Ultrasonographic Mapping of Infectious Pulmonary Lesions in Ruminants: Diagnostic Patterns and Clinical Correlations

Mohammed T Al-Noaemy
Department of OptometryTechnologies, Mosul Medical Technical Institute, Northern Technical University, Mosul, Iraq

* Corresponding Author: **Mohammed T Al-Noaemy**

Article Info

E-ISSN: 3107-6599
Volume: 02
Issue: 05
Received: 10-07-2026
Accepted: 08-08-2026
Published: 06-09-2026
Page No: 17-23

Abstract
Infectious respiratory diseases are among the most important causes of morbidity and mortality in ruminants, and cause significant economic losses on cattle, sheep and goat farms. This review aims to draw an ultrasonographic map of infectious lung lesions in ruminants and identify diagnostic patterns and their clinical relationships. The review was based on the analysis of clinical case studies that used thoracic ultrasonography (TUS) in field conditions, with standardized protocols, a 7.5 MHz probe, and scanning of the third to tenth intercostal spaces. Five main patterns have been classified: inflammatory pneumosclerosis, abscess formation, emphysematous and necrotic lesions, pleural involvement and pleural effusion, and diffuse interstitial changes. These patterns have been associated with bacterial pathogens such as Mannheimia haemolytica, Pasteurella multocida, and Mycoplasma bovis, as well as fungal, parasitic, and mycobacterial pathogens. Ultrasonography has shown utility in determining lesion severity and stage, supporting therapeutic decision and estimating prognosis, with varying sensitivity, specificity and predictive values. It also reviewed clinical cases including infectious pleuropneumonia, lung adenocarcinoma in sheep, and caseous lymphadenitis. The importance of linking clinical, laboratory and imaging data to interpret atypical cases is highlighted. Limitations related to air segments, acoustic window depth, probe pressure, and scanning angle are discussed, and their impact on repeatability. The examination remains dependent on the operator's experience and requires integration with X-rays, CT scans, and laboratory analyses. The review recommends standardization of protocols and expansion of research to improve the accuracy of diagnosis and management of infectious pulmonary diseases in ruminants.

DOI: https://doi.org/10.54660/.IJIADR.2026.2.5.17-23

Keywords: Thoracic ultrasound, ruminants, infectious pneumonia, Pulmonary sclerosis, pleural effusion, Pulmonary abscesses, diagnosis, Clinical correlations

1. Introduction

Infectious respiratory diseases are a significant source of morbidity and mortality in ruminants, accounting for the most costly disease in intensive dairy production and severely affecting beef production. Field investigations have demonstrated that morbidity from respiratory disease exceeds 10% in calves, with mortality rates reporting over 7% in some studies. Ultrasound examinations of the thorax have emerged as a useful tool to assess lung health in ruminants since diagnosis typically relies on the evaluation of clinical findings and thoracic auscultation (Bose & Siva Kumar) [6]. However, these methods can lack sensitivity and specificity. In cattle, pneumonia is one of the most common diseases observed, accompanied by clinical signs of depression, anorexia, increased respiratory frequency, coughing, and nasal discharges (Ermilova & Samburova…, 2022) [17]. Ultrasonographic examination of the thoracic cavity in cattle has gained recognition as a complementary tool for assessing pneumonia, pyothorax, abscesses, and pleuritis directly from the farm due to its non-invasive and easy-to-implement nature. Ultrasonographic mapping of infectious pulmonary lesions in ruminants aims to define specific sonographic patterns associated with infectious pulmonary lesions and their evolution over time (Tharwat & Tsuka, 2024) [48].

Ultrasonic mapping aims to offer an easy, rapid, and reliable way to evaluate pulmonary lesions in ruminants. Five specific ultrasonographic patterns have been associated with infectious pulmonary lesions in ruminants, namely pneumonic consolidation, abscess formation, emphysema, pleural involvement, and diffuse interstitial changes (Cassidy, 2026) [9]. The differentiation of infectious and non-infectious pneumonia is essential to determine treatment protocols accurately. A primary-mode infectious ultrasonographic pattern representing pneumonia or pleuritis is to identify the severity and the stage of progression amongst the high rotor population, which is necessary to ensure immediate treatment to minimize welfares and production loss to the farms. (Buczinski *et al*., 2013) [7]

2. Methodological Considerations in Ultrasonography of Ruminant Lungs

Ultrasonography extends beyond the abdominal cavity and is an emerging application for the thorax in ruminants. Exploratory studies have focused on infectious pulmonary lesions, with specific objectives: to characterize ultrasonographic patterns associated with these lesions; to estimate the diagnostic accuracy, in terms of sensitivity, specificity, and positive and negative predictive values; and to describe clinical correlations linked to provided images. A description of the study design and related methodological considerations follows, addressing the choice of protocols, the handling of artifacts, and the validation and quality-checking procedures used to enhance the trustworthiness of acquired data (Tharwat & Tsuka, 2024)[48](Feitoza *et al*., 2025)[18].

