Plasma cortisol and white blood cell responses in different breeds of bulls: a comparison of two methods of castration

C. C. Chase, Jr, R. E. Larsen, R. D. Randel, A. C. Hammond and E. L. Adams


The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://jas.fass.org
ABSTRACT: To determine plasma cortisol and white blood cell response to castration, Angus (n = 12, 21.4 mo of age), Hereford (n = 6, 21.2 mo of age), and Brahman (n = 24, 20.3 mo of age) bulls nearing maturity were either left intact as uncastrated controls (CON), surgically castrated (SUR) after lidocaine, or castrated by latex rubber banding (BAN). Before and through 35 d after castration (castration d 0), animals were weighed and blood samples were collected for analysis of cortisol and total white blood cell (WBC) count at 2-, 3-, or 7-d intervals. There was a treatment x breed interaction for ADG from d 0 to 7 (P < .05). From d 0 to 14, 0 to 21, 0 to 28, and 0 to 35, ADG tended to be lower for SUR and BAN animals than for CON animals (castrated vs CON, P I .13). No significant differences in ADG were observed between SUR and BAN animals during these times. On d 0, from just before treatment to just after treatment, plasma cortisol concentration increased 3.2 ng/mL for SUR and .1 ng/mL for BAN (SEM = ± .5 ng/mL; SUR vs BAN, P < .03). From d 0 pretreatment to d 2 after treatment, plasma cortisol concentration increased 1.5 ng/mL for castrated (SUR = 2.0 and BAN = 1.1 ng/mL) and decreased 1.6 ng/mL for CON (SEM = ± .7 ng/mL; P < .04). Plasma cortisol concentration was negatively correlated (P < .001) with BW (r = -.17) and BW change (r = -.19). Two days after castration, WBC counts were higher (P < .01) in castrated (SUR = 10,812 and BAN = 11,498 cells/µL) than in CON (8,629 cells/µL) animals (SEM = ± 278 cells/µL). Breed affected ADG (P < .05) and WBC (P < .01) but did not affect plasma cortisol concentration. Castration of bulls nearing maturity by both SUR and BAN procedures elicited short-term elevations in cortisol and WBC and reduced ADG compared with CON. The only difference observed between SUR and BAN treatments was an elevated plasma cortisol in SUR animals just after castration.

Key Words: Castration, Bulls, Stress, Live Weight Gain, Hydrocortisone

Introduction

Castration of male cattle destined for consumption in the United States is a common practice. There are a variety of methods available for castration of male cattle; these include surgical removal of the testicles (Walker and Vaughan, 1980), burdizzo or clamping techniques to crush the spermatogenic cords (Macaulay, 1989), chemical castration (Bagley et al., 1989; Coventry et al., 1989), and rubber bands (Fell et al., 1986; Mellor et al., 1991). The consortium developing the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching recommended that bulls be castrated at as early an age as possible and that calves older than 2 to 3 mo of age be administered a local anesthetic during castration (Consortium, 1988). Furthermore, they recommended that special techniques and procedures to minimize pain, bleeding, and infection be given consideration. Recently, a latex rubber banding technique was introduced that is purported to minimize blood loss, reduce trauma, and decrease exposure to infection when used on older animals (i.e., at or after
weaning). Brazle (1992) indicated that neither daily gains nor health of yearling bulls castrated by banding was different from that of surgically castrated yearling cohorts. The objectives of this study were to evaluate the effects of surgical or band castration and cattle breed on cortisol and white blood cell responses of bulls nearing maturity.

**Materials and Methods**

*Animals and Management.* Angus (n = 12, 400 ± 11.6 kg, 21.4 ± 0.24 mo of age), Brahman (n = 24, 465 ± 8.2 kg, 20.3 ± 0.17 mo of age), and Hereford (n = 6, 395 ± 16.4 kg, 21.2 ± 0.34 mo of age) bulls were stratified within breed by age, BW, and scrotal circumference and randomly assigned to one of three treatment groups. Each treatment group consisted of four Angus, eight Brahman, and two Hereford bulls. Bulls were castrated using surgical (SUR) or latex rubber banding (BAN) techniques, or were left intact as uncastrated controls (CON). Animals were housed in six feedlot pens (two pen replicates/treatment) and were pen-fed daily (4.5 kg of bermudagrass hay and 4.5 kg of concentrate containing 85% corn, 10% protein premix, and 5% molasses mixture per animal). Feed refusals were weighed daily and discarded. Before the experiment, the animals had been fed the concentrate portion of the diet while on pasture for approximately 1 yr. At the end of the experiment (36 d after treatment), animals were sold for slaughter (Central Packing, Center Hill, FL). Carcass data were not collected in this study due to the late age of the animals at castration and the relatively short period of time between castration and slaughter.

