

Lung Ultrasonography and Computer-Aided Scoring System as a Diagnostic Aid for Bovine Respiratory Disease in Feedlot Cattle

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Abstract: Bovine respiratory disease (BRD) is one of the most important diseases in feedlot calves especially in intensely raised and newly transported calves. With the recent availability of modern portable diagnostic techniques, the veterinary practitioner can now be quickly examined the surface and superficial lung parenchyma at farm. The purpose of our study was to investigate the diagnostic utility of computer-aided lung scoring system and lung ultrasonography at initial diagnosis of naturally occurring BRD in feedlot cattle. A total of one hundred thirty-five feedlot calves at high risk of developing BRD were monitored daily during the first month after entry at the feedlot for clinical signs of BRD. Calves with visual signs of BRD identified by pen checkers were examined by computer-aided stethoscope and portable ultrasonography. For each calf examined for BRD, one pen matched apparently healthy calf was selected as control and examined in the same manner. Of the 135 steers, 24 BRD cases with 24 pen matched healthy controls calves were enrolled in our study. All feedlot calves with visual signs of BRD had abnormal lung sounds with lung scores ranging from 2 to 5. Moreover, lung ultrasonography identified lung lesions in 17/24 (70.83%) from BRD affected calves and 3/24 (12.5%) from pen matched controls. Our study results revealed that, using computer aided lung score at initial diagnosis of BRD with lung ultrasonography could help in improve case definition, treatment decision and evaluating disease risk during the initial identification of the diseased animals.

Key word: Feedlot cattle • Lung score • Ultrasonography • Bovine respiratory disease

INTRODUCTION

Bovine respiratory disease (BRD) is a standout amongst the most imperative calf health problems [1] and account for extraordinary financial loss in feedlot cattle industry [2]. It affects all cattle in every phase of production and representing roughly 75% of feedlot morbidity and 50-70% of all feedlot mortalities [3]. This percent of mortality and morbidity relies on upon the protocol of management system in feedlot and the included etiological agent [4]. The economic worldwide impact of BRD on the beef cattle industry been accounted to surpass \$4 billion every year, which incorporates the expenses for treatment, disease prevention and lost profitability due to the mortality and morbidity of the diseased calves [5]. The clinical diagnosis of BRD is

classically based on clinical signs, increased rectal temperature and its accurate determination in clinical field remains challenging [6]. Current strategies of BRD identification are subjective and frequently do not have the ability to predict BRD in its initial phases of development and the treatments based solely on this may lead to unnecessary antimicrobial use [7]. With a specific end goal to minimize this negative economic impact, distinctive individual biomarkers have been implemented at initial diagnosis of BRD for adequate management of these cases according to their anticipated outcome [8]. Several methods including lung auscultation, lung ultrasonography, radiographs, determination of acute phase protein and cytokines concentration have been used to improve accuracy of BRD diagnosis [9]. Among the distinctive diagnostic and prognostic strategies for

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diagnosis of BRD. Buczinsk *et al.* [6] stated that lung auscultation is cheap, less time consuming and can be conducted at chute side. Lung auscultation is subjective strategy and requires a very much experienced individual with great acoustic capacities to accurately recognize unusual and abnormal sounds [9]. To beat these drawbacks, a computer-aided lung auscultation system (Whisper® technology) has been validated for cattle [10]. This system could expand exactness of BRD diagnosis. However, to be helpful its precision to analyze BRD must be fundamentally assessed in a case-control study. Computer-aided lung auscultation system was a promising innovation to enhance accurate diagnosis of BRD in feedlots [11]. Its utilization could build the extent of steers precisely determined to have BRD by decrease in the percent of false-positive judgments. The consequence of this advancement in precision results in a dramatic reduction in feedlot mortality [10].

Lung ultrasonography is a non-invasive demonstrative and diagnostic device that has many applications in bovine medicine [12] including the respiratory infections in cattle [13]. Furthermore, ultrasonography of the lung enabled rapid grouping of the affected animal according to the degree of pneumonic lesion [14]. Compared with other diagnostic methods, such as radiography, ultrasonography has been found to be more sensitive to describe and assess respiratory diseases in cattle [15]. Also, when lung ultrasonography was compared with clinical signs and lung pathology in cattle, significant correlations between the ultrasound scores and pathological findings were identified [13].

Our hypothesis was that using computer-aided lung scoring system and lung ultrasonography could be a valuable tool to diagnosis BRD cases and could be used to influence decisions of treatment at initial identification of BRD in recently received calves. The purpose of our study was to investigate the diagnostic utility of computer-aided lung scoring system and lung ultrasonography at initial diagnosis of BRD in recently received feedlot cattle.

