Diagnosis and treatment of respiratory disease in adult sheep based upon ultrasonographic examination of the chest

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SUMMARY
Introduction - A presumptive aetiological approach is commonly adopted for the treatment of ovine respiratory diseases. This article reports the efficacy of certain treatment strategies for some of the common respiratory diseases based upon ultrasonographic abnormalities affecting the lungs of adult sheep.

Aim - The aim of this study was to report the treatment success of chronic lung diseases in adult sheep where the diagnosis was based upon ultrasonographic examination of the chest.

Materials and methods - Cases were presented to the author in first opinion farm animal practice in the United Kingdom over a two years’ period (2010-2011 inclusive). Ultrasonographic examination of the chest was undertaken in nine adult sheep with acute onset respiratory disease and 36 adult sheep with respiratory diseases associated with weight loss including ovine pulmonary adenocarcinoma (15) chronic suppurative pulmonary disease (6 cases), fibrinous pleurisy (2 cases), pleural/superficial lung abscesses (10 cases) and pyothorax (3 cases).

Results - Ultrasonographic examination of the chest was most helpful in the definitive diagnosis of pleural/superficial lung abscesses where the anechoic areas containing multiple hyperechoic dots bordered distally by a broad hyperechoic capsule were readily detected but generated no adventitious lung sounds. Daily treatment with procaine penicillin for 42 days was successful in all six sheep identified with pleural/superficial lung abscesses measuring 2-8 cm in diameter; only one of four sheep with more extensive lesions, and one of three unilateral pyothorax cases recovered. Pleural frictions rubs were not heard in cases of marked fibrinous pleurisy or when there were adhesions associated with pleural/superficial lung abscesses. Lesions of ovine pulmonary adenocarcinoma (OPA) were sharply demarcated hypoechoic areas extending 6-8 cm into the lung parenchyma in the cranio-ventral lung lobes and had the sonographic appearance of liver but such lesions could not accurately be delineated by auscultation findings. Despite its chronic nature, OPA was the only identified risk factor predisposing to septicaemia in nine sheep.

Discussion - Accurate identification and distribution of pleural and superficial lung pathology necessitated ultrasonographic examination; auscultation failed to identify and delineate lesions. With some experience, systematic ultrasound examination of the ovine chest takes no more than 5 minutes.

Conclusion - Long-term penicillin therapy was successful in 7 of 10 cases of pleural/superficial lung abscesses. Treatment of septicaemia secondary to OPA was unsuccessful in the first five sheep and could not subsequently be justified for welfare reasons once the extensive lung tumour pathology had been identified ultrasonographically.

KEY WORDS
Ultrasoundography, respiratory disease, sheep, diagnosis, treatment.

INTRODUCTION
An aetiological approach to the diagnosis, treatment and control of ovine respiratory diseases is adopted in most review articles and book chapters. However, such precise classification is unrealistic in most general veterinary practice situations because clinical signs are not pathognomic for particular aetiological agents.

The accuracy by which chest auscultation can detect, localise and differentiate ovine lung pathology has been questioned following comparison of adventitious sounds auscultated over normal lung areas and ovine pulmonary adenocarcinoma lesions. Adventitious lung sounds are noises superimposed upon normal lung sounds and tend to occur consistently at the same stage of the breath cycle, over many consecutive breaths. Tachypnoea increases the velocity of air flow in the large airways causing increased audibility of normal breath sounds over the entire lung field by increasing the amplitude of breath sounds and may be confused with wheezes. Recent publication of adventitious lung sounds use the following definitions:

- **Wheezes** - Wheezes are prolonged musical sounds that usually occur during inspiration and occasionally throughout the breath cycle. They result from vibration of airway walls caused by air turbulence in narrowed airways. Wheezes are musical adventitious lung sounds, also called ‘continuous’ since their duration is much longer than that of “discontinuous” crackles. They will typically be heard for more than 80 - 100 msec.