*Procedures.* Experimental procedures were approved by the Subtropical Agricultural Research Station Animal Care and Use Committee. Castrations were performed under the supervision of a veterinarian. The day before castration, BW and scrotal circumference of each bull were measured. On the day of castration (d 0), during restraint in a squeeze chute, two blood samples (pre-surgery) were drawn by jugular puncture. Tetanus vaccine (1 mL; tetanus toxoid; Solvay Animal Health, Mendota Heights, MN) was administered to all animals, and BW and scrotal circumference were measured on each animal. Castration was then performed. Uncastrated CON were restrained similarly for 5 min.

Surgically castrated bulls were given a local anesthetic (Butler lidocaine 2% injectable, Butler Co., Columbus, OH). Twenty-five milliliters of lidocaine was injected in the posterior aspect of the spermatic cord of each testicle. Approximately 3 min later, surgical castration was performed. The surgical method of castration consisted of side-to-side puncture of the scrotum and incision through the ventral aspect of the scrotum from one puncture wound to the other using a Newberry knife, leaving anterior and posterior flaps of scrotal skin (Walker and Vaughan, 1980). Testicular cords were crushed and cut using a Hausman emasculator. Testicular tunics were removed but not scrotal skin.

The procedure used to castrate bulls by BAN was described in the instructions included with the instrument (EZE Bloodless Castrator, Wadsworth Manufacturing, St. Ignatius, MT). Briefly, the castrator was loaded with a supplied grommet and latex tubing. The latex tubing was placed around the scrotum and positioned on the testicular cords as close to the testicles and as far from the belly as possible. The latex tubing was tightened by hand and then by squeezing the grip (racheting) on the instrument. The grommet was applied to the latex tubing and the tubing cut 7.5 cm from the grommet.

Fly spray was applied to the hindquarters (not directly on the wound) of each animal (including CON). A blood sample (approximately 2 min after treatment) was then drawn by jugular venipuncture. At 0800 on d 2, 5, 7, 9, 12, 14, 16, 19, 21, 23, 26, 28, and 35 after castration, animals were weighed prior to being fed. Average daily gain for each animal from d 0 to 7, 0 to 14, 0 to 21, 0 to 28, and 0 to 35 were calculated by linear regression using all inclusive BW. Also on each weigh day, scrotal circumference was measured (in bulls castrated by SUR procedure this measurement was of the scrotal sac), and a jugular blood sample collected from each animal. These blood samples and those collected on d 0 (one pre-surgery and one post-surgery) were processed on the day of collection to yield plasma (collected into blood tubes containing EDTA) and the plasma was stored (−20°C). At a later date, plasma concentrations of cortisol were determined by RIA using a commercially available kit (#031, Pantex, Santa Monica, CA) as validated in our laboratory (Godfrey et al., 1991). Additional jugular blood samples were collected from each bull on d 2, 5, 7, 9, 14, 21, 28, and 35. These blood samples and those obtained on d 0 (one pre-surgery) were collected into tubes containing EDTA to inhibit clotting, and within 48 h of collection total white blood cell counts were determined by Coulter impedance method (Coulter Counter Model S-Plus IV, Coulter Electronics, Hialeah, FL) at the Department of Clinical Pathology, College of Veterinary Medicine, University of Florida, Gainesville.

*Statistical Analysis.* Data were analyzed by ANOVA for a randomized complete block design using the GLM procedures of SAS (1988). A split-split plot model was used with treatment representing the main effect, breed a subplot, and date a sub-subplot. The error term for testing the effect of treatment was pen within treatment and for testing breed and the interaction between breed and treatment was the interaction between breed and pen within treatment. All data are reported as least squares means. Treatment and breed effects were partitioned into orthogonal contrasts, CON vs SUR and BAN, and SUR
vs BAN, and Angus and Hereford (Bos taurus) vs Brahman (Bos indicus), and Angus vs Hereford, respectively. Pearson correlation coefficients and associated probabilities were determined using the CORR procedure of SAS (1988).

