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Effect of Castration Timing, Technique, and Pain Management on Health and Performance of Young Feedlot Bulls in Alberta

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Abstract

A total of 956 feedlot bulls were randomly allocated to one of eight castration groups based on a combination of castration timing, castration technique, and pain management options. Bulls castrated at allocation had a higher occurrence of undifferentiated fever (UF) (P=0.086) and a higher proportion of yield grade Canada 3 carcasses (P=0.002) than those castrated at 70 days post-allocation. Bulls castrated using a band had a lower occurrence of UF (P=0.021), improved average daily gain (live weight basis P=0.056 and carcass weight basis P=0.048), dry matter intake-to-gain ratio (live weight basis P=0.075 and carcass weight basis P=0.066), and higher proportions of quality-grade (QG) Canada Prime carcasses (P=0.018) and QG Canada A carcasses (P=0.020) than bulls castrated surgically. There were no significant ($P \geq 0.100$) differences in animal health or feedlot performance between bulls given analgesia and anesthesia and those that were not. This study suggests that band castration is superior to surgical castration, and delayed castration is beneficial in bull calves at high risk of developing UF.

Keywords: bovine, beef, bulls, castration, feedlot, pain management

Résumé

On a alloué aléatoirement 956 taureaux de parcs d'engraissement à huit différents groupes de castration combinant différentes techniques, différents moments de castration et différentes alternatives de régie de la douleur. L'incidence de fièvre non différenciée et la proportion de carcasses de catégorie Canada 3 étaient plus élevées chez les taureaux castrés à l'allocation (P = 0.086) que chez les taureaux castrés 70 jours suivant l'allocation. Par rapport aux taureaux castrés chirurgicalement, les taureaux castrés avec des bandes élastiques avaient moins de fièvre non-différenciée, un meilleur gain moyen quotidien (par unité de poids vif P = 0.056; par unité de poids de carcasse P = 0.048), un meilleur rapport de la prise alimentaire sur le gain (par unité de poids vif P = 0.075; par unité de poids de carcasse P = 0.066) et une proportion plus élevée de carcasses de catégorie Canada Primé (P = 0.018) et de catégorie Canada A (P = 0.020). Il n'y avait pas de différence au niveau de la santé des animaux ou de la performance au parc entre les taureaux qui avaient reçu une analgésie et une anesthésie et ceux qui n'en avaient pas eu ($P \geq 0.10$). Cette étude suggère que la castration avec des bandes élastiques est supérieure à la castration chirurgicale et qu'un délai de la castration est bénéfique aux veaux mâles à haut risque de développer une fièvre non-différenciée.

Introduction

Castration of male beef cattle is a common practice in commercial feedlot production. Its several advantages include increased growth rates, reduced occurrence of carcasses with dark-cutting meat, and reduced riding problems associated with aggressiveness and sexual behavior.[1,11,17]

Several different procedures are used to castrate male beef cattle. These include: application of a tightened latex band or rubber ring to reduce blood flow to the scrotum; chemical castration; use of a Burdizzo emasculatome or clamping technique to crush the spermatic cord; and surgical removal of the testicles.[2,5,7,10,16,19,24]

Castration has been associated with physiological stress, pain, immune system suppression, and short-term reductions in growth rates.[12,13,23] Several medications have been used with variable results to alleviate or reduce the undesirable side effects of castration.[8,9,12] Results of analgesia medication, as well as alternative castration techniques, have been evaluated to determine the effects on worker safety, castration efficiency, and animal behavior;[8,12,30,32] however, those studies were not designed to evaluate the effect on performance and production of beef cattle in commercial feedlot operations. In addition, the relative cost-effectiveness of using various pain management options, castration techniques, and castration timings in commercial production has not been investigated. Therefore, appropriate, relevant data to determine the optimum combination of castration timing, technique, and pain management in commercial feedlot production do not exist.

The purpose of the study reported herein was to evaluate the effects of castration timing, technique, and pain management on animal health, feedlot performance, and carcass characteristic variables of young bulls in commercial feedlot production in western Canada.

Materials and Methods

General Overview

In this small pen commercial field trial, feedlot bull calves were randomly allocated after arrival at the feedlot to one of eight castration groups based on a combination of the castration timing, technique, and pain management options evaluated in the study. Animals in a castration group were housed within the same pen, which constituted the experimental unit. Study animals were followed from allocation until slaughter, and outcome variables were measured to compare the animal health, feedlot performance, and carcass characteristics of each castration option. Statistical analyses were used to evaluate the effect of each main castration option (timing, technique, and pain management), as well as to test for interactions between the castration options. Differences in castration options that were unlikely to be the result of random chance ($P<0.100$) were subsequently incorporated into economic models to determine the cost-effectiveness of each option.

