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Effect of Castration Method and the Provision of Local Anesthesia on Plasma Cortisol, Scrotal Circumference, Growth, and Feed Intake of Bull Calves[1]

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ABSTRACT: To determine the effects of castration of calves, with or without local anesthesia, on plasma cortisol, scrotal circumference, ADG, and ADFI, 56 Friesian bulls (5.5 mo of age; mean ± SE BW = 173 ± 2 kg) were randomly assigned to each of seven treatments: 1) control (CON); 2) s.c. injection of .1 mg of a human serum albumin-GnRH conjugate with DEAE-dextran adjuvant (HSA-GnRH); 3) burdizzo castration without local anesthetic (BURD); 4) burdizzo castration following local anesthetic administration (BURD + LA); 5) surgical castration without local anesthetic (SURG); 6) surgical castration following local anesthetic administration (SURG + LA); and 7) local anesthetic administration alone (LAA). Blood samples for cortisol analyses were taken via jugular catheter from –2 to 10 h and at 24, 48, and 72 h relative to treatment. Average daily feed intakes were recorded for 5-d periods and calves weighed at 7-d intervals before and after treatment. Local anesthetic alone had no effect ($P > .10$) on any variable. The HSA-GnRH calves had elevated ($P < .05$) plasma cortisol from 2 to 6 h compared with CON calves. Peak plasma cortisol was elevated ($P < .01$) in BURD, BURD + LA, SURG, and SURG + LA compared with CON calves. The SURG calves (46.0 ng/mL) had higher ($P < .03$) peak cortisol than BURD (31.4 ng/mL) and SURG + LA (35.4 ng/mL) calves. There was no difference in peak cortisol between BURD and BURD + LA (26.5 ng/mL) calves. The ADG from d 0 to 7 was reduced ($P < .05$) in calves in BURD + LA, SURG, and SURG + LA treatments (–.01, –.83 and –.24 kg, respectively) compared with CON calves (.54 kg). The ADFI were reduced ($P < .05$) in BURD and BURD + LA calves during d 1 to 5 and in BURD + LA, SURG, and SURG + LA calves during d 6 to 10 compared with CON calves. The scrotal circumferences of BURD and BURD + LA calves were greater ($P < .05$) than those of CON calves for 7- and 35-d periods post-castration, respectively. Castration induced increases in cortisol and decreases in ADG and ADFI. Surgical castration induced a greater plasma cortisol response than burdizzo castration, and the administration of local anesthetic reduced the cortisol response of surgical castrates but was less effective for burdizzo castrates.

Key Words: Castration, Bulls, Hydrocortisone, Liveweight Gain, GnRH

Introduction

The castration of male cattle intended for beef production is a common practice in many countries. Castration decreases the management problems associated with aggressive and sexual behavior (Appleby, 1986) and the incidence of dark-cutting meat is lower among castrated than among intact male cattle (Field, 1971). Techniques used to castrate male cattle include the application of rubber rings or tightened latex bands (Fell et al., 1986; Chase et al., 1995), surgical removal of the testicles (Jennings, 1984), and use of a burdizzo instrument to crush the testicular cords (Robertson et al., 1994). Castration is consi-

dered to cause a degree of pain and stress (Duncan, 1974), and the provision of local anesthesia before castration of cattle is a legislative requirement in some countries and has been recommended for cattle older than 2 to 3 mo of age in the United States (Consortium, 1988). Techniques have been developed that achieve many of the effects of castration by inducing immunoneutralization of hormones of the hypothalamic-pituitary-testicular axis (Adams and Adams, 1992; Finnerty et al., 1994).

The objectives of this study were to evaluate the effects of surgical and burdizzo castration, with and without local anesthesia, and a previously successful immunocastration technique. The hypotheses were that 1) the stress response to castration as measured by plasma cortisol, ADG, and ADFI would be greater following surgical castration than burdizzo castration, with minimal stress effects resulting from an immunocastration technique; 2) the provision of local anesthesia would reduce the cortisol response to castration by surgical and burdizzo methods; and 3) burdizzo castration would induce temporary scrotal swelling.

