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The association between Whisper® lung scores and feedlot performance in crossbred steer calves

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Abstract

A cohort study was conducted in a population of crossbred feeder steers to assess the relationship between Whisper® lung scores taken at feedlot arrival and subsequent health and performance. The primary outcome of interest was average daily gain. Other feeding performance outcomes included feed efficiency, hot carcass weight, dressing percentage, marbling score, fat thickness, and ribeye area. Health performance outcomes included treatment for bovine respiratory disease (BRD), death due to BRD, being diagnosed with chronic BRD, and dying after treatment for BRD. The only significant association between arrival lung score (ALS) and feeding performance was improvement in feed efficiency for those calves with an ALS of 4 ($p = 0.02$) or 5 ($p = 0.005$), where feed efficiency was determined by back-calculation using individual carcass weight and yield obtained at harvest. There was a significant increase in the odds ratio for treatment for BRD for calves with an ALS of 5 (OR 1.27, 95% CI 1.03-1.57, $p = 0.005$), as well as a significant increase in the odds ratio for death due to BRD for calves with an ALS of 4 (OR 1.06, 95% CI 1.00-1.13, $p = 0.02$). This study demonstrates that higher ALS may be associated with increased risk of treatment for BRD and death due to BRD along with improved feed efficiency, but further research is warranted.

Key words: BRDC, lung auscultation score, Whisper®, feedlot, feeding performance, health performance

Introduction

Bovine respiratory disease (BRD) is the most commonly diagnosed disease in feedlot cattle, and is estimated to affect 16.2% of all cattle on feed.[9] On average, the cost of BRD treatment is greater than any other condition seen in feedlots.[9] Lung lesions identified at slaughter are associated with decreased average daily gain and hot carcass weight, less internal fat, and lower marbling scores.[4] Untimely treatment, undiagnosed BRD, or poor response to treatment are associated with lung lesions and economic losses.

If animals likely to experience BRD could be identified at feedlot arrival, some economic losses caused by BRD could be avoided. Breed, arrival weight, and season of the year when cattle arrive at the feedlot are associated with the risk of BRD.[6] Diagnostic tools to identify animals at greater risk of BRD could provide information to help reduce this risk.

Lung auscultation is sometimes used by veterinarians in an attempt to diagnose BRD. DeDonder et al showed that lung auscultation scores assigned by trained personnel could be used to help predict case outcomes of BRD treatments. When compounded with rectal temperature, lung auscultation score was shown to correlate with a calf's risk of death due to BRD.[3] This correlation was seen in calves clinically affected with BRD. To the author's knowledge, there is no published research to determine if lung auscultation scores at arrival processing could predict the risk of death in cattle before being diagnosed with clinical BRD. Furthermore, there is no published research to determine if lung auscultation scores at arrival processing correlate with feeding performance.

The objective of this study was to determine the utility of arrival lung score (ALS) via the Whisper® stethoscope to identify associated production losses in a feedlot setting. The first aim was to determine if ALS was correlated with feeding performance, specifically average daily gain (ADG) and feed efficiency (FE). A secondary aim was to determine if ALS was associated with health outcomes during the feeding period. The final aim was to determine if the ALS was correlated with carcass quality.

Materials and Methods

This study was conducted at a commercial feedlot in central Iowa. It began on August 29, 2017, and was completed on September 28, 2018. It was approved by the Institutional Animal Care and Use Committee of Iowa State University (IACUC Log number 4-17-8496-B).

Study design

This was a cohort study where calves were followed from feedlot arrival through slaughter. The experimental unit was the individual calf, the exposure of interest was ALS, and the primary outcome of interest was ADG. Other feeding performance outcomes investigated included FE, hot carcass weight (HCW), dressing percentage (DRESS), marbling score (MARB), fat thickness (FAT), and ribeye area (REA). Health outcomes of interest were treatment for BRD (RTX), death due to BRD (RD), being diagnosed with chronic BRD (RC), and deaths after treatment for BRD (RCF).

Setting

Calves were fed in outdoor lots with guard rail fencing on 3 sides and a feed bunk for the fourth side. Each pen had 9,500 ft^2 (882.6 m^2) with a concrete floor. Each pen had 84 ft (25.6 m) of bunk space and 12 ft (3.7 m) of water space. Calves were fed a total mixed ration daily that met or exceeded the National Research Council's requirements for growth.[7] Water was provided ad labium via automatic fence-line waterers.

