Lung auscultation as a predictor of lung lesions and bovine respiratory disease treatment outcome in feedyard cattle.

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Abstract

Studies were conducted to examine the ability of lung auscultation to predict bovine respiratory disease complex (BRDC) case outcome in feeder cattle. In the first study Lung sounds were obtained and lung auscultation scores (LAS) were assigned by trained personnel. In the first study antemortem physical examination and LAS were correlated with lung pathology and lesion scores when the cattle at harvest. There was a correlation (R^2 =0.89; P <0.0001) between ante-mortem LAS and post-mortem lung lesion score. Next, a field study was conducted to evaluate LAS and case outcome in feeder cattle treated for BRDC(n = 4,341 head). Lung auscultation score (P <0.01) and rectal temperature (P <0.01) were predictive of cattle with increased risk for BRDC retreatment and death loss rates. The model-adjusted probability of a calf with a lung auscultation score of 2 requiring retreatment was 13% whereas the re-treatment probability for cattle assigned a LAS of 9 was 63%. A rise in rectal temperature from 100 to 108 ºF correlated with a 266% increase in likelihood to be retreated for BRDC.

The risk of death from BRDC increased nearly 2,200%, from 1.7% to 39%, as lung auscultation score severity proceeded from a score of 2 to 9. The risk of death from BRDC increased 196% as rectal temperature proceeded from 100 to 108 ºF. These studies demonstrate that lung auscultation score and rectal temperature could be used as tools to better predict BRDC case outcomes in feeder cattle and facilitate targeted management decisions.

Introduction

Bovine respiratory disease complex (BRDC) is the most common, and costly, disease in feedyard cattle. Significant amounts of money are spent on preventing and treating BRDC in the feedyard in just vaccines and antimicrobials alone. Loneragan estimated initial treatment costs alone in the calendar year of 1999 to be 45.7 million dollars[7]. Total economic losses were recently estimated to be as high as $692 million dollars in a survey from 2005 conducted by the National Agricultural Statistics Service, a division of the United States Department of Agriculture[12].

Death loss associated with BRDC in feeder cattle has been well documented. Vogel and Parrott published a feedyard mortality survey detailing data from 59 feedyards (38,593,575 head of cattle) in seven Midwestern states from January 1990 – May 1993. Deaths due to BRDC were 44.1% of total deaths in these feedyards. Digestive disorders attributed to 25.9%, and “other” causes accounted for 28.6% of all deaths over the three and a half year period[12]. Another estimate is provided by the United States Department of Agriculture (USDA) National Animal Health Monitoring System (NAHMS), in which data were collected from 21,753,082 head of cattle that were placed on feed from 1994 to 1999 (121 feedyards; 12 states)[8]. An analysis of these data found that the mortality tended to increase (P = 0.09) from 10.3 deaths per 1,000 head of cattle in 1994 to 14.2 deaths per 1,000 head of cattle in 1999 for all etiologies. Respiratory mortality rates increased from 5.4 deaths per 1000 head in 1994 to 8.7 per 1000 head in 1999[8].

Aside from obvious economic losses from death loss of cattle, there are performance issues attributed to this disease. Gardner *et al.* found that steers without lung lesions attributed to BRDC at slaughter had improved average daily gain (ADG) relative to cattle that had BRDC lung lesions (3.48 vs. 3.09 lb/d, $P < 0.01$)[5]. Similarly, Bryant *et al.* showed that BRDC lung lesions present at slaughter was associated with a decrease in ADG (0.057 lb/d) in single source calves and up to a 0.65 lb/d decrease in ADG in commingled calves compared to cattle in their respective groups that did not have lung lesions at slaughter[2]. More recently researchers in South Africa found that the negative effect on ADG in feeder cattle due to the presence of lung lesions at slaughter was 0.051 lb/d decrease compared to ADG in cattle without lung lesions at slaughter[11]. Additionally, the researchers reported that the presence of lesions at slaughter was associated with an additional 5.5 d to finish cattle.

In the U.S. feedyard system, disease detection starts with the pen riders. Pen riders are in the pens looking at cattle at least once per day for signs of any illnesses. Clinical signs that are used to identify cattle possibly afflicted with BRDC include respiratory rate, respiratory character, rumen fill, observed anorexia, nasal discharge, ocular discharge, and depression[1]. Chute-side feedyard diagnostics consist of examining clinical signs and taking rectal temperatures. Decisions on therapeutic regimens are often outlined in a treatment protocol and are generally based on a rectal temperature greater than some arbitrary cutoff, for example, ≥103.5 ºF[3].

Rectal temperatures can vary from the influence of such factors as environmental temperature, relative humidity, heat of fermentation, exercise, excitement, and anxiety. These changes in rectal temperature are the result of physiologic change rather than a pathologic one[4]. Vogel *et al* found that for each unit (F) increase in maximum ambient temperature, rectal temperature in all cattle pulled increased 0.07 ºF ($P < 0.01$)[13]. In the same study, they found that the rectal temperatures in cattle pulled and treated for BRDC had no association with the risk of re-treatment or mortality[13].

