The effect of age and method of castration on plasma cortisol in beef calves

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King, B. D., Cohen, R. D. H., Guenther, C. L. and Janzen, E. D. 1991. The effect of age and method of castration on plasma cortisol in beef calves. Can. J. Anim. Sci. 71: 257-263. Plasma cortisol concentration (PCC) was measured at 0, 2 min, 3, 6, 12, 24 and 30 h in 36 calves castrated at 78±12 d of age or 167±14 d of age by either surgical or burdizzo methods or left as bulls (control). At 2 min, bull calves had greater (P<0.05) PCC (22.2±4.5 µg L⁻¹) than burdizzo castrates (10.4±3.0 µg L⁻¹) while surgical castrates were intermediate and not different (P>0.05) from either group (11.4±2.9 µg L⁻¹). There were no further differences between groups until the 30 h postcastration bleed when PCC for bull calves (22.1±6.0 µg L⁻¹) was greater (P<0.05) than surgical (7.4±2.3 µg L⁻¹) and burdizzo (9.5±2.4 µg L⁻¹) castrates. At late castration, there was an immediate rise in PCC 2 min post-castration for burdizzo castrates (32.0±3.1 µg L⁻¹) which was greater (P<0.05) than surgical castrates (18.6±4.1 µg L⁻¹), while bull calves (23.0±1.9 µg L⁻¹) were intermediate and not different from either castration group. At 3 h, PCC of surgical (44.4±4.2 µg L⁻¹) and burdizzo (38.6±8.3 µg L⁻¹) castrates was greater (P<0.05) than bull calves (24.1±8.5 µg L⁻¹). At 6 h, surgical castrates had a greater (P<0.05) PCC (27.5±5.4 µg L⁻¹) than burdizzo castrates (15.3±0.41 µg L⁻¹) but neither group was different (P>0.05) from bull calves (17.2±2.7 µg L⁻¹). There were no further differences between groups up to 30 h postcastration. It was concluded that castration at a young age caused no physiologically detectable stress while physiological stress was detectable in older calves but that, in older calves, burdizzo was less stressful than surgical castration. Average daily weight gain did not differ (P>0.05) between castrated and bull calves.

Key words: Castration, plasma cortisol, age, beef calves

King, B. D., Cohen, R. D. H., Guenther, C. L. and Janzen, E. D. 1991. Conséquences de l'âge et de la méthode de castration sur la concentration plasmatique de cortisol chez les veaux de boucherie mâles. Can. J. Anim. Sci. 71: 257-263. On a déterminé la concentration de cortisol sérique (CCS) à 0 et 2 minutes ainsi qu'à 3, 6, 12, 24 et 30 h chez 36 veaux castrés à 78±12 j ou à 167±14 j par intervention chirurgicale ou utilisation de pinces burdizzo, ou gardés entiers (témoins). Deux minutes après l'intervention, les témoins présentaient une CCS supérieure (P<0.05) (22.2±4,5 µg L⁻¹) à celle des veaux castrés au moyen des pinces burdizzo (10,4±3,0 µg L⁻¹), tandis que la concentration était respectivement intermédiaire ou analogue (P>0.05) à celle des deux groupes précédents chez les animaux castrés par intervention chirurgicale (11,4±2,9 µg L⁻¹). On n'a observé aucune variation entre les groupes jusqu'au prélèvement effectué 30 h après l'intervention, lorsque la CCS des veaux entiers (22,1±6,0 µg L⁻¹) était supérieure (P<0.05) à celle relevée chez les animaux qui avaient subi l'opération (7,4±2,3 µg L⁻¹) ou été castrés au moyen des pinces burdizzo (9,5±2,4 µg L⁻¹). Lorsque la castration est tardive, on assiste à une hausse immédiate de la CCS 2 minutes après l'intervention avec les pinces burdizzo (32,0±3,1 µg L⁻¹), la réaction étant supérieure (P<0.05) à celle obtenue avec l'intervention chirurgicale (18,6±4,1 µg L⁻¹). Chez les veaux entiers, la concentration (23,0±1,9 µg L⁻¹) occupe un niveau intermédiaire mais analogue par rapport aux deux groupes de veaux castrés. À 3 h, la CCS chez les castrats ayant subi l'intervention chirurgicale (44,4±4,2 µg L⁻¹) ou castrés au moyen des pinces burdizzo (38,6±8,3 µg L⁻¹) dépassait (P<0.05) celle observée chez les veaux entiers (24,1±8,5 µg L⁻¹). Au bout de 6 h, la CCS des veaux castrés par intervention chirurgicale
Bulls gain weight faster, produce leaner carcasses and convert feed more efficiently than steers (Field 1971; Arthaud 1977) due to higher levels of circulating testosterone (Bagley et al. 1989; Cohen et al. 1990) yet castration remains a common practice in North America because of the agonistic behavior of bulls in a feedlot (Hinch 1980) and the greater risk of dark red muscle coloration among bulls than steers or heifers (Field 1971; Martin et al. 1971; Buchter 1975). Castration of calves in spring poses a greater risk of infection than in fall because of a greater risk of adverse conditions such as cold, heat, dust, mud and flies. In addition, calves castrated at weaning are often heavier than calves castrated at an early age. For these reasons many producers castrate calves at weaning. Since stress is caused by both weaning (Crookshank et al. 1979; Vessier et al. 1990; Dellmeier et al. 1990) and castration (Cohen et al. 1990), it is generally recommended that these two procedures should not be combined.