Participants

The primary outcome of interest was a change in ADG. Sample size was based on the ability to detect a change of 0.10 lb (0.05 kg) in ADG. In order to detect this difference at a significance level of 0.05 and a power level of 80%, approximately 400 animals were needed in the study.

Dairy/beef crossbred steer calves were procured from calf growing operations in northern Indiana. The number of calves on a given load was determined by the number of calves deemed ready for shipment at the time of cattle procurement. Four loads of 80 to 111 calves were transported to the study feedlot. Criteria for shipment to the feedlot was based on vigor, weight, and frame size. Calves were transported to the research feedlot via a commercial tractor trailer. Because date of arrival and source of calves were seen as potential confounders, each trailer load of calves from a single source was placed in a separate pen and no other calves were added to the pen. Each pen was identified as 1 lot of cattle.

On arrival, calves were placed immediately in their home pen and allowed to rest for 48 h. At the time of initial processing, calves were vaccinated with a 5-way modified-live virus (MLV) respiratory vaccine[a] and a 7-way clostridial vaccine[b], poured with a permethrin and piperonyl butoxide topical[c], and orally drenched with fenbendazole[d] according to label directions. A single extended release growth promoting implant[e] was administered under the skin of the left ear. A sequentially numbered tag was placed in the right ear of each calf, and an ear notch (skin) was collected for immunohistochemistry testing to determine if any calf was persistently infected with bovine viral diarrhea virus (BVDV). Finally, an ALS was collected. No metaphylaxis or feed grade antibiotics were used for control or treatment of BRD at any point throughout the feeding period. At approximately 200 days-on-feed, cattle were re-implanted with a terminal growth-promoting implant[f] placed under the skin of the left ear.

Calves were monitored for sickness once daily. Any calf displaying clinical signs consistent with BRD (depression, decreased rumen fill, increased respiratory effort) was removed from its home pen and taken to the treatment chute for further evaluation. Once in the chute, a rectal temperature was taken. A calf with a rectal temperature greater than 104°F (40°C) or a depression score of at least 2 on a scale of 0 to 4[1] was treated for BRD. The first treatment for BRD was a single subcutaneous (SC) injection of tildipirosin[g] (1.81 mg/lb [4mg/kg] body weight [BW]). A 7-d post-treatment interval (PTI) was observed for any calf treated with tildipirosin. Calves requiring a second treatment for BRD were administered a single SC injection of florfenicol[h] (18.18 mg/lb [40mg/kg] BW). A 4-d PTI was observed for calves treated with florfenicol. Calves requiring a third treatment for BRD were administered a single SC injection of oxytetracycline[i] (13.64 mg/lb [30mg/kg] BW).

A diagnosis of "chronic" was made when an animal was not maintaining its body weight and thriving in its home pen for any reason. Animals could be diagnosed as "chronic" regardless of the number of times they had been treated. All animals that maintained body weight were left in the home pen to remain on trial. When an animal was removed from its home pen, a final weight was collected and that animal's end-point in the trial was labeled as "chronic". Any animal that died while on trial had a final dead weight collected and was recorded as "dead". A post-mortem exam was conducted on every animal that died to determine cause of death. A final live weight was collected at the feedlot 4 to 7 d prior to shipment for harvest. Carcass data were collected on an individual-animal basis in the harvest facilities.

Variables

All subjects were classified by ALS. The Whisper® stethoscope[j] was placed in the instructed location on the right side of the calf's chest, and a recording was taken for 8 sec. Each lung score (1-5) was deemed appropriate by the algorithm software. Any lung score deemed insufficient for analysis was retaken. The stethoscope was operated by a single investigator (JLF) who was blinded to the scores. Scores were recorded by an assistant who did not evaluate calves in the pen for sickness. The proprietary algorithm used was developed as an aid in treatment decisions, and has been shown to be associated with treatment outcome.[3] A lung score of 1 = normal lung sounds; 2 = mild, acute pneumonia with mild crackles and rales; 3 = moderate, acute pneumonia with moderate crackles and rales; 4 = severe, acute pneumonia with severe crackles and rales; and 5 indicates the presence of pathology consistent with chronic pneumonia with diffuse, severe crackles and rales. Cattle with an ALS of 1 were the referent.

Age of each calf at arrival was determined by the birth date written on an ear tag and expressed in months. If an ear tag was missing, the age was not recorded and the missing data was omitted from the statistical evaluation. Individual arrival weights were collected in the chute at the time of initial processing.