Using elevated rectal temperature as the sole diagnostic tool beyond clinical signs is essentially treating on the basis of depression with undifferentiated fever. Treatments based solely on this may lead to unnecessary antimicrobial use[1]. Additional diagnostic tools, such as a stethoscope, may aid in decision making; however, the literature is largely devoid of reports associating the use of a stethoscope as a diagnostic aid to better identify and manage BRDC or predict BRDC-case outcome in feeder cattle. Therefore, the objectives of this paper are to validate a thoracic auscultation scoring system by correlating ante-mortem lung sounds with post-mortem lung lesions and then evaluate chute-side diagnostic tools to predict case outcome in the feeder cattle treated for BRDC in a field setting.

Materials and Methods

Pilot Study

Cattle (n = 36) sold for salvage slaughter from feeding operations were used to validate a lung auscultation scoring system that could diagnose lung lesions. Twenty-seven head were delivered to a small backgrounding feedyard in Booker, Texas, and nine head were presented to Kansas State University Veterinary Diagnostic Laboratory (KSU

VDL). Ante-mortem evaluations that were performed consisted of general physical examinations including rectal temperature and thoracic auscultation. Lung sounds were scored at the time of examination using a 1 – 10 scoring system (Table 1.) utilizing an electronic stethoscope[a].. Regular stethoscopes are commonly utilized in the field to listen to lung sounds in the field. However, the electronic stethoscope was utilized in this study to amplify the lung sounds. Lung score groups were based on level of severity of the adventitious lung sounds. These groupings and case definition (i.e. 1 and 2 equal normal lung sounds; Table 1) were established by veterinarians that had used this technology extensively in the field[9]. When dealing with BRD in feeder cattle, most all of the lung sounds generated are crackles or rales.[9,10] Thus, the difference in severity in the scoring system has been based on the loudness and intensity of the crackles/rales when listening to the lungs of cattle. Lungs were scored systematically with auscultations performed in the area of the cranioventral lung fields and just dorsal to the approximate location of the carina on both the left and right sides of the thorax. Lung sounds were scored for both the left and right side of each calf.

Table 1. Ante-mortem auscultation scoring system

Lung Score	Auscultation Findings
1 – 2	Normal lung sounds
3 – 4	Mild adventitious lung sounds (crackles/rales)
5 – 6	Moderate adventitious lung sounds (crackles/rales)
7 – 9	Severe adventitious lung sounds (crackles/rales)
10	Diffuse, severe adventitious lung sounds (crackles/rales)

In addition to general physical examinations, calves in Booker, TX, were ear tagged with a unique identification system to ensure their proper identification at the packing plant. After examination, the cattle in Booker, TX, were transported to a nearby abattoir for harvest. Several checkpoints were set up within the packing plant in order to ensure the correct lung lesion scores were matched with the correct animal as previously described. At harvest, lungs were evaluated and scored using a scoring system modified from that previously developed by other research groups.,[2,6] (Table 2). Lung lesion scores were determined for both left and right lung lobes.

Table 2. Post-mortem lung lesion scoring system[2]

Lesion score	Post-mortem Findings
0	Normal lung / No lesions
1	Total affected area or volume involving less than one cranioventral lobe (<5% lung volume) and/or adhesions (fibrin tags)
2	Adhesions affecting more than one cranioventral lobe (>5% lung volume) and/or missing piece of lung due to adhesions
3	Missing lung >15% of total lung area (>three cranioventral lobes) and/or active tracheobronchial lymph nodes

Cattle deemed chronically ill from a backgrounding yard in Centralia, KS, were presented to KSU VDL for diagnostic evaluation. All cattle were given similar ante-mortem examinations as the cattle received in Booker, TX, and auscultation scores were similarly assigned. All calves were humanely euthanized and a complete necropsy was performed. Lung lesion scoring was performed with the similar system as the other group of cattle on the study.

Separate lung auscultation scores (LAS) were recorded on the left and right side of each animal and a collective lung lesion score (LLS) was recorded for both the left and right lung respectively. Initial data analysis indicated that there were no LAS or LLS differences between the left or right side of the animal. Therefore, the mean LAS and LLS values for the left and right sides of the cattle were used in the pilot study analysis. Statistical analysis was performed with LAS as the dependent variable to determine the extent of correlation with LLS utilizing linear regression (SAS)[b].

Field Study

A retrospective cohort study was conducted using data obtained from three commercial feedyards located in Kansas, Nebraska and Washington. Cattle enrolled in the study were treated for BRDC by trained feedyard personnel. Cattle that met the following enrollment criteria were included in the study: exhibited clinical signs of BRDC in the home pen and the LAS, rectal temperature, and treatment regimen were recorded at the time of BRDC treatment. Cases meeting the requirements for inclusion in the study totaled 4,341 head of cattle (KS, n = 287; NE, n = 404; WA, n = 3,650). Data recorded for cattle enrolled in the study included animal identification, rectal temperature, lung score, and antimicrobial therapy at first treatment.