Materials and Methods

Animals and Treatments. Fifty-six 5.5-mo-old Friesian bull calves (mean ± SE BW = 173 ± 2 kg) were randomly assigned to each of seven treatments: 1) untreated control (**CON**); 2) s.c. injection with .1 mg human serum albumin-GnRH conjugate (Ciba-Geigy Ltd., St. Aubin, Switzerland) in DEAE-dextran (Sigma Chemical, Poole, Dorset, U.K.) adjuvant (**HSA-GnRH**); 3) burdizzo castration without local anesthetic (**BURD**); 4) burdizzo castration following local anesthetic administration (**BURD + LA**); 5) surgical castration without local anesthetic (**SURG**); 6) surgical castration following local anesthetic administration (**SURG + LA**); and 7) local anesthetic administration alone (**LAA**).

Calves were housed in individual tie-stalls from d −10 (day of treatment = d 0), had ad libitum access to grass silage (in vitro DM digestibility = 742 g/kg), and were supplemented with 1.5 kg of a barley/soybean meal mix (CP = 136 g/kg) per animal daily. Individual silage intakes were recorded for 5-d periods from d −9 to 20. Calves were weighed on d −10 before assignment to treatment, and on d −1, 7, 14, 21, and 35, and ADG determined. Scrotal circumference was measured in CON, HSA-GnRH, BURD, BURD + LA, and LAA calves before treatment on d 0 and on subsequent weigh days. From d 21, calves were housed in groups in a slatted-floor facility.

Calves were fitted with indwelling jugular catheters on d −1 and returned to their tie-stalls. On d 0, blood samples were collected at −2, −1.5, −1, −.5, −.25, 0, .25, .5, .75, 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6, 8, and 10 h relative to the time of treatment for each calf. Further blood samples were taken at approximately 24, 48, and 72 h post-treatment. Heparinized plasma was separated after centrifugation at $1,600 \times g$ and stored at −20°C until assayed for cortisol.

Experimental Procedures. The calves were treated in two groups, 48 h apart, and were treated (including local anesthetic administration and castration) and blood sampled in their individual tie-stalls to minimize handling. Half the CON (n = 4) and all the HSA-GnRH, BURD, and BURD + LA calves were treated on the 1st d, and the remainder of the CON, and all the SURG, SURG + LA, and LAA calves were treated on the 2nd d. All treatments occurred between 1000 and 1100. Environmental conditions in the facility were monitored and were similar on the days of treatment (15 to 18°C, 70 to 90% relative humidity). Because CON calves were already restrained in tie-stalls, they were not subjected to additional handling. The HSA-GnRH calves received 5 mL of the conjugate-DEAE-dextran solution injected s.c. in the neck. The HSA-GnRH conjugate was prepared as described by Finnerty et al. (1994) and dissolved (.04 mg/mL) in PBS (pH 7.4). The DEAE-dextran was dissolved (.1 g/mL) over low heat in PBS (pH 7.4) and equal volumes of the conjugate and DEAE-dextran solutions were mixed by stirring for 2 h before injection. The dose of conjugate (.1 mg/calf) and adjuvant used were based on the successful induction of anti-GnRH antibodies and reduction of plasma LH and testosterone in a previous study (Finnerty et al., 1994). Burdizzo castration was performed in BURD and BURD + LA calves using two 10-s crushes (approximately 1 cm apart) of each testicular cord using a standard burdizzo instrument (La Burdizzo, Corso Sebastopoli 187, 10137 Turin, Italy). Local anesthesia in BURD + LA calves was provided using 2% lidocaine hydrochloride (Lignavet Injection, C-Vet Ltd., Suffolk, U.K.), administered 15 min before treatment. Following the procedure of Skarda (1986), 8 mL of lidocaine was injected into each testicle and allowed to diffuse into the testicular cord. A further 3 mL of lidocaine was injected s.c. on each side of the scrotum where the jaws of the burdizzo would close. Surgical castration was performed in SURG and SURG + LA treatments using an open method, with two incisions of the caudo-ventral scrotum using a scalpel, followed by expression of the testicles and the application of emasculators to crush and cut the testicular cords (Jennings, 1984). The administration of local anesthetic for the SURG + LA treatment was the same as for BURD + LA calves, except that the s.c. infiltration was performed along the lines of subsequent incision of the scrotum. For LAA calves, local anesthetic was administered as for the SURG + LA treatment. All treatments were approved under experimental license from the Irish Department of Health in accordance with the Cruelty to Animals Act, 1876.

