A Comparison of Florfenicol and Tulathromycin for the Treatment of Undifferentiated Fever in Feedlot Calves*

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CLINICAL RELEVANCE

The purpose of this study was to compare the relative cost-effectiveness of florfenicol with that of tulathromycin for treatment of undifferentiated fever (UF) in feedlot calves at ultra-high risk of developing UF that receive metaphylactic tulathromycin on arrival at the feedlot. Calves that received therapeutic florfenicol had lower overall mortality (P = .045) and bovine respiratory disease mortality (P = .050) compared with calves that received therapeutic tulathromycin, but no significant differences were detected in feedlot performance, carcass characteristics, or other animal health variables. There was a net advantage of Can$41.19/treated animal in the florfenicol group versus the tulathromycin group. This study demonstrates that it is more cost-effective to use florfenicol than tulathromycin for the initial treatment of UF in feedlot calves at ultra-high risk of developing UF that receive on-arrival metaphylactic tulathromycin.

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INTRODUCTION

The clinical syndrome referred to as undifferentiated fever (UF), commonly known as bovine respiratory disease (BRD), continues to be one of the most economically significant health problems in calves entering beef feedlots.[1–7] UF, a relatively new term, was introduced in feedlot medicine and production as a more encompassing characterization of the clinical syndrome commonly diagnosed and treated in feedlot cattle.[8] The term was developed mainly because it includes potentially systemic diseases (e.g., bovine viral diarrhea [BVD] virus infection, histophilosis) that are not necessarily confined to or causing disease in the respiratory system at the time of clinical diagnosis but that are often components of the disease process in animals deemed "sick" by feedlot health personnel. In addition, individual veterinary examination of presumably sick feedlot calves is usually not feasible in commercial production systems. In the diagnostic system at Feedlot Health Management Services, a feedlot animal is considered to have UF when it is deemed "sick" based on such subjective criteria as general appearance and attitude, gauntness, and reluctance to move; has a rectal temperature ≥105.0°F; and does not have abnormal clinical signs directly attributable to organ systems other than the respiratory system.

The management of UF continues to become more sophisticated and currently includes both on-arrival metaphylactic and subsequent therapeutic administration of parenteral antimicrobials. Such metaphylactic use of long-acting oxytetracycline or tilmicosin in feedlot cattle at high or ultra-high risk of developing UF has reduced UF morbidity rates, BRD mortality rates, and/or overall mortality rates and improved average daily gain (ADG) and/or feed efficiency.[9–19] Moreover, a recent study by Booker et al showed that it was more cost-effective to use tulathromycin (Draxxin, Pfizer Animal Health) as a metaphylactic antimicrobial in ultra-high-risk calves than tilmicosin or oxytetracycline.[20] These findings have led to the use of tulathromycin in commercial feedlots as an on-arrival metaphylactic antimicrobial in ultra-high-risk calves.

Florfenicol (Nuflor, Schering-Plough Animal Health) is a synthetic, broad-spectrum antimicrobial licensed in Canada and the United States for the treatment of UF in feedlot cattle. Several studies have shown that florfenicol is one of the most efficacious and cost-effective therapeutic antimicrobials for feedlot UF.[6,8,21,22]

Bovine respiratory disease continues to be one of the most economically significant health problems in calves entering beef feedlots.

The comparative cost-effectiveness of florfenicol and tulathromycin for the treatment of clinical UF that occurs after arrival in commercial feedlot production has not been thoroughly studied. In two recently published studies, the clinical efficacy of florfenicol and tulathromycin were compared as part of the pharmaceutical licensing process using treatment success rate as the primary measure of clinical efficacy.[23,24] While treatment success rate information is useful for assessing clinical efficacy as it pertains to pharmaceutical licensing, a void of information describing the final clinical outcome of treatment failures, animals designated