After the animal had been enrolled in the study, the animal treatment outcomes were observed. Feedyard personnel entered treatment outcome data into an animal health computer. The outcome data tracked for this study included retreatment for BRDC or death.

In the field study, three feedyards were used but the numbers of calves (experimental units) from each feedyard were not equally represented and although the observers (persons assigning LAS) were trained by the same veterinarian, they were different at each feedyard. Mixed-model logistic regression was used and to account for potential clustering of outcome within specific feedyards, feedyard was forced into the models as a random variable.

Eight different treatment regimens were utilized by the three feedyards and therapeutic decisions were made depending on clinical findings, rectal temperature and LAS. Therefore, it was assumed that there could be a treatment effect on case outcome (retreatment or death loss rates). The antimicrobial regimen selected was highly co-linear with feedyard and, therefore, antimicrobial regimen was assumed to be at least partially controlled by including feedyard as a random variable in the statistical model.

Predicted values (retreatment and death) were obtained with 95% confidence levels using a model based on either LAS or rectal temperature. Only animals receiving LAS of 2 – 9 were included in the risk analysis Calves that were scored 1 were considered normal and received no BRDC treatment. Nearly all of (105/112) these calves came back to the hospital a second time for BRDC treatment. This would constitute a first treatment not a re-treatment of these calves for BRDC.

Results

Pilot Study

Two calves were removed from the study because one escaped the chute before lung sounds could be captured and the audiogram from another calf had too much background noise to adequately score lung sounds.

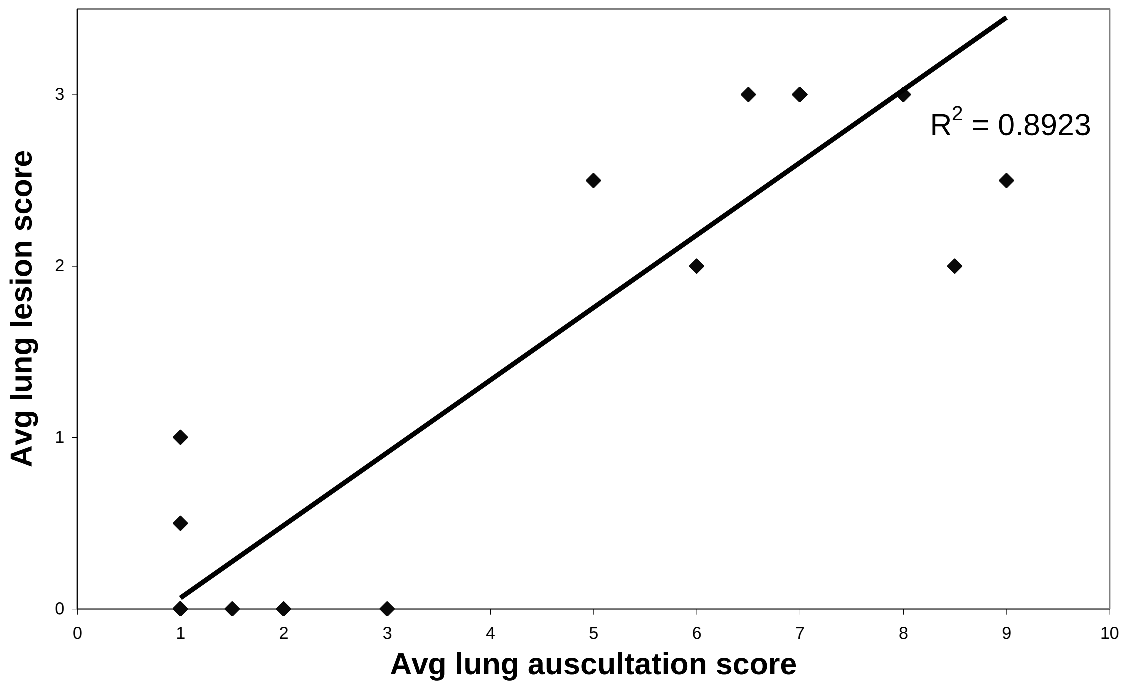
Forty-four percent of all cattle had lung lesions at post-mortem examination. Twenty cattle had LAS of 1 and LLS of 0 and were therefore likely sent to market early for reasons other than chronic respiratory disease as no pulmonary pathology was grossly or clinically evident. Eleven head of cattle received LLS of 3, or had severe lung pathology, and were likely realized due to chronic respiratory disease. The number of calves that were scored in each LAS and LLS are given in Table 3. A majority of the observations received LAS of 1, 7, 8, or 9 and subsequently received LLS of 0 or 3.

The results of the linear regression (Figure 1) revealed a strong positive correlation (R^2 = 0.89; P <0.0001) between ante-mortem LAS and post-mortem LLS. These data indicate that lung auscultation is predictive of lung lesions associated with BRDC.

Table 3. Ante-mortem lung auscultation and post-mortem lung lesion scores for thirty-four head of cattle realized from commercial feeding operations.

