merck Animal Health, Summit, NJ) intramuscularly into the side of the neck. Local anesthetic and the NSAID were administered immediately before castration and/or dehorning. To keep flies away, the castration and dehorning wounds were sprayed with CatronIV (KMG Chemicals, Inc., Houston, TX). All calves were weighed before and 24 h after application of the treatments.
Behavior Data Collection

Immediately after receiving the allocated treatment, each calf was walked quietly back to its home pen. Behavior data were collected by live observation using 5-min scan samples during the first 3 h after application of the treatments. The observer sat outside the pen out of sight of the calves, but had clear visual access to all calves. Behaviors measured included head shaking, ear flicking, tail wagging, foot stamping, head turning, grooming, normal ventral lying, abnormal ventral lying, stretching, standing, walking, abnormal walking, playing, eating, and drinking (Table 1).

Blood Analysis

Blood (10 mL) was taken from a jugular vein of each calf at 0 (baseline), 0.5, 1.5, 2.5, 4, 6, 24, and 72 h after application of the treatments and collected into vacutainers containing heparin (BD, Franklin Drive, NJ). Blood samples were immediately placed on ice before being processed. Whole blood samples collected at 0, 0.5, 6, 24, and 72 h were analyzed to determine total white blood cell (WBC) and differential leukocyte counts (Cell Dyn 3700, Abbott Laboratories, Abbot Park, IL). The neutrophil to lymphocyte ratio (N:L) was calculated by dividing the percentage of neutrophils by the percentage of lymphocytes. All blood samples were centrifuged for 15 min at 1000 × g (20°C), plasma was removed, and then subsequently stored at −20°C for future analysis of cortisol concentrations using a commercially available ELISA kit (Assay Designs, Ann Arbor, MI).

Statistical Analysis

All data were tested for constant variance and departures from normal distribution using the univariate procedures (SAS Inst. Inc., Cary, NC). Data lacking normality were transformed logarithmically and included cortisol concentrations and N:L. Data were subjected to ANOVA using the mixed models procedure of SAS. The behavior observations were divided into six 30-min periods for analysis. The main fixed effects included in the model were treatment and time/period, and the 2-way interaction, whereas day of treatment was included as a random effect. The model had a repeated structure on time allowing incorporation of heterogeneity of variances across time. The SIMULATE option in SAS was used to control for family-wise error rates caused by making multiple comparisons. Individual animal was used as the experimental unit. Results displayed in the graphs, tables, and text are least squares means (± SE); statistical significance was determined at P ≤ 0.05.

RESULTS

Behavior

The time calves spent performing specific behaviors and postures during the first 3 h after application of treatments are presented in Table 2. There was no (P > 0.05) interaction between treatment and time, and no (P > 0.05) differences were observed for behaviors and postures between ANA calves and SHAM calves. Dehorned calves spent more (P < 0.05) time head shaking than control (SHAM and ANA), CAS, and CD calves, whereas calves given pain relief before dehorning spent less (P < 0.05) time head shaking than DH calves (Table 2). The time spent ear flicking was greater (P < 0.05) in DH and CD than SHAM calves, but did not differ (P > 0.05) among CAS, DH, and CD calves. Providing pain relief to calves (CAS+A, DH+A, and CD+A) did not (P > 0.05) affect the time they spent ear flicking compared with CAS, DH, and CD calves. The time spent foot stamping was greater (P < 0.01) in CD than control (SHAM and ANA calves, but not (P > 0.05) different among CAS, DH, and CD calves. Furthermore, administering pain relief before castration and dehorning did not (P > 0.05) reduce the time CD+A calves spent foot stamping compared with CD calves. The DH and CD calves spent less (P < 0.01) time grooming than ANA calves, and giving pain relief increased (P < 0.05) the time CD+A calves spent grooming compared with CD calves.

The time CAS, DH, and CD calves spent eating was less (P < 0.05) than control (SHAM and ANA) calves, whereas CAS+A, DH+A, and CD+A calves spent more (P < 0.01) time eating than CAS, DH, and CD calves.