Study Facilities

The study was conducted at a feedlot near Strathmore, Alberta, that has both large commercial pens and smaller pens (n=50) that are used for research purposes. Each of the smaller pens measures 31.2 ft by 124.4 ft (9.52 m by 37.93 m) and can contain up to 20 animals. There is a minimum of 18.9 inches (0.48 m) of bunk space per animal when 20 animals are housed per pen. The basic design of the research feedlot is representative of the standard designs used in commercial feedlots in Alberta. Open-air, dirt-floor pens are arranged side-by-side with central feed alleys and 20% porosity, wood-fence windbreaks. The feedlot is equipped with a central hospital and weighing facility containing a hydraulic chute, individual animal scale,[a] a chute-side computer for recording animal health data,[b] and separation alleys that facilitate the return of animals to designated pens.

Study Animals

Animals used in the study were auction-market derived, crossbred beef bull calves arriving at the feedlot from October 13, 2005 to December 1, 2005. Upon arrival, animals were moved through a hydraulic chute for a group of procedures known collectively as processing. All animals were ear tagged to provide unique individual animal identification. In addition, all animals received a modified-live viral vaccine containing infectious bovine rhinotracheitis (IBR), parainfluenza-3 (PI_3), bovine viral diarrhea (BVD), and bovine respiratory syncytial (BRS) viruses.[c] Animals also received a *Mannheimia haemolytica* bacterin-toxoid,[d] a multivalent *Clostridium* spp and *Haemophilus somnus* bacterin-toxoid,[e] and topical ivermectin[f] at the rate of 1 mL/22 lb (1 mL/10 kg) body weight (BW). The rectal temperature of each animal was recorded at processing and animals with a rectal temperature of ≥104.0°F (40°C) received subcutaneous florfenicol[g] at the rate of 18.2 mg/lb (40 mg/kg) BW, and animals with a rectal temperature of <104.0°F received intramuscular long-acting oxytetracycline[h] at the rate of 13.6 mg/lb (30 mg/kg) BW. In addition, the ears of each animal were examined for the presence of implants, and animals that had existing implants were either excluded from the study or explanted as deemed appropriate.

At allocation on day 0 of the study, all animals received a zeranol growth implant[i] and a modified-live viral vaccine containing IBR, PI_3, BVD, and BRS viruses.[j] On day 70 of the study for each replicate, all animals were weighed, implanted with a zeranol growth implant, and vaccinated with a modified-live viral vaccine containing IBR and PI_3 viruses.[k] On day 160 of the study for each replicate, all animals were weighed, implanted with an estradiol benzoate and trenbolone acetate growth implant,[l] and vaccinated with a modified-live viral vaccine containing IBR and PI_3 viruses.[k]

Experimental Design

Animals were processed on arrival at the feedlot and accumulated in a large feedlot pen until a sufficient number of candidate animals had been procured to facilitate allocation of two replicates (16 pens). Animals were accumulated and allocated two replicates at a time until all six replicates had been filled (total 48 pens). The average time between arrival and enrollment was two to three weeks. Subsequently, candidate animals were weighed on two consecutive days (day -2 and day -1), ranked by average weight, and randomly assigned to one of eight different castration groups based on a combination of the castration timing, technique, and pain management options evaluated in the study (Table 1). On day -2 of the study, hip height (inches) was measured and recorded for all animals. Castration occurred either at allocation (day 0) or at 70 days post-allocation (day 70). Castration was performed using either the Callicrate Bander[m] to perform band castration (BC) or a Newberry knife, a Serra emasculator, and a closed technique to perform surgical castration (SC). Pain management (AA) was accomplished using a xylazine epidural[n] at a dosage of 0.032 mg/lb (0.07 mg/kg) BW for anesthesia, and intravenous flunixin meglumine[o] at a dosage of 1.0 mg/lb (2.2 mg/kg) BW for analgesia.

As animals were moved through the handling facility on day 0 and day 70, animals allocated to receive the AA pain management option were administered epidural anesthesia by the attending veterinarian and moved to a second handling facility for castration by another attending veterinarian. The interval from administration of anesthesia to castration ranged from 20 to 90 minutes. Animals allocated to the no pain management (NA) group were castrated in the first handling facility by the attending veterinarian.

Animals in each experimental group were housed in separate pens (20 animals/pen). A total of 48 pens were allocated to the study (Table 1). The average individual animal weight of the study pens at allocation was between 505 and 688 lb (230 and 313 kg).

Feeding Program

Mixed complete feedlot diets were blended by combining dry-rolled barley, dry-rolled oats, barley silage, chopped hay, mill-run pellets, and granular supplement in a truck-mounted mixer box[p] equipped with electronic load cells. The diets were formulated to meet or exceed the nutritional requirements of feedlot cattle.[q]