	Post-Mortem Lung Lesion Score							
	Left Lung Field				Right Lung Field			
Ante-mortem Lung Auscultation Score	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
1	19	1	0	0	16	2	0	0
2	0	0	0	0	1	0	0	0
3	1	0	0	0	2	0	1	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	1	0
6	0	0	0	0	0	0	0	1
7	0	0	1	8	0	0	0	6
8	0	0	0	3	0	0	0	2
9	0	0	1	0	0	1	0	1
10	0	0	0	0	0	0	0	0

Figure 1. Scatter plot of average ante-mortem lung auscultation score and post-mortem lung lesion score from thirty-four head of cattle realized from commercial feeding operations (P <0.0001).



Field Study

Cattle treated for BRDC that met the inclusion criteria described in the materials and methods for the field trial totaled 4,341 head. The distributions of calves within each LAS are reported in Figure 2. Ninety-six percent of cattle were observed to have a LAS range from 2 to 6 at the time of first BRDC treatment (Figure 2). Retreatment rate was defined as the percentage of cattle that did not respond to the first BRDC treatment and were subsequently treated a second time. Case fatality rates were the percentage of cattle that were treated for BRDC and died divided by the total number of cattle treated for BRDC.

Retreatment and case fatality rates for assigned LAS for cattle treated for BRDC in all three feedyards are shown in Table 4. Lung auscultation score was associated with probability of retreatment (Figure 3, $P < 0.01$) and case fatality rates (Figure 4, $P < 0.01$) in calves diagnosed and treated for BRDC. The model-adjusted probability of a calf with a LAS of 2 at first treatment for BRDC being retreated was 13% while the retreatment rate for cattle assigned a LAS of 9 was 63%. This increase in retreatment risk associated with increasing LAS score is shown in Figure 3 ($P < 0.01$). The model-adjusted probability of post-treatment death increased from 1.7% to 39% as LAS score increased from 2 to 9 (Figure 4; $P < 0.01$).

Rectal temperatures ranged from 100.1 to 108.0 ºF. Summary statistics of the number of calves, re-treatment, and case fatality rates within each rectal temperature range from all three feedyards can be found in Table 5. Cattle that had rectal temperatures less than or equal to 104.0 ºF (26% of cattle enrolled) were observed to have a retreatment rate of 28.2% and a case fatality rate of 2.5%. Seventy-four percent of cattle enrolled in the study had rectal temperatures greater than 104.0 ºF. The cattle with elevated rectal temperatures were observed to have retreatment rates of 40.6% and a case fatality rate of 5.1% in this study. Rectal temperature was also predictive of retreatment (P <0.01) and case fatality rates (P <0.01) in calves treated for BRDC. A rise in rectal temperature from 100 to 108 ºF correlated with an increase in likelihood to be retreated for BRDC (Figure 5). The risk of death from BRDC increased as rectal temperature proceeded from 100 to 108 ºF (Figure 6).

Figure 2. Distribution of calves by lung auscultation score received at the time of first treatment for bovine respiratory disease complex in three feedyards from three different states.

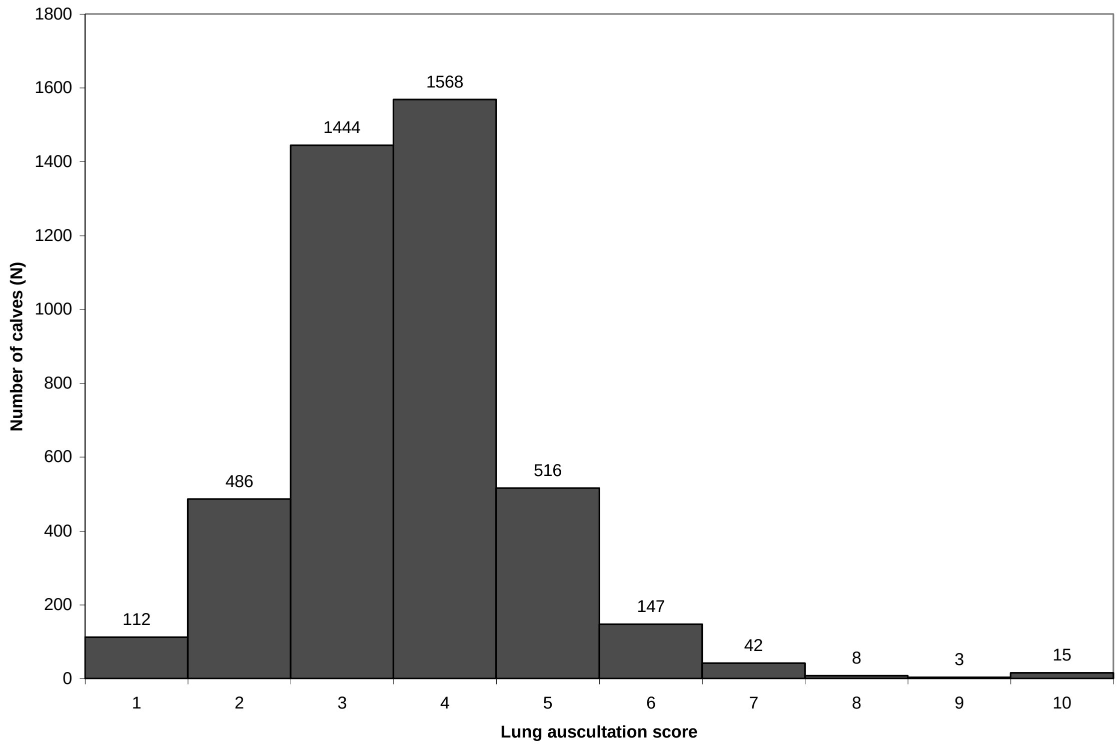


Table 4. Number of calves, and model-adjusted probability of retreatment rates and case fatality rates, by lung auscultation score at the time of initial treatment.