Cortisol. Plasma cortisol concentrations were determined using a commercially available RIA kit (Corti-Cote, Becton Dickinson Immunodiagnostics, Orangeburg, NY), adapted and validated for bovine plasma in our laboratory. Human serum standards were diluted in buffer (PBS + .125% BSA, .93% EDTA, and .1% sodium azide; pH 7.2), and 25 μL of standard, control, or unknown sample pipetted into anti-cortisol antibody-coated tubes. Five hundred microliters of ^{125}I-labeled cortisol tracer (approximately 30,000 cpm) was then added before incubation for 45 min at 37°C. Tubes were decanted, washed once with 1 mL of distilled water, and counted for 2 min in a gamma counter. Parallelism between the standard and unknown samples was demonstrated by using increasing aliquots of a bovine plasma sample: the concentrations (corrected for volume) measured in 5, 10, 15, 20, and 25 μL aliquots were 34.6, 30.5, 30.8, 30.4, and 31.7 ng cortisol/mL plasma, respectively. Mean recovery of added cortisol (soluble hydrocortisone sodium succinate) to bovine plasma was 98%, and the sensitivity of the assay was .6 ng/mL. The stated cross-reactivity of the anti-cortisol antibody with corticosterone, cortisone, dexamethasone, prednisolone, and prednisone was 1.2, .8, .8, 94.1, and 1.2%, respectively. The intraassay CV (n = 6) for samples containing 5.5, 28.1, and 69.2 ng of cortisol/mL, respectively, were 9.3, 5.5, and 4.5%, and the interassay CV (n = 12) for the same samples were 12.9, 4.9, and 5.0%. For each calf, the mean cortisol concentration was calculated for the periods −2 to 0, .25 to 1.5, 2 to 6, and 8 to 24 h relative to treatment. The peak post-treatment cortisol concentration was recorded and the area (ng·mL^{-1}·h) under the cortisol vs time curve above pre-treatment baseline from 0 to 10 h was measured using a commercially available computer-based software package (GraphPad, ISI Software, Philadelphia, PA).

Statistical Analyses. One animal in the SURG + LA treatment group suffered excessive hemorrhage post-castration requiring further surgical intervention; this animal was excluded from all statistical analyses. Statistical analyses were performed using GENSTAT (Lawes Agricultural Trust, 1990). Initially, data from CON animals on mean plasma cortisol for each period, peak cortisol, and 48- and 72-h cortisol concentrations were subjected to ANOVA and tested for differences between the 2 d of treatment. There were no differences ($P > .19$) in cortisol concentrations of CON calves between the 2 d of treatment. Therefore, the data from all animals on mean plasma cortisol, scrotal circumference, ADG, and ADFI were then analyzed by ANOVA with treatment as the effect in the model, and with data from the immediate pre-treatment periods included as covariates in the analyses of post-treatment data (Snedecor and Cochran, 1989). The data on peak, 48-, and 72-h plasma cortisol and area under the cortisol vs time curve were analyzed by ANOVA. All data are presented as least squares means. Fisher's LSD test was used to determine specific differences between means following a significant F-test (Snedecor and Cochran, 1989).

Results

Plasma Cortisol. Mean plasma cortisol concentrations were generally less than 10 ng/mL for CON animals from −2 to 10 h and for animals on other treatments from −2 to 0 h (Table 1; Figure 1). Following castration, cortisol concentrations of BURD, BURD + LA, SURG, and SURG + LA calves increased rapidly, reaching an initial peak within 15 to 30 min (Figure 1). The mean plasma cortisol concentrations

Table 1. The effect of no treatment (CON), administration of a human serum albumin-GnRH conjugate in DEAE-dextran adjuvant (HSA-GnRH), burdizzo castration without (BURD) or with (BURD + LA) local anesthetic administration, surgical castration without (SURG) or with (SURG + LA) local anesthetic administration, or local anesthetic administration alone (LAA) on mean and peak plasma cortisol concentrations and area under the cortisol response curve in bull calves[a]