Equations Used to Calculate Morbidity and Mortality Rates

$$\textbf{First UF Relapse Rate} = \frac{\text{No. of First UF Relapses}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Second UF Relapse Rate} = \frac{\text{No. of Second UF Relapses}}{\text{No. of First UF Relapses}} \times 100\%$$

$$\textbf{Third UF Relapse Rate} = \frac{\text{No. of Third UF Relapses}}{\text{No. of Second UF Relapses}} \times 100\%$$

$$\textbf{Overall Chronicity Rate} = \frac{\text{No. of Animals Designated as Chronic}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Overall Wastage Rate} = \frac{\text{No. of Animals Designated as Chronics That Did Not Die}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Overall Mortality Rate} = \frac{\text{No. of Mortalities Due to All Causes}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{BRD Mortality Rate} = \frac{\text{No. of Mortalities Due to BRD}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Histophilosis}^{a}\ \textbf{Mortality Rate} = \frac{\text{No. of Mortalities Due to Histophilosis}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Lameness Mortality Rate} = \frac{\text{No. of Mortalities Due to Lameness}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{BVD/Enteritis Mortality Rate} = \frac{\text{No. of Mortalities Due to BVD/Enteritis}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Metabolic Mortality Rate} = \frac{\text{No. of Mortalities Due to Metabolic Disease}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

$$\textbf{Other Mortality Rate} = \frac{\text{No. of Mortalities Due to Causes Other than BRD, Histophilosis, Lameness, BVD/Enteritis, or Metabolic Disease}}{\text{No. of Animals Treated for Initial UF}} \times 100\%$$

[a]Disease due to *Histophilus somni* infection.

BRD = bovine respiratory disease; BVD = disease due to bovine viral diarrhea virus infection; UF = undifferentiated fever.

as having chronic disease, and animals that were removed from the study makes it very difficult to properly model the economic impact of improved treatment success; this is because the various clinical outcomes (prolonged convalescence followed by recovery, sale for salvage slaughter, and death loss) have substantially different economic values. A more complete comparison of the relative efficacy and cost-effectiveness of florfenicol and tulathromycin for the treatment of clinical UF in feedlot calves in commercial feedlot production was recently published and revealed a net advantage of US$52.50/animal in favor of the use of tulathromycin.[25] This net advantage was related to lower rates of first UF relapse and overall mortality despite the higher cost of initial UF treatment and increased proportions of yield grade USDA 4 carcasses in animals in the tulathromycin group.[25] However, in that study, experimental calves did not receive a metaphylactic antimicrobial or vaccines containing *Mannheimia haemolytica* or *Histophilus somni* on arrival. Therefore, it is difficult to draw general conclusions and apply the results of that study to populations of feedlot cattle that receive metaphylactic antimicrobials and comprehensive immunization programs to control UF at feedlot arrival. Furthermore, unpublished results (data not shown) from an in-house pilot study conducted by Feedlot Health Management Services with a study design analogous to that used in the current study showed that florfenicol may be more cost-effective than tulathromycin in ultra-high-risk calves that receive metaphylactic tulathromycin on arrival at the feedlot. Generally, there are limited data comparing tulathromycin and florfenicol for the treatment of clinical UF in large-scale, well-designed clinical trials under commercial feedlot production conditions. Thus, the purpose of the current study was to follow up on the results of the pilot study to determine the relative efficacy and cost-effectiveness of florfenicol with that of tulathromycin for the initial treatment of clinical UF in recently weaned, crossbred, beef feedlot calves at ultra-high risk of developing UF that receive metaphylactic tulathromycin on arrival at the feedlot.

Overall mortality and BRD mortality rates were lower in the FLOR group than in the TULA group.

MATERIALS AND METHODS

General Overview

In this commercial field trial, feedlot calves at ultra-high risk of developing UF that received metaphylactic tulathromycin on arrival at the feedlot were randomly allocated at the time of initial diagnosis and treatment of clinical UF to one of two experimental groups: florfenicol or tulathromycin. Experimental animals were followed from allocation until slaughter, and outcome variables were measured to compare animal health, feedlot performance, and carcass characteristics between the two groups. Statistical analyses were used to determine the probability of whether differences in outcome variables between the experimental groups were the result of experimental group effects or random chance. Differences in outcome variables that were unlikely to be the result of random chance ($P < .05$) were subsequently incorporated into an economic model to determine the relative economic impact of florfenicol therapy to that of tulathromycin therapy.