The finisher granular supplement contained monensin[r] and chlortetracycline,[s] formulated into the mixed, complete feedlot diets at levels of 11.4 mg/lb (25 mg/kg) of diet dry matter on a 100% dry matter basis (DM) and 15.9 mg/lb (35 mg/kg) DM, respectively. The finisher granular supplement was included in the mixed complete diets from day 41 in replicates 1 to 4, and from day 30 in replicates 5 and 6 of the study until a minimum of five days prior to shipment of slaughter animals. The withdrawal granular supplement contained monensin and tylosin,[t] formulated into the mixed, complete feedlot diets at levels of 11.4 and 5 mg/lb (25 and 11 mg/kg) DM, respectively. The withdrawal granular supplement was included in the mixed complete diets for a minimum of five days prior to shipment of slaughter animals. From allocation to day 40 in replicates 1 to 4 and from allocation to day 29 in replicates 5 and 6, a medicated premix containing chlortetracycline was added to the mixed, complete feedlot diets to provide 1,000 mg/animal/day of chlortetracycline. The medicated premix and granular supplement were manufactured by a commercial feed mill.[u] The diets were delivered to the pens once or twice daily. Daily feed allowances to each pen were recorded. Water was provided *ad libitum*. Upon completion of allocation for each replicate, the animals were maintained on low energy diets for 26 days and then adapted to a finisher diet over a 20-day period by increasing the proportion of dry-rolled grain and decreasing the proportions of barley silage, dry-rolled oats, chopped hay, and mill-run pellets at five-day intervals. Within each

Table 1. Definition of castration groups and pen allocation in a study to evaluate castration timing, technique, and pain management in young feedlot bulls in Alberta.

Castration timing[1]	Castration technique[2]	Pain management[3]	No. of pens
D0	BC	AA	6
D0	BC	NA	6
D0	SC	AA	6
D0	SC	NA	6
D70	BC	AA	6
D70	BC	NA	6
D70	SC	AA	6
D70	SC	NA	6

[1]D0 = castration at allocation; D70 = castration at 70 days post-allocation.
[2]BC = band castration technique; SC = surgical castration technique.
[3]AA = anesthesia and analgesia; NA = no anesthesia or analgesia.

Table 2. Proportional compositions of the mixed complete diets in a study to evaluate castration timing, technique, and pain management in young feedlot bulls in Alberta.

	Diet[1,2]						
Ingredient	1	2	3	4	5	6	7
Dry-rolled barley	34.57	34.10	44.80	65.36	72.55	78.73	89.12
Barley silage	46.07	30.26	22.41	19.54	13.35	8.04	8.91
Mill-run pellets	17.38	0.00	0.00	13.15	12.16	11.31	0.00
Dry-rolled oats	0.00	29.32	26.84	0.00	0.00	0.00	0.00
Chopped hay	0.00	4.35	3.98	0.00	0.00	0.00	0.00
Granular supplement[3]	1.98	1.97	1.96	1.95	1.94	1.92	1.97

[1]All numbers are expressed as percentages on a 100% dry matter basis.
[2]Animals were maintained on low energy diets (1 to 3) for 26 days, and then adapted to a finisher diet over a 20-day period (3 to 7).
[3]The granular supplement was manufactured by a commercial feed mill (Landmarks, Strathmore, Alberta).

replicate, diet changes occurred on the same date for all pens. Proportional compositions of the diets fed are presented in Table 2.

Animal Health

Study animals were observed once or twice daily by experienced animal-health personnel. Animals exhibiting symptoms of illness were moved to the hospital facility, diagnosed, and treated as per the provided computerized treatment protocols. In this study, the case definition for undifferentiated fever (UF) was a rectal temperature ≥105.0°F (40.5°C), a lack of abnormal clinical signs referable to body systems other than the respiratory system, and no previous treatment history of no fever (NF). The case definition for NF was a rectal temperature <105.0°F, a lack of abnormal clinical signs referable to body systems other than the respiratory system, and no previous treatment history for UF. The treatment events, including treatment date, presumptive diagnosis, drug(s) administered, and dose(s) used were recorded in FHARM.[b] All animals deemed to have chronic disease were weighed and removed from the study. All animals that died during the study were weighed by feedlot personnel and necropsied by the attending veterinarian.

Marketing

Animals in each replicate were fed to a target carcass weight of approximately 810 lb (368 kg). The days-on-feed (DOF) for each replicate ranged between 216 and 280 days. All pens within each replicate were harvested on the same date, and all study animals were harvested at the same packing plant.[v]

Data Collection and Management

All animals were individually weighed on days -2, -1, 70, 160, slaughter (S) -2, and S -1 of the study. Hip height was measured and recorded for all animals on day -2 of the study. All animals that died and those that were removed from the study were weighed. The hot weight, Canada quality grade (QG), and Canada yield grade (YG) of each carcass were collected at slaughter. These data were subsequently entered into a computer spreadsheet program[w] and verified.

The baseline variables, initial weight and hip height, were calculated for each pen. The ancillary production variables, slaughter weight, weight gain, carcass weight, dressing percentage, DOF, and daily dry matter intake (DDMI), were also calculated for each pen.

The outcome variables used to assess feedlot performance were average daily gain (ADG) and the dry matter intake-to-gain ratio (DM:G). Feedlot performance variables were calculated using two methods: the live weight basis method utilized the live weights obtained on day S -2 and day S -1 of the study, minus 4% pencil shrink; and the carcass weight basis method utilized the hot carcass weights obtained from the packing plant divided by a fixed dressing percentage of 60%.

With respect to Canada QG, the proportions of animals grading Canada Prime, Canada AAA, Canada AA, Canada A, and B4 (dark red rib eye) were calculated for each pen. With respect to Canada YG, the proportions of QG Canada Prime, Canada AAA, Canada AA, and Canada A carcasses within each pen that graded YG Canada 1, Canada 2, and Canada 3 were calculated.