Item	CON	HSA-GnRH	BURD	BURD + LA	SURG	SURG + LA	LAA	SEM
Mean plasma cortisol, ng/mL								
−2 to 0 h	7.4	7.0	5.5	7.3	8.7	8.8	6.5	1.20
.25 to 1.5 h	5.0[b]	8.9[bc]	22.6[e]	14.7[cd]	30.9[f]	19.7[de]	4.9[b]	2.16
2 to 6 h	5.3[b]	12.5[cd]	8.2[bc]	11.0[bcd]	21.7[e]	17.3[de]	7.4[bc]	2.37
8 to 24 h	5.7	9.3	8.9	8.3	7.1	10.5	6.2	1.45
48 h	2.7[b]	3.8[b]	4.7[b]	9.7[c]	4.9[b]	2.7[b]	2.9[b]	1.43
72 h	2.6	2.7	2.5	5.4	7.0	3.5	2.2	1.62
Peak plasma cortisol, ng/mL	14.6[b]	23.0[bc]	31.4[cd]	26.5[cd]	46.0[e]	35.4[d]	15.1[b]	3.11
Area under cortisol curve, ng·mL^{-1}·h								
0 to 10 h	5.7[b]	48.9[cd]	46.4[bcd]	40.3[bcd]	105.6[e]	82.4[de]	18.2[bc]	14.55

[a]Data are least squares means, n = 8 per treatment.
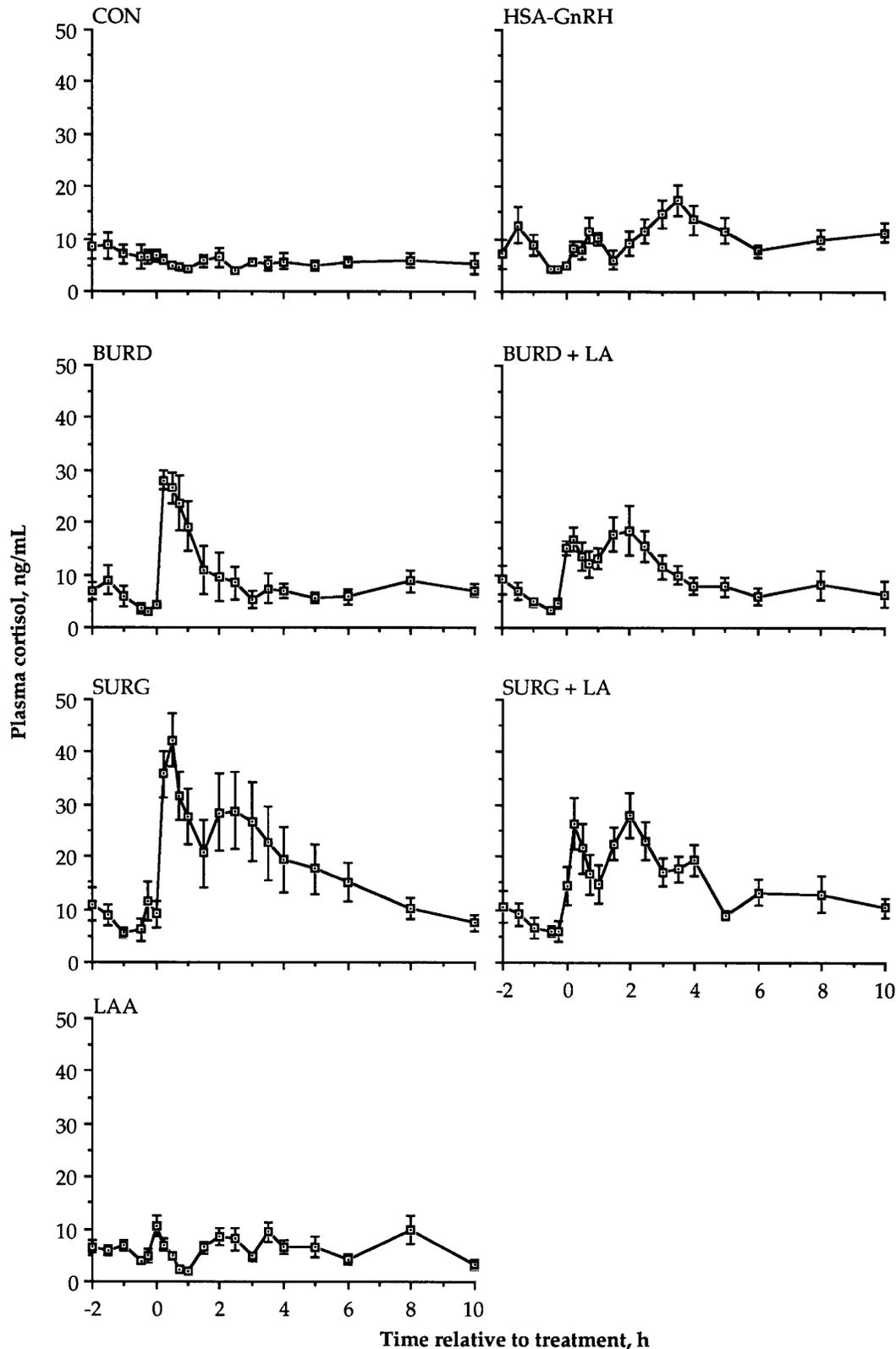[b,c,d,e,f]Means within a row without common superscripts are different ($P < .05$).