**Results**

Animals consumed all of the concentrate offered throughout the experiment but did not eat all of the hay offered during the first 9 d of the experiment (CON, SUR, and BAN animals ate 98.7, 81.3, and 87.4% of the hay fed, respectively). From d 0 to 9, hay consumed averaged .93, .75, and .82% of pre-treatment BW for CON, SUR, and BAN treatments, respectively. Pearson correlation coefficients and associated probabilities were determined using the CORR procedure of SAS (1988).

A treatment × breed interaction for ADG from d 0 to 7 (P < .05) was observed. From d 0 to 7, ADG of SUR-Hereford and SUR-Brahman were lower than their respective CON, but ADG of SUR-Angus did not differ from those of CON-Angus (Figure 1). Average daily gain of BAN-Brahman was lower than that of CON-Brahman, whereas ADG of BAN-Hereford did not differ from that of CON-Hereford, and ADG of BAN-Angus was higher than ADG of CON-Angus. The treatment × breed interaction did not significantly influence ADG from d 0 to 14, 0 to 21, 0 to 28, and 0 to 35 (Table 1). From d 0 to 14, 0 to 21, 0 to 28, and 0 to 35, ADG tended (P ≤ .13) to be greater for CON than for castrated animals. No differences (P > .3) were observed in ADG between SUR and BAN treatments.

![Figure 1. Effect of treatment and breed on ADG from d 0 to 7 after castration. Data are least squares means.](image)

<table>
<thead>
<tr>
<th>Treatmentb</th>
<th>Days</th>
<th>CON</th>
<th>SUR</th>
<th>BAN</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 7</td>
<td>.95</td>
<td>-.33</td>
<td>.66</td>
<td>± .66</td>
<td></td>
</tr>
<tr>
<td>0 to 14</td>
<td>.79</td>
<td>-.02</td>
<td>-.12</td>
<td>± .34</td>
<td></td>
</tr>
<tr>
<td>0 to 21</td>
<td>.84</td>
<td>.43</td>
<td>.06</td>
<td>± .23</td>
<td></td>
</tr>
<tr>
<td>0 to 28</td>
<td>.93</td>
<td>.61</td>
<td>.32</td>
<td>± .18</td>
<td></td>
</tr>
<tr>
<td>0 to 35</td>
<td>.93</td>
<td>.64</td>
<td>.42</td>
<td>± .16</td>
<td></td>
</tr>
</tbody>
</table>

aData are least squares means.

bCON = uncastrated control, SUR = surgically castrated, BAN = castrated by banding.

| Control vs castrated (P ≤ .13). |

Brahman had lower (P < .05) ADG than Angus and Hereford throughout the experiment (Table 2). Average daily gain did not differ (P > .15) between Angus and Brahman.

Plasma concentrations of cortisol prior to surgery were similar between treatments and averaged 16.1, 16.6, and 15.3 ng/mL for CON, SUR, and BAN, respectively (SEM = ± 1.9 ng/mL). From d 0 before treatment to d 0 just after treatment, plasma cortisol concentration increased 3.2 ng/mL for SUR and .1 ng/mL for BAN animals (SEM = ± .5 ng/mL; SUR vs BAN, P < .03; Figure 2). From d 0 before treatment to d 2 after treatment, plasma cortisol concentration increased 2.0 ng/mL for SUR and 1.1 ng/mL for BAN animals but decreased 1.6 ng/mL for CON (SEM = ± .7; castrated vs CON P < .04). A similar pattern existed from d 5 to 9 and 14 to 21 but treatment differences were not significant.

Breed did not affect plasma concentrations of cortisol that averaged 15.5 ± .8, 16.0 ± .6, and 15.4 ± 1.1 ng/mL for Angus, Brahman, and Hereford, respectively. Similarly, breed did not affect the difference in cortisol plasma concentration (calculated as post-treatment cortisol minus pre-treatment cortisol), which averaged −1.4 ± 2.1, −.9 ± 1.4, and .8 ± 2.9 ng/mL. There were no treatment × breed or breed × day interactions for plasma cortisol or difference in plasma cortisol. There were small negative correlations observed between plasma concentration of cortisol with BW (r = −.17; P < .001) or with change in BW (r = −.19; P < .001).