The computerized animal health data were summarized for each pen. From these data, initial UF treatment, initial NF treatment, and overall mortality (mortality due to all causes) rates were calculated for each pen.

Statistical Analysis

The data were analyzed using an analytical software program.[x] The baseline, ancillary production, feedlot performance, and carcass characteristic variables were compared between the experimental groups using least squares analysis of variance for replicate and castration option effects.[26,29] The baseline variables were tested as covariates of the feedlot performance variables. Those covariates with significant (P<0.100) effects were included in the final model used for comparison of each variable between the castration options, as appropriate.[26] The animal health variables were compared between the castration options using linear logistic regression techniques to adjust for the clustering of animal health events within pens.[20,21] For all variables, analyses were conducted to evaluate the effect of each main castration option (castration timing, castration technique, and pain management), as well as to test for interactions between the castration options.

Economic Analysis

The relative cost-effectiveness of the two options for castration timing, technique, and pain management were calculated using a computer spreadsheet program[w] that simulates all economic aspects of feedlot production.[3,15,27,28] The D0 group was compared to the D70 group; the BC group was compared to the SC group; and the AA group was compared to the NA group. In the economic model, the initial weight (600 lb; 273 kg), final weight (1,350 lb; 614 kg), feeder price, slaughter price, processing cost, ration cost, yardage rate, and interest rate were fixed for both options in each comparison. The cost of castration in the D0 and D70 groups and the BC and SC groups was assumed to be equal. The incremental costs of anesthesia and analgesia in the AA group were $10.89/animal and $7.90/animal, respectively; this represented the cost of the drugs used for anesthesia and analgesia. Outcome variables describing the animal health, feedlot performance (carcass weight basis ADG and carcass weight basis DM:G), and carcass characteristics of each experimental group were incorporated into the model when significant (P<0.100) differences existed between the castration options. When there were no significant (P≥0.100) differences between castration options, the animal health, feedlot performance, and carcass characteristics were equated for both castration options in a comparison. All other factors were fixed in the economic simulations. The therapeutic costs used in the economic analysis for UF and NF therapy were $24.35 CDN, $2.11 CDN, and $18.84 CDN for each florfenicol, long-acting oxytetracycline, and enrofloxacin[y] treatment regime, respectively. The purchase price used in the analysis was $110.00 CDN/100 lb (45 kg) BW, the premium for YG Canada 1 carcasses as $3.00 CDN/100 lb carcass weight, the discount for YG Canada 3 carcasses as $-3.00 CDN/100 lb carcass weight, the premium for QG Canada Prime carcasses as $20.00 CDN/100 lb carcass weight, the premium for QG Canada AAA carcasses as $11.00 CDN/100 lb carcass weight, the discount for QG Canada A carcasses as $-6.00 CDN/100 lb carcass weight, and the discount for QG B4 carcasses as $-50.00 CDN/100 lb carcass weight. The interest rate used in the analysis was 4.0%/annum. The value of a dead animal was $0.00 CDN. Feed consumed by animals prior to death was not estimated.

Results

Based on the collection of data on days -2 and -1, a total of 960 young bulls were selected for allocation to the study. However, it was determined on day 0 that four animals were not suitable for allocation to the study (one animal in the BC group could not be banded, one animal was deemed to have a pre-existing scrotal hernia, one animal had been previously castrated, and one animal escaped prior to allocation). As a result, only 956 animals were allocated to the study.

The baseline and ancillary production data summary is presented in Table 3. There were no significant (P≥0.100) interactions detected between the castration options for any of the outcome variables studied.

The castration timing data summary is presented in Table 4. Animals in the D0 group had a higher initial UF treatment rate (P=0.086) and a higher proportion of YG Canada 3 carcasses (P=0.002) than animals in the D70 group. There were no significant (P≥0.100) differences in feedlot performance (live weight basis or carcass weight basis) between the D0 and D70 groups.

The castration technique data summary is presented in Table 5. Animals in the BC group had a lower initial UF treatment rate (P=0.021), an improved ADG (live weight basis P=0.056 and carcass weight basis P=0.048), an improved DM:G (live weight basis P=0.075 and carcass weight basis P=0.066), and higher proportions of QG Canada Prime (P=0.018) and QG Canada A carcasses (P=0.020) than animals in the SC group.

The pain management data summary is presented in Table 6. Animals in the AA group had a lower proportion of QG B4 carcasses (P=0.002) than the NA group. There were no significant (P≥0.100) differences in animal health or feedlot performance (live weight basis or carcass weight basis) between the AA and NA groups.

In the economic analysis, there were advantages of $2.43 CDN per animal in the D70 group as compared to the D0 group; $14.28 CDN per animal in the BC group as compared to the SC group; and $13.65 CDN per animal in the NA group as compared to the AA group.