The study design entailed a retrospective analysis of clinical cases exhibiting ultrasonographic evidence of infectious pulmonary lesions. All examinations were performed on the left side of the thorax, under field conditions, and with a portable ultrasound device. For each patient the recorded images captured the maximum number of lesions visible at the time; controls are thus absent. The readability of still images heavily depends on the timing of acquisition, and they were recorded using a standardized protocol (fast-frame acquisition at a steadily increasing gain until signal saturation or temporary freeze) to avoid permanent alteration by the operator. A description of these acquisition protocols, along with the consequent limitations in the interpretation of specific signs and the recording of indeterminate findings are provided. The pulmonary ultrasonographic study of calves comprises well-established acquisition protocols, but such standardization remained to be documented for adult cattle (Colombo *et al*., 2026)[12](Zhang *et al*.2026)[52].

The data extraction and quality-check protocols aimed to enable reliable interpretations while minimizing the risk of examiner bias. To ascertain inter-observer agreement, the data created a benchmark for extracting findings coming from datasets generated by a third party. Definitions of the examined lesions adhered to an expanding glossary based on exploratory studies. Each study underwent an additional quality assessment of the obtained data and questions. This validation sought to enhance the consistency of early diagnostic imaging, assist future research priorities, and improve the accuracy of case interpretations (Liu *et al*., 2026) [29] (Özer *et al*., 2026)[38].

3. Ultrasonographic Patterns of Infectious Pulmonary Lesions in Ruminants

Bovine pneumonia

represents a relevant health and economic concern in cattle production. In young calves, bronchopneumonia caused by bacterial pathogens is one of the most frequent diseases worldwide, and although other types of pneumonia occur, such as tuberculous pneumonia, it is the most prevalent form. Bronchopneumonia and pleuropneumonia lie at the origin of high mortality rates in both calves and adult cattle (Cilloniz *et al*., 2023) [11].

Thoracic ultrasonography (TUS) is a reliable and useful tool to evaluate the status of the lungs in cattle. It has the advantage of being quick, real-time, easy to perform, and widely accessible. As reported by previous investigations, TUS lesion characteristics can be associated with bacterial pathogens that produce dairy calf pneumonia, specifically Mannheimia haemolytica, Pasteurella multocida, and Mycoplasma bovis. (Mohameden *et al*.2026) [34](Jourquin *et al*., 2022) [24]

Ultrasonographic patterns of infectious pulmonary lesions in ruminants involve thoracic ultrasonography performed on calves from the 3rd to the 10th intercostal space. A portable ultrasound unit with a 7.5 MHz transducer was used to evaluate pleurae and lungs, with maximal depth of lung consolidations, cavitary lesions, and effusions measured. Only lesions deeper than or equal to 1 cm were considered clinically relevant (Khalphallah *et al*., 2022) [25](Kunnary, 2026) [27]. Thoracic ultrasonography was considered positive if any predefined lesions were found, otherwise negative. The depth and intercostal space of each lesion were recorded. Standardized TUS were performed by an experienced operator unaware of other clinical results and conducted without sedation on calves aged 3 to 8 weeks. (Walsh *et al*., 2022) [50]

3.1. Pneumonic Consolidation

Echogenic pulmonary consolidation occurs as a heterogeneous, hypoechoic or sonolucent parenchyma with ill-defined or somewhat irregular borders. The lesion can vary in size and is always associated with increased vascularization, such as a hyperechoic parenchyma with preserved echogenicity and greater-than-expected Doppler activity (Quarato *et al*., 2023) [42].

Bovine pneumonia is responsible for the highest mortality rates in calves. Under the current production systems, knowledge of the epidemiology of the disease is paramount to prevent high economic losses. Several aetiological agents can be involved, but the predominant agents at the beginning of the outbreak are Mycoplasmas, while other agents, such as Pasteurella multocida can be detected later in the disease (Walsh *et al*., 2022) [50].

3.2. Abscess Formation

Tuberculosis is a zoonosis listed by the World Organization for Animal Health (OIE). It can cause economic loss due to decreased production and quality; permanent exclusion from the food chain of infected animals; losses from premature slaughter; and the costs of medication, tuberculosis testing and disinfection (Sadeq Nomi, 2016) [43]. It can be transmitted horizontally, for example, via contact from pasture or feeding equipment, or vertically, for instance through colostrum, milk or direct contact (Berman *et al*., 2021) [4].

In ruminants, Mycobacterium avium subspecies paratuberculosis (MAP) is the causative agent of Johne's disease. The economic impact for ruminant herds in the United States is estimated to exceed $1 billion annually (ABOUELNASR *et al*., 2016) [1]. Ruminants may also be infected by Mycobacterium tuberculsis and Mycobacterium bovis (Commandeur *et al*., 2025) [13].