TABLE 1. Morbidity Data Summary from Allocation to Slaughter*

	Experimental Group				
Morbidity Variable	*FLOR* (n = *281)*	*TULA* (n = *274)*	***Relative Risk†***	***95% CI‡***	**P *Value***
First UF relapse	175 (62.28)	166 (60.58)	1.02	0.90–1.17	.713
Second UF relapse	107 (61.14)	101 (60.84)	0.99	0.83–1.17	.889
Third UF relapse	81 (75.70)	69 (68.32)	1.09	0.91–1.19	.448
Overall chronicity	47 (16.73)	45 (16.42)	0.98	0.67–1.40	.878
Overall wastage	22 (7.83)	15 (5.47)	1.41	0.75–2.72	.283

*Numbers in parentheses are percentages.
†Ratio of the rate of disease in the FLOR group divided by the rate of the disease in the TULA group, corrected for allocation weight effects using Poisson regression in a log linear model.
‡Calculated for each relative risk, corrected for allocation weight effects using Poisson regression in a log linear model.
UF = undifferentiated fever.

Study Facilities

The study was conducted at a commercial feedlot located near Broken Bow, Nebraska, with a capacity of approximately 85,000 animals. The basic design of this feedlot is representative of standard designs used in Nebraska. Open-air, dirt-floor pens are arranged side by side with central feed alleys. There are 176 large pens in the feedlot with capacities of 200 to 600 animals each. The remaining 102 pens are smaller, with capacities of 60 to 200 animals each.

There are two mobile hospital facilities, one permanent hospital facility, and an enclosed processing facility at the feedlot. Each facility has a hydraulic chute equipped with an individual animal scale, a chute-side computer for recording animal health data, and separation alleys to facilitate the return of animals to designated pens. In addition, there are seven recovery and "chronic" pens, 17 receiving pens, and several shipping pens located at the feedlot.

Study Animals

Animals enrolled in the study were crossbred beef steer and bull calves purchased from auction markets throughout the United States. Animals were transported by truck to the feedlot after assembly at auction markets.

On arrival at the feedlot, 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), administered metaphylactic tulathromycin (Draxxin) at 2.5 mg/kg SC, implanted with a trenbolone acetate and estradiol benzoate growth implant (Synovex Choice, Fort Dodge Animal Health), and immunized with a multivalent clostridial–*H. somni* bacterin–toxoid (Bar Vac 7/Somnus, Boehringer Ingelheim Vetmedica). In addition, each animal received an infectious bovine rhinotracheitis virus, parainfluenza-3 virus, BVD virus, and bovine respiratory syncytial virus combination vaccine (Pyramid 5, Fort Dodge Animal Health), an *M. haemolytica* and *Pasteurella multocida* bacterin–toxoid (Pulmoguard PHM-1, Boehringer Ingelheim Vetmedica), and topical ivermectin (0.5%; Ivermectin Pour-On, Durvet; 1.0 ml/10 kg). Also, all bulls were castrated.

At an average days on feed (DOF) of ap-

proximately 110 days for each pen, all animals were reimplanted with Synovex Choice and vaccinated with an infectious bovine rhinotracheitis virus vaccine (Pyramid IBR, Fort Dodge Animal Health).

Experimental Design

Candidate animals arrived at the feedlot between April 27 and September 8, 2006. After processing, animals were moved to designated feedlot pens. Each pen was checked once or twice daily by experienced animal health personnel for evidence of sickness. Animals that were deemed "sick" based on subjective criteria (e.g., general appearance and attitude, gauntness, reluctance to move) were moved from the feedlot pen and presented to one of the mobile hospital facilities. In this study, the case definition for initial UF was an elevated rectal temperature (≥105.0°F), an absence of abnormal clinical signs directly attributable to organ systems other than the respiratory system, a DOF of 7 to 30 days inclusive, and no previous treatment history for any disease. Moribund animals were not eligible for allocation to the study. At the time of allocation, experimental animals were weighed and, using a computer-generated randomization program, randomly assigned to one of two experimental groups:

- **FLOR** (n = 281): Animals were treated in the neck region with a single dose of florfenicol (Nuflor) at 40 mg/kg SC at the time of initial UF therapy.
- **TULA** (n = 274): Animals were treated in the neck region with a single dose of tulathromycin (Draxxin) at 2.5 mg/kg SC at the time of initial UF therapy.