Table 1. Description of behaviors and postures

<table>
<thead>
<tr>
<th>Behaviors and postures</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head shaking</td>
<td>Repeated movement of the head from side to side in a rapid motion.</td>
</tr>
<tr>
<td>Ear flicking</td>
<td>Repeated movement of 1 or both ears in a quick motion independent of head shaking.</td>
</tr>
<tr>
<td>Tail wagging</td>
<td>Rapid tail movements from side to side.</td>
</tr>
<tr>
<td>Foot stamping</td>
<td>When a limb is lifted and forcefully placed back on the ground as the animal is standing.</td>
</tr>
<tr>
<td>Head turning</td>
<td>When the head is moved so that it reaches a point on the body beyond the shoulder.</td>
</tr>
<tr>
<td>Grooming</td>
<td>When the head is positioned at a point on the body behind the shoulder and the animal is licking itself.</td>
</tr>
<tr>
<td>Ventral lying¹</td>
<td>Lying in ventral or sternal recumbency with all 4 legs folded under the body or with full or partial extension of 1 or more legs.</td>
</tr>
<tr>
<td>Lateral lying¹</td>
<td>Calf is not upright and the shoulder and the flank are in contact with the ground.</td>
</tr>
<tr>
<td>Standing</td>
<td>Calf is upright and all 4 hooves are in contact with the ground.</td>
</tr>
<tr>
<td>Walking</td>
<td>Relatively slow continuous movement.</td>
</tr>
<tr>
<td>Eating</td>
<td>Head in the food trough.</td>
</tr>
<tr>
<td>Drinking</td>
<td>Mouth around the waterer.</td>
</tr>
</tbody>
</table>

¹Lateral and ventral lying were combined into 1 category for analysis.
In addition, the time spent drinking was less \((P < 0.05)\) in CD calves than SHAM and ANA calves, but CAS+A and CD+A calves spent more \((P < 0.05)\) time drinking than CAS and CD calves. The time calves spent head turning, lying, and standing did not \((P > 0.05)\) differ among treatments.

**Total White Blood Cell Counts and N:L**

Total WBC did not \((P > 0.05)\) differ among any treatments 0, 0.5, 24, and 72 h after treatment application (Fig. 1). At 6 h after treatment, WBC were greater \((P < 0.05)\) in CAS, DH, and CD than SHAM calves, but did not \((P > 0.05)\) differ among CAS, DH, and CD calves. Moreover, total WBC was less \((P < 0.01)\) in calves given pain relief before dehorning compared with DH calves, but total WBC did not \((P > 0.05)\) differ between CAS and CAS+A or between CD and CD+A calves.

The N:L did not \((P > 0.05)\) differ among treatments at 0, 0.5, 24, and 72 h after treatment application (Fig. 2). However, 6 h posttreatment, N:L counts were greater \((P < 0.05)\) in CAS, DH, and CD than SHAM calves. More importantly, N:L was similar \((P > 0.05)\) among CAS, DH, and CD calves. The N:L was not \((P > 0.05)\) different among calves given pain relief before dehorning and/or castration (CAS+A, DH+A, and CD+A) and control (SHAM and ANA) calves.

**Plasma Cortisol Concentrations**

Plasma cortisol concentrations were not \((P > 0.05)\) different among SHAM and ANA calves at any sampling time, nor did cortisol concentrations differ \((P > 0.05)\) among CAS+A, DH+A, and CD+A and SHAM calves at any sampling time point (Fig. 3). Furthermore, plasma cortisol concentrations did not \((P > 0.05)\) differ among treatments at 0, 24, and 72 h after treatment application. However, plasma cortisol concentrations were greater \((P < 0.005)\) in CAS, DH, and CD compared with SHAM and ANA calves 0.5 h after treatment application. At 1.5 h after application of treatments, cortisol concentrations were greater \((P < 0.005)\) in CAS, DH, and CD than ANA calves, and greater \((P < 0.005)\) in CD than SHAM calves. Cortisol concentrations were less \((P < 0.05)\) in calves given pain relief before castration (CAS+A) than CAS calves 2.5 h after application of treatments. Additionally, plasma cortisol concentrations at 2.5 and 4 h after treatment application were greater \((P < 0.05)\) in CAS, DH, and CD than ANA calves, and greater \((P < 0.05)\) in DH and CD than SHAM calves. Giving pain relief before dehorning in DH+A calves resulted in reduced \((P < 0.05)\) cortisol concentrations compared with DH calves 1.5, 2.5, 4, and 6 h after application of treatments. Giving pain relief to CD+A calves before castration and dehorning resulted in decreased \((P < 0.05)\) cortisol concentrations compared with CD calves 0.5, 1.5, 2.5, 4, and 6 h after application of treatments. Cortisol concentrations remained increased \((P < 0.001)\) in DH and CD compared with ANA calves, and greater \((P < 0.001)\) in CD than SHAM calves 6 h after application of treatments.