Lung auscultation score	Number of calves (n)	Re-treatment rate, %*	Case fatality rate, %**
2	486	25.3	1.0
3	1444	35.0	2.8
4	1568	39.9	4.2
5	516	45.3	8.1
6	147	40.1	14.3
7	42	35.7	26.2
8	8	37.5	25.0
9	3	66.7	33.3

* Re-treatment rate = (calves pulled for second treatment/calves pulled for first treatment)*100

** Case fatality rate = (calves that died/calves pulled for first treatment)*100

Table 5. Number of calves, and model-adjusted probability of retreatment rates and case fatality rates, by rectal temperature at the time of initial treatment.

Rectal temperature, ºF	Number of calves, (n)	Re-treatment, %*	Case fatality rate, %**
100-101.0	40	47.5	5.0
101.1-102.0	133	24.8	0.0
102.1-103.0	319	27.3	2.8
103.1-104.0	643	28.1	2.6
104.1-105.0	1120	33.3	3.1
105.1-106.0	1105	41.1	4.8
106.1-107.0	733	45.7	6.0
107.1-108.0	248	56.0	12.9

* Re-treatment rate = (calves pulled for second treatment/calves pulled for first treatment)*100

** Case fatality rate = (calves that died/calves pulled for first treatment)*100

Figure 3. Predicted risk of retreatment for BRDC by lung auscultation score modeled using logistical regression. The solid line is the model-adjusted risk (probability) of re-treatment. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P <0.0001)

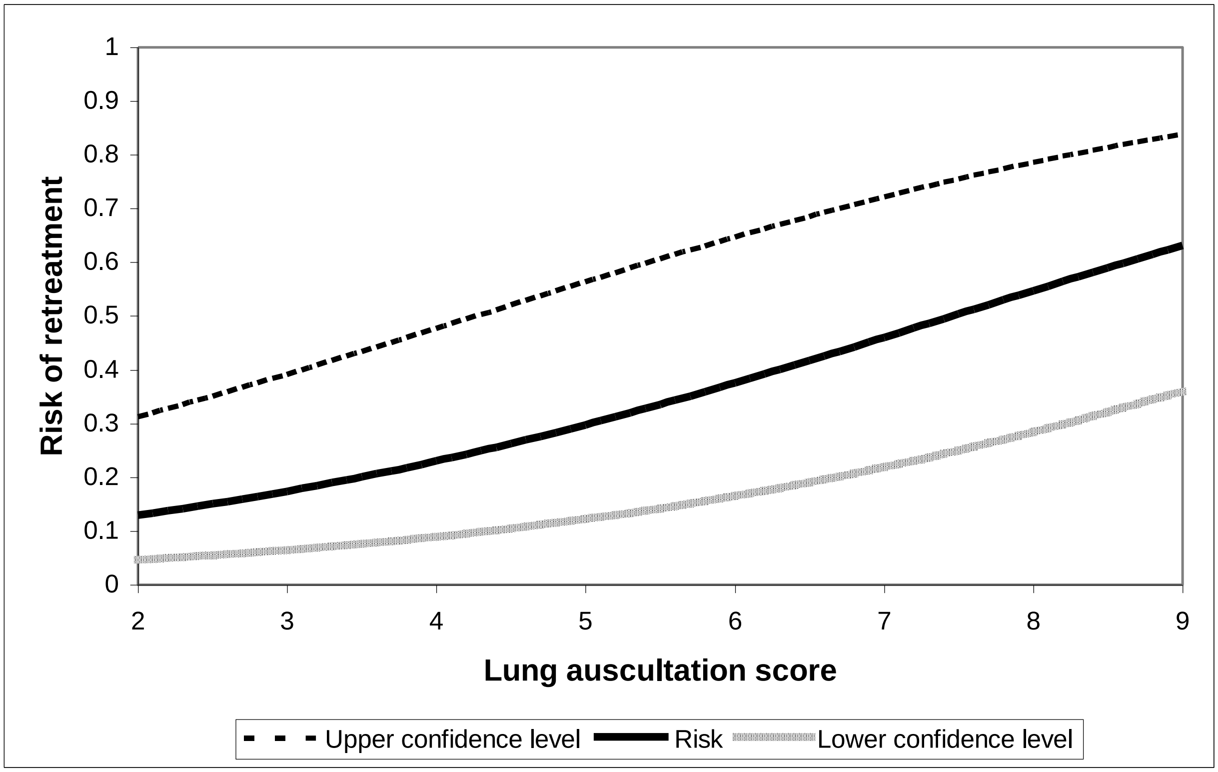


Figure 4. Predicted risk of a calf dying from BRDC by lung auscultation score modeled using logistical regression. The solid line is the model-adjusted risk (probability) of death. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P <0.0001)