- **Crackles** - Crackles are short duration, interrupted, non-musical sounds. Crackles are loud, explosive, short duration (typically 10-30 ms), non-musical, rattling or bubbling sounds.
Coarse crackles are possibly caused by air bubbling through, and causing vibrations of, respiratory secretions within the larger intrathoracic airways, including those that are pooling within the dependent part of the rostral thoracic trachea. The presumptive clinical diagnosis of acute respiratory disease caused by Mannheimia haemolytica and Bibersteinia trehalosi (“pasteurelllosis”) in adult sheep is based upon findings of sudden severe illness; inappetance, pyrexia, marked tachypnoea, and tachypnoea consistent with endotoxaemia. There are no specific adventitious sounds and researchers have simply commented on the presence of ‘loud and prolonged respiratory sounds’10. Increasingly, authors of ovine respiratory disease studies have not attempted to describe auscultation findings but have simply referred to their distribution11; no abnormal sounds recorded (score 0), abnormal sounds audible predominantly anteroventrally (score 1), abnormal sounds audible throughout the entire lung field (score 2). The response of “pasteurelllosis” to antibiotic and non-steroidal anti-inflammatory drug (NSAID) treatments does not necessarily support a specific diagnosis of acute respiratory disease because many other bacterial infections that present with profound endotoxaemia can also recover with treatment12. Simultaneous sound recording and ultrasonographic examination revealed that pyothorax and fibrinous pleurisy caused marked attenuation of lungs sounds. Lesions such as pleural/superficial lung abscesses could not be detected by auscultation11,12. It was concluded that ultrasonographic diagnosis of the thorax is essential to determine the nature and extent of chronic lung and pleural lesion(s) and should be undertaken before any treatment regimen is commenced13,14. This article describes the common ultrasonographic abnormalities affecting the lungs of adult sheep presented to the author in farm animal practice in the United Kingdom over a two years’ period (2010–2011 inclusive) and reports the efficacy of the treatment strategies for some of these diseases based upon similar studies in cattle. This is the first report to describe the successful treatment of pleural/superficial lung abscesses causing weight loss in adult sheep with daily procaine penicillin injections administered for six weeks.

**RESULTS**

**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. An air interface, created by aerated lung parenchyma reflects sound waves and appears as a bright white (hyperechoic) linear echo (Fig. 1). 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.

**Normal sheep**

The surface of normal aerated lung (visceral or pulmonary pleura) was characterized by the uppermost white linear echo with equally-spaced reverberation artefacts below this line (Fig. 1). In normal adult sheep (around 75 to 110 kg) the visceral pleura was observed moving approximately 3 to 5 mm in a vertical plane during respiration. No pleural fluid was visualized in normal sheep. The chest wall was approximately 1.5 to 2.5 cm thick.

**Acute respiratory disease**

**Ovine pulmonary adenocarcinoma and secondary septicaemia** - Ovine pulmonary adenocarcinoma was diagnosed ultrasonographically in all 9 sheep that presented with acute respiratory disease. The diagnosis of sec-
Secondary septicaemia/endotoxaemia was based upon pyrexia >41ºC, toxic mucous membranes, profound depression, inappetance, and tachypnoea > 60 breaths per minute (Fig. 2). Treatment of five sheep with intravenous oxytetracycline and flunixin meglumine failed to effect any improvement in 24 hours and these sheep were euthanased for welfare reasons; the remaining four sheep were euthanased at presentation due to the extensive nature of the OPA lesions which occupied more than one third of the lungs. Necropsy of all nine sheep showed widespread carcase and visceral petechial and ecchymotic haemorrhages, pulmonary congestion and oedema, and the presence of frothy fluid within the trachea (Fig. 3). The first indication of changes in the superficial lung parenchyma caused by OPA in all 24 sheep was the abrupt loss of the bright linear echo formed by normal aerated lung tissue (visceral or pulmonary pleura) to be replaced by a large hypoechoic area in the ventral margins of the lung lobes at the 5th or 6th intercostal spaces (Fig. 4). The hypoechoic areas visualised during ultrasonography, corresponded to lung tissue invaded by tumour cells causing consolidation, which allowed the extent and distribution of the OPA lesions to be accurately defined during the ultrasonographic examination. Focal hyperechoic areas clearly identified within the more cellular-dense areas represented large airways. There were no appreciable ultrasonographic differences between those lungs affected with OPA only and OPA and secondary septicaemia. Abscesses were readily identified within the tumour mass of several cases; some abscesses appeared as discrete hyperechoic circles with an anechoic periphery typical of an inspissated abscess.

