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Evaluation of serum metabolic parameters as predictors of bovine respiratory disease events in high-risk beef stocker calves

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Abstract

The primary objective of this study was to evaluate the association between serum metabolic parameters and the risk of bovine respiratory disease (BRD) in high-risk beef stocker calves. Jugular venous blood samples were collected from mixed-breed beef bull, steer, and heifer calves (*n*=468) at the time of arrival processing at a stocker facility in northeast Georgia. Serum samples were then submitted for determination of serum creatinine, total calcium, phosphorus, magnesium, albumin, serum urea nitrogen, glucose, cholesterol, beta-hydroxybutyrate (BHBA), non-esterified fatty acid (NEFA), sodium, potassium, and chloride concentrations, as well as sodium:potassium ratio and NEFA:cholesterol ratio. Calves were monitored for the development of signs consistent with BRD for 45 days following arrival. A multivariable logistic regression model was created to evaluate the association between serum variables and subsequent risk of BRD. In this analysis, BRD was associated with higher serum potassium, lower serum urea nitrogen, and lower BHBA concentrations at arrival processing. The area under the receiver operating characteristic curve for the ability of the model to predict morbidity was 0.645. These data suggest that hydration status, nutrient balance, and degree of rumen development may play a role in the development of BRD in high-risk beef stocker calves.

Key words: bovine respiratory disease, metabolism, preconditioning, stocker cattle

Résumé

L'objectif principal de cette étude était d'évaluer l'association entre les paramètres métaboliques sériques et le risque du complexe respiratoire bovin (CRB) chez des veaux de boucherie à haut risque dans des parcs d'engraissement. Du sang de ponctions veineuses jugulaires a été recueilli chez des taurillons, des bouvillons et des génisses de boucherie de race croisée (n=468) au moment du traitement à l'arrivée dans un parc d'engraissement du nord-est de l'état de la Georgie. Des échantillons de sérum ont ensuite été analysés pour déterminer la concentration sérique de la créatinine, du calcium total, du phosphore, du magnésium, de l'albumine, de l'azote uréique, du glucose, du cholestérol, du bêta-hydroxybutyrate (BHBA), des acides gras insaturés (NEFA), du sodium, du potassium et du chlorure de même que le rapport entre le sodium et le potassium et le rapport entre les NEFA et le cholestérol. Les veaux ont été suivis pour le développement de signes compatibles avec le CRB dans les 45 jours suivant l'arrivée. Un modèle de régression logistique multiple a été utilisé pour évaluer l'association entre les différentes variables sériques et le risque de développer le CRB. Dans cette analyse, le CRB était associé avec des concentrations sériques plus élevées de potassium et avec des concentrations sériques moins élevées d'azote uréique et de BHBA au traitement à l'arrivée. L'aire sous la courbe ROC pour la capacité du modèle à prédire la morbidité était de 0.645. Ces données suggèrent que l'hydratation, l'équilibre nutritif et le niveau de développement du rumen peuvent jouer un rôle dans le développement du CRB chez des veaux de boucherie à haut risque en engraissement.

Introduction

Bovine respiratory disease (BRD) is the most common cause of morbidity and mortality in North American beef cattle. Not only is BRD a cattle health and welfare concern, but the disease also has considerable economic impacts and is estimated to cost the North American beef cattle industry $1 to 3 billion per year through increased labor, medication costs, and decreased animal performance.[11,12,34] Indeed, data from the 1999 to 2000 Texas A&M Ranch to Rail Survey found that calves treated for BRD during the feeding period incurred an average medication cost of $26.78 and returned $97.08 per head less than untreated calves due to reduced feed efficiency and weight gains, resulting in an average loss of $123.86 for calves treated for BRD.[20] More recent work has shown that cattle treated 1, 2, or 3 or more times for BRD returned $38, $167, and $230/calf less than untreated cattle, respectively.[36] As with the earlier work, a majority of the losses found in this study were from increased days-on-feed (DOF), increased cost of gain (COG), and decreased average daily gain (ADG) and carcass quality.[36]

