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Outcomes following facilitated ankylosis to treat septic arthritis of the distal interphalangeal joint in beef bulls: 22 cases (2006-2018)

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Abstract

Facilitated ankylosis (FA) is a procedure performed to treat septic arthritis of the distal interphalangeal joint (DIPJ) in ruminants. The aim of this procedure is to restore function to the affected digit, providing improved long-term positive outcome. This study describes the outcome of FA in 22 client-owned midwestern beef breeding bulls due to DIPJ sepsis between January 1, 2006 and July 31, 2018. Follow up information was obtained by telephone questionnaire. Signalment, treatment history, diagnostic data, surgical data, postoperative treatment and complications, and long-term outcomes were recorded and described.

Of the 22 beef bulls that underwent a FA, follow-up information was provided for 19. Fourteen of the 19 bulls were successfully used as breeders post-operatively. Increased age and weight were positively correlated with successful breeding long term. Forelimb vs hindlimb disease and laterality of digit affected did not significantly affect outcome. Overall, client satisfaction was high.

In conclusion, beef bulls undergoing a FA of the DIPJ have a good prognosis for long-term breeding regardless of history and clinical presentation. FA should be considered for treatment of septic arthritis in beef bulls.

Key words: septic arthritis, beef bulls, distal interphalangeal joint, lameness, facilitated ankylosis

Introduction

Lameness in cattle continues to be a major concern of the agriculture industry. Overall, the prevalence of lameness in cattle is as high as 54.8% in the United States.[1] Murray and co-workers reported approximately 90% of lameness cases in dairy cattle and 85% of lameness cases in beef cattle admitted to a veterinary teaching hospital originated in the foot.[19] A 2016 study also found that 85% of beef cattle presenting to a veterinary teaching hospital for lameness were diagnosed with a foot lesion, with 20% of those having an infectious etiology.[21] Not only does lameness have a major impact on welfare and health of cattle worldwide, the cattle industry also faces major economic losses as a result of lameness.[22] Griffin et al estimated that lame cattle account for 70% of all sales of non-performing cattle, and that annual losses reflect a $0.70/hundredweight increase in cost of gain for every animal placed in feedlots.[9] In a 2021 report, Horton and associates reported that musculoskeletal/trauma was responsible for 49.7% of culling of feedlot cattle, and that the number of respiratory culls decreased and musculoskeletal/trauma culls increased with increasing hot carcass weight.[12] Additionally, diseases of the feet account for approximately 70% of all lameness cases in feedlot cattle.[9]

Common causes of foot lameness in cattle include foot rot, sole ulcers, sole abscesses, and white line disease.[1,4] With progression of these diseases, septic arthritis (SA) of the distal interphalangeal joint (DIPJ) can result.[4] Although SA in the foot occurs most commonly by extension from sole disease, it may also occur through direct inoculation and by hematogenous spread.[26] In a Canadian study, conditions associated with the SA of the DIPJ represented 4.3% of all foot lesions,[21] with a much higher death/euthanasia rate (32.9%) than that of cattle diagnosed with foot rot (12.4%) or a toe ulcer or sole abscess (14.9%).[27]

Clinically, cattle with SA of the DIPJ present with a swollen, painful coronary band, often with an obvious draining tract and severe lameness.[4] Frequently, diagnosis is made on clinical examination alone, but can be confirmed with radiographs. Ultrasonography has also been described to diagnose DIPJ SA in adult Holstein cattle using a 8 to 12 mHz linear transducer.[11]

Treatment described for this condition includes euthanasia or salvage for slaughter, digit amputation, and facilitated

ankylosis (FA) of the DIPJ.[1,4] Overall, the average successful recovery following FA is 75%, with a mean survival of 18 months reported.[2,7,13,15,22]

Currently, most reported literature is focused on the dairy industry, with few reports on beef cattle. The prevalence of lameness in beef animals at packing plants was 26.6% in cows and 36.3% in bulls in 1 study,[21] while another report described SA of the DIPJ with FA and digit amputation as treatments in 21 German beef breeding bulls with a mean body weight of 1854 lb (841 kg).[13] These authors concluded that both surgical methods were successful, with FA being recommended as the first treatment option. The purpose of the current study was to describe the outcomes of FA in beef bulls for treatment of septic arthritis of the DIPJ. Our hypotheses were: 1) that bulls would have a satisfactory outcome following FA to treat SA of the DIPJ, 2) that younger, lighter bulls have a greater likelihood of being a long-term successful breeder compared to older, heavier bulls, 3) that bulls with forelimb DIPJ lameness would have a more favorable outcome than those with hindlimbs lesions, and 4) that bulls with lesions in predominant weight-bearing digits would have a less favorable outcome than those with lesions in non-predominant weight-bearing digits.