The outcome of interest was ADG. This was a continuous variable expressed in lb/day. This was calculated by subtracting the calf's arrival weight from the final weight to establish total weight gained, and dividing total weight gain by the number of DOF at the time the final weight was taken; a higher ADG was the desired result. Utilizing the methodology outlined in Chapter 19 of the National Academies of Sciences, Engineering, and Medicine's Nutrient Requirements of Beef Cattle[7] where individual carcass weight and yield were obtained at harvest, FE was back-calculated on an individual basis by personnel at the Tri-County Steer Carcass Futurity Cooperative (Lewis, IA). Total net energy delivered to the pen was then allocated across the number of live calves when final weights were taken. This allocation was based on the net energy retained in the form of individual carcass weight and fat (yield grade).[7] Feed efficiency was expressed as a continuous variable and a calculated lower value was the desired result. Hot carcass weight, DRESS, MARB, FAT, and REA were collected at the harvest facility by a contracted data collection service which was blinded to arrival lung score. All were expressed as continuous variables.

The investigators (JLF, TJE) that monitored calf health and administered treatments were blinded to the arrival lung scores. Treatment for BRD was a dichotomous variable; calves were either treated for BRD at least once or not treated at all. Death due to BRD and being diagnosed with chronic BRD were also dichotomous variables; either calves died of BRD or they did not, and calves were either diagnosed with chronic BRD or not. A respiratory case fatality was defined as any calf that died of BRD after being treated for BRD. This was also a dichotomous variable. All fatal BRD cases were classified as RD, but only those that died of BRD that had been treated at least once were classified as an RCF.

Statistical Methods

A causal diagram was used to determine the appropriate set of covariates to estimate both total and direct effect of the exposure of interest (ALS) on the outcome of interest (ADG). A directed acyclic graph-generating software[k] was used to identify covariates that would need to be controlled for in the linear regression model. The causal diagram was created with the input of all authors.

Individual linear regression models were used to evaluate correlations between ALS and FE, HCW, DRESS, MARB, FAT, and REA for those animals that were successfully harvested. Logistic regression models were used to evaluate associations between ALS and RTX, RD, RC, and RCF. A 2-tailed p-value less than or equal to 0.05 was considered significant. Residual plots were created to determine if significant outliers were present in the data. Significant outliers were removed from the data set. Arrival lung score was evaluated as both a continuous variable as well as a factor variable. For arrival lung score, linearity in the logit was evaluated to determine if the variable was a factor or a continuous variable.

Finally, a survival analysis was performed and a survival curve was created for each lung score. This was done to determine if timing of cattle death or diagnoses of chronic BRD was impacted by ALS.

Results

Participants

In total, 401 steers were enrolled at the start of the trial in 4 lots. None of the calves were persistently infected with BVDV based on immunohistochemistry testing. Eleven animals were removed from the trial due to lost identification, and 1 was removed when it was found to be a bull instead of a steer. Health data from 389 steers was used for the health outcomes analyses and ADG analysis. Due to errors in data collection at 1 of the harvest facilities, carcass data were collected on only 227 steers. This resulted in the inclusion of only 227 steers in the FE calculations and analysis.

Descriptive data

Average arrival weight of the 401 initial steers was 485 lb (220 kg), with a range of 328 to 703 lb (149 to 319kg), and average arrival age was 6.75 mo (range 5 to 8.8 mo). The average ALS was 3: 33 calves (8.2%) had a lung score of 1; 107 calves (26.7%) had a lung score of 2; 137 calves (34.2%) had a lung score of 3; 69 calves (17.2%) had a lung score of 4; and 55 calves (13.7%) had a lung score of 5 (Figure 1). Figure 2 shows the distribution of lung scores within each of the 4 lots of cattle.

Health data were available for 389 steers at the end of the study; of these, 132 (33.9%) were treated at least once for BRD. A total of 15 steers died (3.9%). Of the 15 deaths, 8

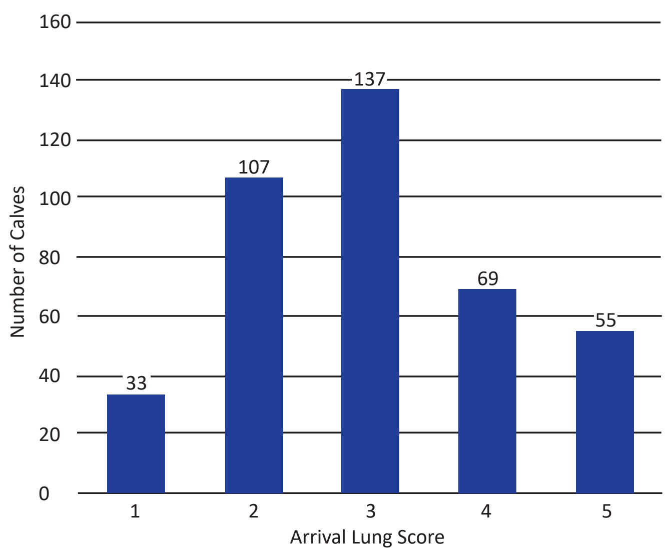

Figure 1. Distribution of arrival lung scores for 401 calves.