Bovine respiratory disease is a multifactorial disease process and factors such as lack of weaning, commingling, long distance transportation, inadequate nutritional status, genetics, and previous health history make certain populations of cattle more susceptible to the development of clinical disease.[10] Stocker calves are typically considered high-risk for BRD due to the combination of stressful events that occur between leaving the farm of origin and arrival at a stocker facility. Stocker calves are often mass treated with antimicrobials at arrival in an attempt to reduce the incidence of BRD, a management strategy referred to as metaphylaxis.[16] While metaphylaxis has resulted in improvements in animal health and performance, research has demonstrated an increased prevalence of multidrug resistant respiratory pathogens following the use of injectable antimicrobials at arrival in stocker and feedlot cattle.[15,16,26,30] Additionally, the animal agriculture industry is faced with the challenge of shifting consumer preferences and increasing scrutiny regarding antimicrobial use in the food supply. Based on concerns associated with metaphylaxis and the subjectivity of visual appraisal traditionally used to diagnose BRD, there is a need for more practical and reliable methods to accurately identify animals that are more likely to develop BRD early in the feeding period.[10,35,38] Through the identification and use of valid biomarkers, prediction of animals at higher risk of disease would allow for earlier treatment of infected calves or separation from herd mates to help reduce the incidence and severity of infectious disease through reduction of pathogen shedding to other susceptible animals.[3]

Recent research from our lab found immunological and physiological differences between auction-market derived calves and single-source, preconditioned calves.[4] Auction-market calves had a significantly greater serum non-esterified fatty acid (NEFA) and significantly lower serum beta-hydroxybutyrate (BHBA) and total calcium concentrations than preconditioned calves. As a result, it is possible these parameters could be used to evaluate the physiological status and disease risk of calves following typical practices associated with an auction-market system. When considering the use of biomarkers as indicators of morbidity during stressful events, there is an association in dairy cattle between elevated serum metabolic parameters obtained during the transition period and risk of postpartum disease.[1,19] Serum NEFA and BHBA measurements are valuable methods for evaluating postpartum dairy cows for negative energy balance and hyperketonemia, respectively, and identifying individual animals at increased risk for developing postpartum diseases, reduced performance, or early culling. With these results in mind, the objective of the current study was to evaluate the association between serum metabolic parameters and risk of treatment for BRD in beef stocker calves at high risk of developing disease. We hypothesized that there would be a difference in serum metabolic parameters in calves that are treated for BRD within 45 days of arrival to a stocker facility and in cattle that are not identified for BRD-related morbidity.

Materials and Methods

This study and all procedures were approved by the University of Georgia College of Veterinary Medicine Clinical Research Committee.

Sample Size

This study was designed as a prospective cohort study. A total sample size of 588 calves was estimated to provide a power of 80% to detect an absolute difference of 10% in BRD incidence between 2 equally sized groups of calves with serum metabolite concentrations above or below the median value, assuming an incidence of 20% in 1 group, 30% in the other, a 2-sided alternative hypothesis, and a type-I error probability of 5%.

Animals and Housing

This study was conducted at a private stocker facility in northeast Georgia. Sample collections were performed on the farm and processed in a University of Georgia College of Veterinary Medicine research laboratory. The animal health protocols and arrival procedures were established by the producer and were not altered for the purpose of this study.