In dairy cows with Johne's disease, the internal and external surfaces of the lung may be colonised by the bacteria. Ulcerative lesions (paratuberculosis) of the lungs but not of the pleura, with the presence of clay-like exudate, were observed in cattle in Egypt. Bovine Tuberculosis (TB) is an endemic disease in Egypt, and in areas where the disease is endemic, thoracic lesions due to bovine TB were simultaneously observed in suspected cattle infected with MAP (Humadi & Mahdi…, 2025) [22](MURID *et al*., 2024) [36].

3.3. Emphysematous and Necrotic Lesions

Similar to emphysema associated with bacteriological infections, lesions classified as emphysematous due to necrotic pneumonia exhibit a variety of typical artifacts: vertical comet-tail artifacts extend from an abnormally hyperechoic segment located within a tissue of normal echogenicity, while 100 percent pronounced loss of hilum indicates a subpleural location. Indications for necrotic pneumonia include cavitation present in association with a pulmonary consolidation pattern involving a description of the margin and echogenicity (Walsh *et al*., 2022) [50]. Lesions associated specifically with necrotic pneumonia correspond to a pattern of consolidation where, alongside a hypoechoic echotexture, the margin of the lesion remains sharply demarcated from adjacent structures; also, cavitation varies considerably in size and shape but often possesses a hyperechoic border resembling an inner ring around a pseudotumoral area (B. Marie, 2016) [3].

3.4. Pleural Involvement and Pleural Effusion

Pulmonary hemorrhage with hematoma, pleuritis, and pleural effusion are common findings in dairy calves with infectious bronchopneumonia, especially Mycoplasma bovis pneumonia. Ruminant thoracic ultrasonography is well-suited to identify lesions in these conditions (Berman *et al*., 2021) [4]. The continuity of the pleural line provides a reliability indicator during pulmonary ultrasound examination. The appearance of fluid, which depends on echogenicity and abundance, can indicate the type of pleural effusion; ancillary signs, such as the presence of lung lesions, indicate a secondary process. In dairy calves, ultrasound findings of pleural effusion, irregularities, and a continuous pleural line have been examined but are sometimes overlooked (Piskač Živković *et al*., 2019) [40].

3.5. Diffuse Interstitial Changes

Diffusely altered lungs often present as an increased number of interstitial B-lines equivalents, uniform speckle pattern, and scattered open, homogeneous spots depending on the context (Walsh *et al*., 2022) [50].

4. Etiologies and Correlative Imaging Features

Mapping lung histopathologies holds promise for infectious lesion diagnosis in ruminants, yet specific pathological interpretation is uncommon. Infectious lesions caused by various pathogens remain leading ruminant morbidity and mortality determinants (Walsh *et al*., 2022) [50]. Although radiography and CT provide thorough anatomic detail, modality access is limited; therefore, ultrasonographic infectious lesion imaging patterns warrant presentation alongside etiological correlations (Chen *et al*.2026) [10].

Ultrasonography describes infectious pulmonary ruminant lesions caused by viruses, bacteria, fungi, parasites, mycobacteria, and rumen contents and is particularly suited to lesions arising from bacterial pathogens (Singh, 2019) [46]. Typical consolidation patterns—multilobar or lobar with diverging drainage pathways—indicate organism origin. Mycotic infections exhibit distinctive echotextures. Tissue-level remodelling is characteristic of parasitic or rumen-effluent inflammatory processes, producing focal nodularity and granulomatous radiopacities (Shi, 2026) [45](Spitzer, 2024) [47].

Bacterial pneumonia constitutes the pre-eminent infectious pulmonary pathology. Bovine and caprine pneumonia align with typical septicaema and aerosol-transmitted patterns; ovine pneumonia similarly aligns with aerosol components. The focal-anterior-ventral predominance of even-staging broncho-interstitial to alveolar inclusions aids ruminant-aerosol challenge distinction. Contaminated-waterborne bacteria progress through gastrointestinal tract entry, ruminal and gastrointestinal secretion routes, and broad-spectrum bacterial patterns inform the likely region; investigation within 24–48 hours by means of scoping and swabbing is common. Typical ultrasonic consolidations, secondary pleural drainage, multilobar and lobar patterns, and medium interstitial or broncho-interstitial drainage denote the origin of affected-arrows patterns (Lateef & Hussein, 2025) [28](Martin *et al*.2026) [32].

4.1. Bacterial Pneumonia

Bovine pneumonia represents one of the most critical health challenges facing cows worldwide. The diseasecausing significant morbidity and mortality in ruminants may be due to viruses, bacteria, fungi, or parasites associated with a variety of predisposing factors (Mekibib *et al*., 2019) [33]. A necropsy-based study in small ruminants in Ethiopia revealed that, of all the bacteria causing pneumonia (e.g., Pasteurella multocida, Mycoplasma spp., and Staphylococcus aureus), the most frequently detected agent was E. coli. The disease accounts for substantial economic losses in cattle, yet works that clearly present the ultrasonographic patterns of the pulmonary lesions and provide specific clinical correlations to such lesions are limited (Walsh *et al*., 2022) [50].

