Research Article

Ultrasonographic Findings in Adult Cattle with some Chronic Respiratory Diseases

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Abstract

Modern 5 MHz portable ultrasound machines provide the veterinary practitioner with an inexpensive, non-invasive tool with which to examine the pleural surfaces and superficial lung parenchyma of cattle with suspected respiratory disease. Systematic ultrasound examination of both sides of the chest need not take the busy farm animal practitioner more than 5 minutes. The primary aim of this study was to describe the ultrasonographic findings of chronic lung and pleural lesions in adult cattle, their relative incidence rates and, where appropriate, the response to extended treatment regimen using procaine penicillin. All adult cattle with chronic weight loss and/or poor milk production referred to the University of Edinburgh, Veterinary School over a two years’ period (2010-2012) were examined for respiratory disease. Clinical examination included detailed auscultation of the chest with digital recording of lung and heart sounds, ultrasonography of the lungs, heart and liver, and necropsy examination of cattle euthanased for welfare reasons and/or treatment failure. Cattle with ultrasonographic changes affecting the lungs and pleurae were admitted to the study. Lesions consistent with chronic supplicative pneumonia are first detected ultrasonographically in the fifth to seventh intercostal spaces 5 to 25 cm dorsal to the olecranon represented by numerous hypoechoic columns extending 2 to 8 cm into the lung parenchyma which are bordered distally by bright white (hyperechoic) lines when the transmitted sound waves contact normal aerated lung. Moving the ultrasound probe head ventrally, there are large hypoechoicogenic areas with the echogenic appearance of liver (hepatoid) corresponding to lung consolidation. Pleural effusion, present in varying quantities in individual cases of dilated cardiomyopathy, thymic lymphosarcoma and diffuse fibrosing alveolitis, is readily identified as an anechoic area which increases in depth as the probe head is moved ventrally with consequent dorsal displacement of the ventral margins of the lung lobes which may be consolidated. Metastases to the lungs in one cow were only imaged on the lung surface, appearing as discrete 2-3 cm diameter hypoechoic areas without a marked capsule, but are present throughout all lung lobes at necropsy. Trueperella pyogenes was isolated from the lower respiratory tract of three of five adult cattle with chronic supplicative pneumonia. Extended duration treatment with procaine penicillin was effective in 10 of 15 adult cattle with chronic supplicative pneumonia; no other antibiotic therapy was examined.

Keywords: Ultrasonography; Respiratory disease; Cattle; Diagnosis

Introduction

Auscultation is considered an important component of veterinary clinical examination [1] but the extent to which auscultation of the bovine chest can detect, localise and specify lung pathology has not been critically investigated because it relies upon the accurate recollection of lung sounds when lesions are revealed at necropsy often days to weeks later. Furthermore, Rabeling et al. (1998) stated that it is difficult to assess the extent of damage to lung tissue in bovine bronchopneumonia by clinical investigation alone and employed ultrasonography to characterise lung pathology in young calves [2]. Their statement is supported by recent studies that have highlighted a lack of correlation between lungs sounds and distribution of pathology in cases of ovine pulmonary adenocarcinoma [3] and other sheep respiratory diseases [4,5]. Nonetheless, reference textbooks variably describe abnormal lower respiratory tract sounds as clicking, popping or bubbling sounds, crackles, wheezes, and pleuritic friction rubs [1,6]. Progression of the disease process to the stage that severe respiratory disease exists is defined whereby expiratory sounds are as harsh as inspiratory sounds [1]. Abutarbush et al. (2012) reported that ultrasonography using a 3.5 MHz sector transducer was not particularly effective as a prognostic/diagnostic tool for early detection of bovine respiratory disease but may be useful in targeted populations of cattle with respiratory diseases of longer duration (such as pens containing chronic cases) [7].

Chronic supplicative pneumonia has long been considered a common condition in cattle of all ages with non-specific clinical signs of weight loss, coughing, depression, and intermittent fever present for weeks or months before presentation to the veterinary surgeon [8]. The disease is characterised by lung abscesses and bronchictasis and a poor response to antimicrobial therapy with bacteria such as Trueperella (formerly Arcanobacterium) pyogenes commonly isolated from affected lung tissue at necropsy [9]. While abnormal auscultatory findings have been reported over the cranioventral lung field of such cases [10], no descriptions were supplied. An accurate diagnosis of chronic supplicative pneumonia presents the veterinary practitioner with numerous difficulties.