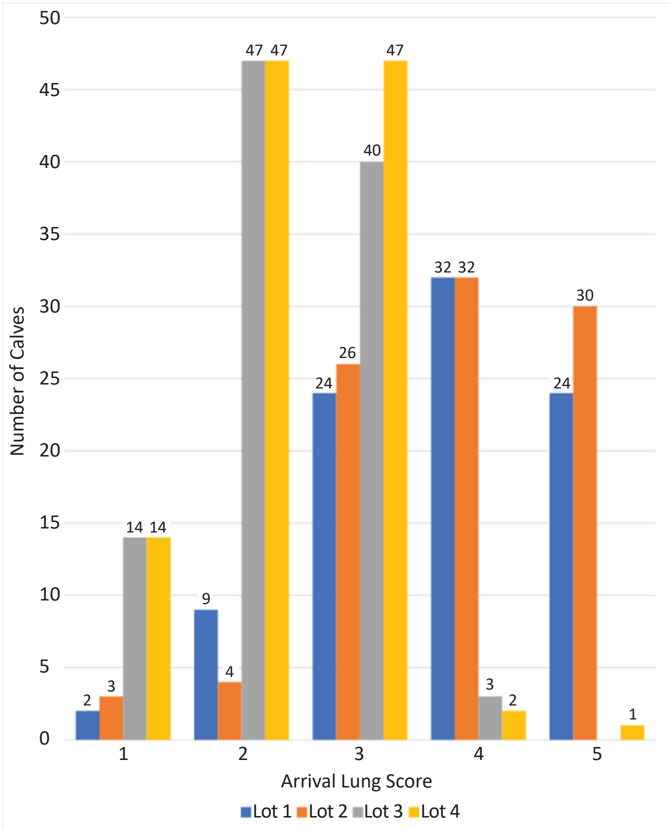

Figure 2. Distribution of arrival lung scores for 401 calves by lot.

(2.1%) died of BRD and 7 (1.8%) died of other causes. Forty steers (10.3%) were classified as chronic during the trial. Of these, 18 (4.6%) were diagnosed with chronic pneumonia and 22 (5.7%) were diagnosed with other chronic illnesses, predominantly lameness. Table 1 displays the descriptive data and the incidence of each health metric by lot, while Table 2 displays the descriptive data by ALS.

Main Results

Both age and weight at arrival were significant covariates (Figure 3). Lot was added to the linear mixed model as a fixed effect, and ALS was evaluated as a factor variable. While ADG numerically increased with lung score, differences were not statistically significant ($p > 0.1$). Mean ADG and standard error for each ALS is displayed in Table 3. Calculated FE numerically improved as lung score increased (Table 4), but this improvement was only statistically significant for calves with an ALS of 4 ($p = 0.02$) or 5 ($p = 0.005$). Univariate linear models for HCW, DRESS, MARB, FAT, and REA all showed no significant association between the variables and ALS.

A summary of treatment outcomes and deaths due to BRD are shown in Table 5. There were no significant differences in percentage of cattle treated for BRD, death loss due to BRD, chronic rate, or case fatality rate in calves treated for BRD across ALS scores.

The odds of being treated for BRD was significantly greater for those calves with an ALS of 5 when compared to the referent group (ALS 1; $p = 0.02$). The odds of calves with an ALS of 4 dying of BRD were significantly greater than those of the referent group ($p = 0.04$). The odds of being diagnosed with chronic BRD or suffering from a fatal case of BRD did not change with ALS. Only 1 untreated animal died of BRD; this animal had an ALS of 5. Survival curves of all 5 lung scores did not differ significantly at any point in time, nor did survival to slaughter differ among lung scores (Figure 4).

Discussion

In general, analysis of diagnostic tests can be difficult. In cases where no gold standard exists, a diagnostic test analysis becomes nearly impossible. Classification bias was a major concern in this trial. With no gold standard for the diagnosis of BRD, it became impossible to know the true association between ALS and true incidence of BRD. As a result, measures of cattle feeding performance (ADG and FE) were used as a proxy for BRD incidence. Cattle with BRD are known to have reduced ADG and less favorable FE. Economic variables are easier and more reliably quantified than health measures as there is less classification bias in measuring ADG and FE compared to health metrics such as diagnosis and treatment of BRD, and defining chronic cases.

