Pulmonary Ultrasound in the Diagnosis of Respiratory Disease in Dairy Calves - Systematic Review

Ultrassonografia Pulmonar no Diagnóstico de Doença Respiratória em Bezerras Leiteiras- Revisão Sistemática

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ABSTRACT
Bovine respiratory disease (BRD) is a common health challenge for dairy calves during the first weeks of life. It can be caused by several environmental factors and pathogens, such as bacteria and viruses, presenting alterations called pulmonary consolidations. BRD shows nonspecific clinical signs, a high rate of subclinical cases and triggers several health consequences, such as impaired growth, reduced weight gain, interference in production and reproduction during the first lactation, and in some cases, animals can also die. In addition economic losses such as: increase in the rate of involuntary culling and reduction of the source of replacement of productive cows in the herd can also occur. There are some forms of diagnosis evaluating clinical signs such as fever and discharges. However, these methods are not sufficient to confirm the clinical diagnosis and do not allow the measurement of the degree of pulmonary lesions. However, the disease can also be diagnosed by pulmonary ultrasound, presenting a high rate of accuracy. This study reviews systematically the main studies that performed pulmonary ultrasound evaluation in the diagnosis of BRD and reported results that showed the efficacy of the use of this method in the clinical diagnosis of the disease. The technique is considered noninvasive, fast, capacity of detecting animals with subclinical BRD and uses the same ultrasound device used in the reproductive management of cows. In addition, ultrasonography has other benefits such as cost reduction, reduced use of antimicrobials, evaluation of the extent of lung lesions, positive influence on animal health and support of profitability of a dairy operation.

Keywords: Bovine, Clinic, Diagnosis, Lung, Ultrasound.

RESUMO
A doença respiratória bovina (DRB) é um acometimento comum em bezerras leiteiras durante as primeiras semanas de vida. Pode ser causada por diversos fatores ambientais e agentes patogênicos, como bactérias e vírus, apresentando alterações denominadas consolidações pulmonares. A DRB apresenta sinais clínicos inespecíficos, alto índice de casos subclínicos e desencadeia diversas consequências a saúde, como comprometimento do crescimento, redução no ganho de peso, interferência na produção e reprodução durante a primeira lactação e, em alguns casos, os animais vão à óbito. Além de causar prejuízos econômicos, como elevação da taxa de descarte involuntário e redução da fonte de reposição de vacas produtivas no rebanho. Existem algumas formas de diagnóstico avaliando sinais clínicos como febre e descargas nasais. Porém, esses métodos não são suficientes para confirmação do diagnóstico clínico e não permitem a mensuração do grau de lesões pulmonares. Contudo, a doença também pode ser diagnosticada por meio de ultrassonografia pulmonar, apresentando alto índice de acurácia. Este trabalho revisou

sistemicamente os principais estudos que realizaram avaliação ultrassonográfica pulmonar no diagnóstico de DRB e relatou resultados que mostram a eficácia da utilização deste método no diagnóstico clínico da doença. Portanto, a técnica é considerada não invasiva, apresenta rápida realização, capacidade de detectar animais com DRB subclínica e pode ser realizada pelo mesmo aparelho de ultrassom empregado no manejo reprodutivo de vacas. Além disso, a ultrassonografia apresenta outros benefícios como, redução de custos, utilização adequada de antimicrobianos, avaliação da extensão de lesões pulmonares, influência positiva na saúde dos animais e lucratividade da propriedade leiteira.

Palavras-chave: Bovino, Clínica, Diagnóstico, Pulmão, Ultrassom.

1 INTRODUCTION

The correct management of breeding and health systems aims to increase profitability, generating animals more predisposed to faster development and economical production (DUBROVSKY *et al.*, 2019[a]). Several diseases affect heifers in their first weeks of life, such as respiratory disorders, and may be related to complications during the peripartum, such as incorrect colostrum feeding, failures in the cure of the navel and challenging weather patterns (CALLAN and GARRY, 2002; DUBROVSKY *et al.*, 2019[a]; GORDEN and PLUMMER, 2010; LOUIE *et al*., 2018). According to Guterbock (2014), there are several respiratory diseases in cattle, such as bovine respiratory disease (BRD), acute pulmonary edema and emphysema, allergic reactions, pulmonary vermin, diffitteria, atypical interstitial pneumonia, amongst others.