Figure 1. Mean ± SE cortisol concentrations of bull calves left untreated (CON), administered a human serum albumin-GnRH conjugate in DEAE-dextran adjuvant (HSA-GnRH), castrated using a burdizzo (BURD), castrated using a burdizzo following local anesthetic administration (BURD + LA), surgically castrated (SURG), surgically castrated following local anesthetic administration (SURG + LA), or administered local anesthetic alone (LAA).
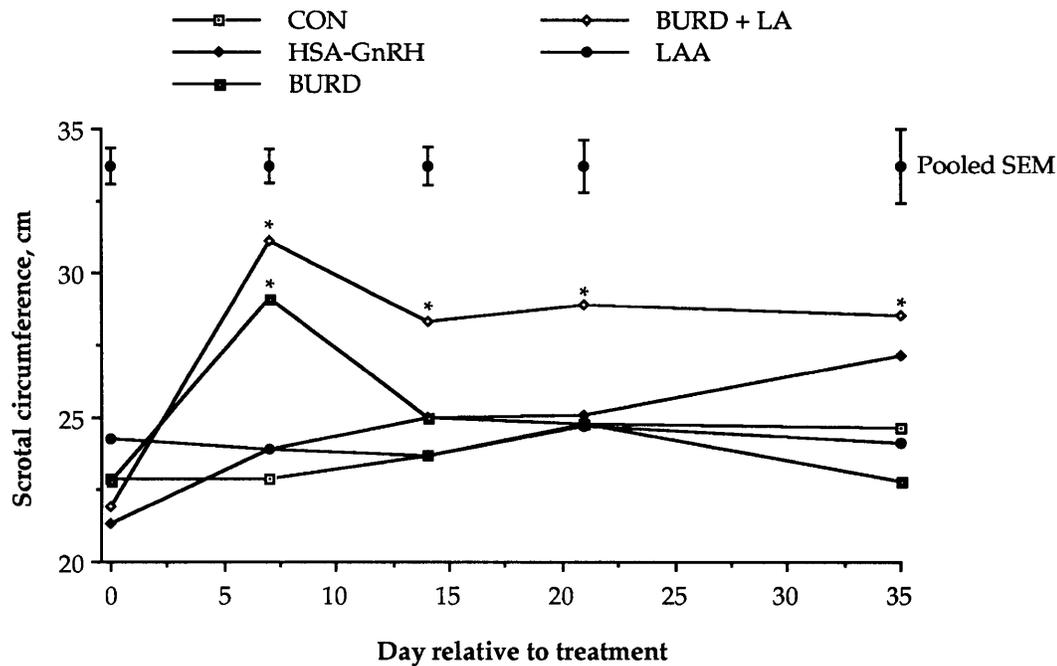
Figure 2. Scrotal circumference of bull calves left untreated (CON), administered a human serum albumin-GnRH conjugate in DEAE-dextran adjuvant (HSA-GnRH), castrated using a burdizzo (BURD), castrated using a burdizzo following local anesthetic administration (BURD + LA), or administered local anesthetic alone (LAA). *Within day, value differs ($P < .05$) from CON value.