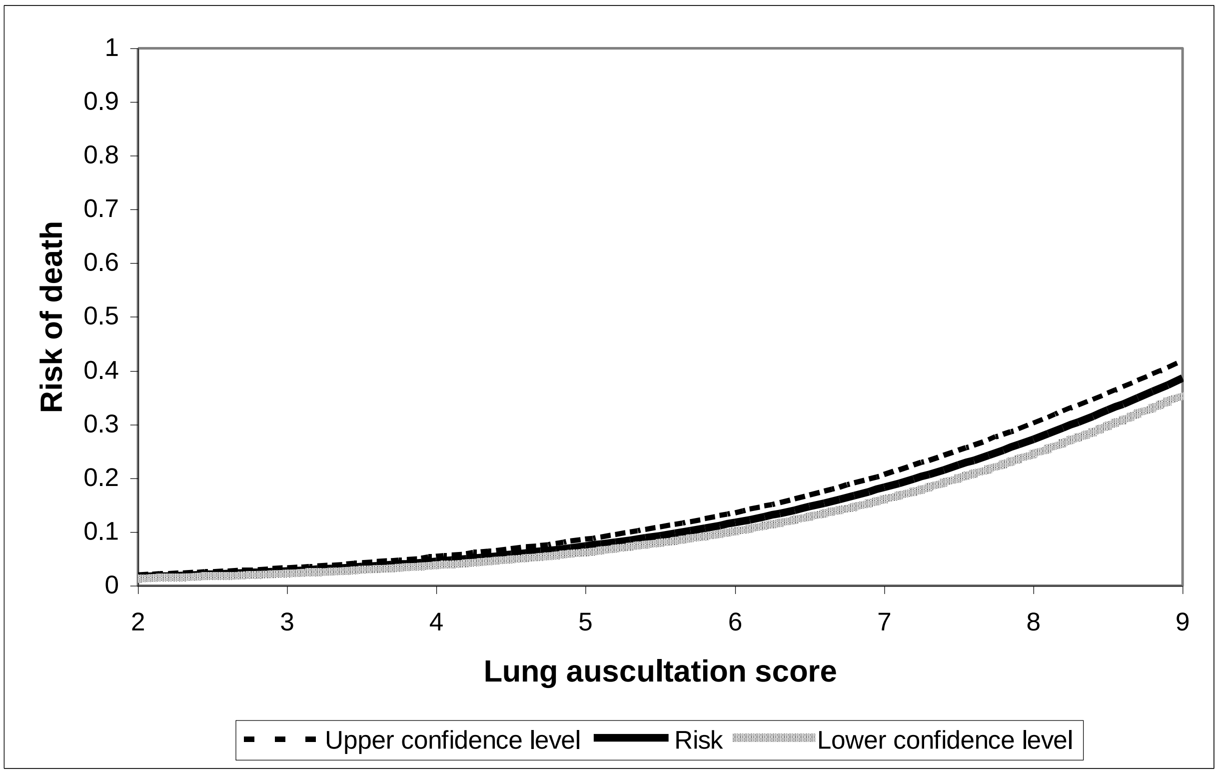


Figure 5. Predicted risk of re-treatment for BRDC by rectal temperature modeled using logistical regression. The solid line is the model-adjusted risk (probability) of re-treatment. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P <0.0001)