While many veterinary surgeons have employed ultrasonography in bovine fertility management for the past 25 years, these portable machines can also be used to further examine the bovine chest [11-13], and abdomen including the body wall, peritoneum, umbilicus, rumen, abomasum, intestines, liver, kidney, umbilical structures, and bladder [14]. The sensitivity and specificity of ultrasonography for detecting bronchopneumonia in calves were 0.85 and 0.98, respectively [2].

Typical microorganisms associated with acute respiratory disease in growing cattle includes Mannheimia haemolytica, Pasteurella multocida and Histophilus somni [15,16]. T. pyogenes remains a common isolate from cases of chronic supplicative pneumonia in cattle [9,17]. Whilst many antibiotics have been introduced for the treatment of acute infections in young stock [16,18] penicillin was used for chronic respiratory infections in the present series based upon previous success with this therapeutic regimen where T. pyogenes was the most common isolate.
This article describes the common ultrasonographic abnormalities affecting the lungs and pleurae of 21 adult cattle with chronic respiratory disease and pleural effusion presented to the author in farm animal practice in the United Kingdom over a two years’ period (2010-2012) and evaluated an extended treatment course of procaine penicillin. Lung and pleural pathologies identified during the ultrasonographic examination were confirmed at necropsy in 11 cases.

Materials and Methods

Thirty five adult cattle with weight loss and/or poor milk production reported to be over 2-8 weeks duration, where a definitive diagnosis could not be established by clinical examination, were referred to the University of Edinburgh, Veterinary School over a two years’ period (2010-2012). This study considered the likely primary cause of weight loss and poor production then further investigated the ultrasonographic findings, and the relative disease incidence rates of those cattle with chronic respiratory diseases. Seventeen of 35 cows were diagnosed with bacterial respiratory diseases; 15 cows with chronic suppurrative pneumonia; two year-old (10), three year-old (2) and more than four years (3), and two cows more than four years with pleural abscesses but without associated peritoneal/reticular pathology. These cattle originated from 150 to 600 dairy cow units. A 12 year-old cow with diffuse fibrosing alveolitis and associated pleural effusion originated from a beef herd. The single cases of thymic lymphosarcoma and dilated cardiomyopathy (both two year-old), causing extensive pleural effusion, originated from beef and dairy farms, respectively. One 10 year-old beef cow presented with metastases to the lungs from a primary uterine adenocarcinoma. The dairy cows were housed year-round in cubicle sheds, milked twice daily, and fed a total mixed ration based on grass silage with added cereals and soya bean meal. The three beef cows were fed a ration of grass silage supplemented with 2 Kg mineralised barley and housed in straw yards; all three cows were housed at the time of presentation. The causes of chronic weight loss and/or poor milk production in the other 14 cattle were liver abscesses (3), endocarditis (3), pericarditis (1), chronic peritonitis (4), paratuberculosis (2), and pyelonephritis (1). Twelve diagnoses were confirmed at necropsy; one cow with liver abscesses and one with pyelonephritis were successfully treated and discharged.

Examinations included auscultation of the entire lung field on both sides of the chest with digital recording of lung and heart sounds, ultrasonography of the lungs, heart and liver, and necropsy examination of cattle euthanased for welfare reasons and/or treatment failure. Eighteen cattle with pathology of the lungs and/or pleurae identified during ultrasonographic examination are included in the present study, and three cows with an extensive pleural effusion. Fifteen adult cattle with no clinical or ultrasonographic evidence of respiratory, cardiac and hepatic disease were included in this study as controls. The control cattle comprised animals with paratuberculosis, chronic mastitis, and musculoskeletal problems. Single cases diagnosed with infectious bovine rhinotracheitis and lungworm (Dictyocaulus viviparous) infestation based upon laboratory testing were excluded from the study. To mimic the time constraints of general veterinary practice, ultrasonographic examination of the chest, including skin preparation time, totaled no more than 5 minutes.