BRD occurs when there is pulmonary inflammation and consolidation caused by pathogens, which are often common to the bovine respiratory tract (GUTERBOCK, 2014). In addition, there may be the development of more severe lesions, such as abscess and pulmonary fibrosis (McGUIRK, 2008; GUTERBOCK, 2014). The disease is frequent in young calves (USDA, 2012), and represents a large part of the losses in this period (McGUIRK, 2008). According to Dubrovsky *et al.* (2020), most animals present the disease around the fourth week of life. It can be considered multifactorial, being mainly caused by immunosuppression, stress, pathogens and other factors related to the environment (CALLAN and GARRY, 2002; GORDEN and PLUMMER, 2010; BINVERSEI, 2018; BUCZINSKI *et al.*, 2018[a]; DUBROVSKY *et al*., 2019[b], 2020), often leading to the development of concomitant diseases such as, bronchopneumonia (GRIFFIN *et al.*, 2010), defined by the presence of serophilous or purulent exudate in bronchiolos and lobular congestion or hepatization,which may be caused by rupture of

abscesses in the airways resulting from infection by bacteria in the bloodstream (RADOSTITS *et al.*, 2007). This condition, after digestive tract disorders, represents the second cause of morbidity in dairy calves (FRANCOZ *et al.*, 2015; BUCZINSKI *et al.*, 2016).

The main pathogens causing BRD are bacteria such as *Mannheimia haemolytica*, *Mycoplasma* spp., *Pasteurella multocida* and *Hemophilus somnus*(CALLAN and GARRY, 2002), in addition to different viruses such as Bovine Respiratory *Sincicial* Virus (BRSV), *Parainfluenza Virus Type 3* (PI-3), Bovine *Herpesvirus Type 1* (BHV-1), Bovine Viral Diarrhea *Virus* (BVDV) and Bovine *Coronavirus* (BCV) (FRANCOZ *et al.*, 2015). These agents, when in contact with the respiratory system, can lead to inflammation and pulmonary consolidation (GUTERBOCK, 2014), the latter being detected only by ultrasound evaluation and considered as any detectable heterogeneous hypoechoic area (TEIXEIRA *et al.*, 2017), and may affect one or more pulmonary lobes (BABKINE and BLOND, 2009).

BRD is rarely diagnosed early, due to nonspecific clinical signs and the various factors that lead to its occurrence, thus making it difficult to determine the severity and extent of lesions (JUNG and BOSTEDT, 2004; McGUIRK, 2008). Therefore, if reliable diagnostic methods are not used, there may be a high number of animals infected and not diagnosed by veterinarians. In addition, the disease has a high number of subclinical cases, which consequently do not receive adequate treatment (BUCZINSKI *et al.*, 2014, 2016). This study aims to systematically review the main studies that used pulmonary ultrasound evaluation in the detection of BRD and report relevant results and information that show the feasibility and efficacy of using this method in the clinical diagnosis of animals affected with BRD.

2 METHODS FOR DIAGNOSING BOVINE RESPIRATORY DISEASE

The animal affected with BRD often does not present evident clinical signs of the disease (McGUIRK, 2008; DUBROVSKY *et al.*, 2019[b]). When they are present, the most common are: fever, lethargy, nose and eye discharges and changes in respiratory function (BUCZINSKI *et al.*, 2013, 2016). In most cases, the diagnosis is made through the evaluation of clinical signs, mainly, increased body temperature (BUCZINSKI *et al.*, 2013; GUTERBOCK, 2014).