A chronic stressor, such as mixing of cattle (Mench et al. 1990) or penning (Friend et al. 1985), causes an increase in plasma cortisol over time. An acute stressor causes a rapid increase in the concentration of plasma adrenal corticosteroids which steadily decline to homeostasis (Stott 1981). Castration is an acute stressor and different methods of castration have been shown to cause different responses in plasma cortisol concentrations (Cohen et al. 1990). Concerns of stress caused by normal husbandry practices have led to research on alternate methods of castration. Chemical castration can be effective but the procedure requires considerable care (Cohen et al. 1991). Immunocastration has shown promising results but barriers remain to the formulation of a vaccine (Gonzalez et al. 1990).

Blood cortisol is an indicator of physiological as opposed to behavioral stress in beef animals (Dantzler and Mormede 1983). When plasma cortisol concentration is used for this purpose it is important to establish the pattern of cortisol change (Crookshank et al. 1979), the base line value (Herd 1989) and to recognize that restraining an animal will also cause a rise in plasma cortisol concentration (Ray et al. 1972). There are differences in the circadian patterns of circulating cortisol in adult and preruminant calves, mostly attributed to nutrient intestinal absorption (Gardy-Godillot et al. 1990). This could indicate a differing response in cortisol release in preruminant and fully ruminating calves following the application of the same stressor. This paper reports on the plasma cortisol concentrations in bull and steer calves castrated at two ages by either surgical or burdizzo methods.

**MATERIALS AND METHODS**

One hundred and forty-two crossbred calves of mixed breeding (Hereford, Angus, Charolais, Simmental and Maine-Anjou sires) from the University of Saskatchewan herd at the Termuende Research Station were allocated to either an early (70 calves) or late (72 calves) castration group. Calves in the early castration group were castrated on 23 May 1990 at 78 ± 12 d of age (mean weight 118 ± 16 kg) and calves in the late castration group were castrated 2 wk prior to weaning on 21 Aug. 1990 at 167 ± 14 d of age (mean weight 218 ± 33 kg). Calves within these groups were further assigned to one of three subgroups: surgical

**Mots cléś:** Castration, cortisol sérique, âge, veau de boucherie
castration, burdizzo castration or bull calves (restrained but not castrated). Each subgroup was balanced for age, weight and sire breed. At both castration times, 18 calves, six selected at random from each subgroup, were used for blood collection. Calves were returned to their dams after each blood collection and allowed to suckle freely.

Calves in the early castration group were restrained using a Big Valley Tipping table while those in the late castration group were restrained by halter in a WW squeeze chute. Care was taken in the handling of calves to minimize stress prior to the restraint and castration procedures. Surgical castration was done using a Newberry knife and emasculator while burdizzo castration was done by crushing each spermatic cord separately in a burdizzo emasculator. Bull calves were restrained in the same manner as castrated calves for 2 min, which was the average length of time taken for each castration. All castrations were done by a veterinarian (E. D. Janzen). Blood samples were taken into heparinized vacuum tubes via the jugular vein from six calves in each of the three subgroups prior to the procedure, immediately after the procedure (Hargreaves and Hutson 1990) and 3, 6, 12, 24 and 30 h postcastration. Blood was immediately centrifuged at 1300 × g, plasma drawn off, placed in ice, transported to the laboratory and frozen at −20°C until analyzed. Plasma cortisol was determined on duplicate samples within 3 wk of collection using a Direct Cortisol Kit that is a double-antibody [125I]RIA (Diagnostic Products Corporation, Los Angeles, CA) with a minimum detectable level of 2.0 μg L⁻¹. The intra-assay CV was 6.3% ± 0.67 for the early castrations and 3.9% ± 0.25 for the late castrations and the inter-assay CV was 5.2% ± 0.69. Calves were weighed on 23 May and every 28 d to weaning.