Ultrasonographic examination of the chest was undertaken using a 5.0 MHz sector transducer connected to a real-time, B-mode ultrasound machine [13]. A 10 cm wide strip of skin was shaved on both sides of the thorax extending in a vertical plane from below the point of the elbow to the caudal edge of the scapula corresponding to the 6th or 7th intercostal spaces (Figure 1). The prepared skin overlying the chest wall could be freely moved up 5-10 cm which allowed examination of the caudal aspect of the dorsal lung field. The skin was soaked with warm tap water then ultrasound gel was liberally applied to the wet skin to ensure good contact [19]. The transducer head was firmly held at right angles against the skin overlying the intercostal muscles of the 6th or 7th intercostal spaces and the thorax examined in both longitudinal and transverse planes. The cranial aspect of the thorax were scanned by moving the transducer head cranially from the 6th or 7th intercostal space into the next more cranial intercostal space once or twice as the transducer was moved down the chest wall. The ipsilateral forelimb was held forward to facilitate access to the ventral aspect of the thoracic wall to image the heart. It was important to visualise the echogenic (white) line of the normal visceral pleura [2] before scanning the more ventral areas (Figure 2). If there was doubt concerning the imaged lesion the visceral pleura was followed down the chest wall to identify the junction between normal lung and the suspected area of pathology. All ultrasonographic examinations were undertaken by the author.

The location of the lung and pleural/lung lesion(s) was outlined on each side the chest and sound recordings taken over the centre of the

Figure 1: Cow with chronic suppurative pneumonia showing the shaved area of skin from behind the shoulder down to the elbow to allow ultrasonographic examination of the ventral lung field.

Figure 2: The surface of normal aerated lung (visceral or pulmonary pleura) of normal cattle is characterized by the continuous white linear echo. Comet tails arise from the visceral pleural surface in this image. The probe head is at the top of the image; dorsal is to the right. Centimeter gradations are indicated on the right hand margin.
lesion(s) and at distances from the lesion(s) including areas of normal lung. Sound recordings were made using a standard stethoscope head connected to a microphone (Olympus ME-15; Misco) by a short piece of plastic tubing. The electrical output of the microphone was pre-amplified before digitization and storage using a commercial voice recorder (Olympus WS-321M; Misco). Sound files were saved as.wav files for future study but also allow subjective comparison of auscultated sounds over the lung and pleural pathologies with normal lung located dorsally. The location and nature of the lesions were confirmed at necropsy, including histopathology where necessary, in five cows with chronic suppurative pulmonary disease, two cows with extensive unilateral pyothorax, and three cows with pleural effusion (dilated cardiomyopathy, thymic lymphosarcoma and diffuse fibrosing alveolitis, respectively). Ten cows, with similar ultrasonographic changes to the five cows’ euthanased for welfare reasons with chronic suppurative pulmonary disease, responded well to antibiotic therapy and were discharged after two to six weeks.

All cattle with a clinical and ultrasonographic diagnosis of chronic suppurative pneumonia were treated with 12 mg/kg of procaine penicillin injected intramuscularly once daily for 42 days with meat and milk withdrawal intervals of 5 and 11 days, respectively. All cases received an injection of flunixin meglumine before clinical examination, and for the next two to four days.

Results

Auscultation findings

Increased wheezes were auscultated over normal lung situated dorsally and consolidated lung identified in the ventral lung field of 15 cattle with chronic suppurative pneumonia; no coarse crackles were identified. Reduced volume of normal lung sounds were auscultated over the ventral chest wall on the affected side in two cows with pleural abscesses but the area delineated over the chest wall by auscultation was less than one half the area revealed at necropsy. In three cows with extensive pleural effusion, auscultation underestimated the volume of transudate present within the chest.

Interpretation of ultrasonographic findings

The sonograms are presented with the probe head/chest wall at the top of the image; dorsal is to the right and ventral to the left of the image. Centimetre dot markers are displayed on the margin of the images and should be consulted to ascertain the depth of field presented. The bright white hyperechoic linear echo that represents the pleural surface (Figure 2) is the result of a large difference in acoustic impedance between the chest wall and the aerated lung [2]. The sonogram below the white linear echo may contain equidistant reverberation artefacts. The area visualized below the linear echo, including the reverberation artefacts, does not represent lung parenchyma thus the initial ultrasound machine setting should be 7-10 cm which examines approximately 3 cm of chest wall then pleurae, and superficial lung parenchyma.

Normal cattle

The surface of normal aerated lung (visceral or pulmonary pleura) of 15 normal cattle was characterized by the uppermost white linear echo with equally-spaced reverberation artefacts below this line. In normal adult cattle (around 600 kg), the visceral pleura was observed moving approximately 5 mm in a vertical plane during respiration. Comet-tail artefact (Figure 2) represents a series of closely spaced discrete echoes indicating the focal accumulation of a small amount

of highly reflective material, often gas bubbles [12] and is occasionally seen in cattle with no obvious lung pathology. No pleural fluid was visualized in normal cattle. The chest wall was approximately 2.5-3.5 cm wide. No lung abnormalities were observed in the 15 normal cattle at necropsy.