Calves sampled in this study were mixed-breed beef calves purchased between March 4, 2019 and April 17, 2019. All calves were of unknown age and health history, light weight (400 to 500 lb; 181 to 227 kg), and commingled from various sources. The calves were purchased from 5 auction markets in northeast Georgia and 1 in western South Carolina. Following purchase, the calves were transported 30 to 125 miles (48 to 201 km) to the stocker facility, where they were rested overnight in dirt-bedded receiving pens in an open-sided barn with free-choice access to Coastal Bermudagrass hay and water. The calves were processed the following morning and sorted into pens based on sex and body weight. Arrival processing included administration of a custom autogenous bacterin[a] containing the following antigens: *Clostridium perfringens* types C and D, *Mannheimia haemolytica*, *Mycoplasma bovis*, *Histophilus somni*, *Pasteurella multocida*, and *Staphylococcus chromogenes*, and a multivalent modified-live viral (MLV) respiratory vaccination[b] containing bovine viral diarrhea virus type 1 and 2, bovine herpes virus 1, parainfluenza-3 virus, and bovine respiratory syncytial virus, and treated for external and internal parasites with topical moxidectin[c] and oral fenbendazole,[d] and given an individually numbered ear tag. Bull calves were left intact and not castrated either surgically or by band at the operation.

All calves were treated with injectable oxytetracycline[e] to prevent BRD using the label dose for disease treatment and were given an injectable trace mineral supplement according to the manufacturer's instructions.[f]

After processing, calves were moved into 1 to 2 acre primary pens with ad libitum access to water and round bale Coastal Bermudagrass hay (8.5% crude protein [CP], 31.6% crude fiber [CF], 51.2% total digestible nutrients [TDN] on a dry-matter basis) and provided a free-choice concentrate ration (CP 13.8%, CF 22.6%, TDN 66.9% on a dry-matter basis) with no more than 40 calves per pen. Chlortetracycline (CTC) was not included in the feed. Calves less than 450 lb (205 kg) were managed together, regardless of sex, while heifers, steers, and bulls greater than 450 lb (205 kg) were managed in pens based on sex. Ten to 14 days after arrival, calves were revaccinated with a MLV respiratory vaccine[b] including bovine viral diarrhea virus type 1 and 2, bovine herpes virus 1, parainfluenza-3 virus, and bovine respiratory syncytial virus. Following revaccination, calves were moved to a series of 2 to 4 acre paddocks and transitioned to a free-choice co-product ration (CP 15.1%, CF 25.6%, TDN 63.0% on a dry-matter basis) that was fed from a self-feeder and round bale Coastal Bermudagrass hay (8.5% CP, 31.6% crude fiber CF, 51.2% TDN on a dry-matter basis). A standardized recording system was established for the producer to record BRD morbidity and treatment date for individual calves. Calves were monitored once daily for 45 days after arrival processing for signs of BRD that included lethargy, decreased gut fill, reduced interest in feed, ocular and nasal discharge, and increased respiratory effort. A rectal temperature was not collected prior to administration of antimicrobial therapy. Animals determined to be a clinical case were treated according to farm protocols with either injectable oxytetracycline[e] or injectable tulathromycin[g] per label instructions. Choice of antimicrobial was based on the producer's subjective interpretation of disease severity, with more severely affected animals being administered tulathromycin and less severely affected animals administered oxytetracycline. The farm's animal morbidity monitoring and treatment protocols were not altered for the purpose of this study to facilitate compliance with study protocol.

Sample Collection and Processing

Jugular blood samples were collected from calves at the time of arrival processing, prior to the administration of any animal health products. Animals were omitted from sampling if they displayed any signs of morbidity at the time of processing including lameness, nasal or ocular discharge, or corneal ulcers. Calves were restrained in a chute with a head catch and halter for safety and proper sample collection. Ten mL of blood were aseptically collected from the jugular vein via venipuncture with a sterile 18-gauge vacutainer needle into red-top tubes without anticoagulant.[h]

Within 2 hours of collection, the samples were taken to a laboratory for processing and storage. The blood tubes were incubated for 3 hours at 98.6°F (37.0°C) and then centrifuged at 3200 rpm for 12 minutes. Serum was separated, then aliquoted into 3–1.5 mL microcentrifuge tubes. One of the serum aliquots was submitted to Texas A&M Veterinary Diagnostic Laboratory for a Transitional Herd Metabolic Profile and creatinine. The Transitional Herd Metabolic Profile measured serum calcium (mg/dL), phosphorus (mg/dL), magnesium (mEq/L), albumin (g/dL), blood urea nitrogen (mg/dL), glucose (mg/dL), cholesterol (mg/dL), NEFA (mEq/L), sodium (mEq/L), potassium (mEq/L), chloride (mEq/L), sodium:potassium ratio, BHBA (mmol/L and converted into mg/dL), and NEFA:cholesterol. Additional serum aliquots were stored at -112.0°F (-80°C) for additional measurements if needed.