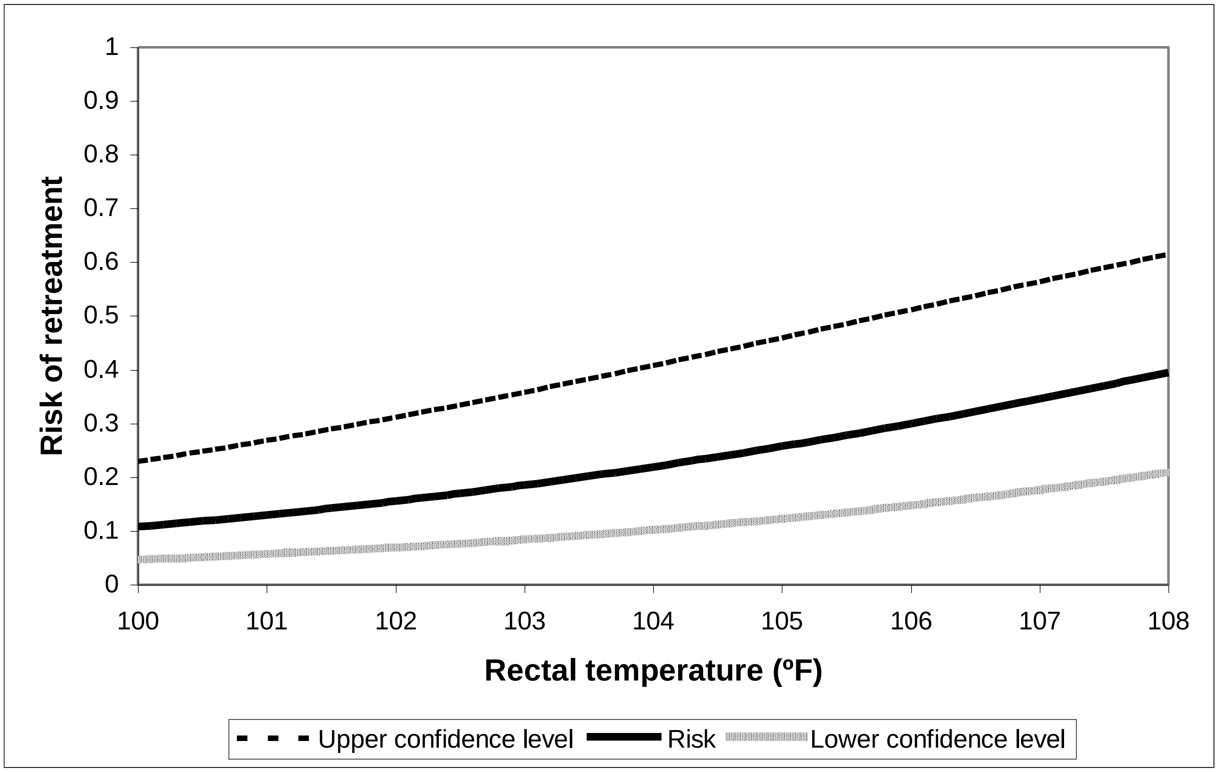
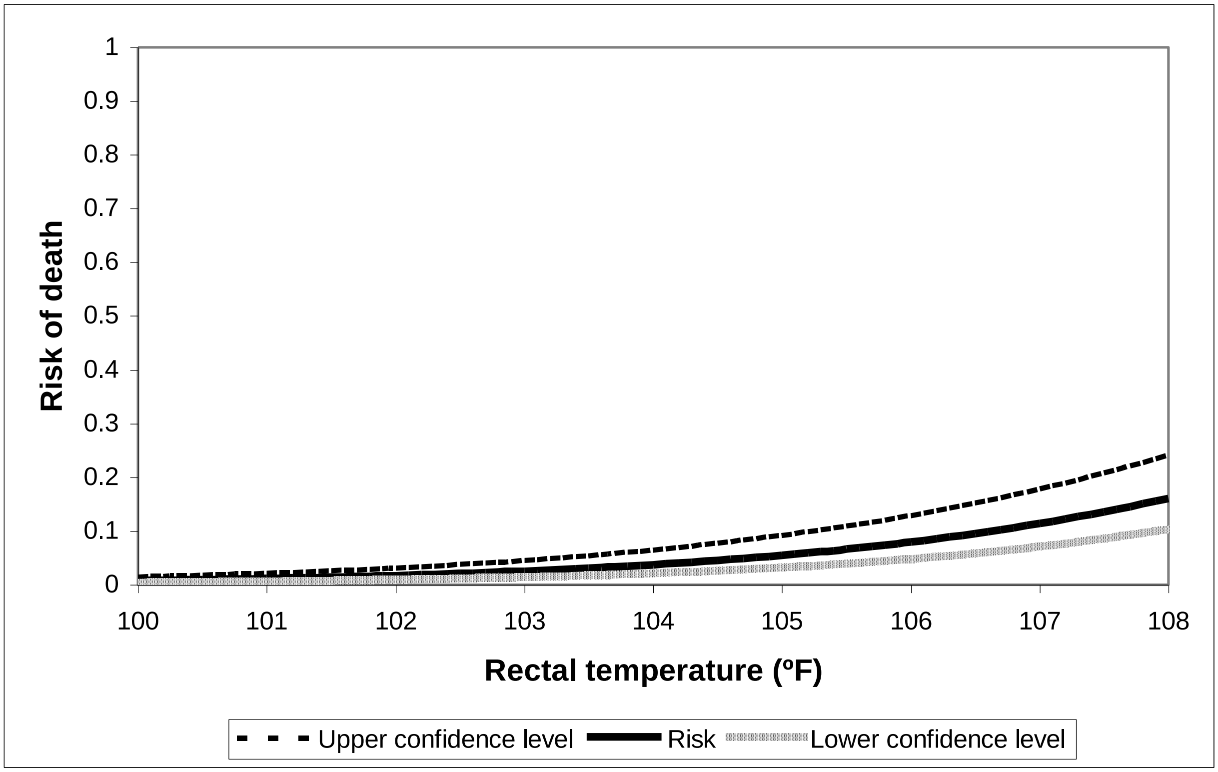


Figure 6. Predicted risk of a calf dying from BRDC by rectal temperature modeled using logistical regression. The solid line is the model-adjusted risk (probability) of death. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk.