The precise clinical diagnosis in young animals favors several practices of correct sanitary management in the rearing of calves, such as the rational use of antibiotics for

the treatment of the disease (BUCZINSKI *et al.*, 2013; ADAMS and BUCZINSKI, 2016) and adjustments in the growth rate of infected animals. In this context, calves can express their full genetic potential, presenting efficient growth and less possibility of being culled from the herd (BACH, 2011; SCHAFFER *et al.*, 2016; BUCZINSKI *et al.*, 2018[b]), positively influencing the profitability and success of the activity.

There are several semiological methods and complementary tests to evaluate the respiratory system, such as auscultation, radiography, percussion, and ultrasound (BABKINE and BLOND, 2009). However, clinical veterinarians working in dairy farms often conclude the diagnosis by evaluating clinical signs and thoracic auscultation, through the detection of abnormal sounds such as crackling and pulmonary wheezing. However, this approach may result in low specificity when related to other causes that may lead to pulmonary alterations (BUCZINSKI *et al.*, 2016). These authors compared thoracic auscultation and ultrasound as forms of clinical diagnosis. Auscultation resulted in sensitivity of 72.9% and specificity of 53.3%, while ultrasound results were 76.5% and 92.9%, respectively.

There are diagnostic techniques by scoring typical clinical signs of BRD, such as the model proposed by McGuick (2008), created in order to score signs such as ocular and nasal secretion, cough, rectal temperature and position of the ears. The animals are evaluated on a scale of 0 to 3, 0 being designated as normal and 3 intended for severely abnormal signals. Another evaluation model was developed by Maier et al., (2019) observing clinical signs such as deep eyes, low body condition score and abnormal breathing, as indicative of BRD. However, only these methods of evaluation of clinical signs are not sufficient to perform the accurate diagnosis (BUCZINSKI *et al*., 2013; GUTERBOCK, 2014; BUCZINSKI *et al*., 2016; QUICK *et al.*, 2020).

Clinical diagnosis may be hindered mainly in the manifestation of subclinical or chronic disease (CRAMER and OLLIVETT, 2019), considering that BRD presents a high number of subclinical cases detected only in necropsy (WITTUM *et al.*, 1996; THOMPSON *et al.*, 2006). Incorrect diagnosis of the disease may cause undue treatment and excessive use of antibiotics (McGUIRK, 2008; BUCZINSKI *et al.*, 2013; GUTERBOCK, 2014; BUCZINSKI *et al.*, 2015; ADAMS and BUCZINSKI, 2016).

In addition to the damage caused to health during the manifestation of the disease, there is growth impairment throughout the development of the animal (VIRTALA *et al*., 1996; BACH, 2011; BUCZINSKI *et al.*, 2013; GUTERBOCK, 2014; McGUIRK and PEEK, 2014; ADAMS and BUCZINSKI, 2016; CRAMER and OLLIVETT, 2019). Thus,

there is a higher risk of culling even before the first parturition due to lower daily weight gain (GPD), (McGUIRK and PEEK, 2014; ADAMS and BUCZINSKI, 2016; SCHAFFER *et al.*, 2016; CRAMER and OLLIVETT, 2019) and lower milk production in the first lactation (McGUIRK and PEEK, 2014; SCHAFFER *et al.*, 2016; TEIXEIRA *et al.*, 2017; DUNN, *et al.*, 2018).

According to Bach (2011), dairy heifers that had four or more cases of BRD, consequently, presented higher age at first parturition and higher chance of culling, in addition to the probability of 1.87±0,14 (P<0,05) higher than not completing the first lactation compared to animals that did not present the disease. According to Schaffer *et al.* (2016), BRD was associated with increased risk of culling before the first parturition, between the first and second lactation, and even lower milk production. In addition, Teixeira (2017) found a correlation between pulmonary lesions detected by ultrasound and decreased reproductive efficiency after the first parturition.