Statistical Analysis

Calves were grouped by disease status (untreated or treated) and data entered into a computerized spreadsheet program.[i] For this study, the following records were kept: sample number, animal tag number, arrival date, processing date, sex, first treatment date, transitional metabolic profile variables, and serum creatinine concentrations. Normality of the data was assessed based on histograms. Metabolic profile data were compared between untreated and treated calves using a Mann-Whitney U test. Data are reported as median and 10th and 90th percentiles. For this test, a value of $P < 0.10$ was considered a tendency and a value of $P < 0.05$ was considered significant. To evaluate the association of metabolic profile parameters with disease status, a generalized estimating equations logistic regression model with robust standard errors and exchangeable correlation structure was used. Sex was included as a fixed effect and week of arrival was included as a clustering variable to account for the correlation in responses of animals arriving during the same week. All variables were first screened using univariable logistic regression. Any variables with a $P < 0.2$ in the univariable analysis were included in a manual backward elimination process for the multivariate model. For the multivariate model, only variables with a $P < 0.05$ were retained. Odds ratios (OR) and 95% confidence intervals (CI) were calculated. The predictive ability of the final model was assessed by evaluating the area under a receiver operating characteristic (ROC) curve. All analyses were performed with commercially available statistical software.[j]

Results

Due to market constraints and calf availability, the producer stopped purchasing cattle before the end of the planned enrollment period. As a result, only 468 calves were enrolled into the study between March 5 and April 18, 2019. Of the enrolled calves, 371 (79.3%) were heifers, 76 (16.2%) were bulls, and 21 (4.5%) were steers. Forty-one (8.8%) of the 468 calves were diagnosed with BRD once by the producer during the 45-day observation period. Of the

41 calves treated for BRD, 28 were heifers (68.3%), 11 were bulls (26.8%), and 3 were steers (7.31%). There was no association between sex and risk of BRD ($P = 0.107$). Compared with calves diagnosed with BRD, calves that remained healthy had a tendency towards a higher blood urea concentration ($P = 0.089$) and lower serum creatinine ($P = 0.068$, Table 1).

Variables associated with morbidity in the final multivariable logistic regression model were urea ($P = 0.048$), potassium ($P < 0.001$), and BHBA ($P < 0.001$, Table 2). For every 1 mg/dL increase in blood urea concentration, the odds of BRD decreased by 5.7%. For every 1 mEq/L increase in serum potassium concentration, the odds of BRD increased by 29%. And for every 1 mg/dL increase in serum BHBA concentration, the odds of BRD decreased by 37.7%. The area under the receiver operating characteristic curve for the ability of the model to predict morbidity was 0.645 (95% confidence interval, 0.563-0.727, Figure 1), which would be consistent with a model that has limited or weak predictive ability. For comparison, a model with perfect predictive ability would have an area under the curve (AUC) of 1.0, and a model that has no predictive ability (e.g., a coin flip) would have an AUC of 0.5.

Discussion

It has been well established that BRD is a complex disease process affecting the health, productivity, and welfare of beef cattle. Stocker cattle are considered higher risk for developing BRD due to a combination of naïve immune status, weaning and transport stress, and a host of other factors.[40] Based on the increased risk of BRD in this population of animals, it is common practice for stocker producers to administer antimicrobials at arrival, a practice referred to as metaphylaxis. Metaphylaxis has been shown to significantly reduce BRD-related morbidity and mortality and improve animal performance.[17,29] Despite improvements in cattle health with the use of metaphylaxis, there is a potential for this practice to select for multidrug resistant organisms and contribute to treatment failure.[40] The goal of this study was to investigate the clinical utility of using serum biomarkers to predict the risk of BRD in individual stocker calves at arrival. The objective was to continue working towards the development of a valid and practical tool to assist with the identification of certain individuals at higher risk for developing BRD to allow for more selective individual animal

Table 1. Comparison of metabolic profile parameters (median, 10th-90th percentiles) for untreated stocker cattle and those that were treated for bovine respiratory disease within 45 days of arrival. Reference ranges reported here are from the Texas A&M Veterinary Medical Diagnostic Laboratory.