Discussion

This is the first study to specifically evaluate options for castration timing, technique, and pain management under commercial feedlot production conditions. Unlike previous studies on this topic, the present clini-

Table 3. Baseline and ancillary production data summary in a study to evaluate castration timing, technique, and pain management in young feedlot bulls in Alberta.

Baseline or Ancillary Production Variable	Mean	Standard Error
Initial weight (lb)[1]	599.3	± 10.8
Hip height (inches)[2]	44.86	± 0.18
Slaughter weight (lb)[3]	1,352.5	± 5.8
Weight gain (lb)[4]	753.2	± 10.9
Carcass weight[5]	816.1	± 3.8
Dressing percentage[6]	60.34	± 0.07
Days-on-feed (days)[7]	238.6	± 3.3
Daily dry matter intake (lb/animal/day)[8]	19.50	± 0.11

[1]Initial weight represents the average of the day -2 and day -1 weights.
[2]Hip height represents the average hip height on day -2.
[3]Slaughter weight represents the average of the day S -2 and day S -1 weight less a 4% shrink.
[4]Weight gain represents the average slaughter weight minus the average initial weight.
[5]Carcass weight represents the total carcass weight divided by the number of carcasses.
[6]Dressing percentage represents total carcass weight divided by total slaughter weight multiplied by 100.
[7]Days-on-feed represents the average slaughter date minus the average allocation date.
[8]Daily dry matter intake represents the total dry matter delivered in the interval minus total dry matter removed in the interval, divided by the number of animal days in the interval.

cal trial investigated the effect of different castration options on the production aspect of commercial feedlot operations, including feedlot performance and carcass characteristic variables.

The animals and experimental design used in this study were very representative of commercial feedlot production systems commonly used in Alberta, where mixed-breed animals are acquired from many different sources through the auction-market system. Therefore, the results and conclusions of this study have very good external validity for extrapolation to other commercial feedlot operations in Alberta. In theory, the study could have been done using a smaller sample size if animals from the same breed and source had been used as a method for reducing the coefficient of variation observed in the study. However, the investigators were concerned that a targeted population with minimal inherent variation would not be representative of the majority of bull calves entering Alberta feedlots. As a result, the investigators designed the study using mixed-breed animals of unknown origin, and increased the study sample size to compensate for the larger coefficient of variation associated with this approach.

Although reported extensively in the literature, behavioral changes and stress levels associated with castration were not investigated in this study.[5,10,12,19,24,30,32] Stress response in cattle castrated after six months of age has been shown to be higher than that of cattle castrated at six months of age or younger.[4,22] In addition, it has been shown that the younger a calf is when castrated, the less stressful the castration procedure.[18] These responses are related to the trauma and discomfort associated with castration as testicular size increases.[4] Moreover, weight loss has been shown to increase as the age at castration increases.[4] This observation was noted during a relatively short follow-up period, and the duration of weight loss persistence was not described. In the current study, castration resulted in significantly (P<0.100) inferior ADG and DM:G in the period immediately following castration as compared to non-castrated animals (data not shown). From day 0 to day 70, the ADG and DM:G of animals castrated on day 0 was approximately 20% worse than animals not castrated on day 0. From day 70 to day 160, the ADG and DM:G of animals castrated on day 70 was approximately 14% worse than animals not castrated on day 70. However, by the end of the feeding period, there were no significant (P≥0.100) differences in ADG and DM:G between animals castrated on day 0 as compared to animals castrated 70 days later. Moreover, there were reductions (P<0.100) in the occurrence of UF and the occurrence of YG Canada 3 carcasses associated with delayed castration, which resulted in an economic benefit of $2.43 CDN/animal. The reduced UF treatment rate associated with delayed castration may be a result of moving the castration event out of the early feeding period when peak levels of UF occur. In terms of the improved YG associated with delayed castration, perhaps the presence of the testicular hormones for an extra 70 days led to the production of leaner carcasses. Interestingly, there was no apparent increase in the level of QG B4 (dark red rib eye) carcasses associated with delayed castration.

Table 4. Castration timing data summary in a study to evaluate castration timing, technique, and pain management in young feedlot bulls in Alberta.

Variable	D0[8]	D70[8]	*P*-value
	Animal Health Data Summary		
Initial UF treatment, %[1]	15.48	12.19	0.086
Initial NF treatment, %[1]	5.85	6.61	0.632
Overall mortality, %	4.36	3.20	0.369
	Feedlot Performance Data Summary		
Average daily gain, lb[2]			
Live weight basis[3]	3.12	3.11	0.669
Carcass weight basis[4]	3.16	3.13	0.430
Dry matter intake-to-gain ratio[5]			
Live weight basis[3]	6.24	6.29	0.425
Carcass weight basis[4]	6.17	6.24	0.242
	Carcass Data Summary		
Quality Grade, %[6]			
Canada Prime	1.13	1.81	0.302
Canada AAA	58.91	54.70	0.168
Canada AA	38.20	41.70	0.274
Canada A	0.90	0.88	0.963
Canada B4	0.64	0.70	0.884
Yield Grade, %[7]			
Canada 1	55.71	58.84	0.359
Canada 2	29.00	31.91	0.336
Canada 3	15.28	9.25	0.002