In addition to these economic losses resulting from the rearing of affected animals, the profitability of the property can be compromised, considering that heifers constitute the main source of replacement of adult cows productive in the herd (McGUIRK, 2008; BACH, 2011; BUCZINSKI *et al.*, 2013; GUTERBOCK, 2014; BUCZINSKI *et al.*, 2018[b]; CRAMER and OLLIVETT, 2019; DUBROVSKY *et al.*, 2020). Early detection, besides minimizing economic losses (McGUIRK, 2008; BACH, 2011; CRAMER and OLLIVETT, 2019) and costs that could be avoided (BACH, 2011; CRAMER and OLLIVETT, 2019) assists in the treatment of the disease (BUCZINSKI *et al.*, 2013). Therefore, thoracic ultrasonography is indicated to improve the diagnosis of BRD (RABELING *et al.*, 1998; BUCZINSKI *et al.*, 2013; OLLIVETT *et al.*, 2013, 2015; ADAMS and BUCZINSKI, 2016; BUCZINSKI *et al.*, 2016, 2018[a]; CRAMER and OLLIVETT, 2019).

3 DIAGNOSIS BY PULMONARY ULTRASONOGRAPHY

Currently, there is still no gold standard for the diagnosis of BRD in young heifers or calves (BUCZINSKI *et al.*, 2015). However, pulmonary ultrasonography can be considered a screening technique that evaluates pulmonary lesions resulting from the disease (RABELING *et al.*, 1998; JUNG and BOSTEDT, 2004; BUCZINSKI *et al.*, 2013; ADAMS and BUCZINSKI, 2016; BUCZINSKI *et al.*, 2016, 2018[a]; CRAMER and OLLIVETT, 2019). This diagnostic method can be performed quickly by pulmonary scanning (BUCZINSKI *et al.*, 2016), and by the same ultrasound device used by

veterinarians working in the reproductive area of dairy farms (ADAMS and BUCZINSKI, 2016), contributing significantly to the ruminant clinic and consequently to the development of better veterinary practices globally.

According to Hussein *et al.* (2018), the ultrasound follow-up of heifers affected with bronchopneumonia helped to evaluate the development of the disease. However, it was not possible to relate evaluation results of ultrasound images with the clinical cure of the animals, considering that they still had visible lung lesions by ultrasound. Dunn *et al.* (2018), analyzed dairy heifers in order to evaluate the effects of pulmonary consolidation (ultrasound lesions>3cm) on the mortality rate and production in the first lactation, reporting that no increase in the number of deaths or age-related at first birth was found, however, affected animals showed a reduction in milk production in the first lactation.

Rabeling *et al.* (1998) in a study with 18 animals up to 5 months of age and with pneumonia or bronchopneumonia, compared data obtained by pulmonary ultrasound evaluation with necropsy findings. They collected 78 abnormal pulmonary samples, of which 69 had purulent catarrhal bronchopneumonia. Therefore, thoracic ultrasonography showed high efficacy in the evaluation of pulmonary lesions that were confirmed at necropsy, with estimated specificity of 85 to 94%, consistent with the results found by Ollivett *et al.* (2015), which considered sensitivity and specificity around 64% and 100%, respectively.

Buczinski *et al.* (2014) reported that only 41.1% (23/33) of the animals that presented pulmonary lesions during the ultrasound evaluation had received treatment prior to the evaluation. This demonstrates that the technique proves to be viable for the diagnosis of subclinical animals and the establishment of a plan for recognition and treatment of infected animals. In another study, Buczinski *et al.* (2018[a]) evaluated the prevalence of BRD detected by ultrasound in 39 dairy herds, through a visit made in the summer and another in winter. At each visit to the herd, 6 to 12 young heifers were evaluated. The authors found median prevalence values of around 8% and 15% in summer and winter, respectively.