Prior to the start of this trial, we did not have a good estimate of the distribution of lung scores. Originally, it was hypothesized that the distribution would be front-end loaded, with the majority of cattle having lung scores of 1 and 2 and only a few calves having lung scores of 4 and 5. This was derived from previous research using the Whisper® stethoscope as a diagnostic tool.[3] The distribution of lung scores in cattle treated for illness in a previous study was heavily skewed to the left, with only 1.5 to 3.0% of cattle having a lung score of 4 or 5.[3] However, the distribution of lung scores in the current study showed a bell curve centered at lung score 3. Both lung scores of 4 and 5 were more common than lung score 1. This difference could be due to the population of calves that arrived at the feedlot with undiagnosed BRD. Clinical evaluation fails to identify all cases of BRD in the feedlot.[8,11] In the present study, the ALS for all calves, both treated and untreated, was determined during arrival processing. Furthermore, the impact of age, weight, and transportation on ALS have not been investigated. More cattle need to be evaluated at feedlot arrival in order to better understand the normal distribution of ALS.

The discrepancies seen between the lung score distribution do not impact the generalizability of this study to other populations. This study had a higher proportion of cattle with ALS 4 and 5, which made the association easier to identify but does not mean that the association does not exist in a population of cattle with fewer ALS 4 and 5.

Previous research has demonstrated the utility of using causal diagrams to determine the appropriate set of covariates for which to adjust.[5,6] Figure 3 shows the causal diagram

Table 1. Descriptive data for 389 calves by lot.

Variable	Lot 1	Lot 2	Lot 3	Lot 4
Number of observations, n	80	95	103	111
Average arrival age, months	6.9	7.3	6.2	6.7
Maximum arrival age, months	7.9	8.8	7.4	7.4
Minimum arrival age, months	6.5	6.1	5.1	6.1
Average arrival weight, lb	504.2	507.5	493.0	448.2
Maximum arrival weight, lb	705	690	695	640
Minimum arrival weight, lb	340	365	350	330
Number ALS 1 N=33 (8.5%)	2 (2.5%)	3 (3.2%)	14 (13.6%)	14 (12.6%)
Number ALS 2 N=105 (27.0%)	8 (10.0%)	4 (4.2%)	46 (44.7%)	47 (42.3%)
Number ALS 3 N=134 (34.4%)	21 (26.3%)	26 (27.4%)	40 (38.8%)	47 (42.3%)
Number ALS 4 N=66 (17.0%)	29 (36.25%)	32 (33.7%)	3 (2.9%)	2 (1.8%)
Number ALS 5 N=51 (13.1%)	20 (25.0%)	30 (31.6%)	0 (0.0%)	1 (0.9%)
Treatment for BRD N=132 (33.9%)	27 (33.8%)	37 (38.9%)	37 (35.9%)	31 (27.9%)
Death due to BRD N=8 (2.1%)	2 (2.5%)	1 (1.1%)	1 (0.9%)	4 (3.6%)
Diagnosed with chronic BRD N=18 (4.6%)	1 (1.3%)	3 (3.2%)	5 (4.8%)	9 (8.1%)
BRD case fatality rate N=7 (5.3%)	2 (7.4%)	1 (2.7%)	1 (2.7%)	3 (9.6%)

Table 2. Descriptive data for 389 calves by arrival lung score (ALS).

Variable	ALS 1	ALS 2	ALS 3	ALS 4	ALS 5
Number of observations, n	33	105	134	66	51
Average arrival age, months	6.5	6.5	6.7	7.1	7.1
Maximum arrival age, months	7.6	7.5	8.8	8.5	8.3
Minimum arrival age, months	5.2	5.1	5.1	6.1	6.5
Average arrival weight, lb	481.7	487.2	483.5	491.9	485.7
Maximum arrival weight, lb	640	705	695	665	640
Minimum arrival weight, lb	340	330	345	340	345
Number Lot 1 N=80 (20.6%)	2 (6.1%)	8 (7.6%)	21 (15.7%)	29 (43.9%)	20 (39.2%)
Number Lot 2 N=95 (24.4%)	3 (9.1%)	4 (3.8%)	26 (19.4%)	32 (48.5%)	30 (58.8%)
Number Lot 3 N=103 (26.5%)	14 (42.4%)	46 (43.8%)	40 (29.9%)	3 (4.5%)	0 (0.0%)
Number Lot 4 N=111 (28.5%)	14 (42.4%)	47 (44.8%)	47 (35.1%)	2 (3.0%)	1 (2.0%)

used to determine the necessary covariates needed to model the effect of ALS on ADG. This causal diagram showed that arrival weight and arrival age were the only 2 covariates that needed to be adjusted for in the final model. Lot was included in the linear mixed model as a fixed effect because it accounted for source, date of arrival, and pen density in which the calves were fed. These were the only 3 variables that differed among the feeding groups.