Chronic suppurative pneumonia

Appetite was markedly reduced in the 15 dairy cows with chronic suppurative pneumonia and two cows with pleural abscesses. All animals refused the concentrate component of the ration at admission. Milk production was reduced to 25-50% of expected yield. Ten animals presented with a sub-normal to normal rectal temperature (37°C to 38.5°C); five cows showed a slight fever (39°C to 39.2°C) including two cows receiving antibiotic treatment. All cattle were dull and depressed and often stood with the neck extended and the head held lowered. Subjective visual appraisal suggested that cows had an anxious/painful expression. All cattle coughed repeatedly during the clinical examination, ultrasonographic and sound recording session which lasted for a total of approximately 20 minutes. A purulent nasal discharge was intermittently present but was noted in all cattle at some stage during the 20 minutes’ examination period and was most notable on the ground in front of the cattle stocks after the clinical examination. The respiratory rate was increased above 48 breaths per minute with a marked abdominal effort in all animals; three cows were mouth-breathing at presentation. Marked flaring of the nostrils was observed during inspiration in four animals. Chest auscultation failed to delineate lung pathology in 15 adult cattle with chronic suppurative pneumonia.

As the probe head was advanced ventrally from normal lung tissue present in the dorsal lung field, the first ultrasonographic change in lung parenchyma attributed to chronic suppurative pneumonia, and confirmed at necropsy in five cows, was the columnar irregularity of the hyperechoic linear echo of the normal visceral (pulmonary) pleura in the antero-ventral apical and cardiac lung lobes (Figures 3-7). The dorsal margin of the lung pathology commenced 5-25 cm above the point of the elbow at the 6th and 7th intercostal spaces and extended from this level to the ventral margin of the lung lobes (Figures 8-10). These hyperechoic “columns” extended 2-8 cm from the visceral pleura and were bordered distally by bright hyperechoic lines as

Figure 3: Loss of the continuous white linear echo formed by the normal visceral (pulmonary) pleura (see Figure 2) replaced by hypoechogenic areas giving a columnar appearance representing a lobular distribution at the dorsal margin of lung pathology (see Figure 4).
the sound waves contacted either normal aerated tissue or smaller airways deeper within the lung tissue. Ventrally, ultrasonographic examination imaged the diseased lung as a large hypoechoic area (up to 30 cm in the vertical plane in severe cases) containing multiple 5-10 mm wide hyperechoic lines which extended up to 6-8 cm into the lung parenchyma. There were no discernible changes in the nature and distribution of ultrasonographic changes between recordings made at admission in 10 cows and discharge two to six weeks later. In many cases it was possible to image the right lung and liver in the same field; diseased lung had the sonographic density of liver (Figure 11).

Small discrete lung abscesses were observed in two of five cows at necropsy and the hypoechoic areas identified during ultrasonographic examination more commonly represented consolidated lung parenchyma, usually with a distinct lobular appearance, with purulent material within smaller airways (bronchiectasis). *Trueperella pyogenes* was isolated from the lower airways of 3 of 5 chronic suppurative pneumonia cases at necropsy.
Five of seven cows did not respond to antibiotic therapy when the sonographic changes representative of chronic suppurative pneumonia extended more than 10 cm above the level of the olecranon of the elbow because this area represented more than 30% of lung involved in the disease process.

**Pleural abscesses**

Unilateral pyothorax was diagnosed in two cows (Figures 12,13). The visceral pleuron was only visible for 10-20 cm at the top of the chest wall. The separation of the pleurae increased rapidly as the probe head was moved ventrally. The pleural space was filled by a uniform anechoic area containing many hyperechoic spots representing gas echoes within the abscess. Despite intensive antibiotic, non-steroidal anti-inflammatory drugs and supportive therapy both cows were euthanased for welfare reasons within 48 h of admission. Necropsy revealed the pleural space contained approximately 35-50 L of purulent material. There was no evidence of a penetrating reticular foreign body as the cause of the pleural abscesses.