MATERIALS AND METHODS

A total of one hundred thirty-five feedlot calves 6-8 month-old were recently transported to the commercial and research university feedlot at South Farms Beef cattle and Sheep Field Laboratory (Urbana, IL, USA) and processed within 24 hours after entry to the feedlot. For the period of the study, the calves were grouped randomly in 16 x 64 ft / pens with roughly 30 head per pen. All calves were monitored daily during routine pen

observations for clinical signs of BRD (e.g. changes in behavior, anorexia, ocular or nasal discharge, cough and change in the breathing pattern) according to the feedlot unit health management protocols. Individual calves were diagnosed with respiratory disease when they meeting clinical criteria and presented the following clinical signs: lethargy, abnormal appetite, reluctance to approach the feeder while being fed, lack of rumen fill, labored breathing, nasal discharge with rectal temperature $>37^{\circ}\text{C}$. Once a case of respiratory disease was identified, the calf was brought in squeeze chute to be examined and treated. In addition, pen matched clinically healthy control calves were similarly examined at the same time. Body temperature ($^{\circ}\text{C}$), respiratory rates, pulse rates of the calves were examined and recorded.

The computer-aided lung score was assessed by using Whisper stethoscopes (Whisper®, Geissler Corp, Plymouth, MN, USA) and software rendering a 5-point lung score scales according to [10] Calves were examined while calf was standing, without sedation in a squeeze chute. The stethoscope was placed over the 5th intercostals space of the right thoracic wall over the apical lobe of the lung and approximately 10 cm above the elbow. This position depends on BRD pathogens enter through the airways; the apical lobe typically is the first site of infection, so the Whisper algorithms are trained to that location. It took about eight seconds to obtain a lung score at chute-side using the computer system. Recorded lung sounds were then automatically transmitted wirelessly to a computer located within 2 m of the stethoscope and analyzed by software provided by the manufacturer. This program software displayed spectrogram of recorded sounds, preprocessed lung sounds to remove heart sounds and potential interference from the environment and classified acoustic patterns into lung scores ranging from 1 to 5 (1 = normal, 2 = mild acute, 3 = moderate acute, 4 = severe acute, and 5 = chronic) as depicted in (Table 1).

Ultrasonographic examinations were carried out using either the portable Easi Scan ultrasound device (EasiScan™, BCF Innovative Image Technology, LLC, USA) which equipped with 4.5 to 8.5 MHz Broadband straight linear probe or the portable digital color doppler SonoScape ultrasound system (S8, Exp™, SonoScape Co, Ltd., Shenzhen, China) which equipped with 2-6.8MHz Convex probe. The use of the ultrasound device is depending on the availability of the device at the time of BRD diagnosis. The probe was directly applied on the thorax after 70% isopropyl alcohol had been sprayed onto the area of interest to achieve a good image quality. The thorax of each calf was systematically scanned with

Table 1: Clinical status of calves according to different lung score as detected by Whisper statoscopes manufacturer (1 = normal, 2 = mild acute, 3 = moderate acute, 4 = severe acute and 5 = chronic)

Lung score	Severity	Clinical status
Lung Score 1	Normal	Animal has clear lung sound and has no signs of respiratory diseases
Lung Score 2	Mild Acute	Mild acute respiratory affection. Animal displayed early symptoms
Lung Score 3	Moderate acute	Moderate acute respiratory affection. Animal displayed most of respiratory sings
Lung Score 4	Sever acute	Sever acute respiratory affection. Lung tissue was deteriorating and consolidated
Lung Score 5	Chronic	Chronic respiratory affection. Animal has advanced symptoms and permanent lung tissue damage is present.

the transducer held parallel to the ribs, from the 7th to the 11th intercostal space [6]. Each thoracic sonogram was evaluated according to appearance of parietal and visceral pleurae, as well as lung parenchyma, fluid in the pleural space, well-ventilated lung, the presence of comet-tail, reverberation artifacts and the consolidated lung [16]. Lung consolidation was defined as the ability to observe the abnormal lung parenchyma as a heterogeneous hypoechoic to echoic area [6].

After examination, the BRD affected calves were treated with a single dose of tilmicosin (10mg/kg SC; Micotil, Elanco Animal Health). Immediately after being sampled and treated, the calves were returned to their original group pen.