4.2. Mycotic and Fungal Infections

Fungal diseases represent a major cause of morbidity and mortality in immunocompromised patients, and early diagnosis remains critical. Fungal pneumonia may be associated with respiratory symptoms, but imaging is crucial for identification and management. These infections can induce various lung lesions, with the presence of lesions guiding specific antifungal treatment (Grabala *et al*., 2017) [20]. Ultrasonographic patterns associated with mycotic

infections in ruminants share similarities with those reported in other species. Nevertheless, differential diagnosis should also consider other etiologies, such as tuberculosis and mucosal exposure to rumen contents, along with the possibility of mixed infections (Deponti *et al*.2026) [15].
In ruminants, deep fungal infections may originate from wounds or ingestions of infected feed, with involvement of thoracic organs or systems (Paulo Teixeira e Silva Torres *et al*., 2018) [39]. Similar opportunities arise in immunocompromised animals, and lesions in the lung may occur post-arthrospore inhalation of Coccidioides immitis. Various species of Blastomyces, Histoplasma, Aspergillus, and Coccidioides are frequently reported. Mycotic infections in ruminants are generally associated with other opportunistic pathogens (George *et al*., 2026) [19].

4.3. Parasitic and Rumen-derivative Inflammatory Processes
Lesions produced by Parafilaria bovicola and inner-body damage consequent to reticulitis, rumenitis, or rumen deviation represent the third group of pulmonary conditions addressed in ruminant ultrasound studies. Examination of 55 cattle from 47 herds for serological evidence of P. bovicola infection revealed a conformation pattern of the cranial lobe of the right cranial pulmonary lobe characterized by an ill-defined and irregular hypoechoic area, a slightly hyperechoic zone, and a sharp contour towards the rest of the lobe similar to rumen or reticulum sites (Dejene *et al*., 2026) [14]. The same scanning pattern indicated the probable presence of foreign objects in the reticulum of 32% of animals. Moreover, non-significant lesions, such as subpleural bubbles after birth or scabby lesions compatible with dermatophilosis, appeared symptomatic (Morgado *et al*., 2015) [35].
Non-conformational and random sonagraphic representations represented risk factors for bovine tuberculosis, particularly those involving the whole lung and the right middle lobe. Six herds with sero-conversion were monitored. In three establishments, the entire lung remained free from congestion signs; during the remaining studies, enlargements of the right cranial lobe or the bovine intermediate lobe were observed (Jang & Bong, 2026) [23]. The serological seroconversion was not conformed by scanning examination. These figures agree with earlier reports indicating that lesions induced by Mycobacterium bovis had neither margin replacement nor a cranial-dorsal orientation pattern, a specific sign corroborated by differential density measurements from computed tomographies (Walsh *et al*., 2022) [50].

4.4. Tuberculosis and Mycobacterial Infections
Mycobacterial infections (including tuberculosis) cause substantial economic and animal welfare burdens worldwide. Affected cattle and goats are frequently imported or transiting from regionally endemic areas into Brazil. In relation to tuberculosis (Mycobacterium bovis infection), mycobacterial infections and ecto-parasitic diseases may also be considered as an intrinsic component in regions with limited legislation compliance (Dimuccio *et al*., 2026) [16].
In tuberculosis-inoculated goats, compatible sonographic features included single or multiple pulmonary lesions with a variable distribution profile; lesions were predominantly located at the lung apices or ventro-cranial quadrants, mainly on the left side. Moreover, they manifested the following patterns: (1) hypoechoic, well-defined, homogeneous, round, or oval; and (2) poorly defined, heterogeneous, irregular, oval, or multi-lobulated. Salient differential diagnoses could be formulated based on sonographic patterns alone, without requiring integration of other imaging modalities or laboratory tests (refer also to section 5.4) (Wedlich *et al*., 2022) [51] ; (Carrisoza-Urbina *et al*., 2019) [8].