A maximum volume of 10 ml was administered at each injection site. Animals in both experimental groups were returned to their original feedlot pen after allocation and treatment.

After receiving initial UF therapy, experimental animals were observed once or twice daily by experienced animal health personnel for evidence of recurrent or relapse disease. The animal health personnel were blinded to the experimental status of each animal. Animals selected as "sick" with recurrent clinical UF, based on the subjective assessment criteria described previously, were diagnosed as UF relapses provided there was an absence of abnormal clinical signs directly attributable to organ systems other than the respiratory tract and that at least 72 hours had elapsed since the most recent course of UF therapy. UF relapses were treated as follows, and all cattle were returned directly to their original feedlot pen after each treatment.

- **First UF relapse:** Single dose of ceftiofur crystalline free acid (Excede Sterile Suspension, Pfizer Animal Health; 6.6 mg/kg SC in the ear)
- **Second UF relapse:** Single dose of enrofloxacin (Baytril 100, Bayer Animal Health; 7.7 mg/kg SC in the neck region)
- **Third UF relapse:** Single dose of tilmicosin (Micotil 300 Injection, Elanco Animal Health; 10 mg/kg SC in the neck region)

Three postallocation relapse treatment regimes (first, second, and third UF relapses) were the maximum permitted for all animals in the study. Once an animal was treated as a third UF relapse, no further treatment for UF was attempted. Animals that were identified with clinical UF subsequent to treatment for a third UF relapse were deemed to be "chronics," as were animals unsuitable to be returned to their designated feedlot pens after treatment based on subjective appraisal of the attitude and appearance. Finally, all other diseases were treated according to a standard feedlot protocol provided by con-

TABLE 2. Mortality Data Summary from Allocation to Slaughter*

	Experimental Group				
Mortality Variable	*FLOR* (n = *281)*	*TULA* (n = *274)*	***Relative Risk†***	***95% CI‡***	**P *Value***
Overall mortality	77 (27.40)	94 (34.31)	0.78	0.61–0.99	.045
BRD mortality	59 (21.00)	74 (27.01)	0.76	0.56–1.00	.050
Histophilosis mortality	6 (2.14)	7 (2.55)	0.86	0.30–2.46	.771
Lameness mortality	0 (0.00)	2 (0.73)	N/A	N/A	N/A
BVD/enteritis mortality	0 (0.00)	0 (0.00)	N/A	N/A	N/A
Metabolic mortality	4 (1.42)	5 (1.82)	0.79	0.20–2.95	.718
Other mortality	8 (2.85)	6 (2.19)	1.23	0.53–2.84	.633

*Numbers in parentheses are percentages.
†Ratio of the rate of disease in the FLOR group divided by the rate of the disease in the TULA group, corrected for allocation rectal temperature (overall mortality and BRD mortality) and allocation weight effects using Poisson regression in a log linear model.
‡Calculated for each relative risk, corrected for allocation rectal temperature (overall mortality and BRD mortality) and allocation weight effects using Poisson regression in a log linear model.
BRD = bovine respiratory disease; BVD = bovine viral diarrhea virus infection.

sulting veterinarians. All treatment events, including treatment date, presumptive diagnosis, and drug(s) and dose(s) administered, were recorded in the chute-side computer system.

The animal health events of each animal were followed from allocation to slaughter. "Chronics" that did not die were classified as wastage. Trained feedlot personnel prosected all animals that died during the study using a standardized method and captured appropriate digital images as outlined in the written necropsy protocol provided by the study investigators. Subsequently, these images were electronically transferred to the study investigators and the cause of death of each animal was determined by a veterinarian based on the findings of the gross postmortem examination. Animals that did not die were either fed to market weight and shipped for regular slaughter (Tyson Fresh Meats, Lexington, NE) or sold for salvage slaughter according to the standard procedures used at the feedlot.