The statistical analyses were done using the SPSS version 22 (IBM Corp, Version 22.0, Armonk, NY, USA, 2013) statistical package. Student's t- test was used for the analysis of the significance of the differences ($p < 0.05$) in means of different variable between the groups of healthy and BRD-affected calves.

RESULTS

Of the received 135 calves, 24 calves were observed with visual BRD signs and 24 were selected as pen-matched clinically healthy control at the time of initial BRD diagnosis. The most common and earliest recognizable clinical signs of those calves that develop BRD include varying degree of depression, shallow rapid respiration, off feed, dyspnea in some cases and nasal discharge (purulent and sometime muco-purulent), fever, ocular discharge, cough and some cases suffer from dry cough. The obtained results of the clinical

examination (body temperature, respiratory rate and pulse rate) in the BRD affected calves and pen matched control are presented in (Table 2) including mean, standard deviations, minimum, maximum values and significance of differences between the groups.

All feedlot calves with visual signs of BRD had abnormal lung sounds including one or more of increased bronchial sounds, crackles, and wheezes detected by auscultation with computer-aided lung scores ranging from 2 to 5 (Fig. 1). Only three calves from those calves that developed BRD had lung score 1. While in the group of pen matched clinically healthy calves we observed 18, 4 and 2 calves had lung score of 1, 2 and 3 respectively and no calves were detected with lung score 4 or 5 (Fig. 1).

Lung ultrasonographic examinations of those calves that develop BRD identified lung lesions in 17/24 (70.83%) from the BRD cases and 3/24 (12.5%) from the pen matched controls. In pen matched healthy control group were scanned the lung to characterize the ultrasonographic appearance of normal lung tissue. The normal lung parenchyma could not be evaluated due to air-filled pulmonary tissue which blocks the progression of the ultrasound waves. Normal lung tissue was characterized by white linear echo with equally-spaced reverberation artifacts below this line moving synchronously during respiration. No pleural fluid was visualized in these normal calves. The thoracic wall was approximately 2 to 3 cm wide (Fig. 2). While in the BRD affected calves, lung ultrasonography showed wedge shaped hypoechoic zones with thickened plural line, distorted plural line and plural effusion (Fig. 3). Some cases showed hyperechoic circumscribed area with

Table 2: Clinical parameters (rectal temperature (°C), respiratory rate/min and pulse rate/min) in pen matched clinically healthy and BRD affected calves.

Variables	Group of calves					
	BRD affected Claves			Pen matched control calves		
	Mean ± SE	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Rectal temp (°C)	40.19±0.09 ^a	40	41	39.43± 0.15 ^b	38.2	39.8
Respiratory rate/min	58.22±1.7 ^a	32	116	36.56±1.3 ^b	28	68
Pulse rate/min	140.66±3.18 ^a	70	176	89.0±1.52 ^b	48	144

Data are presented as mean ± S.E. Mean values with different superscript letters in the same raw are significantly different at P=0.05

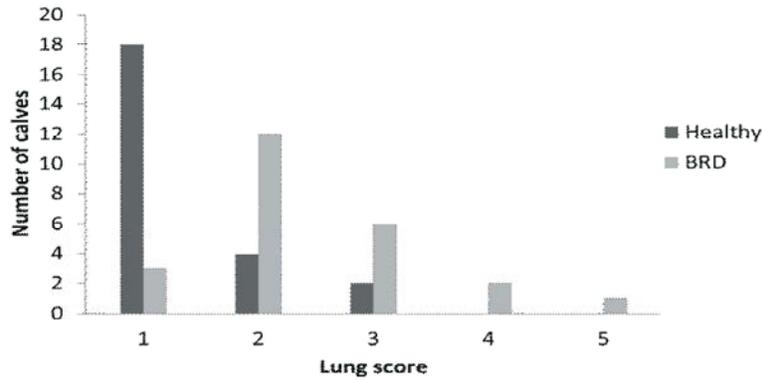


Fig. 1: Distribution of calves by lung score (1 = normal, 2 = mild acute, 3 = moderate acute, 4 = severe acute and 5 = chronic) during initial diagnosis of BRD and from pen matched healthy controls calves.