Parameter	Reference range	Untreated (n = 426)	Treated (n = 41)	*P**
Calcium (mg/dL)	8.30-10.4	8.61 (7.58-9.46)	8.77 (7.26-9.41)	0.691
Phosphorus (mg/dL)	4.90-9.10	7.70 (6.40-9.30)	7.50 (5.90-9.54)	0.172
Magnesium (mEq/L)	1.50-2.50	1.80 (1.60-2.10)	1.80 (1.50-2.07)	0.579
Albumin (mg/dL)	3.10-4.30	3.11 (2.55-3.53)	3.04 (2.47-3.42)	0.220
Urea (mg/dL)	10.0-25.0	9.85 (5.50-16.4)	8.50 (5.06-15.5)	0.089
Glucose (mg/dL)	31.0-77.0	69.0 (48.0-95.0)	66.0 (52.0-89.7)	0.392
Cholesterol (mg/dL)	73.0-280	105 (72.0-147)	106 (61.6-167.7)	0.732
Sodium (mEq/L)	135-153	139 (126-145)	140 (128-146)	0.349
Potassium (mEq/L)	3.90-6.00	6.10 (5.10-7.60)	6.25 (5.50-8.42)	0.293
Chloride (mEq/L)	92.0-117	101 (92.0-107)	101 (95.3-107)	0.512
NEFA (mEq/L)	0-0.60	0.325 (0.159-0.595)	0.305 (0.113-0.598)	0.215
BHBA (mg/dL)	-	2.41 (1.61, 3.80)	2.43 (1.48, 3.17)	0.121
NEFA:Cholesterol	-	0.118 (0.059-0.242)	0.107 (0.042-0.238)	0.150
Na:K	-	22.3 (18.5-26.1)	22.5 (16.9-24.6)	0.437
Creatinine (mg/dL)	0.50-1.70	1.03 (0.740-1.40)	1.06 (.835-1.52)	0.068

* *P*-value for the Mann-Whitney test

Table 2. Multivariable logistic regression model evaluating serum metabolic parameters as predictors of bovine respiratory disease in 468 calves at a single stocker operation in northeast Georgia. Model adjusted for clustering of calves by arrival week.

Variable	Coefficient (SE)	Odds Ratio (95% CI)	*P*
Urea (mg/dL)	-0.06 (0.03)	0.94 (0.89, 1.00)	0.048
Potassium (mEq/L)	0.25 (0.06)	1.29 (1.14, 1.46)	< 0.001
BHBA (mg/dL)	-0.46 (0.10)	0.63 (0.52, 0.77)	< 0.001
Constant	-2.17 (0.60)	NA*	< 0.001

* Not applicable

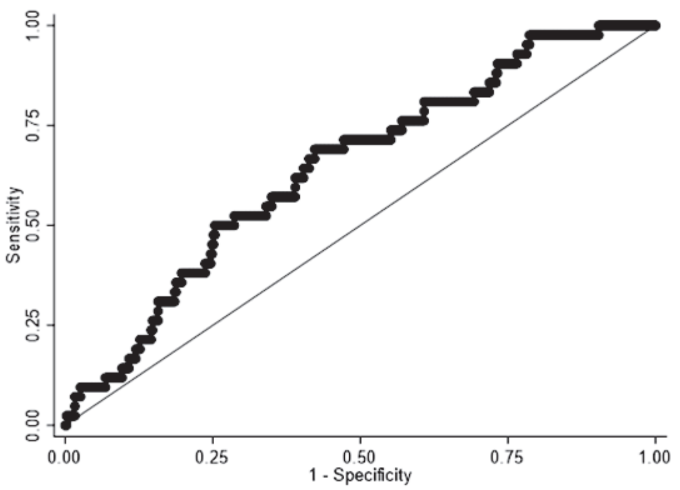

Figure 1. Receiver operating characteristic curve (ROC) for the final logistic regression model containing urea, potassium, and BHBA concentrations as predictors of bovine respiratory disease in 468 stocker calves. The area under the ROC curve is 0.645.