of LAA calves did not differ ($P > .50$) from those of CON calves over any time period (Table 1). The BURD and BURD + LA calves had greater ($P < .01$) mean plasma cortisol than CON calves during the .25- to 1.5-h period, but not during the 2- to 6-h or 8- to 24-h periods, whereas mean cortisol concentrations in SURG and SURG + LA calves were greater ($P < .01$) than those in CON calves during the .25- to 1.5-h and the 2- to 6-h periods. The BURD + LA and SURG + LA calves had reduced ($P < .05$) cortisol concentrations only during the .25- to 1.5-h period compared with BURD and SURG calves, respectively. The HSA-GnRH calves had greater ($P < .05$) mean cortisol concentrations than CON calves during the 2- to 6-h period and tended ($P = .06$) to have higher peak cortisol (23.0 vs 14.6 ng/mL). The peak cortisol concentrations of SURG were greater ($P < .01$) than BURD calves and, whereas peak cortisol was reduced ($P < .03$) for SURG + LA compared with SURG calves, there was no difference ($P > .20$) between BURD + LA and BURD calves. Area under the cortisol vs time curve from 0 to 10 h did not differ ($P > .20$) between SURG and SURG + LA, or between BURD and BURD + LA calves ($P > .50$), although SURG calves (105.6 ng·mL^{-1}·h) had a greater ($P < .01$) area than BURD calves (46.4 ng·mL^{-1}·h). At 48 h after treatment, only BURD + LA calves had elevated ($P < .01$) cortisol compared with CON calves (9.7 vs 2.7 ng/mL). At 72 h there were no differences ($P > .27$) between treatments.

Feed Intake. Calves consumed all of the daily concentrate offered throughout the experiment. Pre-treatment ADFI did not differ ($P > .90$) between treatments (Table 2). In the period from 1 to 5 d after treatment, calves in BURD and BURD + LA treatments had reduced ($P < .05$) ADFI compared with CON calves. There were no differences ($P > .05$) between CON calves and SURG, SURG + LA, HSA-GnRH, and LAA calves during the same period. From 6 to 10 d after treatment, only BURD + LA, SURG, and SURG + LA calves had lower ($P < .05$) ADFI than CON calves. No differences ($P > .80$) between treatments were observed in ADFI from d 11 to 15 or 16 to 20 after treatment.

Average Daily Gain. There were no differences ($P > .70$) in ADG between treatments in the week before treatment (Table 2). From d 0 to 7 after treatment, BURD + LA, SURG, and SURG + LA calves had lower ($P < .05$) ADG than CON calves ($-.01$, $-.83$, $-.24$ and .54 kg, respectively). The ADG of SURG calves were lower ($P < .05$) than that of SURG + LA calves, but the ADG of BURD (.41 kg) and BURD + LA calves were not different ($P > .10$). From d 8 to 14, there were no differences ($P > .50$) in ADG between treatments. Only BURD calves had lower ($P < .05$) ADG than CON calves from d 15 to 21 and there were no effects ($P > .30$) of treatment on ADG from d 22 to 35.

Scrotal Circumference. Before treatment, mean scrotal circumference was 22.9, 21.3, 22.8, 21.9, and 24.3

Table 2. The effect of no treatment (CON), administration of a human serum albumin-GnRH conjugate in DEAE-dextran adjuvant (HSA-GnRH), burdizzo castration without (BURD) or with (BURD + LA) local anesthetic administration, surgical castration without (SURG) or with (SURG + LA) local anesthetic administration, or local anesthetic administration alone (LAA) on ADFI and ADG in bull calves[a]

				Treatment				
Item	CON	HSA-GnRH	BURD	BURD + LA	SURG	SURG + LA	LAA	SEM
ADFI, kg								
−5 to 0 d	3.93	3.70	4.18	3.68	4.13	3.86	3.98	.165
1 to 5 d	3.92[cd]	3.53[bc]	3.40[b]	3.41[b]	3.67[bcd]	3.54[bc]	3.97[d]	.145
6 to 10 d	4.36[e]	4.31[de]	4.16[cde]	4.01[c]	3.74[b]	4.05[cd]	4.17[cde]	.096
11 to 15 d	4.31	4.39	4.16	4.40	4.42	4.47	4.29	.167
16 to 20 d	4.56	4.69	4.68	4.67	4.79	4.74	4.73	.124
1 to 20 d	4.30	4.23	4.11	4.13	4.17	4.21	4.32	.100
ADG, kg								
−7 to −1 d	1.18	.85	1.09	1.08	1.09	.77	1.08	.179
0 to 7 d	.54[e]	.47[de]	.41[de]	−.01[cd]	−.83[b]	−.24[c]	.63[e]	.175
8 to 14 d	.78	.85	.85	.92	1.20	1.11	.50	.249
15 to 21 d	1.62[cd]	1.68[cd]	1.06[b]	1.43[bcd]	1.23[bc]	1.92[d]	1.77[cd]	.192
22 to 35 d	.72	.93	.95	.95	.83	.74	.73	.101
0 to 35 d	.85[bc]	1.00[c]	.87[bc]	.86[bc]	.61[a]	.81[b]	.83[b]	.052