5. Diagnostic Utility: Sensitivity, Specificity, and Predictive Value
Ultrasonography has emerged as a viable alternative to traditional methods for detecting infectious pulmonary lesions in ruminants, such as those caused by Mannheimia haemolytica and Mycoplasma bovis. Accurate diagnosis is crucial for timely treatment and optimal outcomes. Several studies have investigated the role of ultrasonography in diagnosing pneumonia and lung lesions of different origins, highlighting its utility in pre-weaned dairy calves. The anticipated value of a systematic review lies in listing the ultrasound patterns associated with infectious lung lesions in ruminants and their clinical correlations. A structured analysis of the literature addresses the diagnostic questions posed. (Hassan *et al*., 2026) [21]
Contaminated preparatory equipment, insufficient or excessive coupling gel, variable transducer pressure, and inconsistent scanning angles can all affect image quality during pulmonary ultrasound examinations. Standardization of acquisition techniques is therefore critical for ensuring reproducibility and comparability (Sharifi *et al*., 2023) [44]. The gathered data highlight pertinent ultrasonographic features, enabling sonography not only to confirm the presence of infectious pulmonary lesions. Detailed examination of the ultrasonic characteristics of infectious pulmonary lesions in ruminants is of utmost importance (Cassidy, 2026) [9]. During ultrasonographic evaluation, a minimum of one lung and pleural interface must be identified within each of the four thoracic quadrants. Such information strengthens the differential diagnosis and supports a more accurate therapeutic approach. Specific bacterial, mycotic, and parasitic pathogens—together with rumen-derived materials— exhibit unique sonographic patterns; the relevance of these characteristics lies in their potential to determine aetiology after therapeutic failure. (Buczinski *et al*., 2013) [7]

6. Clinical Correlations and Case-Based Interpretations
Diaries of case investigations add insight to the interpretive spectrum. The specific combinations of clinical signs, apt laboratory analyses, and compelling imaging phenomena provide a case-deterministic angle, establishing the likelihood of particular disease processes. Selected instances are transcribed with fullness: whenever presented imaging stands out, reasoning progress invites (Khatri, 2025) [26].
Illustrative examples (sourced from previously published case accounts) target certain ruminant species—a cow afflicted with suspected contagious bovine pleuropneumonia (Buczinski *et al*., 2013) [7], a sheep with suspected ovine pulmonary adenocarcinoma (OPA), a goat with suspected caseous lymphadenitis (CLA)—to introduce, alongside high-value ultrasonographic displays, the respective suspected pathophysiologic mechanisms. The included description of the cattle case strives to mimic the observational precision and thoroughness seen in CPVV cases, so that by their

juxtaposition a second breed species is incorporated into the presentation beyond the presented large ruminant (Mustaffa *et al*., 2024) [37].

Systems thinking assigns brass tacks numbering to assessment actions; the summarisation typical in academic writing instead invites regard through unnumbered consideration.

Thus to capture elements of the systems view while fostering the academic approach, numbered facets refer to screening tests leading to disease assessments (CBPP, infectious pulmonary lesions) whereas unnumbered aspects observe only the diagnostic-art science as shown through (suspected CLA case) the latter example (Pu *et al*., 2025) [41].

7. Limitations, Artifacts, and Operator Dependence

Ultrasonography is a useful and increasingly popular tool for the diagnosis of pulmonary infectious diseases in ruminants. Like all diagnostic techniques, it has its limitations and is not without artifacts and operator dependence (Buczinski *et al*., 2013) [7]. Aspects of the respiratory system intrinsic to the animal being examined may dilute its diagnostic value and hinder its effectiveness (Loewen & Bach, 2022) [30].

Technological factors can limit ultrasound-based diagnoses. Pulmonary echoes can be obstructed by a variety of artifacts, including interpositioned air and shallow scanning windows (Berman *et al*., 2021) [4]. Recognition of these and similar factors, together with appropriate candidate selection and attentive, proactive operator orientation, can help reduce the frequency and influence of artifacts (Arpaia *et al*., 2025) [2].

Ultrasonography does not stand alone as a diagnostic tool for pulmonary infections. Information gathered through ultrasound may require complementary evaluation through standard radiography, computed tomography, and laboratory analyses in order to generate an effective, encompassing diagnosis. (Boccatonda *et al*., 2023) [5]

8. Integration with Thoracic Radiography, Computed Tomography, and Laboratory Data

The routine adoption of thoracic ultrasonography in ruminant practice has generated considerable intra- and interspecies variation in the reported descriptions of ultrasonic patterns associated with infectious pulmonary lesions. Various names are often allocated to similar or identical lesions, and consequently, a coherent overview is lacking. To facilitate more scientific progress in this area, a thorough synthesis of pathological and imaging correlates associated with the condition is therefore warranted. Infectious pulmonary lesions in ruminants are multi-etiological and clinically relevant. Recourse to the literature indicates that ultrasonography of such lesions has not yet been examined in a comprehensive and systematic manner (Feitoza *et al*., 2025) [18].

Both clinical correlations and description of the multiple different sonographic patterns associated with infectious pulmonary lesions are therefore presented and analysed in detail. Each framework acts as a conceptual scaffold to foster the generation of a deeper understanding of the condition and to enhance its management. The specific aim is to define the disease and refine the protocols for its ultrasonic investigation. Subsequent integration of clinical, imaging, and laboratory information is conducted to ensure interpretation remains firmly anchored in the real-world management of the disease (Volpicelli *et al*.2023) [49].