treatment and management. While the serum metabolic parameters had limited ability to predict BRD in an individual animal, there were some associations that could be useful in predicting an increased risk of developing BRD at the population level. While the practicality of submitting blood for a serum metabolic profile is questionable, it was hoped that this work would potentially lead to the development of chuteside diagnostics that could be employed in a point-of-care (POC) manner. These POC tests would avoid the delays associated with submission of blood samples to diagnostic labs and the negative impacts of delayed health management in high-risk populations of beef cattle.

Our primary variables of interest in this study were NEFA, BHBA and total calcium, which are used as biomarkers for nutrient metabolism in the dairy industry to detect cows experiencing metabolic stress.[38] Traditionally, NEFA and BHBA have been used to monitor the metabolic status of periparturient dairy cows and the subsequent risk of developing diseases during the transition period.[23] In dairy animals, fat is mobilized in early lactation to serve as an energy source. Triglycerides within fat stores are then broken down into glycerol and NEFA. The NEFA enter the blood stream and are taken up by the liver. Non-esterified fatty acids taken up by the liver are then oxidized to provide energy or transferred to the udder to support lactation. Unfortunately, during times of high NEFA production, some NEFA are converted into BHBA. As a result, high levels of NEFA or BHBA in serum reflect excessive fat mobilization.[25] A multi-regional study across the United States found an association between elevated NEFA and BHBA and the subsequent development of disease in transition dairy cattle, elevated serum NEFA and reduced serum total calcium concentrations in the 2 weeks prior to parturition are associated with increased risk of displaced abomasum.[6] Alterations in these metabolic parameters and increased risk of subsequent disease in the periparturient dairy cow is attributed to the stress of the transition period resulting in a period of insulin resistance, reduced feed intake, negative energy balance, lipolysis, weight loss, reduced immune function, and hypocalcemia.[18] Although a recently weaned beef calf is not undergoing the same physiological challenges as a transition dairy cow, both animals experience stressful events resulting in derangements to their metabolic status, feed intake, and subsequent risk of disease. Nevertheless, in our study, NEFA and calcium were not significantly associated with BRD, while BHBA was a significant predictor.

The negative association of BHBA with BRD in this current model may indicate more mature rumen development in calves that did not develop BRD. In 1 study, blood BHBA concentrations were greater in dairy calves weaned early compared to the calves weaned later, with increases in blood BHBA being closely associated to availability and consumption of calf starter grain.[24] It was suggested that higher concentrations of blood BHBA in early weaned calves likely indicated production of acetate and butyrate and maturation of rumen function. Our finding that increased serum BHBA concentrations were associated with a reduced probability of developing BRD may indicate calves less likely to be treated for BRD arrive to the stocker facility with more advanced rumen development and greater readiness to transition to the feeding regimens of these operations.