Materials and Methods

Case Selection and Medical Records

Medical records for beef bulls over 1 year of age intended for breeding that underwent FA between January 1, 2006 and July 31, 2018, at The Ohio State Veterinary Medical Center, were reviewed. Signalment, body weight, affected digit, duration of lameness, previous treatments, clinical presentation, diagnostics performed, preoperative and post-operative treatments, post-operative complications, cast application, and short- and long-term outcomes were recorded. Short-term follow-up (2-mo post-operative) was performed at cast change if applicable, and long-term follow-up (>6 mo following surgery) was obtained by telephone questionnaire with the owner. Owners were asked if the bull was introduced to cows and if so, whether or not they were successful breeders following surgical intervention. A bull was deemed successful if able to breed greater than 80% of cows exposed, based on estimation from the owner. Overall satisfaction with owner experience was recorded on a scale of 1 to 5, with 1 being completely unsatisfied and 5 being completely satisfied.

Statistical Analysis

All data were analyzed using STATA.[a] The association between continuous data (age and weight) and a successful outcome was assessed using the non-parametric Wilcoxon rank sum test. Categorical predictors (hindlimb vs forelimb, principal weight-bearing digit (medial digit of forelimb, lateral digit of hindlimb) vs contralateral digit, antibiotic or pain management administration, and wooden claw block application were assessed with Fisher exact test.

Results

A total of 22 beef bulls intended for breeding underwent facilitated ankylosis to manage DIPJ sepsis. Breeds represented included Aberdeen Angus (6), mixed breed beef (4), Red Angus (3), Shorthorn (3), Maine Anjou (2), Brangus (1), Horned Hereford (1), Longhorn (1), and Simmental (1). The median age of the bulls was 4 years, with a range from 1 to 7 years. Median body weight was 1600 lb (725 kg), ranging from 800 lb to 2500 lb (363 kg to 1,136 kg) (Table 1).

Twenty-one of 22 (95.5%) bulls presented with severe lameness. Five of 21 (22.7%) lame bulls had swelling of the affected foot reported in the medical record, and 1 bull (1/22; 4.5%) presented with swelling of the digit not associated with lameness. Duration of clinical signs varied from 3 d to 7 mo, with a median of 4 d. Treatment prior to presentation included antibiotics (14/22 bulls; 63.6%), analgesics (5/22; 22.7%), and a claw block (5/22; 22.7%) to elevate the affected digit. Seven of 22 (31.8%) bulls received no treatment prior to presentation.

On presentation, each bull was observed ambulating to assess the degree of lameness, and then positioned on a hydraulic tilt table or chute in lateral recumbency. Careful monitoring of comfort and signs of bloat was performed to minimize risk of recumbency-associated complications. Feet were cleaned of debris, and assessed for pain with hoof testers in combination with trimming to locate the origin of lameness. Further diagnostics included phalangeal radiographs (20 bulls; 91%), DIPJ ultrasound (1 bull; 4.5%), and arthrocentesis of the DIPJ (1 bull; 4.5%) to confirm the diagnosis of SA of the DIPJ. Thoracic limb lameness was diagnosed in 6 of 22 (27.2%) bulls, and pelvic limb lameness was diagnosed in the remaining 16 (72.8%) head. The predominant weight-bearing digit was affected in 17 (77.3%) bulls, while the non-predominant weight-bearing digit was affected in 5 (22.7%) bulls.

Table 1. Association of age and weight of bulls undergoing facilitated ankylosis of the distal interphalangeal joint with successful long-term breeding success.

	Overall n = 19	Successful breeder n = 14	Unsuccessful breeder n = 5	Wilcoxon Rank Sum P-value
Age, years (range)	4 (1-7)	5 (3-7)	2 (1-7)	0.0443
Weight, lb (range)	1600 (800-2500)	1800 (1200-2500)	1200 (800- 1500)	0.0078

Following the confirmation of SA of the DIPJ, FA was performed on all bulls. The procedure was performed immediately following diagnosis with each patient restrained on the table. After clipping hair from the coronary band to the fetlock circumferentially and sterile skin preparation, regional limb perfusion (RLP) was performed prior to surgical intervention in all 22 bulls. Briefly, a tourniquet was placed mid-metatarsus and a 19-gauge butterfly catheter or an 18-gauge 1.5-inch needle was used for the RLP. Of the RLP administered, 11 bulls were administered lidocaine alone (50%); lidocaine followed by ampicillin sulbactam (1.5 grams) as previously described (10/17 bulls; 59%);[6] or lidocaine followed by 1 g of florfenicol (1/22 bulls; 4.5%).