[1]UF = undifferentiated fever; NF = no fever.
[2]Average daily gain (ADG), average number of pounds gained per day during the feeding period. The effect of animals that died has been removed from the ADG values.
[3]Live weight basis values were calculated using shrunk live weights obtained prior to slaughter.
[4]Carcass weight basis values were calculated using carcass weights obtained at slaughter, converted to live weights using a fixed dressing percentage of 60.0%.
[5]Dry matter intake-to-gain ratio (DM:G), ratio of the pounds of feed (expressed on a 100% dry matter basis) necessary for 1 pound of gain. The effect of animals that died has been removed from the DM:G values.
[6]Quality Grade (QG) Canada Prime, proportion of carcasses within a pen that graded QG Canada Prime; Quality Grade Canada AAA, proportion of carcasses within a pen that graded QG Canada AAA; Quality Grade Canada AA, proportion of carcasses within a pen that graded QG Canada AA; Quality Grade Canada A, proportion of carcasses within a pen that graded QG Canada A; Quality Grade B4, proportion of carcasses within a pen that graded QG B4 (dark red rib eye).
[7]Yield Grade (YG) Canada 1, proportion of carcasses within a pen that graded YG Canada 1; Yield Grade Canada 2, proportion of carcasses within a pen that graded YG Canada 2; Yield Grade Canada 3, proportion of carcasses within a pen that graded YG Canada 3.
[8]D0 = bulls castrated on day 0; D70 = bulls castrated on day 70.

While band castration is superior to surgical castration in this study, in a review study of 19 clinical trials related to castration, it was reported that the ADG was not affected by the method of castration.[4] In addition, it has been reported that band castration of 14-month-old cattle results in a slower growth rate when compared to surgical castration for the same age group.[14] Bretschneider[4] suggests that this observation may be due to prolonged wound healing after band castration. In the current study, the time that it took for the scrotum to detach after band castration was not measured. The reason for the discrepancy in the effects of castration method on ADG beween the current study and previously reported studies is unknown. However, the results of the current study clearly demonstrate that it is more cost-effective ($14.28 CDN/animal) to use band castration than surgical castration in young feedlot bulls weighing approximately 600 to 800 lb (273 to 364 kg).

Many endogenous blood products, such as haptoglobin and cortisol, have been used to evaluate the castration-associated stress response in cattle.[9,18] Haptoglobin has been suggested to be a better indicator of castration associated stress than cortisol.[9] A review of the various papers published on this topic suggests there are no significant differences in castration-associated stress (as measured by cortisol concentration)

Table 5. Castration technique data summary in a study to evaluate castration timing, technique, and pain management in young feedlot bulls in Alberta.

Variable	BC[8]	SC[8]	*P*-value
	Animal Health Data Summary		
Initial UF treatment, %[1]	11.62	16.25	0.021
Initial NF treatment, %[1]	5.30	7.29	0.225
Overall mortality, %	3.75	3.72	0.981
	Feedlot Performance Data Summary		
Average daily gain, lb[2]			
Live weight basis[3]	3.15	3.09	0.056
Carcass weight basis[4]	3.18	3.11	0.048
Dry matter intake-to-gain ratio[5]			
Live weight basis[3]	6.21	6.32	0.075
Carcass weight basis[4]	6.14	6.27	0.066
	Carcass Data Summary		
Quality Grade, %[6]			
Canada Prime	2.36	0.68	0.018
Canada AAA	56.22	57.39	0.698
Canada AA	39.49	40.41	0.770
Canada A	1.56	0.22	0.020
Canada B4	0.48	0.86	0.359
Yield Grade, %[7]			
Canada 1	57.53	57.02	0.881
Canada 2	30.71	30.20	0.866
Canada 3	11.76	12.77	0.583

[1]UF = undifferentiated fever; NF = no fever.
[2]Average Daily Gain (ADG), average number of pounds gained per day during the feeding period. The effect of animals that died has been removed from the ADG values.
[3]Live weight basis values were calculated using shrunk live weights obtained prior to slaughter.
[4]Carcass weight basis values were calculated using carcass weights obtained at slaughter, converted to live weights using a fixed dressing percentage of 60.0%.
[5]Dry matter intake-to-gain ratio (DM:G), ratio of the pounds of feed (expressed on a 100% dry matter basis) necessary for 1 pound of gain. The effect of animals that died has been removed from the DM:G values.
[6]Quality Grade (QG) Canada Prime, proportion of carcasses within a pen that graded QG Canada Prime; Quality Grade Canada AAA, proportion of carcasses within a pen that graded QG Canada AAA; Quality Grade Canada AA, proportion of carcasses within a pen that graded QG Canada AA; Quality Grade Canada A, proportion of carcasses within a pen that graded QG Canada A; Quality Grade B4, proportion of carcasses within a pen that graded QG B4 (dark red rib eye).
[7]Yield Grade (YG) Canada 1, proportion of carcasses within a pen that graded YG Canada 1; Yield Grade Canada 2, proportion of carcasses within a pen that graded YG Canada 2; Yield Grade Canada 3, proportion of carcasses within a pen that graded YG Canada 3.
[8]BC = band castration technique; SC = surgical castration technique.

between the different methods of castration[4] because, although surgically castrated calves exhibit the highest stress response, it is not significantly higher than the stress reponse of band castrated calves. Conversely, plasma haptoglobin levels were consistently higher in surgically castrated calves than intact calves and band castrated calves. Moreover, there was no significant difference in plasma haptoglobin concentrations between intact calves and band castrated calves.[9,13,14] Therefore, regarding castration-associated stress, several studies have found that band castration is superior to surgical castration. This finding is supported by the improved animal health and feedlot performance observed in band castrated calves in the current study.