**Chronic suppurative pneumonia** - A primary septic focus, most often extensive chronic mastitis (5 sheep), was present in all six emaciated adult sheep diagnosed with chronic suppurative pneumonia. Ultrasonographically, there were large hypoechoic areas extending 4 to 6 cm into the lung which are bordered distally by bright white (hyperechoic) lines as the sound waves contacted normal aerated tissue deeper within the lung (Fig. 5). The lung lesions were not clearly demarcated like OPA cases (Fig. 4). All six sheep were euthanased for welfare because of the supplicative mastitis and the extensive lung lesions.
Pleural/superficial lung abscesses - Numerous 2-10 cm diameter well-encapsulated pleural/superficial lung abscesses were imaged in 10 adult sheep presenting with chronic weight loss. Affected sheep presented with chronic weight loss over several weeks to months and were often dull although appetite appeared normal. The rectal temperature was only slightly elevated (up to 40.0°C). At rest affected sheep were tachypnoeic, coughed occasionally and there was a scant mucopurulent nasal discharge. The hyperechoic linear echo representing the normal visceral pleura was lost with the pleural abscess appearing as an uniform anechoic area containing many hyperechoic dots which represent gas echoes bordered by a broad white line representing the abscess capsule (Figs. 6-8). Daily treatment with procaine penicillin for 42 days was successful in all six sheep identified with less than four abscesses 2-8 cm in diameter (Figs. 6-7). The appetite and general demeanour of four remaining sheep with four or more 6-10 cm diameter pleural abscess (Fig. 8) improved with treatment but these sheep failed to gain weight over the course of treatment and were euthanased for welfare reasons.

Fibrinous pleurisy - The visceral pleura (bright linear echo) appeared thicker than normal and displaced 2 to 3 cm from the parietal pleura by an area of varying hypoechogenicity (Fig. 9) representing fibrin exudation (pleurisy) between the parietal and visceral pleurae.

Pyothorax - With extensive pleural abscessation the lesion involved most of one side of the chest and contained up to 3 litres of pus. The pleurae were separated by a uniform hypoechoic to anechoic area containing many hyperechoic spots representing gas echoes within the abscess (Fig. 10). In unilateral pyothorax cases, auscultation of the lung field on the affected side revealed an absence of lung sounds but transmitted gut sounds, particularly rumen contraction sounds, when the pyothorax occupied the left thorax. Auscultation of the contralateral chest revealed increased audiility of normal lung sounds. Heart sounds were increased due to displacement of the heart towards the unaffected side. One of three sheep with pyothorax responded to 42 consecutive days' penicillin injections.

DISCUSSION

In most veterinary practice situations, provisional diagnoses will continue to be based upon history, clinical examination, response to antibiotic therapy, and in unsuccessful cases by post mortem examination. The limitations of auscultation of
the chest in formulating a specific diagnosis of ruminant lung pathologies can be examined by downloading sounds via the Internet recorded over specific lung pathologies11,12. The most easily recognized adventitious lung sounds in this study were moderate to severe coarse crackles in sheep with OPA. No readily discernible differences in lungs sounds could be detected during auscultation between those recordings made directly over the tumour mass, at the dorsal margin of the tumour mass, and over normal lung above the lesion. Coarse crackles are probably caused by air bubbling through, and causing vibrations within, respiratory secretions in the larger intrathoracic airways and trachea6 hence the general lack of correlation between the distribution of the OPA lesions (anterior-ventral lung lobes) and adventitious lung sounds (fluid within the trachea at a level approximately two-thirds up the chest wall). While the presence of widespread audible crackles may help establish a diagnosis of OPA, their distribution does not accurately define distribution of the lung pathology3. In this study, OPA appeared to be the most important risk factor for susceptibility to acute respiratory disease thought to be pasteurellosis based upon classical findings at necropsy3.

Pleural/superficial lung abscesses were common in adult sheep but were difficult to diagnose by clinical examination alone which may explain why there are few clinical descriptions of this condition13. Trueperalla (formerly Arcanobacterium) pyogenes is a common isolate from lung abscesses in sheep16. Treatment of suspected T. pyogenes with procaine penicillin must be continued for 4-6 weeks because of the time-dependent pharmacokinetics of the drug. Penicillin is non-irritant, inexpensive, well-tolerated and can be given by either intramuscular or subcutaneous injection. T. pyogenes is also the most common bacterial isolate from CSPD in adult cattle. The good treatment response in sheep with chronic pleural/lung abscesses in this study is not easily explained because the abscesses had a thick capsule and appeared little changed sonographically at the end of antibiotic therapy. No other infectious diseases were found that could otherwise explain the response to antibiotic therapy. Elevated fibrinogen and serum globulin concentrations reflect the sheep’s response to chronic bacterial infection but such changes are not specific to one particular organ system and further ancillary testing is necessary. As the cost of ultrasonographic examination only involves the veterinarian’s time, enthusiastic clinicians are encouraged to try this technology as part of their clinical investigation particularly those sheep that present with chronic weight loss and an increased respiratory rate at rest. Ultrasonography provides an inexpensive, non-invasive tool with which to examine the pleural surfaces and superficial lung parenchyma. Systematic ultrasound examination of both sides of the chest need only take 5 minutes.

References