There are 3 well described approaches for a FA of the DIPJ including solar, bulbar, abaxial, and modified abaxial.[1,29] Surgical approach to the DIPJ was selected based on location of swelling, if present. Surgical approach was further modified to address any additional affected structures of the foot, including the distal sesamoid bone (2/22 bulls), deep digital flexor tendon (1/22 bulls), coronary band (3/22 bulls), and surrounding soft tissues.

After accessing the DIPJ by following the fistulous tract (when present) or sharp dissection through unaffected tissue, a ½-inch sterile drill bit was then introduced into the joint space and aimed in a plantaro/palmaro-dorsal direction to exit the dorsal claw wall, avoiding contact with the coronary band to ensure that new horn growth remained unaffected. The joint was then further debrided with a Spratt bone curette, and thoroughly lavaged with dilute betadine and water or saline solution.

Of 22 bulls, 14 (63.6%) received systemic antibiotics perioperatively: florfenicol was administered a median of once with a range of 1 to 3 times (10/22 bulls; 45.5%); oxytetracycline was administered once (3/22; 13.6%); ceftiofur crystalline free acid was administered once (1/22; 4.5%); ceftiofur hydrochloride was administered 3 times (1/22; 4.5%); procaine penicillin G was administered once (1/22; 4.5%); and tulathromycin was administered once (1/22; 4.5%). Seventeen bulls received anti-inflammatory therapy including flunixin meglumine administered a median of once with range of 1 to 4 times (12/22 bulls; 54.5%); meloxicam was administered a median of 3 times with range of 1 to 13 times (11/22; 50.0%); dexamethasone was administered once (1/22; 4.5%); and phenylbutazone was used for 10 days (2/22; 9.0%). Some bulls were administered more than 1 antibiotic (3/22 bulls; 13.6%) and/or anti-inflammatory (5/22 bulls; 22.5%).

Hoof blocks were applied to the unaffected digit in all bulls, and cold hose hydrotherapy to provide analgesia and to reduce tissue edema was performed in 9 of 22 bulls (40.9%). The surgical site was flushed in subsequent tablings in 13 (59.1%) bulls, claws soaked in water containing Epsom salt in 13 cases, and an intralesional pharmacy compounded iodoform paste (bismuth subnitrate 250 mg/gm, iodoform 500 mg/gm, parafin 250 mg/gm) was applied topically in 13 cases.[16] Affected limbs were bandaged, and a foot cast was applied to 20 (90.9%) prior to discharge. The cast was applied with the wooden claw block in place, and extended to encompass the fetlock to provide stabilization to the DIPJ. Clients were instructed to maintain cast stabilization for 8 weeks. The median hospital stay prior to discharge was 7.5 d with a range of 0 to 34 d, while the median length of time between presentation and casting was 5.5 d, with a range of 1 to 10 d.

Follow-up Outcomes

All bulls were discharged alive from the hospital, and 14 returned for cast removal following placement, allowing short-term follow-up. The cast was in place for a median of 55 d (28 to 75 d) prior to re-presentation for these 14 head. Six of these bulls (43%) had no complications other than mild lameness, while the remaining 8 head were reported to have phalangeal edema (2/14; 14%), ulceration or abscessation of the sole (6/14; 43%), or phalangeal hyperextension (1/14; 7%) as previously defined.[8] None of these animals had a cast replaced at the time of cast removal.

Nineteen animals were available for long-term follow-up, ranging from 1 to 13 years following FA. Fourteen of the 19 were reported to be successful breeders, achieving an owner-estimated pregnancy in at least 80% of exposed cows. Of the 5 bulls that were unsuccessful breeders, owners reported chronic lameness (2), inability to maintain routine hoof care (1), and/or the bull was sold for reasons unrelated to lameness (2). The owner median satisfaction rating for the FA procedure was 5 on a scale of 1 to 5, with a range of 3 to 5.

The continuous variables age and weight were highly correlated and both significant predictors of the long-term outcome of breeding. Due to the small sample size, the measure of association between successful outcome and age and successful outcome and weight was tested using the non-parametric Wilcoxon rank sum test. The difference in the rankings of both age and weight for each group (successful breeder vs non-successful breeder) were significantly different ($p < 0.05$).