[a]Data are least squares means, n = 8 per treatment.
[b,c,d,e]Means within a row without common superscripts are different ($P < .05$).

cm (pooled SEM = .61 cm) for CON, HSA-GnRH, BURD, BURD + LA, and LAA calves, respectively (Figure 2). The scrotal circumference of HSA-GnRH or LAA calves did not differ ($P > .10$) from CON calves at any stage after treatment. On d 7 after treatment, due to scrotal swelling, the scrotal circumference of BURD and BURD + LA calves was greater ($P < .001$) than that of CON calves. Scrotal circumference of BURD + LA calves remained greater ($P < .05$) than that of CON calves up to and including the final measurement on d 35.

Discussion

Castration by burdizzo or surgical methods caused a rapid increase in plasma cortisol, which remained elevated for up to 8 h following castration. An increase in plasma cortisol following castration is consistent with the results of other research. Cohen et al. (1990) recorded increased plasma cortisol at 3 and 6 h post-treatment in surgically castrated Holstein calves. Serum cortisol was elevated 3 and 7 d after surgical castration of 6- to 9-mo-old crossbred cattle (Faulkner et al., 1992), and Johnston and Buckland (1976) recorded increased plasma corticoid concentrations 15 min, 24 h, and 48 h after castration and dehorning of 4-mo-old cattle. The return of cortisol concentrations to control values by the 8- to 24-h period following either burdizzo or surgical castration in the present study is probably due to the calves having been handled from an early age and being younger than those of Faulkner et al. (1992). Robertson et al. (1994), in an experiment examining the cortisol response of Ayrshire calves castrated at 6, 21, or 42 d of age, measured increasing cortisol responses to castration with increasing age. Similar results were obtained by King et al. (1991) castrating calves at 78 or 167 d of age. In addition, having the calves cannulated, housed, and blood-sampled in tie-stalls in the present study may have reduced the difference in plasma cortisol concentrations between castrates and controls recorded in other studies. Cattle learn to associate handling procedures and facilities with aversive events that have occurred previously (Pascoe, 1986), and the handling and restraint for venipuncture of cattle that have been castrated days previously may in itself induce a cortisol rise.

It is possible, although unlikely, that housing the calves in tie-stalls in this study may have increased basal cortisol concentrations in such a way as to mask the effects of castration beyond 8 to 24 h. Ladewig and Smidt (1989) recorded no difference in mean plasma cortisol concentrations between tethered or untethered 14-mo-old bulls. Furthermore, the pre-treatment and post-24-h plasma cortisol concentrations measured in the present study were generally less than 9 ng/mL, which has been considered the upper limit for basal plasma cortisol in cattle (Grandin, 1993).

The greater peak cortisol and mean concentrations during the .25- to 1.5-h and 2- to 6-h periods of SURG compared with those in BURD calves indicate a greater initial stress and inflammatory response to the surgical castration procedure. Higher peak cortisol concentrations following surgical compared with burdizzo castration of cattle were also recorded in other studies (Macaulay, 1989; Robertson et al., 1994). King et al. (1991) reported no difference in plasma

cortisol concentrations between surgical and burdizzo calves at 3 h post-treatment but higher concentrations for surgically castrated calves at 6 h. Pain and inflammation due to trauma are major inducers of cortisol secretion following surgery (Kehlet, 1991). The reductions in cortisol due to local anesthetic administration in SURG + LA and BURD + LA calves and the failure of local anesthetic in LAA calves to have any effect on cortisol concentrations indicate that part of the SURG- and BURD-induced increases in cortisol resulted from the influence of pain-associated afferent nervous activity.