Castrating calves remains a routine procedure that is performed by trained farm or veterinary personnel with or without pain management protocols.[6] The effect of using pain medications on castration-associated stress and some production variables has been previously studied,[8,12,30,31] with variable results observed. In some studies, pain management has resulted in improved ADG, while in other studies it has made no difference.[8,12,30,31] In the current study, use of pain management as a castration option failed to improve the animal health or

Table 6. Pain management data summary in a study to evaluate castration timing, technique, and pain management in young feedlot bulls in Alberta.

Variable	AA[8]	NA[8]	*P*-value
	Animal Health Data Summary		
Initial UF treatment, %[1]	13.48	14.00	0.899
Initial NF treatment, %[1]	5.12	7.55	0.142
Overall mortality, %	3.57	3.92	0.780
	Feedlot Performance Data Summary		
Average daily gain, lb[2]			
Live weight basis[3]	3.10	3.13	0.367
Carcass weight basis[4]	3.13	3.17	0.310
Dry matter intake-to-gain ratio[5]			
Live weight basis[3]	6.29	6.24	0.354
Carcass Weight Basis[4]	6.24	6.17	0.295
	Carcass Data Summary		
Quality Grade, %[6]			
Canada Prime	1.56	1.38	0.778
Canada AAA	56.70	56.91	0.946
Canada AA	40.39	39.50	0.779
Canada A	1.12	0.66	0.408
Canada B4	0.00	1.33	0.002
Yield Grade, %[7]			
Canada 1	57.41	57.15	0.940
Canada 2	29.69	31.23	0.608
Canada 3	12.91	11.62	0.489

[1]UF = undifferentiated fever; NF = no fever.
[2]Average daily gain (ADG), average number of pounds gained per day during the feeding period. The effect of animals that died has been removed from the ADG values.
[3]Live weight basis values were calculated using shrunk live weights obtained prior to slaughter.
[4]Carcass weight basis values were calculated using carcass weights obtained at slaughter, converted to live weights using a fixed dressing percentage of 60.0%.
[5]Dry matter intake-to-gain ratio (DM:G), ratio of the pounds of feed (expressed on a 100% dry matter basis) necessary for 1 pound of gain. The effect of animals that died has been removed from the DM:G values.
[6]Quality Grade (QG) Canada Prime, proportion of carcasses within a pen that graded QG Canada Prime; Quality Grade Canada AAA, proportion of carcasses within a pen that graded QG Canada AAA; Quality Grade Canada AA, proportion of carcasses within a pen that graded QG Canada AA; Quality Grade Canada A, proportion of carcasses within a pen that graded QG Canada A; Quality Grade B4, proportion of carcasses within a pen that graded QG B4 (dark red rib eye).
[7]Yield Grade (YG) Canada 1, proportion of carcasses within a pen that graded YG Canada 1; Yield Grade Canada 2, proportion of carcasses within a pen that graded YG Canada 2; Yield Grade Canada 3, proportion of carcasses within a pen that graded YG Canada 3.
[8]AA = anesthesia and analgesia; NA = no anesthesia or analgesia.

feedlot performance of castrated calves, and resulted in an increased production cost ($13.65 CDN/animal) due to the cost of anesthesia and analgesia. Similar results were shown in a recent study, where use of local lidocaine anesthesia had no effect on performance, post-castration behavior or vocalization during castration, regardless of castration method utilized.[25] However, results of the current study do not imply that pain medication should not be used during castration; only that it is not cost-effective to do so. As a result, decisions and recommendations regarding inclusion of pain management as part of the castration process should be based on other factors, and will likely require regulation and producer education to ensure adoption and compliance.

In this study, there was a delay of two to three weeks between feedlot arrival and allocation to the study. While all animals were processed at feedlot arrival, this delay likely reduced the observed post-allocation occurrence of UF because some UF cases occurred prior to allocation. This reduced the power of the study to detect differences in morbidity between the castration options evaluated in the study. However, the collection of a sufficient number of bulls for allocation of 16 pens at a time was done to facilitate allocation procedures that distributed animals with different initial weights in a replicate evenly across the experimental groups to control the coefficients of variation for the feedlot performance variables.

In this study, no interactions were detected between the castration options evaluated. As a result, the effective sample size for each castration option was 24 replicates, which generally provided sufficient experimental power to detect differences between castration options. In cases where the results showed virtually no numerical differences between the two options evaluated, statistical power is not a concern. However, in cases where numerical trends were accompanied by *P*-values in the 0.060-0.150 range, additional replication would be required to determine if the observed differences were produced by chance alone and could not be replicated, or were unlikely to result by chance alone and represented true differences between the two options evaluated.