Plasma cortisol concentration (PCC) data were compared for effects of method of castration, age at castration and postcastration time interval by repeated measures analysis of variance (Fordham et al. 1989) and Fisher’s Protected LSD using a Macintosh SE/30 micro-computer and the SuperAnova software package (Abacus Concepts, Berkeley, CA). Weight gain data from all calves in the early castration group were compared for differences between castration subgroups by analysis of variance (Snedecor and Cochran 1973) using the StatView software package (Abacus Concepts, Berkeley, CA). Calves from the late castration group were not included in this analysis since they were all bulls until 2 wk prior to weaning.

RESULTS AND DISCUSSION

There were no significant differences (P>0.05) between castration subgroups within age groups for mean baseline PCC (Figs. 1 and 2) but mean PCC for calves at 167 d (23.7 ± 2.7 μg L⁻¹) was greater (P<0.001) than that of calves at 78 d of age (9.7 ± 1.6 μg L⁻¹). These values are considerably greater than the 4.5 μg L⁻¹ and 4.4 μg L⁻¹ reported by Frield et al. (1985) and Gardy-Godillot et al. (1989) respectively for 6-wk-old Holstein calves preconditioned to handling and restraint and fitted with jugular catheters or the 3.7 μg L⁻¹ and the 5.3 μg L⁻¹ reported by Boandl et al. (1989) and Cohen et al. (1990), respectively, for 7–16 wk and 7–9 mo old Holstein calves which were not fitted with jugular catheters but were preconditioned to handling and restraint. However, they compare favorably with the baseline PCC of 25–28 μg L⁻¹ for uncatheterized, unconditioned weaning calves of unspecified age and breed, though presumably of beef breeding, reported by Crookshank et al. (1979). Catheterization and preconditioning of suckling beef calves is not possible without removing them from their natural environment and handling and housing them as is normal practice for dairy calves. Naive calves were used so that the observed responses would reflect as closely as possible those of farm cattle (Hargreaves and Hutson 1990). Therefore, baseline PCC in our calves and those used by Crookshank et al. (1979) are almost certainly elevated by the stress associated with handling and restraint and, in our case, temporary removal from their dams. Further elevations of PCC following castration of calves, as in our experiment, or transportation, as in the experiment of Crookshank et al. (1979), would therefore represent an indication of stress over and above that associated with handling and restraint.

At early castration, bull calves had greater (P<0.05) PCC (22.2 ± 4.5 μg L⁻¹) after 2 min of restraint than burdizzo castrates (10.4 ± 3.0 μg L⁻¹) while surgical castrates were intermediate and not significantly different (P>0.05) from either group (11.4 ± 2.9 μg L⁻¹; Fig. 1). While these
Fig. 1. Plasma cortisol concentration of calves castrated at 78 d of age.

Fig. 2. Plasma cortisol concentration of calves castrated at 167 d of age.
values indicate that restraint is a stressor, we are unable to explain the greater and more variable PCC in bull calves. Two calves in the control group had PCC values which were considerably greater while one calf had a PCC considerably less than the mean for the control group. Laboratory analyses for PCC for these three calves was repeated with no indication of analytical error. Application of the Anscombe and Tukey test for outliers (Snedecor and Cochran 1973) did not suggest that data from any of these calves should be rejected. Ray et al. (1972) reported an increase in PCC with increasing length of time an animal spent in a chute. The order of processing calves in our experiment was random and there were no differences between groups for the time spent in the chute. However, all 142 calves were separated from their dams at this time for weighing and we cannot say whether or not calves in the control subgroup were separated for a longer time than those in the castration subgroups. Nevertheless, our data suggest that removal from the dam and restraint of young calves during the castration procedure caused as much or more immediate stress than castration per se.

The greatest PCC occurred at 3 h postcastration for both surgical and burdizzo castrates but the differences between the three subgroups were not significant (P > 0.05). PCC of castrated calves declined at 6 h and stabilized at 12 h. PCC in bull calves declined at the 3-h bleed and remained steady until 30 h postcastration when at 22.1±6.0 μg L⁻¹ it was greater (P<0.05) than both surgical (7.4±2.3 μg L⁻¹) and burdizzo (9.5±2.4 μg L⁻¹) castrates. As was the case for 2 min PCC data, repeat laboratory analyses and statistical testing gave no indication of outlying data. The greater PCC in bull calves might be attributed to time of feeding. For example, Gardy-Godillot et al. (1989), reported peaks in PCC at 1.45, 3 and 5 h after milk feeding and the 30-h blood collection may have coincided with one of these peaks for the bull calves but not for the castrated calves due to behavior modification following castration. Although all calves were observed to suckle during this postcastration period, we did not record the frequency or duration of each suckling. Hudson et al. (1975) reported that there were no diurnal rhythms of PCC in mature cattle but Gardy-Godillot (1989) suggested that diurnal patterns of PCC may be very different in perumnant calves. Nevertheless, the PCC in castrated calves closely resembled those previously reported as normal for calves of this age (Friend et al. 1985; Gardy-Godillot et al. 1989), suggesting that castration of young calves caused very little physiological stress.