Bulls reported to be successful breeders had FA performed at a median age of 5 years, bulls reported to be unsuccessful breeders had a FA performed at a median age of 2 years ($p=0.04$). Successful breeders had a median body weight of 1800 pounds (820 kg) at the time of FA, and unsuccessful breeders had a median body weight of 1200 pounds (550 kg) at the time of FA ($p=0.0078$) (Table 1).

For all categorical variables compared using a Fisher's exact test, no significant ($\alpha = 0.05$) associations between categorical variables (front limb vs hind limb, medial vs lateral claws, predominant weight-bearing vs non-predominant weight bearing digit and treatment vs no treatment, claw block application) was significantly associated with "successful breeder post-operatively" (Table 2).

Table 2. Association of breeding success of bulls undergoing facilitated ankylosis of the distal interphalangeal joint with various variables.

	Outcome of Facilitated Ankylosis			
		Not bred N = 5 (26%)	Bred N= 14 (74%)	Fishers exact test
Lateral vs medial claw				0.305
Lateral claw	N = 12 (63%)	2 (17%)	10 (83%)	
Medial claw	N = 7 (37%)	3 (43%)	4 (57%)	
Forelimb vs hindlimb				0.570
Forelimb	N = 5 (26%)	2 (40%)	3 (60%)	
Hindlimb	N = 14 (74%)	3 (21%)	11 (79%)	
Predominant weight-bearing vs non- pre. weight-bearing digit				1.000
Predominant weight-bearing	N = 15 (79%)	4 (27%)	11 (73%	
Non-predominant weight-bearing	N = 4 (215)	1 (25%)	3 (73%)	
Any treatment vs no treatment				1.000
Treatment prior to presentation	N = 14 (74%)	4 (29%)	10 (71%)	
No treatment prior to presentation	N = 5 (26%)	1 (20%	4 (80%)	
Antibiotics vs no antibiotics				1.000
Antimicrobial therapy	N = 13 (68%)	4 (31%)	9 (68%)	
No antimicrobial therapy	N = 6 (32%)	1 (17%)	5 (83%)	
Pain treatment vs no pain treatment				0.430
Analgesia provided	N = 14 (74%)	3 (21%)	11 (79%)	
No analgesia provided	N = 5 (26%)	2 (40%)	3 (60%)	
Toe soak vs no toe soak				0.53
Foot soak performed	N = 4 (21%)	0 (0%)	4 (100%)	
Foot soak not performed	N = 15 (79%)	5 (33%)	10 (67%)	

Discussion

Facilitated ankyloses procedures are recommended for valuable breeding animals as an alternative to salvage procedures (claw amputations) to increase chances of longevity in the herd. There is a paucity of information in the veterinary literature regarding the outcomes of FA in American beef bulls for treatment of SA of the DIPJ. We hypothesized that younger, lighter-weight bulls would have a greater likelihood of breeding success long-term due to a greater healing potential, lighter body weight on the affected digit, and less risk of contralateral limb breakdown. We also hypothesized that a facilitated ankyloses of the forelimb or non-predominant weight-bearing digit would have a greater prognosis than the rear or predominant weight-bearing digit due to the bull's body biomechanics during breeding. Neither hypothesis was supported by findings in the current study.

In this study, age of the bull at presentation had a statistically significant impact on the outcome. A bull was more likely to be a successful breeder as age at the time of FA increased. Weight was positively correlated with age. Thus, it was also determined that a heavier bull was more likely to be a successful breeder. This contradicts our first hypothesis, and results from prior studies which suggested that younger, lighter-weight bulls have a more favorable outcome when performing a FA.[4,14] These animals should have superior healing potential as well as decreased force on a diseased joint. It is thought that an older bull's breeding experience, increased libido, and semen quality compared to younger bulls may explain the improved breeding potential in the older bulls.[17,18] Therefore, despite having a diseased joint, older bulls are still able to breed successfully because of a learned internal drive to breed. Since the status of breeding soundness examinations (BSE) of every bull is not known, it is possible that younger bulls not yet proven in the herd could fail a BSE if performed.

The authors of the present study did not consider costs of the procedure and convalescence time, which could impact the client's decision on treatment options. Thus, older bulls diagnosed with SA of the DIPJ may not be worth the financial investment or recovery maintenance. If factored into the study, this could skew results, suggesting that only older bulls with high value, increased owner compliance, and breeding potential received a facilitated ankylosis and were included in this study.