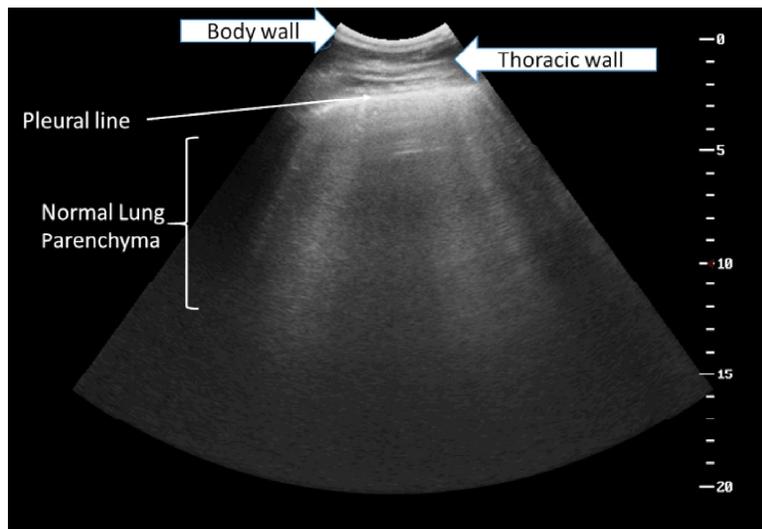


Fig. 2: Ultrasonography of lung and pleura of clinically healthy feedlot calves taken on the 7th inter-costal space from right side showed body, Thoracic wall, normal pleural line and normal lung parenchyma.

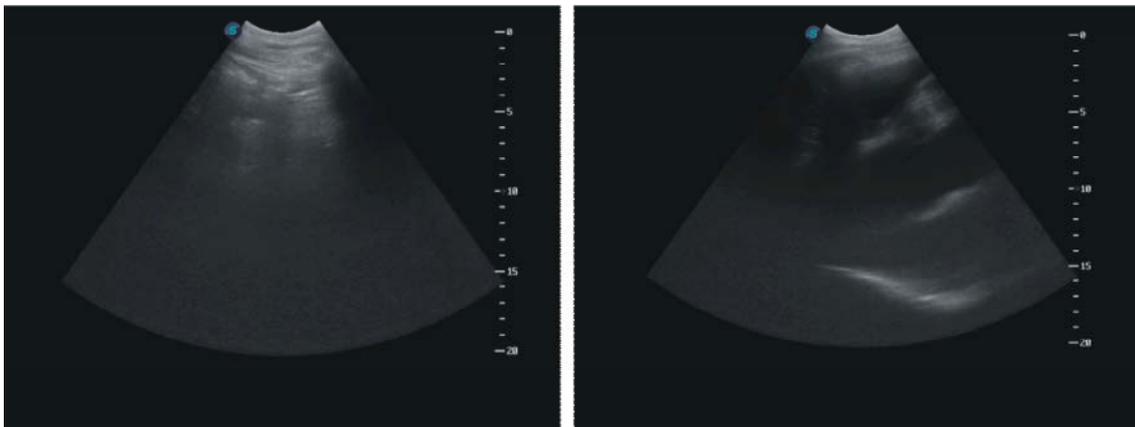


Fig. 3: Ultrasonography of lung and pleura of feedlot calves that developed BRD taken on the 7th inter-costal space from side showed thickened pleural line, distorted pleural line and pleural effusion.

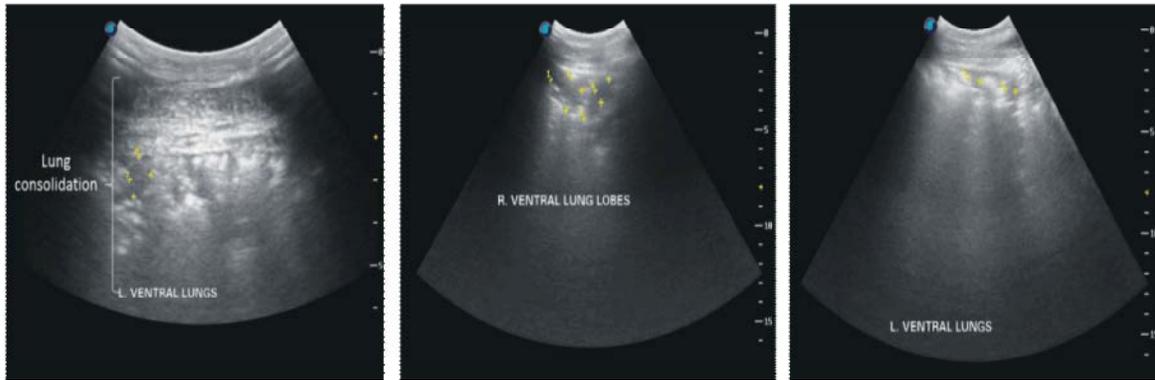


Fig. 4: Ultrasonography of lung and pleura of feedlot calves that developed BRD taken on the 7th inter-costal space from side showed hyperechoic flakes in the pleura and pleural sac due to inflammation of the pleura and pleural sac, hyper-echoic circumscribed area with anechoic area in the center due to inflammation of lung parenchyma with evidence of lung consolidation.

anechoic area appeared in the center due to inflammation of lung parenchyma. In addition, some BRD affected calves had ultrasonographic evidence of consolidated lung (Fig. 4).