The integrated cortisol response represents the area under the cortisol time curve (AUC) over the first 6 h after treatment application. The AUC was greater \((P < 0.01)\) in CAS, DH, and CD than control (SHAM and ANA) calves (Fig. 4). Additionally, the AUC did not \((P > 0.05)\) differ among control (SHAM and ANA) calves and CAS+A, DH+A, and CD+A calves, but the AUC was less \((P < 0.05)\) in calves receiving pain relief (CAS+A, DH+A, and CD+A) calves when compared with their CAS, DH, and CD contemporaries.

**Table 2.** Frequency of behaviors and postures performed by calves after control handling (SHAM), surgical castration (CAS), amputation dehorning (DH), surgical castration and amputation dehorning (CD), control handling plus pain relief (ANA), surgical castration plus pain relief (CAS+A), amputation dehorning plus pain relief (DH+A), and surgical castration and amputation dehorning plus pain relief (CD+A)

<table>
<thead>
<tr>
<th>Item</th>
<th>SHAM</th>
<th>ANA</th>
<th>CAS</th>
<th>CAS+A</th>
<th>DH</th>
<th>DH+A</th>
<th>CD</th>
<th>CD+A</th>
<th>Pooled SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head shaking</td>
<td>0.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>16.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.4&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.2&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2.98</td>
<td>0.001</td>
</tr>
<tr>
<td>Ear flicking</td>
<td>0.3&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.6&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>1.1&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>0.0&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.4&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>1.4&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>4.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.0&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>1.73</td>
<td>0.019</td>
</tr>
<tr>
<td>Tail wagging</td>
<td>0.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.6&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.7&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>19.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.31</td>
<td>0.046</td>
</tr>
<tr>
<td>Foot stamping</td>
<td>0.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.1&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.1&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.66</td>
<td>0.011</td>
</tr>
<tr>
<td>Head turning</td>
<td>0.3</td>
<td>0.8</td>
<td>1.7</td>
<td>0.3</td>
<td>1.9</td>
<td>1.7</td>
<td>1.1</td>
<td>2.2</td>
<td>0.69</td>
<td>0.339</td>
</tr>
<tr>
<td>Grooming</td>
<td>12.2&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>17.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10.0&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>11.7&lt;sup&gt;babc&lt;/sup&gt;</td>
<td>4.4&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>7.5&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.3&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>3.50</td>
<td>0.038</td>
</tr>
<tr>
<td>Eating</td>
<td>22.8&lt;sup&gt;d&lt;/sup&gt;</td>
<td>21.7&lt;sup&gt;d&lt;/sup&gt;</td>
<td>11.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28.6&lt;sup&gt;e&lt;/sup&gt;</td>
<td>5.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.3&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.65</td>
<td>0.001</td>
</tr>
<tr>
<td>Drinking</td>
<td>11.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.1&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.5&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2.89</td>
<td>0.035</td>
</tr>
<tr>
<td>Lying</td>
<td>26.9</td>
<td>23.1</td>
<td>29.7</td>
<td>15.9</td>
<td>17.5</td>
<td>16.7</td>
<td>25.0</td>
<td>18.5</td>
<td>5.51</td>
<td>0.329</td>
</tr>
<tr>
<td>Standing</td>
<td>68.1</td>
<td>71.1</td>
<td>64.2</td>
<td>79.9</td>
<td>75.0</td>
<td>78.6</td>
<td>69.7</td>
<td>77.1</td>
<td>5.87</td>
<td>0.229</td>
</tr>
</tbody>
</table>

<sup>a–e</sup>Least square means with different superscripts within each row differ at \(P < 0.05\).
Conversely, the AUC did not \((P > 0.05)\) differ between CAS and DH calves, but was greater \((P < 0.01)\) in CD than CAS and DH calves.