Feeding Program

Standard mixed complete feedlot diets, formulated to meet or exceed National Research Council nutritional requirements of feedlot cattle were offered ad libitum. Feedlot diets were blended by combining dry-rolled corn, high-moisture corn, corn silage, alfalfa hay, corn steep liquor, and supplement in a modern, batch-milling facility equipped with overhead bins. The supplement was manufactured in a granular form by a commercial feed mill (Farr Better Feeds, Animal Nutrition Division, Cargill, Duncan, NE). Animals were adapted to a finisher diet over a 30- to 35-day period by increasing the proportions of dry-rolled and high-moisture corn and decreasing the proportions of corn silage and alfalfa hay at approximately 7-day intervals. Diets were delivered to pens once or twice daily using truck-mounted mixers on load cells. Daily feed allowances to each pen were recorded. Water was provided ad libitum.

Data Collection and Management

The computerized animal health data were collected, verified, and summarized. From these data, risk rates for first UF relapse, second UF relapse, third UF relapse, overall chronicity, overall wastage, overall mortality (mortality due to all causes), BRD mortality (mortality due to BRD), histophilosis mortality (mortality due to *H. somni* infection), lameness mortality (mortality due to lameness), BVD/enteritis mortality (mortality due to BVD or enteritis), metabolic mortality (mortality due to metabolic disease), and other mortality (mortality due to causes other than BRD, histophilosis, lameness, BVD/enteritis, or metabolic disease) were calculated for each experimental group (see box on page 130).

The weight of each animal was measured and recorded at allocation, and the carcass weight of each animal shipped for regular slaughter was retrieved from the packing plant. These data were subsequently imported into a spreadsheet program (Microsoft Excel 2003), where the ancillary production and feedlot performance variables (allocation weight, slaughter weight, carcass weight, weight gain, DOF, and ADG) were calculated for each animal and summarized for each experimental group. Carcass weights were converted to live slaughter weights using a fixed dressing percentage of 63.0%. The dry-matter intake:gain ratio was not calculated because the commingled study design did not facilitate the collection of individual animal–specific or experimental group–specific feed intake.

The yield grade (YG) and quality grade (QG) designations of each animal shipped for regular slaughter were retrieved from the packing plant. With respect to YG, the proportion of animals grading USDA 1, USDA 2, USDA 3, and USDA 4 was calculated for each experimental group. With respect to QG, the proportion of animals grading USDA Prime, USDA Choice, USDA Select, No Roll, and USDA Standard was calculated for each experimental group.

Statistical Analysis

Data were analyzed using an analytical software program (SAS for Windows, Release 9.1, SAS Institute, Cary, NC). The various animal health indices were compared between the experimental groups using Poisson regression in a log linear model for experimental group effects, with individual animals as the unit of analysis.[26,27] Body weight and rectal temperature obtained at allocation were included as covariates in the model for each animal health outcome variable when significant ($P < .05$) effects were detected. Calculation of CIs was done using the partially maximized likelihood function (likelihood ratio-based CIs).[28]

Ancillary production and performance variables were compared between the experimental groups using least squares analysis of variance for experimental group effects.[29] The baseline variables were tested as covariates of the feedlot performance variables and included in the final model used for comparison of each variable between the experimental groups when significant ($P < .05$) effects were detected.[28] Carcass characteristic variables were compared between the experimental groups using rectangular contingency tables to assess the overall distributions of YG and QG and two-by-two tables to compare the frequency of each YG and QG level, using likelihood ratio χ^2 tests.[28]

Economic Analysis

The relative cost-effectiveness of the experimental groups was calculated using a proprietary computer spreadsheet program (Microsoft Excel 2003) that simulates all economic aspects of feedlot production.[1-4,6,20,25] The actual morbidity and mortality rates, carcass weight–based average daily gain, and carcass characteristics of each experimental group were