Restraint of bull calves at the time of late castration did not significantly (P > 0.05) increase PCC (Fig. 2) as was the case at early castration possibly because the calves had been handled more frequently and become

### Table 1. Effect of method of castration of beef calves at 78 d of age on liveweight and average daily gain

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Surgical</th>
<th>Burdizzo</th>
<th>Bulls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liveweight (kg)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>117±3.5</td>
<td>118±3.5</td>
<td>119±3.3</td>
</tr>
<tr>
<td>June</td>
<td>144±3.6</td>
<td>148±4.3</td>
<td>149±4.6</td>
</tr>
<tr>
<td>July</td>
<td>185±4.7</td>
<td>188±6.2</td>
<td>190±5.3</td>
</tr>
<tr>
<td>August</td>
<td>213±5.7</td>
<td>225±5.8</td>
<td>218±6.2</td>
</tr>
<tr>
<td><strong>Average daily gain (kg d⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-June</td>
<td>0.97±0.05</td>
<td>1.07±0.05</td>
<td>1.09±0.09</td>
</tr>
<tr>
<td>June-July</td>
<td>1.15±0.05</td>
<td>1.15±0.07</td>
<td>1.16±0.05</td>
</tr>
<tr>
<td>July-August</td>
<td>1.01±0.06</td>
<td>1.11±0.05</td>
<td>1.01±0.05</td>
</tr>
<tr>
<td>May-August</td>
<td>1.00±0.03</td>
<td>1.08±0.03</td>
<td>1.02±0.04</td>
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</tbody>
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² Mean ± standard error of the mean.
better conditioned to the handling and restraint procedures (Crookshank et al. 1979), including temporary removal from their dams. Burdizzo castration caused an immediate (2 min) rise in PCC which was greater ($P<0.05$) than that following surgical castration (32.6±3.1 vs. 18.6±4.1 $\mu$g L$^{-1}$, respectively; Fig. 2). PCC of bull calves (23.0±1.9 $\mu$g L$^{-1}$) was intermediate to and not different ($P>0.05$) from that of either castration group. PCC increased from 2 min to 3 h postcastration for both surgical and burdizzo castration groups at which time bull calves (24.1±8.5 $\mu$g L$^{-1}$) had a lower PCC than either the surgical (44.4±4.2 $\mu$g L$^{-1}$; $P<0.001$) or burdizzo (38.6±8.3 $\mu$g L$^{-1}$; $P<0.05$) calves. At 6 h postcastration, PCC of surgical castrates (27.5±5.4 $\mu$g L$^{-1}$) had declined but was still greater ($P<0.05$) that of burdizzo castrates (15.3±4.1 $\mu$g L$^{-1}$) although neither group was different ($P>0.05$) from bull calves (17.2±2.7 $\mu$g L$^{-1}$). There was a slight but nonsignificant rise in PCC in all groups at 12 h postcastration which may have been associated with a severe electrical storm which occurred at that time. The pattern of change agrees with our previous data (Cohen et al. 1990) but, our present study suggests that while castration of calves at 78 d of age causes little physiological stress, castration at 167 d causes significant physiological stress.

Method of castration had no effect ($P>0.05$) on liveweight on any weigh day or on average daily gain between consecutive weigh days from 23 May to 21 Aug. (Table 1). This may have been due to low levels of testosterone secretion in young calves (Peters and Ball 1987) and increased sexual activity in bull calves as they reached puberty and the concentrations of circulating testosterone increased. We have reported similar findings for preweaning growth rate and liveweight in bull and steer calves castrated either surgically or chemically (Cohen et al. 1991) and Ritar et al. (1990) have also reported similar results for rams and wethers.

From our data, we conclude that castration of calves up to 78 d of age caused minimal physiological stress but at 167 d it caused significant stress but stress following burdizzo castration was less than that following surgical castration for older calves. Delaying castration until 2 wk before weaning resulted in no growth advantage.

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