There was a treatment × day interaction for total white blood cell counts (P < .02; Figure 3). Two days after castration, total white blood cell counts were higher (P < .01; SEM = 278 cells/μL) in castrated animals (SUR = 10,812 and BAN = 11,498 cells/μL) than in CON animals (8,629 cells/μL). This same pattern was evident on d 8 and 14, but treatment differences were not significant. In general, total white blood cell counts of castrated animals (SUR and BAN) seemed to rise and fall similarly to one another and more over a wide range of values than those of CON bulls.
Table 2. Effect of breed on ADG (kg/d) of male cattle

<table>
<thead>
<tr>
<th>Breed</th>
<th>Days</th>
<th>Angus</th>
<th>Brahman</th>
<th>Hereford</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 to 7</td>
<td>.11 ± .28</td>
<td>-.42 ± .27</td>
<td>.60 ± .54</td>
</tr>
<tr>
<td></td>
<td>0 to 14</td>
<td>.46 ± .22</td>
<td>-.25 ± .16</td>
<td>.44 ± .31</td>
</tr>
<tr>
<td></td>
<td>0 to 21</td>
<td>.52 ± .15</td>
<td>.21 ± .10</td>
<td>.61 ± .21</td>
</tr>
<tr>
<td></td>
<td>0 to 28</td>
<td>.60 ± .11</td>
<td>.37 ± .08</td>
<td>.89 ± .16</td>
</tr>
<tr>
<td></td>
<td>0 to 35</td>
<td>.66 ± .12</td>
<td>.42 ± .08</td>
<td>.91 ± .16</td>
</tr>
</tbody>
</table>

aData are least squares means ± SE.

Angus and Hereford (Bos taurus) vs Brahman (Bos indicus; P < .05).

Breed affected (P < .01) white blood cell counts. There were no treatment × breed or breed × day interactions (P > .2) for white blood cell counts. White blood cell counts were higher (P < .02) in both Angus (10,586 ± 474.0 cells/µL) and Brahman (11,614 ± 329.0 cells/µL) than in Hereford (7,828 ± 652.9 cells/µL).

Before castration, scrotal circumference averaged 29.6, 32.2, and 29.5 cm for Angus, Brahman, and Hereford, respectively. As expected, little difference in scrotal circumference occurred in CON bulls (Figure 4). In SUR animals, although the testicles were removed from the scrotal sac, swelling following castration increased the scrotal sac circumference by an average of 4 cm 2 d after castration. From d 2 through 35, scrotal sac circumference decreased 10 cm in SUR animals. Scrotal circumference of BAN animals decreased by d 2, was increased by d 5, gradually decreased through d 7, and then remained relatively constant through d 21. Complete loss of scrotum and contents in BAN animals occurred as early as d 5 and as late as d 35 (Figure 5). By d 21, 50% of BAN animals had lost their scrotum and contents. On d 36, all animals were slaughtered at a local abattoir and each passed inspection for meat wholesomeness.

**Discussion**

Results from this experiment allowed us to determine cortisol and white blood cell response of...
Figure 4. Effect of treatment and day after castration on difference in scrotal circumference. Difference in scrotal circumference was calculated as the post-treatment scrotal circumference minus the pre-treatment scrotal circumference. Data are least squares means. CON = uncastrated control, SUR = surgically castrated, BAN = castrated by banding. Treatment x day (P < .05), pooled SEM = 1.63 cm.

Figure 5. Cumulative percentage of animals with complete loss of scrotum and contents through 35 d after castration by banding. BAN = castrated by banding.

postpubertal bulls castrated by two different methods. The 1st wk after castration, SUR animals did not consume all of the hay that was offered and SUR-Brahman and SUR-Hereford lost BW. Both the BAN and SUR treatments tended to have lower ADG than CON from d 0 to 14, 0 to 21, 0 to 28, and 0 to 35 after castration. There were no significant differences in ADG between the SUR and BAN treatments. The BAN treatment did not improve animal performance over SUR in this experiment. Faulkner et al. (1992) reported that SUR animals had lower ADG and gain/feed and tended to have lower feed intakes from 0 to 27 d after castration than CON. One other report compared purchased yearling steers to bulls castrated by BAN or SUR (Brazle, 1992). Results from that study indicated that BAN animals had lower ADG during a 110-d period than purchased steers, and that there was no significant difference between BAN and SUR animals in terms of gain or health.