The failure of the local anesthetic administration to reduce plasma cortisol concentrations in either burdizzo or surgical castrates beyond the .25- to 1.5-h-period is probably a function of the duration of action of lidocaine hydrochloride. In a study by Wood et al. (1991), castration of lambs resulted in increases in plasma cortisol for 60 min that were eliminated by the pre-castration administration of lidocaine. Similarly, lidocaine infiltration reduced the short-term (30 min) behavioral changes caused by castration of 2-wk-old piglets, but not the more prolonged (6 to 8 h) behavioral changes in 8-wk-old piglets (McGlone and Hellman, 1988). The duration of anesthesia following the regional infiltration of lidocaine without an added vasoconstrictive agent is approximately 1 h (Reichl and Quinton, 1987). For castration of cattle of the age used in the present study, a local anesthetic such as bupivicaine, which has a duration of action twice that of lidocaine (Hall and Clarke, 1991), may be more effective.

The elevation in plasma cortisol in the HSA-GnRH calves during the 2- to 6-h-period after treatment was somewhat surprising because local anesthetic injections in LAA calves had no effect, and i.m. injections in cattle resulted in only minor, transient increases in cortisol in a study by Alam and Dobson (1986). The cortisol increase in HSA-GnRH calves may have been due to an inflammatory process associated with the use of an adjuvant. The adjuvant DEAE-dextran has been observed to increase body temperature and decrease feed intake when administered to cats (Swift and Enright, personal communication), although carbohydrate polymer adjuvants such as DEAE-dextran have been shown to cause relatively little inflammation compared with oil-based adjuvants such as Freund's complete adjuvant (Johnson, 1994).

The reduction in ADG in SURG calves from d 0 to 7 after treatment has also been observed in other studies. ZoBell et al. (1993) recorded lower ADG for surgical and banded castrates from 0 to 28 d after treatment. In contrast, King et al. (1991) reported no difference in monthly ADG in either surgical or burdizzo castrates compared with controls. The ADG of BURD calves in the present study was not different from that of CON calves from d 0 to 7 but was lower from d 15 to 21. It is difficult to understand how the

provision of local anesthesia in SURG + LA calves, which only reduced cortisol for 1.5 h after castration, would have also resulted in a higher ADG from d 0 to 7 compared with that of SURG calves. There was no difference in ADG between BURD + LA and BURD calves. Faulkner et al. (1992) recorded no castration × analgesic interaction for ADG following butorphanol and xylazine administration before surgical castration. The administration of local anesthetic in the present study, either to BURD + LA or SURG + LA calves, had no effect on the reductions in ADFI caused by burdizzo or surgical castration. Reductions in feed intake were only present up to 10 d post-castration; a previous study indicated only a tendency for castration to reduce feed intake over 27 d (Faulkner et al., 1992).

The scrotal swelling that occurred in BURD and BURD + LA calves has also been observed in studies that used comparable castration techniques. Chase et al. (1995) disrupted the blood supply to the distal scrotum and testicles using tightened latex bands; scrotal circumference was increased on d 5 after treatment and then declined. This is similar to the increase measured in scrotal circumference on d 7 for BURD castrates in the present study. The prolonged increase in scrotal circumference of BURD + LA castrates is probably related to the technique of local anesthetic administration. Local anesthetic or agents introduced with it, remaining in the testicle after the disruption of venous and lymphatic drainage, may have contributed to the inflammatory reaction. Prolonged scrotal swelling as a result of the use of this method of induction of local anesthesia in conjunction with burdizzo castration would be undesirable, although correct use of the burdizzo should cause afferent nerves from the testicles to be destroyed (Robertson et al., 1994), thus minimizing any pain involvement.

In conclusion, both surgical and burdizzo castration caused increases in plasma cortisol concentrations and decreases in feed intake and weight gain; however, the cortisol rise was greater and more prolonged for surgical castrates. The provision of local anesthesia by intratesticular and subcutaneous administration of lidocaine reduced the cortisol response in the first 1.5 h after castration with either method but had little effect thereafter. Burdizzo castration caused scrotal swelling that was prolonged in calves administered local anesthetic. Subcutaneous administration of a conjugate and adjuvant mixture designed to induce immunocastration resulted in only transient increases in cortisol.

Implications

Castration causes reductions in feed intake and growth that persist beyond the duration of cortisol

elevation, indicating that such performance measurements are useful additional measurements to stress-related hormone concentrations in evaluating the stress response of cattle to this procedure. Short-acting local anesthetics have a role in reducing or removing any acute pain associated with castration but seem to be less effective at alleviating the overall stress response as measured by plasma cortisol.

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