(P <0.0001)



Discussion

In the study reported herein, we demonstrate that as LAS in cattle increase in severity the likelihood of finding severe post-mortem lung lesions increase. These data also show that LAS is predictive of retreatment rates and case fatality rates in various populations of feeder cattle treated for BRDC in that elevated LAS at the time of BRDC therapy was associated with increased risk of a calf being retreated or dying from BRDC. Also, rectal temperature was shown in this study to be predictive of retreatment and case fatality rates in cattle suffering from BRDC.

The percentage of cattle with lung lesions at slaughter in the pilot study is consistent with other published reports of post-mortem lung lesion examination in feedyard cattle[2.5.11]. These similarities in post-mortem lung lesions were interesting due to the fact that cattle involved in the study reported here were sold to salvage slaughter due to poor performance or diagnosed as chronically ill whereas previous reports involved cattle shipped as fat cattle to a harvest facility. Forty two percent of all the cattle in our pilot study had lung lesions at post-mortem examination. Researchers found that 54% of all cattle from a commercial feedyard in Nebraska had lung lesions present at slaughter[2]. Other publications report similar results of 37% and 43%, respectively[5,11]. In one paper the austhors report slighter higher lesion incidence (72%) lung lesion rates at in feeder cattle at the time of slaughter[14].

Very little literature exists on relationships between diagnostic techniques and case outcomes. Researchers have evaluated case outcomes subsequent to BRDC treatment for relationships to the following clinical parameters: packed cell volume, plasma total protein, rectal temperature, maximum ambient temperature, body weight, and changes in body weight[13]. The only one variable they found associated with treatment outcome was a lower body weight relative to the estimated average pen weight (or changes in body weight) was associated with an increased risk of cattle not surviving to slaughter[13].

The field study reported herein demonstrates that rectal temperature was predictive of re-treatment and case fatality rates in cattle treated for BRDC which is in disagreement with findings from other published reports[13]. However in their study, rectal temperature in cattle treated for BRDC was correlated with ambient temperature when treatments occurred. We did not track the ambient temperatures in the field study. However, a study conducted in a feedyard in Central KS during the months of June through August did record record high ambient temperatures (some over 100 °F) during their study[13]. It is likely that ambient temperature was much more variable during our field study based on time of year in which it was conducted (October to June) or based on a geographical location (WA, NE and KS) than the study previously mentioned.

Retreatment rates and case fatality rates differed between the feedyards included in this study. The three feedyards in this field study had retreatment rates that ranged from 12.8 – 40.1% and case fatality rates from 3.9 – 8%. The range of these data is somewhat surprising. Although there was no feedyard by LAS interaction, the feedyard in WA had greater retreatment rates than the two feedyards in KS and NE. The opposite was true for case fatality rates, with the KS and NE yards having higher values than the WA feedyard. The feedyard in WA also had the most observations (3,650 head) compared to the other two feedyards. This example explains the need for technology to help identify sick cattle in the home pen or the use of LAS matched with clinical signs to decrease the number of cattle pulled to the chute not suffering from BRD. A feedyard that treats more cattle within a given health risk (potentially cattle not sick with BRD) would be expected to have a lower case fatality rate than a feedyard that treats fewer, more clinically ill cattle classified within the same health risk category. In this type of scenario, the BRD treatment is not more effective in the lower case fatality rate feedyards compared to the higher case fatality rate feedyards. The higher case fatality rate feedyards do a better job of diagnosing the right cattle to treat and have fewer false pulls than the lower case fatality rate feedyards.

Evaluator bias at the time of lung auscultation scoring could affect the results of the field study. The evaluation of calf clinical appearance (clinical signs of BRDC; i.e., depression, nasal discharge, etc) in the home pen or hospital chute could clearly bias the evaluator's interpretation and scoring upon thoracic auscultation. Treatment regimen selected after evaluation could be a confounding variable. Lastly, as mentioned previously, 84 percent of the data came from one feedyard and may introduce a feedyard effect that might not have been completely controlled in the model even though it was forced into the model.

Further research utilizing the stethoscope to assign different BRDC treatments based on severity of LAS score is warranted. Today, newer antimicrobial products used for BRDC treatment are costly compared to earlier earlier options. A controlled study evaluating case outcomes in cattle treated with different antimicrobial therapies within different LAS could improve case outcomes or decrease treatment costs in cattle suffering from BRDC. Future studies should measure performance and subsequent carcass characteristics in cattle within different LAS classes. These data could be used by producers to change marketing strategies of cattle to maximize profitability.

Conclusions

Lung auscultation scoring requires minimal capital input and can be performed chute side. These data indicate that lung auscultation can be used by trained technicians to predict case outcomes for BRDC. The results of this study may serve veterinarians and managers as they design treatment protocols better aimed at those animals associated with a higher risk of treatment failure or death from BRDC.

Endnotes

[a] 3M Littman Electronic Stethoscope Model 4100, St. Paul, MN, USA

[b] Statistical Analysis Software, Version 9.1.3, SAS Institute Inc., Cary, NC, USA

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