Plasma cortisol concentration increased in SUR but not BAN animals immediately after castration. However, 2 d after castration, increases in cortisol were similar between SUR and BAN treatments, and both were higher than CON. Other researchers have reported higher cortisol or corticoid concentrations up to 7 d after castration in cattle (Johnston and Buckland, 1976; Friend, 1991; Faulkner et al., 1992). Although none of these former studies included a BAN treatment per se, use of rubber bands for castration of calves has been used. Mellor et al. (1991) reported no increase in plasma cortisol in either 1-wk-old calves castrated with elastrator bands or in uncastrated controls. In contrast, Fell et al. (1986) observed that concentrations of cortisol in saliva from 4- to 11-wk-old calves were highest for surgically castrated calves, lowest for uncastrated control calves, and were intermediate for elastrator-banded calves. The rapid rise in cortisol observed just after SUR in the present study agrees with the acute response in cortisol observed for castrated calves (Friend, 1991). In the present study, although plasma cortisol concentration increased in both SUR and BAN treatments on d 2 after castration, no treatment differences were observed on d 5. These results indicate that the cortisol response for SUR was an acute, intense elevation of short duration, and that for BAN was of less initial intensity but also of short duration.

Castration treatment affected white blood cell counts on d 2 after treatment; castrated animals (SUR and BAN) had greater counts than CON. This coincided with greater changes in plasma cortisol concentration. Macaulay (1989) reported higher total white blood cell counts for SUR- or burdizzo-castrated calves than for sham-castrated calves. The treatment range in white blood cell counts observed in the present study (7,000 to 14,000 cells/μL), are in the normal range reported for cattle (Benjamin, 1978). The elevated white blood cell counts observed on d 2 after castration also fell within this normal range. Thus, although the bulls in this study were castrated at an older age than is typically recommended for SUR, the white blood cell count data support our subjective assessment that the health of the animals was not compromised.
There was a treatment x breed interaction for ADG from d 0 to 7. This seemed due to the body weight loss in SUR-Herford, SUR-Brahman, and BAN-Brahman that did not occur for SUR-Angus, BAN-Angus, or BAN-Hereford. In addition to the observed breed differences in ADG, these results also suggest breed differences in response to a stressor. Breed did not affect pre- or post-castration plasma concentrations of cortisol in the present study. Bos indicus cattle possess unique physiological and behavioral attributes that differ from Bos taurus cattle (Turner, 1980; Randel, 1994a,b). In previous studies with growing cattle, B. indicus x B. taurus crossbred calves had higher blood cortisol concentrations than B. taurus or B. taurus crossbred calves (Blecha et al., 1984; Zavy et al., 1992). However, when mature purebred B. indicus were compared to mature purebred B. taurus, blood cortisol concentrations were similar in bulls (Berardinelli et al., 1992) and were higher in Angus than in Brahman cows (Stahringer et al., 1994). The data in the present study, using nearly mature purebred males, are in agreement with those of Berardinelli et al. (1992). Last, the lower white blood cell counts observed in the Hereford than in the Angus animals in the present study seems to be consistent with previous results (Benjamin, 1978). Although an interaction between treatment and breed was observed for d 0 to 7 ADG, suggesting breed differences in response to a stressor, neither change in plasma cortisol concentration nor white blood cell count was influenced by an interaction between treatment and breed.

Implications

Although there are a variety of castration methods available for use on young bulls, castration of older animals is limited to surgical or latex rubber banding procedures. Surgical castration, but not banding, elicited an immediate, acute stress response as measured by increased blood cortisol concentration. Both castration procedures elevated blood cortisol and white blood cell counts only a couple days after castration and these stress responses were of short duration. Performance was similar between animals castrated by surgical and banding procedures and tended to be lower than that of uncastrated bulls.

Literature Cited


This article has been cited by 2 HighWire-hosted articles:
http://jas.fass.org#otherarticles