Average daily gain numerically increased as ALS increased. However, once the linear mixed model adjusted for arrival weight, arrival age, and controlled for lot, there were no significant differences between any of the ALS. Wilson et al reported an increase in ADG for calves treated for BRD compared to calves that were never treated[10]. Because this increase in ADG was most prominent in the feeding period immediately after treatment, it was concluded that the increase was a result of compensatory gain. Increased rates of treatments among calves with ALS of 4 and 5 would mean more cattle experiencing compensatory gain as Wilson et al noted, leading to the numerically increased ADG. However, the increase was small and not statistically significant. Calves in the current study were also on feed for an extended period of time. The maximum days-on-feed was 367 d, with average days-on-feed being 294.7 d. Cattle were harvested when contracted dates could be arranged with the harvest facilities. It is possible that the effects of ALS could be mitigated by the extended period of time these cattle spent on feed. Calves with higher ALS had more time to accumulate compensatory gain later in the feeding period.

In the current study, it was not possible to feed calves grouped by ALS so that FE could be measured by actual feed intake, so FE was calculated using a previously described methodology.[7] Calculated FE improved in the ALS 4 and 5 groups. Busby found that steers treated for BRD at least once

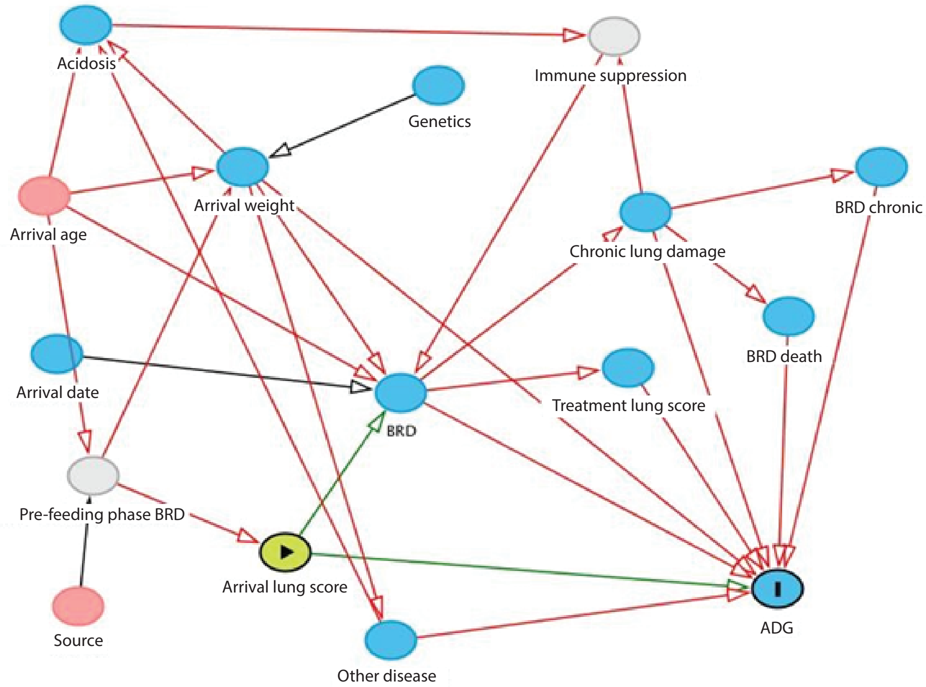

Figure 3. Causal diagram created for model building.

Table 3. Model adjusted least square mean (± SE) of average daily gain by arrival lung score (ALS); deads were not included. Model included arrival weight and lot as fixed effects. Arrival lung score 1 was the referent.

Outcome	ALS 1	ALS 2	ALS 3	ALS 4	ALS 5
Number of observations, n	33	105	134	66	51
Average daily gain, lb/day	2.54 ± 0.09	2.51 ± 0.04	2.56 ± 0.04	2.60 ± 0.04	2.67 ± 0.04

Table 4. Univariant linear regression model least square means (± SE) of calculated feed efficacy and carcass characteristics by arrival lung score (ALS); deads were not included. Arrival lung score 1 was the referent.