The significance of serum urea concentrations in the model may further support the theory that calves on a better plane of nutrition may be less likely to require treatment for BRD. Protein intake and nutrient balance may be evaluated by measuring blood urea concentrations in cattle.[33] Increased dietary protein results in a surplus of nitrogen that can be made available for rumen microbial growth. Excess nitrogen can be absorbed across the rumen epithelium and converted into urea.[14] As a result, animals in a positive protein balance would have higher concentrations of blood urea nitrogen. In Holstein heifers, blood urea nitrogen, propionate, butyrate, and total volatile fatty acid concentrations have been shown to increase linearly with increasing crude protein concentration in the ration.[8] These data would support the theory that certain calves had a better nutrient balance prior to arrival, resulting in a reduced probability of being treated for BRD. Another possibility is that calves more likely to become clinically ill would arrive under immunological stress with increased energy demands resulting in less available protein and energy for conversion into urea and volatile fatty acids. Either of these theories would be consistent with an association of increased urea and BHBA with a reduced probability of treatment for BRD following arrival. It is interesting to note that another study concluded that elevated plasma urea nitrogen (PUN) in high-stress feedlot heifers was associated with increased incidence of clinical disease when compared to calves with lower PUN concentrations.[9] The study speculated that elevated PUN upon arrival may reveal a catabolic state in calves as a result of long transportation and high stress and may be an indicator of existing disease or increased susceptibility to disease. The reason for the conflicting results in the previous and current studies is unclear, although the proportion of calves with clinical signs of BRD was much higher in the previous study (79%), and the mean PUN was much lower (1.45 mM/L or 4 mg/dL), suggesting that the underlying study populations may not be comparable.

Within our model, elevated serum potassium was associated with an increased risk of developing BRD. Although the reason for this association between elevated potassium and the subsequent risk of developing BRD is unclear, it may be a reflection of hydration status and extent of shrink in certain individuals. Shrink is considered the loss of body weight, from both gut fill and total body tissue, often attributed to the long periods of transportation of cattle. The primary factor affecting shrink is the length of time of feed and water withdrawal, which can increase shrink up to 2 percentage units during environmentally stressful conditions such as high ambient temperature, transport, or extra or rough handling.[7] Chronic stress and dehydration related to transportation and the transition to a stocker facility then predisposes cattle to BRD due to alterations in the immune system.[31] Based upon this information, elevated potassium could be a reflection of increased stress and shrink in certain individuals, potentially those rapidly weaned and transported, compared to calves weaned and exposed to a feeding regimen prior to transport. Calves managed well prior to transport would likely have reduced stress and shrink, resulting in fewer predisposing factors to developing BRD.

The results of this study may further support the value of preconditioning calves prior to movement from the farm of origin. The purpose of a preconditioning program is to prepare a weaned calf to better handle stresses that occur with transportation, commingling, nutritional changes, increased exposure to infectious pathogens, environmental changes, and immunological challenges. Generally, preconditioning programs consist of weaning at least 45 days prior to shipment, castration, dehorning, vaccination, anthelmintic treatment, exposure to a concentrate diet and water troughs, individual animal identification via ear tags, and growth-promoting implants.[11,37] Research has demonstrated improvements in both health and performance in subsequent feeding periods of calves having undergone preconditioning compared to calves abruptly weaned and shipped or purchased from an auction-market.[27,28] Despite its advantages, however, preconditioning programs require increased input and resources at the farm of origin resulting in the underutilization of this management strategy.

There are various limitations of this study which must be considered when interpreting the results. Our sample size was calculated with the expectation of 20% morbidity in calves during the 45 days following arrival based on rates of BRD-related morbidity in feedlot cattle and mortality in cow-calf operations.[13,21,22] A recent study evaluating metaphylaxis in southeastern stocker calves reported a morbidity risk of 48% within 28 days of arrival.[40] At the end of our data collection, however, morbidity was only 9% for this population of calves. This could be caused by various factors such as mild weather conditions, low levels of infectious disease, effective arrival processing procedures, the high proportion of heifers, or the potential for calves with clinical BRD to not be diagnosed as ill by the producer. In addition to the low levels of morbidity, the producer stopped purchasing calves near the end of the collection period resulting in 468 calves sampled. The combination of low morbidity and availability of calves did not allow us to reach our sample size of 588 calves with a 20% incidence of BRD. Although significant associations between serum metabolic parameters and risk of BRD were found, the inability to reach the predetermined sample size and low levels of morbidity could have caused meaningful associations between other metabolic parameters and BRD to be overlooked. It is also possible that a larger sample size and higher risk of BRD could have improved the robustness of the final model and given it more clinical utility moving forward. Furthermore, the use of this particular formulation of oxytetracycline for disease control purposes is extra-label and, as a result, could have confounded the results of the study or, more likely, reduced the external validity of the work reported. As stated previously, the protocols were not altered for the purposes of this study to ensure compliance with study protocols and provide a more realistic scenario for the typical southeastern stocker producer. Future studies with larger numbers of animals in similar production systems with higher levels of mortality might allow for the robustness of the model to be improved and additional conclusions to be gleaned. Also, the use of drugs approved for disease control purposes might show different results due to changes in BRD patterns or prevalence.