The authors hypothesized that bulls with a forelimb lesion would have a better prognosis for return to breeding than those with a hindlimb SA of the DIPJ, as a bull needs to be able to balance and thrust on his hindlimbs during breeding. Previous research has been shown that a bull can compensate for mild lameness, and semen quality is not significantly affected by lameness; thus, if able to mount, a bull has a high likelihood of successful insemination.[10] It is possible that even if some lameness remained following FA in a pelvic limb, it was mild enough that the bull was able to compensate. This may explain the lack of difference in outcome between bulls with forelimb lesions and those with hindlimb lesions. In addition, the authors hypothesized that

FA performed on predominant weight-bearing digits would result in a less favorable outcome. However, laterality of the digit affected was not associated with a significant difference in outcome, and a good prognosis for return to breeding was found for bulls, regardless of the digit affected.

A limitation to this study is that only 22 cases of FA in beef bulls were included, with follow-up obtained on 19 bulls. Due to the small sample size, power of the statistical tests performed may be too low to accurately detect differences between variables and their effect on a successful breeding outcome. Thus, many of the variables recorded in this study were insignificant and not reported.

Some treatments provided raise concern for animal care and well-being. One bull's record did not report the use of anti-inflammatory drugs. Use of NSAIDS for pain stemming from lameness is beneficial. Flunixin meglumine has been shown to improve locomotion score, increase pressure placed on the affected foot, and decreased recumbency on the day of treatment and the day following treatment.[5,23] Meloxicam also improves locomotion score, specifically after resection of the distal interphalangeal joint.[20] It should be addressed that although phenylbutazone was used to provide inflammatory relief in 2 of 22 bulls, its use is currently discouraged for use in beef cattle.[25] This decision was made prior to recommendations against the use of this drug in food animals because of its longer half-life resulting in decreased dosing.[18]

Medical records of 8 bulls did not report the use of antibiotics perioperatively (systemically or regionally). While no explanation in the clinical reasoning behind the absence of antibiotherapy in those bulls could be found in the medical record, adequate curettage and drainage from the surgery site with no concomitant adjacent cellulitis may have triggered this therapeutic choice. However, the use of antibiotics for pedal infection is commonly reported.[24] Similarly, studies on RLP in cattle using florfenicol and ampicillin-sulbactam have shown that antimicrobial levels in venous blood and synovial fluid in joints distal to a tourniquet can reach concentrations at and above the MIC for bacterial pathogens associated with SA of the DIPJ.[24] Although this requires the use of antimicrobials in an extra-label manner, RLPs provide adequate drug concentration with reduced systemic exposure and lowers the risk of meat residue.[24]

Tap water was used for all forms of water treatment, including cold-hose hydrotherapy as previously described, foot soak, and wound flush. Reports in human literature suggest that the use of tap water to cleanse wounds does not increase infection rate; thus, for ease of use and decreased cost, tap water was utilized in all cases of cold-hose hydrotherapy. There is also evidence that the use of cleansers with added iodine antiseptic is effective against gram-positive, gram-negative, fungal, and protozoal wound pathogens.[28]

Additional therapy often utilized in cattle to prevent phalangeal hyperextension is securing the affected digit to the contralateral digit with wire. This ensures the affected digit heals at the appropriate angle. Unfortunately, medical records in this study did not report the use of a wire in cases affected by digital hyperextension or in other cases to prevent digital hyperextension.

Conclusions

This study suggests that older bulls had an increased likelihood of successfully breeding long term. Location of the lesion (forelimb vs hindlimb and digit laterality) did not affect outcome. Prior treatment did not affect long-term breeding potential. Facilitated ankylosis should be considered for beef bulls with SA of the DIPJ regardless of the chronicity of the condition and age of the bull. Based on the results of this study, there is a good prognosis for return to breeding function following FA.

Endnote

[a]StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP

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Author Contributions

Jordan BA, DVM: Contributions to conception and design of work, acquisition of data, interpretation of data, and manuscript preparation; Lozier JW, DVM, MS, DACVS-LA: Contributions to the conception and design of work, interpretation of data, and manuscript preparation; Parker EM, BVSc, MPH, DACVPM: Analysis and interpretation of data; Niehaus AJ, DVM, MS, DACVS-LA: Manuscript preparation; Baker MR, BS, BA: Acquisition of data; Lakritz J, DVM, PhD, DACVIM, DACVCP: Conception and design of work and manuscript preparation.

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