Outcome	ALS 1	ALS 2	ALS 3	ALS 4	ALS 5
Number of observations, n	12	47	67	56	45
Feed efficiency, lb feed/lb gain	8.01 ± 0.25	7.75 ± 0.13	7.63 ± 0.10	7.42 ± 0.08*	7.30 ± 0.09†
Hot carcass weight, lb	826.75 ± 90.25	831.61 ± 31.20	794.37 ± 35.67	821.64 ± 32.96	806.65 ± 35.65
Dressing percentage, %	59.1 ± 1	61.9 ± 0	59.8 ± 1	61.6 ± 1	59.4 ± 1
Marbling score	510.08 ± 27.58	465.60 ± 16.60	457.69 ± 14.58	469.22 ± 14.57	462.05 ± 16.34
Fat thickness, inch	0.41 ± 0.08	0.38 ± 0.02	0.38 ± 0.02	0.40 ± 0.02	0.38 ± 0.02
Ribeye area, square inch	14.83 ± 0.34	14.87 ± 0.21	14.21 ± 0.24	14.40 ± 0.25	14.36 ± 0.28

* p-value 0.02
† p-value 0.005

had significantly improved FE.[2] He hypothesized that this was due to a reduction in feed intake. Feed efficacy is simply a ratio of feed consumed to weight gained. If disease is reducing feed intake by a greater proportion than it is reducing the weight gain, then cattle will appear to be more efficient. Compensatory gain seen after treatment, as noted by Wilson et al, coupled with reduced feed intake could lead to significant improvements in FE. Wilson et al also noted an improvement in FE with increasing number of BRD treatments.[10] This is in contrast to other research that found treatment for BRD had a negative effect on FE.[4]

None of the carcass metrics showed a trend or association with ALS. Previous research has shown that steers treated for BRD have lighter carcasses, less fat, and lower

Table 5. Incidence of each health metric by arrival lung score (ALS).

Outcome	ALS 1	ALS 2	ALS 3	ALS 4	ALS 5
Number of calves, n	33	105	134	66	51
Treatment for BRD	7 (21.2%)	30 (28.6%)	49 (36.6%)	23 (34.8%)	23 (45.1%)
Death due to BRD	0 (0.0%)	2 (1.9%)	0 (0.0%)	4 (6.1%)	2 (3.9%)
Diagnosed with chronic BRD	0 (0.0%)	5 (4.8%)	10 (7.5%)	1 (1.5%)	2 (3.9%)
BRD case fatality	0 (0.0%)	2 (6.7%)	0 (0.0%)	4 (17.4%)	1 (4.3%)

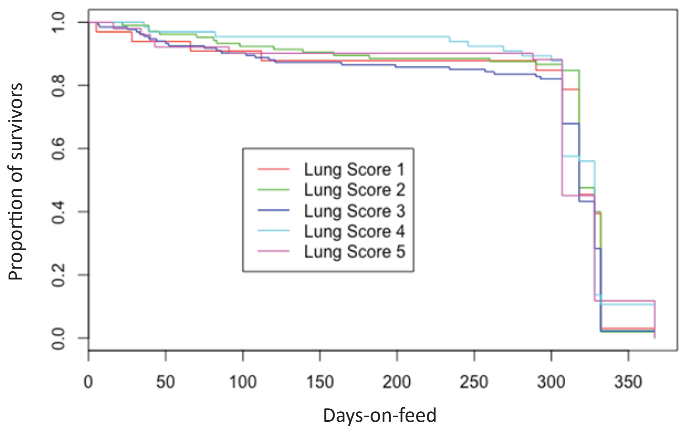

Figure 4. Survival curve by arrival lung score.

quality grades at slaughter.[4] Calves with an ALS of 5 were the only group with a statistically significantly increased risk of being treated for BRD. Without a strong association with BRD treatment, it would not be expected that carcass traits would be associated with ALS. There is also selection bias in the reported carcass metrics. These cattle were harvested at 2 separate harvest facilities. One of those facilities only slaughtered cattle that were black hided and could qualify for the Certified Angus Beef program. Because of this, cattle were sorted by coat color when they were harvested. Pens of cattle were shipped in the same order that they were received, and the entire pen was shipped within a week to the 2 harvest facilities. Carcass data were lost from 1 plant, which resulted in the data not being a random sample of the cattle in this trial. Cattle with ALS of 4 and 5 were disproportionately over-represented in the carcass data. Overall, the relatively small number of cattle that did have complete carcass data made it difficult to find significant differences due to this unintended reduction in sample size.