**DISCUSSION**

Surgical castration and amputation dehorning can cause behavioral and physiological changes indicative of pain and distress in calves (Stafford and Mellor, 2005a,b); however, little is known about the effect of

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**Figure 1.** Total white blood cell counts (WBC, least square means ± SE) of calves \((n = 10\) calves/treatment) in response to: (Panel A) control handling (SHAM), control handling plus pain relief (ANA), surgical castration (CAS), and surgical castration plus pain relief (CAS+A); (Panel B) SHAM, ANA, amputation dehorning (DH), and amputation dehorning plus pain relief (DH+A); (Panel C) SHAM, ANA, surgical castration and amputation dehorning (CD), and surgical castration and amputation dehorning plus pain relief (CD+A). At each time point, least square means lacking a common letter differ at \(P < 0.05\).

**Figure 2.** The neutrophil to lymphocyte ratio least square means (± SE) of calves \((n = 10\) calves/treatment) in response to (Panel A) control handling (SHAM), control handling plus pain relief (ANA), surgical castration (CAS), and surgical castration plus pain relief (CAS+A); (Panel B) SHAM, ANA, amputation dehorning (DH), and amputation dehorning plus pain relief (DH+A); (Panel C) SHAM, ANA, surgical castration and amputation dehorning (CD), and surgical castration and amputation dehorning plus pain relief (CD+A). At each time point, least square means lacking a common letter differ at \(P < 0.05\).
combining these procedures on the distress response in calves. Furthermore, an objective of the present study was to determine if known effective methods of pain relief for castration (Stafford et al., 2002) and dehorning (McMeekan et al., 1998) were as effective at eliminating the pain caused by these procedures when combined. In the present study, surgically castrated calves spent more time tail wagging and less time eating, which is in agreement with Fisher et al. (2001) and Robertson et al. (1994), who found that surgically castrated calves grazed less and swished their tails more than intact calves. Moreover, dehorned calves in the present study spent more time head shaking, ear flicking, tail wagging, and less time grooming and eating. Similarly, Sylvester et al. (2004) also found that calves spent more time head shaking, ear flicking, and tail flicking (wagging) after amputation dehorning than control calves. These results suggest that the behavioral response to castration and dehorning may be procedure specific, possibly due to the location of the tissue damage and the type of tissue damage. For example, it would be expected that castration results in an initial nociceptor barrage due to cutting the scrotal sac, followed by a more visceral response originating in the peritoneal cavity due to the manipulation of the testes and spermatic cords. Amputation dehorning would also result in an initial nociceptor barrage due to the process of amputation, but continued nociceptor impulses may arise from stimulation by inflammatory mediators at the site of the injury (McMeekan et al., 1998). Interestingly, calves that were castrated and dehorned exhibited similar behavioral patterns to those that experienced these procedures singularly, signifying that the behavioral response was exacerbated by combining these procedures.

In the present study, calves lost approximately 1% of their BW over the 24 h period after castration and/or dehorning, and conversely, control (SHAM and ANA) calves and calves that received pain relief gained approximately 1.4% of their BW, though this response

Figure 3. Plasma cortisol concentrations (least square means ± SE) of calves (n = 10 calves/treatment) in response to (Panel A) control handling (SHAM), control handling plus pain relief (ANA), surgical castration (CAS), and surgical castration plus pain relief (CAS+A); (Panel B) SHAM, ANA, amputation dehorning (DH), and amputation dehorning plus pain relief (DH+A); (Panel C) SHAM, ANA, surgical castration and amputation dehorning (CD), and surgical castration and amputation dehorning plus pain relief (CD+A). At each time point, a single cross (†) indicates treatments differ (P < 0.05) from ANA; a double cross (‡) indicates treatments differ (P < 0.05) from SHAM; and an asterisk (*) indicates treatments differ (P < 0.05) from calves given pain relief.