**Pleural effusion**

Extensive pleural effusion was caused by right-sided heart failure in cattle with diffuse fibrosing alveolitis, dilated cardiomyopathy (Figures 14,15), and thymic lymphosarcoma. An increasing depth of fluid (anechoic area) separated the pleurae as the probe head was moved down from about the midpoint on the chest wall. At the ventral margin of the lung field the effusion extended up to 20 cm (including 3 cm of chest wall). The pleural effusion was readily identified as an anechoic area with dorsal displacement of the ventral margins of the lung lobes (Figure 14). With extensive effusion, the ventral lung margins were consolidated.

**Discussion**

Despite the considerable lung pathology in adult cattle diagnosed with chronic suppurative pneumonia, fever was an uncommon clinical finding in the present study and is in broad agreement with previous reports [8,10]. This situation differs significantly from acute respiratory disease in growing cattle where fever >40.0ºC is considered the most important selection criterion for antibiotic therapy [16,18]. The absence of pyrexia is a very important clinical finding because clinicians may be unwilling to commit to a prolonged course of antibiotic therapy in cattle with a normal, even subnormal, rectal temperature. Procaine penicillin was selected in the present study because *T. pyogenes* was the most common bacterial isolate from the lower airways at necropsy, and was cultured from 28.6% of lungs in diseased calves [17]. There are initiatives in many countries to encourage the responsible use of antimicrobial drugs in veterinary practice [20]. There is the tendency for clinicians to use newer antibiotic formulations for cattle diseases when penicillin would have sufficed [21].

The surface of normal aerated lung (visceral or pulmonary pleura) was characterized by the uppermost hyperechoic linear image, often with equally-spaced reverberation artefacts below this line as previously described [22], moving 5-10 mm during respiration [23]. Comet tails were observed during ultrasonographic examination of several normal cows where no gross lung pathology was detected at necropsy and these artefacts were considered to be of no clinical significance. Comet tails have been described in cattle with pulmonary emphysema [11] but because there are few primary causes of severe emphysema in adult cattle the presence of emphysema may
only be significant because it results secondarily from extensive lung pathology.

Classification of the ultrasonographic changes into fine-, medium- and coarse-grained structures based upon the echogenic pattern with <10, 10-20 and >20 hyperechogenic zones per centimetre penetration of pneumatic lung tissue [2] was considered unnecessarily complicated and did not aid formulating the prognosis in the present study. Rather, the hypoechocic changes had a distinct columnar appearance dorsally representing the lobular distribution of superficial lung pathology. Much of the diseased lung in cattle in the present study was hypoechocic and had the sonographic appearance of liver most graphically illustrated when pneumatic right ventral lung, diaphragm then liver could be imaged at the same time. Pulmonary consolidation appears as a hypoechocic area and its echo texture may look like liver parenchyma [12]. The area of the chest wall which overlay lung pathology defined ultrasonographically was considered more helpful in formulating a prognosis than the classification of the ultrasonographic changes [2] in the present study. Metastasis from an uterine adenocarcinoma imaged as a large hypoechocic area extending 5 cm into the lung parenchyma bordered by a hyperechocic line (Figures 16,17). There was a typical lobular distribution of lung lesions. This lesion was more sharply defined than lobular consolidation associated with chronic suppurative pneumonia because the lesion is likely more cellularly dense.

Alternative approaches to the diagnosis of chronic suppurative pneumonia in general practice include the response to antibiotic therapy although this regimen would also treat chronic bacterial pneumonia in general practice include the response to antibiotic therapy although this regimen would also treat chronic bacterial pneumonia because the lesion is likely more cellularly dense. Necropsy findings are shown in Figures 3, 5, 7).

Ultrasonographic examination of the chest is helpful in the definitive diagnosis of chronic supplicative pneumonia in cattle with suspected respiratory disease, and more generally in cattle presenting with poor performance and weight loss. There are numerous hypoechocic columns extending 2-6 cm into the lung parenchyma which are bordered distally by bright white (hyperechocic) lines as the transmitted sound waves contact normal aerated lung/smaller airways. As the ultrasound probe is moved ventrally down the chest wall, the lung loses this columnar appearance and becomes hypoechocic with multiple large hyperechocic dots. Chest auscultation failed to accurately define and delineate lung and pleural pathologies in adult cattle. With some experience, ultrasonographic examination of both sides of the bovine chest takes less than five minutes. Treatment efficacy will be based upon further published evidence of response to various antibiotic regimens once the nature and extent of the lung pathology has been determined ultrasonographically. Such information will be invaluable to veterinary practitioners challenged with the differential diagnosis of weight loss and poor production in adult cattle.

References