Based on management and facility constraints, the producer was responsible for monitoring cattle for morbidity. Prior to the study, it was established that the producer primarily treated calves for BRD based on apparent lethargy, reduced feed intake, purulent nasal discharge, and increased respiratory rate and effort. Rectal temperatures were not obtained at the time of treatment. Monitoring animal behavior and clinical illness in this manner is a common form of evaluating cattle health and presumptively treating for BRD.[39] However, research has shown that diagnosing BRD based on clinical illness has a low sensitivity of 61.8% and low specificity of 62.8%.[35] Despite the potential of low levels of infectious disease in the study subjects, it is feasible that morbid individuals were not accurately diagnosed and treated for BRD. Although unlikely, it is also possible that, due to the fact rectal temperature was not collected, cattle were overtreated and the risk of morbidity was falsely elevated. Although there are clear limitations with this approach, in our experiences it is an approach commonly taken by stocker producers in the Southeast.

Upon arrival to the farm, the calves from various auction markets would be delivered and unloaded into holding pens for the night. This producer utilized order-buyers, who may purchase individually marketed calves and sort them into more uniform groups before delivering them to the stocker facility. The additional processes associated with an order-buyer further increases exposure of these high-risk calves to novel environments, commingling, and feed and water restrictions.[32] Following arrival processing the next morning, the calves were sorted into various groups based on sex, body weight, and space availability. Based on the use of an order-buyer followed by the variety in calf sorting methods, it was not possible to make associations of groups by source or pens following processing due to lack of records. Although all calves were managed similarly with an identical diet, arrival procedures, BRD monitoring, and being separated into various groups could affect the incidence of disease. An additional limitation is the relatively small geographical source of this population of calves being primarily from northeast Georgia.

Although this study did not identify a strongly predictive biomarker for the prediction of BRD, it did allow a characterization of the calves' metabolic and physiologic state. In livestock production units, the health status of the herd as a whole is of paramount importance, with subclinical disease or nutritional imbalance potentially contributing to suboptimal productivity.[25] As a result, these data provide more insight into physiologic and nutritional status of this population of stocker calves, with the model providing associations of certain metabolic parameters and the subsequent treatment of calves being treated for BRD.

Conclusions

These data suggest that hydration status, nutrient balance, and degree of rumen development might play a role in the development of BRD in high-risk beef stocker calves. Based on these findings, more data are needed to further characterize the immune and physiological state of stocker calves with the goal of identifying a practical chute-side diagnostic test to identify calves at increased risk for BRD.

Endnotes

[a] Custom autogenous vaccine, Newport Laboratories, Worthington, MN
[b] Pyramid 5, Boehringer Ingelheim Animal Health, Duluth, GA
[c] Cydectin Pour-On, Bayer Animal Health, Shawnee Mission, KS
[d] Safe-Guard, Merck Animal Health, Millsboro, DE
[e] Noromycin 300 LA, Norbrook Labs, Overland Park, KS
[f] Multimin 90, Mutlimin USA, Inc., Fort Collins, CO
[g] Draxxin, Zoetis, Kalamazoo, MI
[h] Vacutainer Red Top Blood Collection Tubes, Becton Dickinson, Franklin Lakes, NJ
[i] Microsoft Excel, Microsoft, Redmond, WA
[j] Stata, version 15.1, StataCorp, LP, College Station, TX

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