DISCUSSION

BRD constitutes one of the most difficult health concerns among recently transported feedlot cattle. As livestock production becomes more intensified so, practical economical effort should be made to minimize the disease risk and the mortality rate [17]. Accurate diagnosis of BRD especially in recently received calves is the major issue in feedlot management system and essential for successful treatment [18]. Historic, the clinical examinations and the elevated rectal temperature of the calves with BRD was the prognostic indicators for evaluation of disease severity. However, it is hard to gauge the damage severity and functional changes of lung tissue in an adequate way just by clinical examination [19]. In addition, the therapeutic measure based only on the clinical examination may lead to unnecessary antimicrobial use and development of antimicrobial resistance. In this manner, there is a requirement for other particular individual biomarker and additional diagnostic tools to estimate the individual disease risk [18]. Therefore, this study was intended to assess the utilization capacity of recently used clinical approach, for example, (computer-aided lung scoring system and lung ultrasonography) to increase the accuracy of BRD diagnosis in feedlot calves. Several researches showed a weak relationship between lung lesions at harvest and the antimicrobial treatment history

[11]. This weak relationship might be due to lack of sensitivity and specificity of available diagnostic biomarker. To overcome this, we evaluate the ability of Whisper® lung scores to diagnose the BRD affected calves. The use of the computer-aided electronic stethoscope (Whisper® technology) has enhanced our ability to accurately diagnose BRD than rectal temperature taken by digital thermometer [10]. As mentioned before in the study of [11], whisper lung score was helping in the improvement of individual case diagnosis and in this way better adjusts the right treatment to the right disease. Moreover, it gives a critical jump forward in enhancing the success in diagnosis and care of feedlot calves with BRD. Based on our result, we inferred that this computer-aided lung score technology can possibly diminish the extent of the proportion of falsely diagnosed feedlot cattle with BRD and thus, could diminish the overuse of antimicrobials in commercial feedlots. In addition to computer aided lung score technology, we used handheld ultrasonographic machine as screening methods for BRD in recently transported feedlot cattle. Hand held ultrasonography is the ideal choice for clinical diagnosis at chute side. Ultrasonography of the thorax may enable the better evaluation of pleural surface of the lung and superficial lung parenchyma [20]. The ultrasonography of the lungs and pleura in healthy animals provides information that can be used as a reference when examining animal with suspected disease of the thorax [21]. The presence of air within the normal lung prevents the ultrasound waves from penetrating deeply into the lung parenchyma [14]. Therefore, the normal lung tissue and parenchyma is showed a uniformly hyperechoic line on ultrasound. Ultrasonography of the lung using hand

held ultrasound during initial diagnosis of BRD took about 2 minute while the calf is being in chute and this therefore would add significant cost beneficial ratio to the veterinary examination in general practice. Our ultrasonographic examination of the BRD affected calves after one month of arrival showed hypoechoic zones were seen on the surface of the lung with thickened plural line, distorted plural line and plural effusion. Some cases showed hyperechoic circumscribed area with anechoic area appeared in the center due to inflammation of lung parenchyma. In addition, some BRD affected calves had ultrasonographic evidence of consolidated lung. These results agreed with those reported by [6] in pneumonic calves. Interestingly, all the calves that showed lung lesion using ultrasonography has lung score > 2. These results suggest that clinical assessment of diseased calves based on lung score combined with lung ultrasonography may be used successfully to classify animals into groups with higher and lower probabilities of lung lesions. Therefore, our study successfully assessed the clinical utility of computer-aided lung scoring system and lung ultrasonography in commercial feedlot cattle related to the first diagnosis of BRD.

CONCLUSION

The results of our study reported that computer aided lung score is higher in BRD affected calves than in pen matched clinically healthy calves. In addition, all the calves that showed lung lesion using ultrasonography has lung score > 2. Following our observations, assessment of the BRD by using computer aided lung score at initial diagnosis of BRD together with lung ultrasonography may help in treatment decision and thus contribute to the reduction of therapeutic costs. In our opinion, these studies are important because using of portable device in diagnosis of BRD in recently received calves is seldom. Therefore, its use might be useful in the evaluation and management strategies of respiratory disease during early feeding periods.

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