Conclusion

This study suggests that band castration is superior to surgical castration, and delaying castration is beneficial in bull calves at high risk of developing UF. There were no significant ($P \geq 0.100$) differences in animal health or feedlot performance between bulls given analgesia and anesthesia and those that were not.

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Endnotes

[a]Animal Weighing and Controlled Sampling (AWACS), Mix-Weigh Inc., Calgary, AB
[b]Feedlot Health Animal Record Management© (FHARM), Feedlot Health Management Services Ltd. (FHMS), Okotoks, AB
[c]Pyramid® FP 5, Wyeth Animal Health, Division of Wyeth Canada, Guelph, ON
[d]One Shot®, Pfizer Animal Health, Pfizer Canada Inc., Kirkland, QC
[e]Fermicon 7/Somnugen™, Boehringer Ingelheim (Canada) Ltd., Burlington, ON
[f]Unimectrin Pour-On or Ivomec® Pour-On, Merial Canada Inc., Baie D'Urfé, QC
[g]Nuflor®, Schering-Plough Animal Health, Division of Schering Canada Inc., Pointe-Claire, QC
[h]Tetradure® LA 300, Merial Canada Inc., Baie D'Urfé, QC
[i]Ralgro®, Schering-Plough Animal Health, Division of Schering Canada Inc., Pointe Claire, QC
[j]Bovi-Shield® NC 4, Pfizer Animal Health, Pfizer Canada Inc., Kirkland, QC
[k]Bovi-Shield® IBR-PI3, Pfizer Animal Health, Pfizer Canada Inc., Kirkland, QC
[l]Synovex® Plus, Wyeth Animal Health, Division of Wyeth Canada, Guelph, ON
[m]No Bull Enterprises LLC, St. Francis, KS
[n]Rompun® 20 mg/mL Injectable, Bayer Healthcare, Animal Health Division, Bayer Inc., Toronto, ON
[o]Banamine®, Schering-Plough Animal Health, Division of Schering Canada Inc., Pointe Claire, QC
[p]Harshmixer, Hydraulics Unlimited Mfg. Co., Eaton, CO
[q]Nutrient Requirements of Beef Cattle, National Research Council, 1996
[r]Rumensin®, Elanco Animal Health, Division of Eli Lilly Canada Inc., Guelph, ON
[s]Aureomycin®, Alpharma Canada Corporation, Mississauga, ON
[t]Tylan®, Elanco Animal Health, Division of Eli Lilly Canada Inc., Guelph, ON
[u]Landmark Feeds Inc., Strathmore, AB
[v]Cargill Foods, High River, AB
[w]Microsoft® Office Excel 2003, Microsoft Corporation, Redmond, WA
[x]SAS™ for Windows, Release 9.1, SAS Institute Inc. Cary, NC
[y]Baytril®, Bayer Healthcare, Animal Health Division, Bayer Inc., Toronto, ON

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INFORMATION

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INDICATIONS NUFLOR Injectable Solution is indicated for treatment of bovine respiratory disease (BRD), associated with *Mannheimia haemolytica*, *Pasteurella multocida*, and *Histophilus somni (Haemophilus somnus)*, and for the treatment of bovine interdigital phlegmon (foot rot, acute interdigital necrobacillosis, infectious pododermatitis) associated with *Fusobacterium necrophorum* and *Bacteroides melaninogenicus*. Also, it is indicated for the control of respiratory disease in cattle at high risk of developing BRD associated with *Mannheimia haemolytica*, *Pasteurella multocida*, and *Histophilus somni (Haemophilus somnus)*.

RESIDUE WARNINGS: Animals intended for human consumption must not be slaughtered within 28 days of the last intramuscular treatment. Animals intended for human consumption must not be slaughtered within 38 days of subcutaneous treatment. Do not use in female dairy cattle 20 months of age or older. Use of florfenicol in this class of cattle may cause milk residues. A withdrawal period has not been established in preruminating calves. Do not use in calves to be processed for veal.

WARNINGS: NOT FOR HUMAN USE. KEEP OUT OF REACH OF CHILDREN. This product contains materials that can be irritating to skin and eyes. Avoid direct contact with skin, eyes, and clothing. In case of accidental eye exposure, flush with water for 15 minutes. In case of accidental skin exposure, wash with soap and water. Remove contaminated clothing. Consult a physician if irritation persists. Accidental injection of this product may cause local irritation. Consult a physician immediately. The Material Safety Data Sheet (MSDS) contains more detailed occupational safety information.

For customer service, adverse effects reporting, and/or a copy of the MSDS, call 1-800-211-3573.

CAUTION Not for use in cattle of breeding age. The effects of florfenicol on bovine reproductive performance, pregnancy, and lactation have not been determined. Intramuscular injection may result in local tissue reaction which persists beyond 28 days. This may result in trim loss of edible tissue at slaughter. Tissue reaction at injection sites other than the neck is likely to be more severe.

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