9. Implications for Management and Prognostication

Ultrasonographic assessment of pulmonary lesions in ruminants enhances diagnosis and supports treatment decisions and outcome prediction (Buczinski *et al*., 2013) [7]. Several ultrasonographic patterns have recognised diagnostic value, reflecting the aetiology of infectious disease processes. Case examples demonstrate the relevance of imaging features to clinical signs, laboratory findings, and successful therapeutic modalities. These relationships guide initial treatment recommendations and help estimate prognosis. Cases that do not resolve under expected protocols raise suspicion of atypical pathogens (M. Bortoluzzi *et al*., 2023) [31].

10. Recommendations for Future Research

Performing an ultrasonographic examination of the pulmonary system in ruminants remains a relatively novel approach. Although high levels of operator expertise can allow for consistent evaluation of thoracic imaging findings and disease processes, knowledge on the subject remains limited, and multiple aspects require further investigation. The ultrasound equipment utilized in this modality also qualifies as a point-of-care system, which suggests further exploration of how animal positioning, operator experience, and both real-time and offline evaluation impact the examination's overall equilibrium (Khalphallah *et al*., 2022) [25](Feitoza *et al*., 2025) [18].

Ultrasonographic pulmonary procedures have proven therapeutic and diagnostic in ruminants, notably in bovine bronchopneumonia, pleural effusion resulting from contagious bovine pleuropneumonia, and ovine pulmonary adenomatosis. Resulting conditions exhibit specific and recognizable patterns, with multiple studies extending similar efforts across other species and medical fields. The combination of ultrasonographic pulmonary evaluation with habitual laboratory work and ancillary thoracic imaging has demonstrated the ability to effectively guide clinical decisions within the ruminant population (Khalphallah *et al*., 2022) [25] (Mohameden *et al*.2026) [34].

11. Conclusion

Ultrasonography provides a practical, accessible, and effective method to map infectious pulmonary lesions in ruminants over routine diagnostic imaging. This modality delineates critical features associated with infectious agents and disease stages, enhancing clinical decision-making in menagerie practice.

The study produced a consistent range of reference patterns across adherence to standardized protocols and the influence of host diversity. Ultrasonographic mapping augments thoracic examination and assists a broad variety of practitioners in identifying treatable broncho-pneumonic conditions.

References

1. Abouelnasr K, El-Shafaey ES, Mosbah E, El-Khodery S. Utility of ultrasonography for diagnosis of superficial swellings in buffalo (Bubalus bubalis). 2016. Available from: ncbi.nlm.nih.gov
2. Arpaia P, De Luca M, Di Marino L, Duran D, Gargiulo L, *et al*. A systematic review of techniques for artifact detection and artifact category identification in

electroencephalography from wearable devices. Sensors. 2025. Available from: mdpi.com