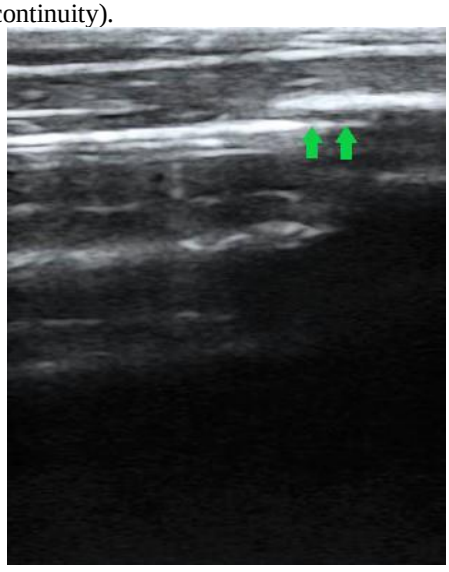
According to Cramer and Ollivett (2019), heifers who had pulmonary consolidation evaluated by ≥ 1cm ultrasound in their first manifestation of the disease, showed a 0.11 Kg/d fall in the average daily gain (ADG), when compared to animals without pulmonary consolidation. In another study, the same authors evaluated behavior characteristics and realized that calves with clinical BRD presented lower speed of milk

intake compared to subclinical or healthy animals (688, 782, 844mL/min, respectively), (CRAMER *et al.*, 2020).

Other alterations caused by BRD were proposed by Adams and Buczinski (2016), evaluating lung lesions in three-month-old calves, using an ultrasound imaging score scale ranging from 1 to 4 points. One (1) was attributed to heifers who did not present pulmonary consolidation and 4 considered as extensive consolidation (injury area > 6mm) or presence of abscess in the pulmonary parenchyma or significant pleural effusion (area >1cm). Animals designated as 4 on the evaluation scale had a higher risk of death or culling from the herd (26%) compared to the other groups (1%, 3% and 5% for scores 1.2 and 3, respectively).

Another model of ultrasound evaluation of BRD, proposed by Ollivett *et al.* (2011), and adapted by Teixeira *et al.* (2017), is based on the evaluation of the presence or absence of pulmonary consolidation (Figure 1), by means of screening of intercostal spaces (ICS) in the dorsoventral direction, from the 2nd to the 10th EIC (right antimer) and from the 3rd to the 9th ICS (left antimer). Buczinski *et al.* (2016) also considered pulmonary consolidation with indication of BRD, evaluating ultrasound images based on deviation (hypoecoic part) in the pleural line. In another study, Ollivett *et al.* (2015) included the evaluation of the right 1st and 2nd ICS on pulmonary ultrasound scan. Thus, they obtained the classification of the highest number of animals with lung lesions compared to the method mentioned by the authors previously.

Figure 1- Evaluation of a Pulmonary Ultrasound. Ultrasound imaging showing detectable pulmonary consolidation (green arrow), represented by heterogeneous hypoecoic area without hyperecoic line of pleural surface (pleural line discontinuity).



These studies demonstrate the importance of the correct diagnosis of BRD through thoracic ultrasound, which is shown to be a noninvasive method easily performed in the field, allowing the detection of pulmonary lesions (RABELING *et al.*, 1998; BUCZINSKI *et al.*, 2013; OLLIVETT *et al*., 2013, 2015; ADAMS and BUCZINSKI, 2016; BUCZINSKI *et al.*, 2016, 2018[a]; CRAMER and OLLIVETT, 2019). Buczinski *et al.* (2013) reported the importance of establishing assessments of the type and extent of lung injury. Another important factor in ultrasonography would be the possibility of differentiating active lesions and traces of inactive lesions prior to evaluation, allowing better precision of the method (BUCZINSKI *et al.*, 2018[b]), in addition to the lower use antimicrobials (ADAMS and BUCZINSKI, 2016). In addition, the overlap between structures and the lack of standardization of the technique may limit its dissemination in the veterinary medical clinic.

4 CONCLUSIONS

Thoracic ultrasound to diagnose BRD is a method that can be performed by the same ultrasound device used in the reproductive assessments of a dairy farms. The examination is fast, noninvasive and non-contaminating, but requires the professional to acquire knowledge in advance in the visual evaluation of ultrasound images.

Animals diagnosed with subclinical BRD may receive appropriate treatment to avoid the development of lesions and long-term consequences such as lower weight gain, lower milk production, higher risk of culling and other diseases. Finally, this method should be improved and standardized as a way to facilitate the dissemination and use by veterinarians and consequently in farms in general.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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