TABLE 3. Ancillary Production and Feedlot Performance Data Summary*

	Experimental Group		
Production/Performance Variable	*FLOR*	*TULA*	**P *Value***
Allocation weight (lb)†	531.1 (7.9)	531.2 (8.1)	.994
Slaughter weight (lb)‡	1,238.6 (9.2)	1,243.0 (9.5)	.693
Carcass weight (lb)§	780.3 (5.8)	783.1 (6.0)	.693
Weight gain (lb)#	696.2 (9.2)	700.6 (9.5)	.693
Days on feed**	276.4 (3.4)	277.4 (3.5)	.806
Average daily gain (lb/day)††	2.57 (0.05)	2.58 (0.05)	.813

*Values presented are least squares means, with the standard error of each least squares mean in parentheses. Values have been corrected for the significant ($P < .05$) effects of allocation weight when appropriate. Complete weight data from allocation to regular slaughter were available from 180 animals in the FLOR group and 157 animals in the TULA group.
†Calculated using the individual animal live weight obtained at the time of allocation.
‡Calculated using the individual animal carcass weight, converted to a live weight using a fixed dressing percentage of 63.0%.
§Calculated using the individual animal carcass data obtained at regular slaughter.
#Calculated using the allocation and slaughter weights of the individual animal.
**Calculated using the allocation and slaughter dates of the individual animal.
††Calculated using the weight gain and days on feed of the individual animal.

included in the economic model when the probability of each observed difference being due to chance alone was <5% ($P < .05$). When there were no significant ($P \geq .05$) differences between the experimental groups, the morbidity and mortality rates, average daily gain carcass weight basis, and carcass characteristics of the FLOR group were used for both experimental groups. All other factors were fixed in the economic simulations. The initial UF therapy costs used in the economic analyses were Can$23.14 (Canadian dollars) and Can$25.99 for FLOR and TULA, respectively. These costs were based on Canadian pharmaceutical pricing for treating a 531-lb animal. The therapeutic antimicrobial costs used in the economic analyses were representative of the market costs of the products used and standardized between experimental groups.

The economic value of the difference in overall mortality between the two groups was calculated based on a feeder purchase price of Can$102/100 lb body weight and an interest rate of 6%/year. The value of chronics that did not die (wastage) was reduced by Can$100.00/animal as compared with other study animals. The value of a dead animal was Can$0.00. Feed consumed by animals before death was not estimated.

RESULTS

The morbidity and mortality data summaries are presented in Tables 1 and 2, respectively. Overall mortality and BRD mortality rates were lower ($P = .045$ and $P = .050$, respectively) in the FLOR group than in the TULA group. There were no significant differences detected in UF relapse rates, overall chronicity and overall wastage rates, or other cause-specific mortality rates between the experimental groups at the $P < .05$ level.

The ancillary production and feedlot per-

formance data summary is presented in Table 3, and the carcass characteristic data summary is presented in Table 4. Complete weight and carcass records from allocation to regular slaughter were available from 337 animals. Incomplete records encompassed 171 dead animals, 26 animals shipped for salvage slaughter, and 21 animals that could not be successfully tracked through the packing plant at the time of regular slaughter. There were no significant differences detected in carcass weight–based ADG, YG variables, or QG variables between the experimental groups at the $P < .05$ level (Tables 3 and 4).

Using Canadian pharmaceutical prices in the economic modeling, there was a net advantage of Can$41.19/treated animal in the FLOR group compared with the TULA group as a result of the lower costs of the initial UF treatment (Can$2.91/treated animal) and overall mortality (Can$38.28/treated animal).

This study demonstrates that florfenicol is more cost-effective than tulathromycin for initial UF treatment in feedlot calves at ultra-high risk of developing UF that receive metaphylactic tulathromycin on arrival at the feedlot.

DISCUSSION

This study demonstrates that florfenicol is more cost-effective than tulathromycin for initial UF treatment in feedlot calves at ultra-high risk of developing UF that receive metaphylactic tulathromycin on arrival at the feedlot. This was evidenced by the significant reduction in overall and BRD mortality rates and the net advantage of Can$41.19/treated animal in the florfenicol group compared with the tulathromycin group.