The treatment rate for BRD numerically increased as ALS increased; however, only the calves with an ALS of 5 had an odds ratio significantly higher than the referent ALS of 1 (P=0.02). Calves with an ALS of 5 were 27% more likely to be treated for BRD than calves with any other ALS. This is not the odds ratio for suffering from BRD, it is the odds ratio for being diagnosed with and treated for BRD. Classification bias almost certainly is an issue with this metric as there is no gold standard for diagnosis of BRD. The odds ratio for calves dying from BRD was significantly higher in those with an ALS of 4 compared to other ALS (P=0.04). Calves with an ALS of 4 had a 6% increase in the odds of dying from BRD compared to other calves. Unlike morbidity, cause of death can be accurately diagnosed by performing a necropsy. However, possibly due to the small number of respiratory deaths, significant differences in deaths between lung scores were not found. In addition, the relatively small numbers of BRD deaths and BRD treatments meant that significant differences in case fatality rates were not found.

The survival curve analysis (Figure 4) showed no differences in timing of death due to BRD or being diagnosed with chronic BRD. There was no association between ALS and the odds of being diagnosed with chronic BRD or dying after treatment for BRD. It was hypothesized that calves with more extensive lung lesions would be treated sooner and develop chronic BRD sooner; however, the survival curve did not support this hypothesis.

If ALS is a proxy for previous lung damage due to BRD, then more extensive lung pathology can lead to an increased risk of BRD treatment and death. By knowing that a higher ALS is associated with higher risk of treatment or death, interventions could be used to help mitigate some of that risk,

Table 6. Unadjusted odds ratios (95% confidence intervals) of univariate health performance models.

Outcome	LS 1	LS 2	LS 3	LS 4	LS 5
Treatment for BRD	1.00	1.07 (0.90-1.30)	1.16 (0.97-1.39)	1.15 (0.94-1.39)	1.27 (1.03-1.57)*
Death due to BRD	1.00	1.02 (0.96-1.07)	1.00 (0.95-1.05)	1.06 (1.00-1.13)†	1.04 (0.98-1.11)
Diagnosed with chronic BRD	1.00	1.05 (0.97-1.14)	1.07 (0.99-1.16)	1.02 (0.93-1.11)	1.04 (0.95-1.14)
BRD case fatality	1.00	1.23 (0.71-2.16)	1.17 (0.69-2.01)	1.12 (0.63-1.97)	0.93 (0.53-1.67)

* p-value 0.02
† p-value 0.04

such as selectively treating calves at arrival with a high ALS or placing them in a lower stress environment (such as on pasture). Since ALS is not associated with being diagnosed with chronic BRDC or an increase in BRDC case fatality, the treatment outcome should still be favorable.

Conclusion

While ADG numerically increased as ALS increased, no significant correlations could be made between ADG and ALS in this project. Calculated FE was significantly improved in those calves with ALS of 4 and 5. Odds of being treated for BRD and dying of BRD tended to increase with ALS, but the increase was small and only significantly different in calves with the highest ALS. Statistically significant differences in carcass traits were nearly impossible to find due to an inadvertent decrease in power caused by a loss of a significant amount of data at the harvest facility. The algorithm for assignment of lung scores used in this study was originally designed to aid in treatment decisions and has been associated with treatment outcomes. The idea of developing a different algorithm that could be used at feedlot arrival to better predict feeding and health performance should be explored. Further investigation is needed to determine if a Whisper® stethoscope lung score taken at arrival is associated with long-term feeding performance or health outcomes.

Endnotes

[a] Vista 5®, Merck Animal Health, Whitehouse Station, NJ
[b] Vision 7®, Merck Animal Health, Whitehouse Station, NJ
[c] Ultra Boss®, Merck Animal Health, Whitehouse Station, NJ
[d] Safe-Guard®, Merck Animal Health, Whitehouse Station, NJ
[e] Revalor-XS®, Merck Animal Health, Whitehouse Station, NJ
[f] Revalor 200®, Merck Animal Health, Whitehouse Station, NJ
[g] Zuprevo®, Merck Animal Health, Whitehouse Station, NJ
[h] Nuflor®, Merck Animal Health, Whitehouse Station, NJ
[i] 300 Pro LA®, Norbrook Laboratories, Newry, Northern Ireland
[j] Whisper® Veterinary Stethoscope, Merck Animal Health, Whitehouse Station, NJ
[k] DAGitty v2.3, http://www.dagitty.net/dags.html#

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