Figure 4. Area under the cortisol response curve during the first 6 h (least square means ± SE) after control handling (SHAM), surgical castration (CAS), amputation dehorning (DH), surgical castration and amputation dehorning (CD), control handling plus pain relief (ANA), surgical castration plus pain relief (CAS+A), amputation dehorning plus pain relief (DH+A), and surgical castration and amputation dehorning plus pain relief (CD+A). Bars lacking a common letter differ at P < 0.05.
was not significant (results not presented). Surgical castration was also found to reduce ADG in bulls (Chase et al., 1995; Fisher et al., 1996; Earley and Crowe, 2002). In the present study, calves that were castrated and/or dehorned spent less time eating compared with calves that received pain relief before castration and/or dehorning, suggesting that this reduction in BW was due to the reduction in time spent eating and, hence reduced gut fill. Therefore, giving calves pain relief is likely to prevent any detrimental consequences that these painful procedures may have on calf performance. Total WBC and the N:L were greater in castrated and/or dehorned calves 6 h after treatment application. Contrary to these results, Earley and Crowe (2002) observed that surgical castration had no effect on total WBC in 5-mo-old calves compared with control calves 1, 3, or 7 d after castration. Chase et al. (1995) reported, however, that the total WBC were greater 2 d after surgical castration in 20-mo-old bulls. In addition, Doherty et al. (2007) found that the N:L was greater in calves 12 h after disbudding, and the response was abolished by giving calves local anesthetic before disbudding. Changes in leukocyte proportions in response to castration and/or dehorning suggest that these painful procedures have the ability to modulate the immune system, which could potentially be prevented by providing calves with pain relief. Immune modulation due to pain caused by castration and/or dehorning could potentially be detrimental to animals that are also being exposed to a new environment (e.g., feedlot) and new pathogens. These physiological changes could lead to increased disease susceptibility, which could be prevented by providing adequate pain relief.

The peak cortisol response was observed 0.5 h after castration and/or dehorning, and was similar among all treatments, suggesting that CD calves experienced a similar level of pain-induced distress as CAS and DH calves. Surgical castration and amputation dehorning elicited a cortisol response similar to that caused by giving an injection of adrenocorticotrophic hormone (Sylvester et al., 1998b; Stafford et al., 2002), which suggests that these procedures applied singularly cause a maximal cortisol response. Therefore, any further increment in the pain experienced by these calves may be difficult to detect due to this potential ceiling effect in the peak cortisol response. The AUC has previously been used to rank the relative noxiousness of different methods of castration and/or tail docking in lambs (Mellor and Stafford, 2000). In the present study, the AUC cortisol response was similar among castrated and dehorned calves, but greater in calves that were subjected to the combined procedure, indicating that CD calves experienced more pain-induced distress than CAS and DH calves.

The efficacy of local anesthetics, analgesics (e.g., NSAID), or both to mitigate the pain caused by castration and dehorning in calves has been described in the literature. Local anesthetic alone was not sufficient to abolish the cortisol response to castration in calves, but local anesthetic combined with a NSAID (ketoprofen) virtually eliminated the cortisol response to castration for up to 8 h (Stafford et al., 2002). Similarly, providing local anesthesia alone was not sufficient to abolish the cortisol response caused by amputation dehorning in calves (McMeekan et al., 1998; Sylvester et al., 1998a; Sutherland et al., 2002); however, administering both a local anesthetic and a NSAID before dehorning eliminated the cortisol response for up to 24 h (Sutherland et al., 2002). Furthermore, local anesthetic and the NSAID were administered immediately before castration and/or dehorning in the present study to reduce the necessity and extra stress caused by handling calves more than once (once to administer the analgesia and second to administer the treatment). The pain relief protocol used in the present study virtually eliminated the cortisol response caused by castration and/or dehorning, suggesting that administering pain relief in the form of an anesthetic and analgesic immediately before castration, dehorning, or both can provide effective pain relief for these procedures.

The behavioral and physiological changes caused by castration, dehorning, or both suggest that calves experience distress and pain for at least 6 h after applying these procedures. Furthermore, combining castration and dehorning appears to exacerbate these responses to the procedures. Pain relief, in the form of local anesthetic and a NSAID administered before castration and/or dehorning markedly reduced the responses to these procedures. Therefore, it is recommended that pain relief should be administered to calves before castration, dehorning, or both to reduce the pain experienced by young calves due to these procedures.

**LITERATURE CITED**