As noted in the introduction, the study by Schunicht et al demonstrated that tulathromycin was superior to florfenicol when it was used as a treatment for the initial occurrence of UF in calves that did not receive a metaphylactic antimicrobial or vaccines containing *M. haemolytica* or *H. somni* at the time of feedlot arrival.[25] The findings of the current study may seem to contradict the results of the Schunicht et al study; however, in the current study, animals treated for UF with tulathromycin had already received tulathromycin at feedlot arrival to control UF. Perhaps sensitive microorganisms were targeted with the metaphylactic use of the drug and the microorganism populations that caused UF in the study animals were not as sensitive to tulathromycin as they might otherwise have been. Metaphylactic use of tulathromycin may have selected for bacterial populations with greater resistance to tulathromycin, or sensitive populations may have developed or acquired resistance to tulathromycin after metaphylactic exposure. The latter seems less likely considering the relatively short interval between metaphylactic and therapeutic exposure. Another possibility is that the use of metaphylactic tulathromycin and vaccines containing *M. haemolytica* or *H. somni* at the time of feedlot arrival may have sufficiently changed the milieu of bacterial pathogens that caused disease in the current study such that florfenicol became a more effective therapeutic antimicrobial than it was in the study by Schunicht et al. Additional research is needed to further under-

TABLE 4. Carcass Characteristic Data Summary*

	Treatment Group		
Carcass Characteristic Variable	*FLOR*	*TULA*	**P *Value***
Yield grade (overall effect)†			**.227**
USDA 1	38 (21.11)	43 (27.39)	.179
USDA 2	97 (53.89)	85 (54.14)	.963
USDA 3	38 (21.11)	27 (17.20)	.363
USDA 4	7 (3.89)	2 (1.27)	.125
Quality grade (overall effect)‡			**.358**
USDA Prime	0 (0.00)	2 (1.27)	.080
USDA Choice	66 (36.67)	59 (37.58)	.863
USDA Select	77 (42.78)	65 (41.40)	.799
No Roll	36 (20.00)	31 (19.75)	.953
USDA Standard	1 (0.56)	0 (0.00)	.262

*Carcass data were available from 180 animals in the FLOR group and 157 animals in the TULA group.
†Yield grade values are the number of carcasses, expressed as a percentage of carcasses in parentheses, from each experimental group that graded in each yield grade category.
‡Quality grade values are the number of carcasses, expressed as a percentage of carcasses in parentheses, from each experimental group that graded in each quality grade category.

stand the mechanisms responsible for differences in relative therapeutic efficacy between florfenicol and tulathromycin depending on the situation in which the two antimicrobials are compared.

Theoretically, it is possible that type 1 experimental error in the current study, the study by Schunicht et al, or both could explain the vast difference in relative outcome observed between the two studies. However, the results of the study by Schunicht et al are supported by additional studies with similar experimental designs,[21,22] and the results of the current study are in agreement with unpublished results from an in-house pilot study conducted by Feedlot Health Management Services with a study design analogous to that used in the current study (data not shown). As a result, it seems likely that the difference in relative therapeutic efficacy between florfenicol and tulathromycin is a real phenomenon that depends on the situation in which the two antimicrobials are compared and is unlikely to be the result of a type 1 experimental error.

Based on the differences in outcomes between the current study and the study by Schunicht et al, it will be tempting for some veterinarians and researchers to conclude that using the same antimicrobial for both metaphylaxis and treatment in the same animal will result in inferior outcome regardless of the antimicrobial used. While it is possible that these findings may not necessarily be restricted to tulathromycin, it is probably not appropriate to broadly conclude that this is a general phenomenon based solely on the current study.

More importantly, the findings of the current study and the study by Schunicht et al highlight the usefulness and importance of conducting well-designed, large-scale field trials that incorporate all of the standard disease prevention, control, and treatment programs normally used in commercial feedlot production so that the results obtained have external validity for extrapolation to other similar production scenarios. In addition, the results of these studies reinforce the multifactorial and sophisticated character of the disease prevention, control, and treatment programs that may be implemented in each feedlot operation.

CONCLUSION

The results of this study demonstrate that it is more cost-effective to use florfenicol than tulathromycin for the initial treatment of UF in feedlot calves at ultra-high risk of developing UF that receive metaphylactic tulathromycin on arrival at the feedlot.

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