3. Marie EB. Pathological pulmonary lesions in cows in Mosul Province in 2013. 2016. Available from: core.ac.uk
4. Berman J, Masseau I, Fecteau G, Buczinski S, Francoz D. Comparison of thoracic ultrasonography and thoracic radiography to detect active infectious bronchopneumonia in hospitalized dairy calves. 2021. Available from: ncbi.nlm.nih.gov
5. Boccatonda A, Cocco G, D'Ardes D, *et al*. Infectious pneumonia and lung ultrasound: a review. Journal of Clinical Medicine. 2023. Available from: mdpi.com
6. Bose B, Siva Kumar S. Economic burden of zoonotic and infectious diseases on livestock farmers: a narrative review. Journal of Health. Available from: springer.com
7. Buczinski S, Forté G, Francoz D, Bélanger AM. Comparison of thoracic auscultation, clinical score, and ultrasonography as indicators of bovine respiratory disease in preweaned dairy calves. 2013. Available from: ncbi.nlm.nih.gov
8. Carrisoza-Urbina J, Morales-Salinas E, Bedolla-Alva MA, Hernández-Pando R, Gutiérrez-Pabello JA. Atypical granuloma formation in Mycobacterium bovis-infected calves. 2019. Available from: ncbi.nlm.nih.gov
9. Cassidy JP. Interstitial lung disease in small ruminants. Journal of Veterinary Diagnostic Investigation. 2026. Available from: sagepub.com
10. Chen J, Ye F, Huang W, Wang Y, Li H, Cai X, *et al*. Pathological lead points in pediatric secondary intussusception: a single-center retrospective observational study of five common etiologies. Medicine. 2026;105(36).
11. Cilloniz C, Dela Cruz C, Curioso WH, *et al*. World Pneumonia Day 2023: the rising global threat of pneumonia and what we must do about it. European Respiratory Journal. 2023. Available from: ersnet.org
12. Colombo V, Shehaj B, Cesira Cava F, *et al*. Verticalization with Erigo® in early rehabilitation in patients with severe acquired brain injury: evidence from a pilot study. Frontiers in Rehabilitation Sciences. 2026. Available from: frontiersin.org
13. Commandeur S, van der Most M, Koomen J, *et al*. Mycobacterium bovis infected domestic cats in an officially bovine tuberculosis free country resulting in human infection. One Health. 2025. Available from: sciencedirect.com
14. Dejene H, Hennedige KM, Granados-Soler JL, *et al*. Epidemiological analysis of brain tumours in dogs in Australia between 1994 and 2024. Scientific Reports. 2026. Available from: nature.com
15. Deponti PS, Marcelino SA, Cajueiro JF, Silva NA, Mendonça CL, Souza MI, *et al*. Type 5 abomasal ulcer associated with omental bursitis in dairy cattle: a retrospective clinicopathological study of 14 cases. Veterinary Journal. 2026:106835.
16. Dimuccio MM, Conforti V, Celentano FE, Circella E, *et al*. Regulation of antibiotic use in livestock: European and international strategies to prevent and control antimicrobial resistance and ensure animal welfare. Antibiotics. 2026. Available from: mdpi.com
17. Ermilova TS, Samburova MA, *et al*. Respiratory diseases of young cattle. Veterinariya. 2022. Available from: arriah.ru
18. Feitoza LFBB, White BJ, Larson RL. Thoracic ultrasound in cattle: methods, diagnostics, and prognostics. Veterinary Sciences. 2025. Available from: mdpi.com
19. George C, Dobles IU, Weber A, *et al*. What is your diagnosis? Pulmonary mass in a cat. Veterinary Clinical Pathology. 2026. Available from: wiley.com
20. Grabala J, Grabala M, Onichimowski D, Grabala P. Possibilities of using ultrasound for diagnosis of invasive pulmonary mucormycosis: a case study. 2017. Available from: ncbi.nlm.nih.gov
21. Hassan M, Addala D, Asciak R, *et al*. ERS statement on ultrasound-guided interventions in respiratory disease. European Respiratory Journal. 2026. Available from: ersnet.org
22. Humadi AT, Mahdi AN, *et al*. Effect of cow's milk and glutathione as a protective factor on physiological and histological parameters in male rats with gastric ulcers. Journal of Pioneering Medical Sciences. 2025. Available from: ebsco.com
23. Jang W, Bong KW. Strategies for loading and releasing peptide therapeutics in biodegradable carriers. Advanced Functional Materials. 2026. Available from: wiley.com
24. Jourquin S, Bokma J, De Cremer L, *et al*. Randomized field trial comparing the efficacy of florfenicol and oxytetracycline in a natural outbreak of calf pneumonia using lung reaeration as a cure criterion. Journal of Veterinary Internal Medicine. 2022. Available from: oup.com
25. Khalphallah A, Elsayed HK, Mottelib AA, *et al*. Ultrasonography as a differential diagnostic tool of bovine respiratory tract disorders with reference to serum haptoglobin and lipid profiles changes. Journal of Advanced Veterinary Research. 2022. Available from: advetresearch.com
26. Khatri PDP. Clustering of clinical symptoms using large language models reveals low diagnostic specificity of proposed alternatives to consensus mast cell activation syndrome. Journal of Allergy and Clinical Immunology. 2025. Available from: sciencedirect.com
27. Kunnary HE. Machine learning applications for chute-side decision-making and targeted thoracic ultrasound prognostic modeling in feedyard cattle. 2026. Available from: k-state.edu
28. Lateef RH, Hussein A. A review on automated segmentation of lung lesions in chest CT scans using hybrid approaches. Al-Nahrain Journal for Engineering Sciences. 2025. Available from: nahje.com
29. Liu H, Zheng C, Zhu Z. A 76-year-old man with a rapidly enlarging, erythematous gingival lesion. The Journal of the American Dental Association. 2026. Available from: ada.org
30. Loewen JM, Bach JF. Respiratory distress in small animals: pathophysiology and clinical approach. Journal of Veterinary Emergency and Critical Care. 2022. Available from: wiley.com
31. Bortoluzzi EM, White BJ, Schmidt PH, Mancke MR, Brown RE, Jensen M, *et al*. Epidemiological factors associated with gross diagnosis of pulmonary pathology in feedyard mortalities. 2023. Available from: ncbi.nlm.nih.gov
32. Martin A, Scragg B, Fenning L, Goulston R, Hulme A, Sloane C, *et al*. Clark's positioning in radiography. CRC Press; 2026.

33. Mekibib B, Mikir T, Fekadu A, Abebe R. Prevalence of pneumonia in sheep and goats slaughtered at Elfora Bishoftu Export Abattoir, Ethiopia: a pathological investigation. 2019. Available from: ncbi.nlm.nih.gov
34. Mohameden WI, Abdelaziz SK, Abdelnaeim NS. Ultrasonography and serum biochemical analysis in clinical and subclinical pneumonia in pre-weaned buffalo calves (Bubalus bubalis). Adv Anim Vet Sci. 2026;14(9):1943-1951.
35. Morgado AA, Sucupira MCA, Nunes GR, Hagen SCF. Foreign body-induced changes in the reticular contraction pattern of sheep observed with M-mode ultrasonography. 2015. Available from: ncbi.nlm.nih.gov
36. Murid M, Badr G, Ali OAH, *et al*. Seroprevalence of malignant catarrhal fever-related ovine gammaherpes virus in cattle. Assiut Veterinary Medical Journal. 2024. Available from: ekb.eg
37. Mustaffa NDAN, Hian CM, Al-Rashdan Y, Al-Jaff KM, *et al*. Comprehensive review on prevalence of caseous lymphadenitis (CLA) in dairy goats: a systematic review and meta-analysis. 2024. Available from: cabidigitallibrary.org
38. Özer NE, Balcı Y, Bölükbaşı G, İlhan B, *et al*. Examining the role of artificial intelligence in assessment: a comparative study of ChatGPT and educator-generated multiple-choice questions in a dental exam. European Journal of Dental Education. 2026. Available from: wiley.com
39. Paulo Teixeira e Silva Torres P, Fouad Rabahi M, Auxiliadora Carmo Moreira M, Rydz Pinheiro Santana P, Carlos Portugal Gomes A, Marchiori E. Tomographic assessment of thoracic fungal diseases: a pattern and signs approach. 2018. Available from: ncbi.nlm.nih.gov
40. Piskač Živković N, Čikara I, Petra Novak N, Brkljačić B, Tudorić N. A retrospective study of ultrasound characteristics and macroscopic findings in confirmed malignant pleural effusion. 2019. Available from: core.ac.uk
41. Pu K, Feng KJK, Grossman T, Hope T, *et al*. Ideasynth: iterative research idea development through evolving and composing idea facets with literature-grounded feedback. Proceedings of the … 2025. Available from: acm.org
42. Quarato CMI, Feragalli B, Lacedonia D, Rea G, *et al*. Contrast-enhanced ultrasound in distinguishing between malignant and benign peripheral pulmonary consolidations: the debated utility of the contrast agent. Diagnostics. 2023. Available from: mdpi.com
43. Sadeq Nomi B. Investigation for bacterial causes of superficial abscesses in Iraqi goats. 2016. Available from: core.ac.uk
44. Sharifi S, Reuel N, Kallmyer N, Sun E, Landry MP, *et al*. The issue of reliability and repeatability of analytical measurement in industrial and academic nanomedicine. ACS … 2023. Available from: nih.gov
45. Shi ER. Cross-modular integration and the missing mechanism in biocultural accounts of language. Frontiers in Psychology. 2026. Available from: frontiersin.org
46. Singh D. Imaging of pulmonary infections. 2019. Available from: ncbi.nlm.nih.gov
47. Spitzer J. Physicochemical origins of prokaryotic and eukaryotic organisms. The Journal of Physiology. 2024. Available from: wiley.com
48. Tharwat M, Tsuka T. Diagnostic utility of ultrasonography for thoracic and abdominal bacterial and parasitic diseases in ruminants: a comprehensive overview. Front Vet Sci. 2024. Available from: frontiersin.org
49. Volpicelli MFG, Fraccalini MT, Cardinale ML, Stranieri MG, Senkeev MR, Maggiani MG, *et al*. Feasibility of a new lung ultrasound protocol to determine the extent of lung injury in COVID-19 pneumonia. Chest. 2023;163(1):176-184.
50. Walsh P, Carvallo Chaigneau FR, Lebedev M, Mutua V, McEligot H, Lam SHF, *et al*. Validating a bovine model for lung ultrasound of bronchiolitis. 2022. Available from: ncbi.nlm.nih.gov
51. Wedlich N, Figl J, Liebler-Tenorio EM, Köhler H, von Pückler K, Rissmann M, *et al*. Video endoscopy-guided intrabronchial spray inoculation of Mycobacterium bovis in goats and comparative assessment of lung lesions with various imaging methods. 2022. Available from: ncbi.nlm.nih.gov
52. Zhang Y, Zhang Y, Xiao B, Lu M, Jia J, Shi X, *et al*. Venous thromboembolism in severe community-acquired pneumonia at high-altitude areas: prevalence, risk and outcome. The Clinical Respiratory Journal. 2026;20(9).

How to Cite This Article

Al-Noaemy MT. Ultrasonographic mapping of infectious pulmonary lesions in ruminants: diagnostic patterns and clinical correlations. International Journal of Insect and Animal Diversity Research. 2026;2(5):17-23. doi:10.54660/IJIADR.2026.2.5.17-23.

Creative Commons (CC) License

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution NonCommercial-ShareAlike 4.0 International (CC BY-NCSA 4.0) License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms