Enzootic pneumonia-like lesions: Ultrasound vs pathological findings under field conditions

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Summary

Thoracic ultrasonography has been increasingly utilized as a diagnostic tool in human and veterinary medicine. However, limited data are currently available about its field application in pigs. The present study aimed to evaluate the feasibility of thoracic ultrasonography in pigs affected by enzootic pneumonia-like lesions. Following technique verification on cadavers, ultrasound investigations were performed on the thorax of healthy and diseased live pigs to assess lungs. Overall, results indicated that ultrasonography was effective to discriminate between healthy and diseased lungs, with enzootic pneumonia-like lesions showing an easily recognizable ultrasonographic pattern. Thoracic ultrasonography could contribute to better manage porcine respiratory diseases.

Keywords: swine, pneumonia, thoracic ultrasonography, pathology

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Resumen - Lesiones similares a la neumonía enzoótica: Ecografía versus hallazgos patológicos en condiciones de campo

La ecografía torácica se ha utilizado cada vez más como herramienta diagnóstica en medicina humana y veterinaria. Sin embargo, actualmente se dispone de información limitada sobre su aplicación de campo en cerdos. El presente estudio tuvo como objetivo evaluar la viabilidad de la ecografía torácica en cerdos afectados con lesiones similares a la neumonía enzoótica. Tras la verificación de la técnica en cadáveres, se realizaron investigaciones de ultrasonido en el tórax de cerdos vivos sanos y enfermos para evaluar los pulmones. En general, los resultados indicaron que la ecografía fue eficaz para discriminar entre pulmones sanos y enfermos, con lesiones similares a las de neumonía enzoótica que muestran un patrón ecográfico fácilmente reconocible. La ecografía torácica podría contribuir a un mejor manejo de las enfermedades respiratorias porcinas.

Résumé - Lésions apparentées à la pneumonie enzootique: Trouvailles échographiques vs pathologiques en conditions de terrain

L'échographie thoracique est utilisée de plus en plus couramment comme outil diagnostique en médecine humaine et vétérinaire. Toutefois, des données limitées sont actuellement disponibles concernant son utilisation sur le terrain chez les porcs. La présente étude visait à évaluer la faisabilité de l'échographie thoracique chez les porcs ayant des lésions apparentées à la pneumonie enzootique. À la suite d'une vérification de la technique sur des cadavres, des examens échographiques ont été effectués sur le thorax de porcs vivants sains et malades pour évaluer les poumons. De manière générale, les résultats indiquaient que l'échographie était efficace pour discriminer entre les poumons sains et malades, avec les lésions apparentées à la pneumonie enzootique montant un patron échographique facilement reconnaissable. L'échographie thoracique pourrait contribuer à mieux gérer les maladies respiratoires porcines.

Respiratory disorders are widely recognized as the leading cause of financial losses to the pig industry due to veterinary care costs, decreased performance, and increased mortality. The etiology of porcine respiratory disorders is usually complex, with several pathogens acting together to determine the clinical and pathological outcomes. As a consequence, the term porcine respiratory disease complex (PRDC) has been introduced to indicate a multifactorial respiratory disease in growing and finishing pigs.[1,2]

Mycoplasma hyopneumoniae is among the most important causative agents of PRDC and is recognized as the primary pathogen of the so-called enzootic pneumonia (EP), a chronic and worldwide diffuse respiratory disease usually showing high morbidity and low mortality rates. Dry cough is the main clinical sign, which is greatly exacerbated by physical activity and may last for weeks to months. In EP-affected pigs, pulmonary lesions are bilateral consisting of slightly red or grey areas of bronchopneumonia, which affect the cranio-ventral parts of both lungs. Such gross findings are not pathognomonic for *M hyopneumoniae* as other pathogens (eg, swine influenza

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virus) may induce similar lesions. Microscopically, bronchointerstitial pneumonia and hyperplasia of the bronchial associated lymphoid tissue are the most relevant lesions.[3,4]

The present study aimed to assess the strengths and weaknesses of thoracic ultrasonography in pigs to provide suitable information to diagnose respiratory diseases, a special emphasis being placed upon EP-like lung lesions.

Materials and methods

This investigation was conducted in a farrow-to-finish pig herd (about 200 sows) with a recent history of severe respiratory disease. Pigs were not vaccinated for *M hyopneumoniae* and cases of EP complicated by *Pasteurella multocida* had been repeatedly diagnosed during the previous weeks.

Ultrasonography was performed using a linear multifrequency ultrasound transducer (probe Chison L7V-A, 5.3-10 MHz; Chison Medical Technologies Eco 3 Expert). A pregnancy-check ultrasound machine (3.5 MHz convex probe; manufacturer unknown) was also used.

Lung ultrasonography

Pigs (n = 8; 12-16 weeks of age) that spontaneously died after showing respiratory distress were necropsied. Lungs were removed from the chest and carefully examined. Thereafter, ultrasonography was performed by applying the transducer on the lung surface in both healthy and diseased areas. This step confirmed the ultrasound pattern of normal and diseased lungs. In this case, the linear multifrequency ultrasound transducer was used at 10 MHz.

Ultrasonography on pig cadavers and lungs

Transcutaneous ultrasonography was conducted along the left and right thoracic walls of pig carcasses (n = 8; 12-16 weeks of age) using some anatomic sites (ie, the elbow, the heart, and the intercostal spaces) as landmarks (Figure 1). Subsequently, the pigs were necropsied, and the ultrasound findings compared with the pathological findings. Once again, lungs were removed from the chest, carefully inspected, and further examined by ultrasonography. The linear multifrequency ultrasound transducer was used at 5.3 MHz on carcasses and at 10 MHz on lungs.

Ultrasonography on clinically healthy and diseased live pigs

Ultrasonography was carried out on live, clinically healthy pigs aged 4 (n = 8), 8 (n = 8), and 12 (n = 8) weeks, randomly selected from two batches. Likewise, ultrasonography was performed on live pigs (n = 8; 12-16 weeks of age) showing prominent respiratory clinical signs (dry coughing) and, therefore, confined in the recovery pen. To this aim, pigs were placed in the lateral decubitus position with no sedation or hair clipping required. Specifically, the pig was placed with its back facing an operator, who restrained the pig by holding the two forelimbs with one hand, and the two hindlimbs with the other hand. The linear multifrequency ultrasound transducer was used at 5.3 MHz.

Results

Lung ultrasonography

All lungs under study showed gross lesions compatible with EP (Figure 2). Ultrasonography of diseased areas showed a homogeneous, "liver-like" appearance, with hyperechogenic spots and lines of variable size and shape (Figure 3). The healthy lung parenchyma could not be shown by ultrasonography. Its air content induced the appearance of the so-called A-lines, ie, reverberation artefacts running parallel to the pleural surface. The images obtained by the pregnancy-check ultrasound machine were of lower quality because they were photographs of the device screen (this tool was unable to store and download images; Figure 3).

Ultrasonography on pig cadavers and lungs

The aforementioned ultrasonographic patterns were easily recognized also on pig carcasses. The intercostal spaces corresponding to disease ultrasonograms were recorded before necropsy. Gross findings consisted of bilateral foci of EP-like bronchopneumonia and were consistent with ultrasonograms.

Ultrasonography on clinically healthy and diseased live pigs

Thoracic ultrasonography took about 5 min/pig. No disease ultrasonogram was observed in clinically healthy pigs at 4, 8, and 12 weeks of age. On the contrary, ultrasonograms compatible with bronchopneumonia were always detected in pigs with respiratory syndrome at 12 to 16 weeks of age (Figure 4). Although providing images of different quality, ultrasonograms obtained using the linear multifrequency ultrasound transducer provided similar ultrasonographic pattern at the same anatomical site when compared with the 3.5 MHz sector transducer.

Discussion

In modern and intensive pig farming, it is always important to assess the impact (ie, the prevalence and severity) of pneumonia, as well as monitor the effectiveness of strategies implemented to treat and prevent such disease conditions.[5] The Madec's grid is the most common method used to score lung lesions and is usually performed on slaughtered pigs.[6] However, EP lesions can be missed when the animals recover, this being more probable in heavy pigs slaughtered at 9 to 10 months of age. Accordingly, some studies indicate that losses are associated with a clinical history of pneumonia rather than with lung lesions at slaughter. This is not surprising when the impact of complex and multifactorial disorders is investigated.[7,8]

Clinical assessment and laboratory tests (eg, serological test) can be complementary to scoring lesions at slaughter providing useful information about the timing of infection and the prevalence and severity of the disease to plan effective control strategies.[1,7] Investigative methods on live animals should be easy, fast, reliable, and cost-effective, yet such requisites often remain disregarded. As an example, systems for cough recording could be of value for early EP detection, but they are still unavailable in practice.[7] Likewise, radiography is a highly informative tool, but not feasible under field conditions.[9]

In human[10,11] and veterinary medicine, thoracic ultrasonography has been increasingly used as a diagnostic tool, as well as to monitor clinical outcomes on individual patients. In particular, a number of scientific papers have been published regarding the application of thoracic ultrasonography in pets, ruminants, and horses.[12-17] To the best of our knowledge, limited data are currently available about thoracic ultrasonography in pigs under field conditions, with only a few reports dealing with experimental investigations.[18-20] Overall, the present study indicates that ultrasonography is effective to discriminate between healthy and diseased lungs with

Figure 1: Topography of thoracic and abdominal organs of a pig carcass A) before and B) during necropsy. This picture provides a practical tool to investigate the lung, which is bordered by a yellow line. As landmarks, the ribs (blue circles), the heart (H) and the liver (L) are also indicated. The transducer was placed and moved along the intercostal spaces, from the axillary region to the 10th and 11th rib.

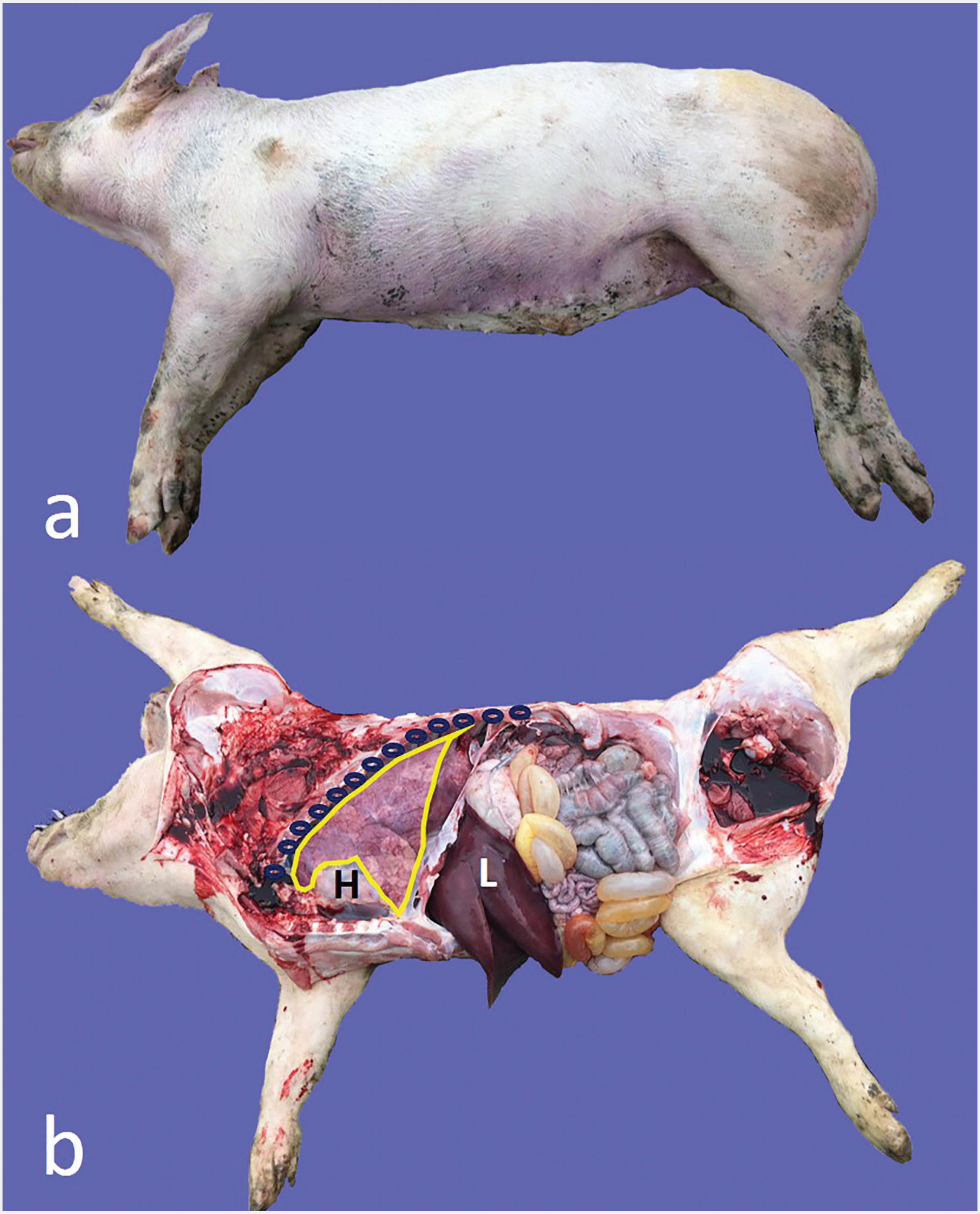
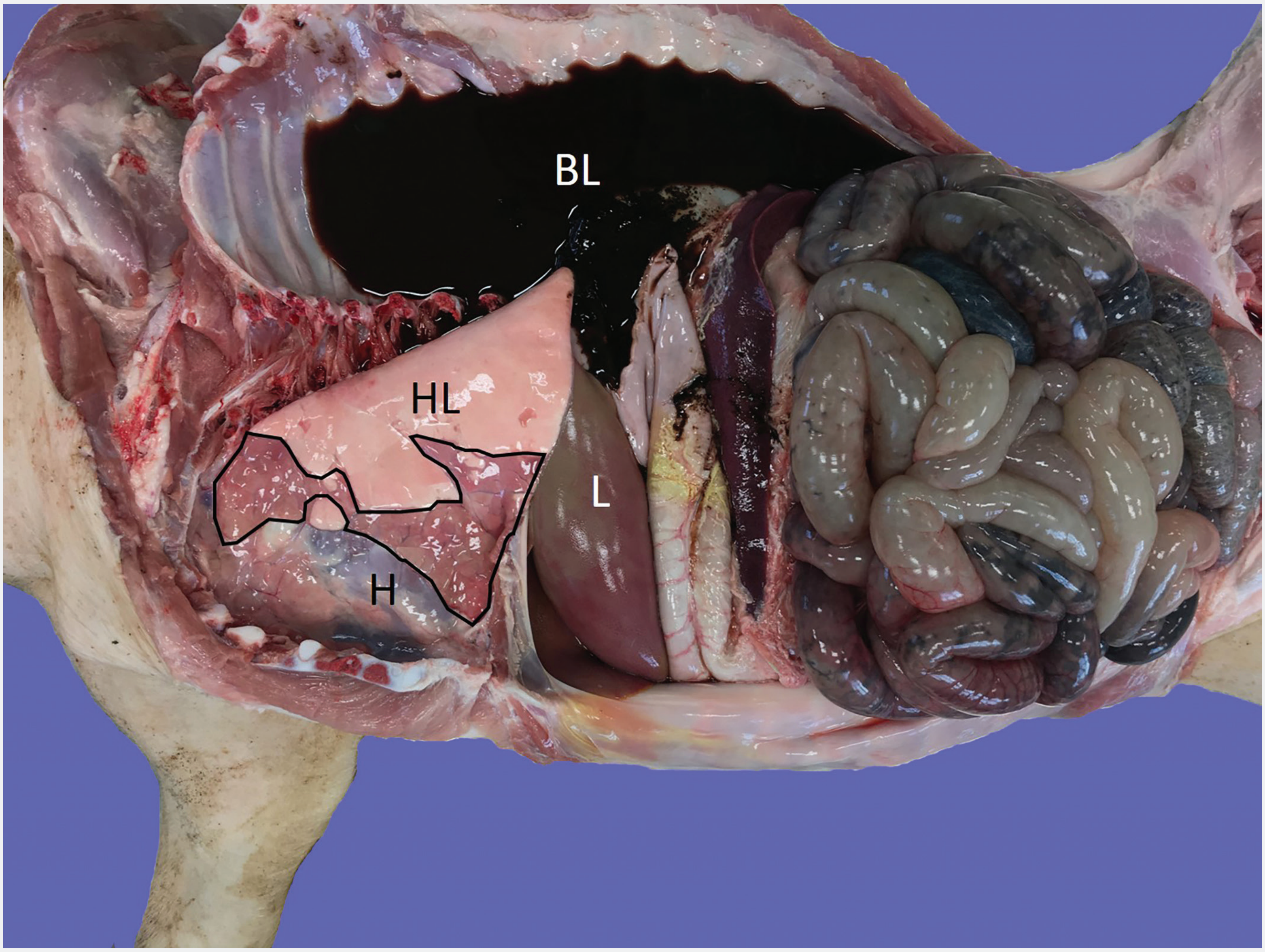


Figure 2: Pig necropsy. Typical slightly red or grey EP-like lesions affect the cranio-ventral portions of the left lung (black outline). The heart (H), the healthy lung (HL) and the liver (L) are also indicated. This pig died because of a severe gastric ulceration and a large amount of blood (BL) was released after opening the stomach.



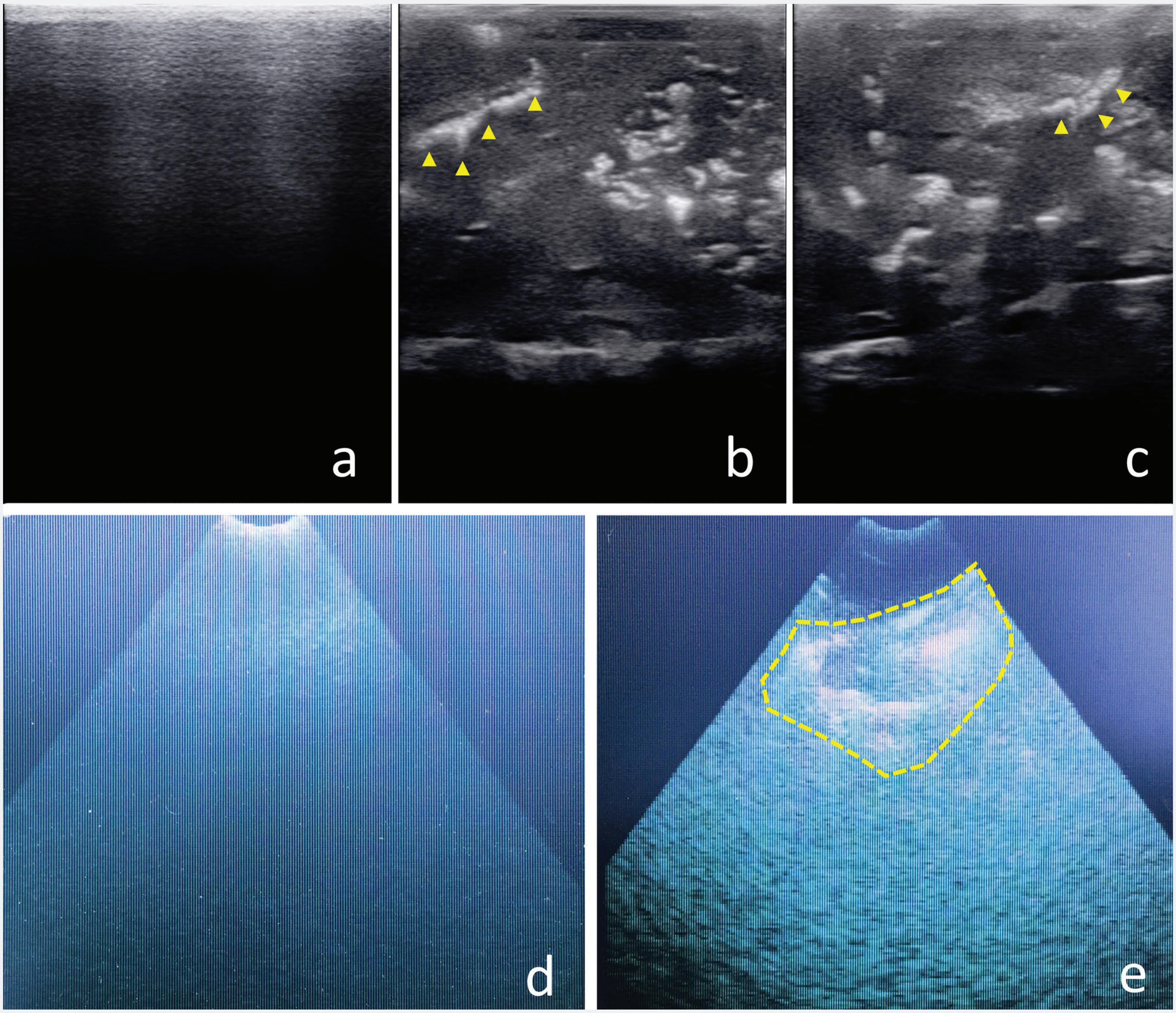
EP-like lesions showing an easily recognizable appearance. In our opinion, the main strengths of thoracic ultrasonography include:

- Ultrasonography is considered safe both for investigators and for pigs.
- It is inexpensive, as ultrasound transducers are commonly available on pig farms where they are routinely used to detect pregnancy. When the same ultrasound equipment is used at different herd sites, it is essential to comply with biosecurity measures to avoid the spread of pathogens.
- Thoracic ultrasonography could be useful to evaluate the main features of lung lesions (ie, extent, involvement of cranio-ventral vs dorsal-caudal areas, unilateral vs bilateral distribution, absence vs presence of pleuritis), which are needed to better address the diagnostic approach and a rational and effective treatment.

The main weaknesses of thoracic ultrasonography that should be considered include:

- Accurate interpretation of the ultrasonographic patterns requires targeted professional training even though image acquisition is relatively easy. For example, severe pleuritis and pericarditis, as observed in Glasser's disease affected pigs, can be very easily identified by ultrasonography, while the detection of virus-induced interstitial pneumonia, although possible, requires more focused skills.
- Because of the reverberation artefacts, thoracic ultrasonography can only detect disease conditions reaching the pleural surface, thus overlooking deeper lesions (eg, abscesses fully embedded within the lung parenchyma).
- Thoracic ultrasonography could be time-consuming in large pig farms where a high number of animals should be investigated to have a suitable sample size. As a consequence, this tool may not be routinely used to determine EP prevalence.
- Thoracic ultrasonography often provides a presumptive diagnosis, which should be confirmed by further laboratory investigations. This is crucial for proper management of PRDC through vaccination strategy or to select the most effective antimicrobial.
- Thoracic ultrasonography is less accurate and should not replace post-mortem investigations, even under the best conditions. Moreover, post-mortem changes (eg, reduction of pulmonary air content) make the

Figure 3: Direct ultrasound examination of lungs. A) Ultrasonogram of a healthy lung showing echogenic bands which represent reverberation artefacts. B) and C) Pneumonic foci were characterized by a homogeneous, hypoechoic, liver-like texture and by small, irregular, and scattered hyperechoic structures. Linear or branched-shaped hyperechoic areas (bronchograms; yellow arrows) were also observed. Images A, B, and C were obtained using a linear, multifrequency ultrasound transducer (Chison Medical Technologies Eco 3 Expert) at 10 MHz of frequency. Ultrasonogram images obtained by means of a pregnancy-check ultrasound machine (3.5 MHz convex probe), directly applied to D) healthy or E) diseased lungs, where pneumonic areas could be easily identified (yellow outline).



interpretation of ultrasonograms more challenging and could provide false positive results, especially when ultrasonography occurs several hours after death.

To conclude, thoracic ultrasonography could be a useful tool for the clinical appraisal of pig herds to assess the kinetics of respiratory infections/diseases, as well as the severity and the main features of pneumonia. Data resulting from thoracic ultrasonography should integrate with, not replace, other diagnostic tools, including necropsy, with the aim to manage PRDC in a more precise and rational manner.

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Conflict of interest

None reported.

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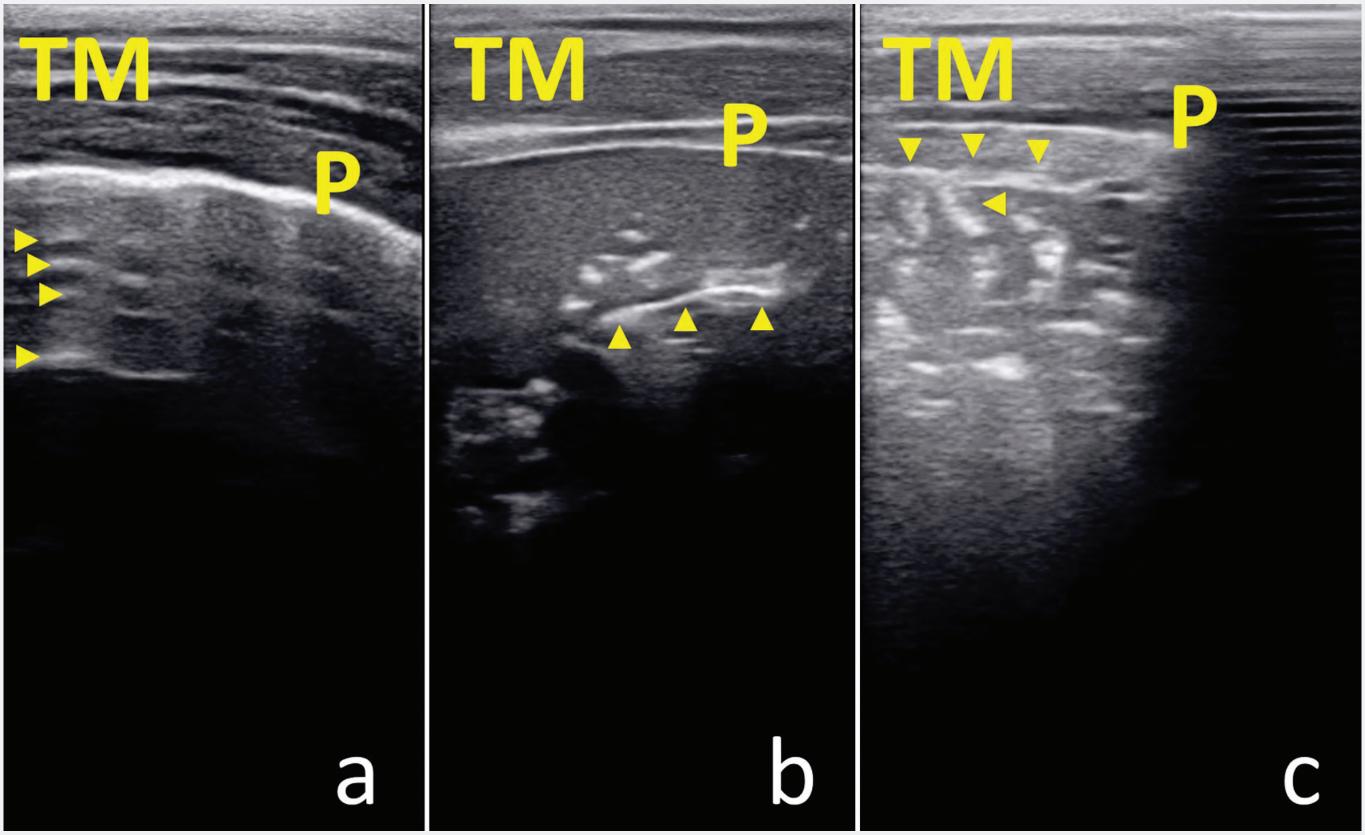
Figure 4: Ultrasound examination of live pigs. In A) healthy pigs, the thoracic wall (TM), the pleural layers (P), and the reverberation artefacts (arrows) are seen. Ultrasonograms of B) and C) diseased pigs are dominated by dot, round, irregular, or linear/branched-shaped hyperechoic texture (yellow arrows). The thoracic ultrasonography was obtained using a linear, multifrequency ultrasound transducer (Chison Medical Technologies Eco 3 Expert) at 5.3 MHz of frequency.



with the rules and regulations governing research or the practice of veterinary medicine in their country or region.

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Conversion tables

Weights and measures conversions

Common (US)	Metric	To convert	Multiply by
1 oz	28.35 g	oz to g	28.35
1 lb (16 oz)	0.45 kg	lb to kg	0.45
2.2 lb	1 kg	kg to lb	2.2
1 in	2.54 cm	in to cm	2.54
0.39 in	1 cm	cm to in	0.39
1 ft (12 in)	0.3 m	ft to m	0.3
3.28 ft	1 m	m to ft	3.28
1 mi	1.6 km	mi to km	1.6
0.62 mi	1 km	km to mi	0.62
1 in^2	6.45 cm^2	in^2 to cm^2	6.45
0.16 in^2	1 cm^2	cm^2 to in^2	0.16
1 ft^2	0.09 m^2	ft^2 to m^2	0.09
10.76 ft^2	1 m^2	m^2 to ft^2	10.8
1 ft^3	0.03 m^3	ft^3 to m^3	0.03
35.3 ft^3	1 m^3	m^3 to ft^3	35.3
1 gal (128 fl oz)	3.8 L	gal to L	3.8
0.26 gal	1 L	L to gal	0.26
1 qt (32 fl oz)	0.95 L	qt to L	0.95
1.06 qt	1 L	L to qt	1.06

Temperature equivalents (approx)

°F	°C
32	0
50	10.0
60	15.5
61	16.1
65	18.3
70	21.1
75	23.8
80	26.6
82	27.7
85	29.4
90	32.2
102	38.8
103	39.4
104	40.0
105	40.5
106	41.1
212	100.0

°F = (°C × 9/5) + 32
°C = (°F - 32) × 5/9

Conversion calculator available at: amamanualofstyle.com/page/si-conversion-calculator

Conversion chart, kg to lb (approx)

Pig size	Lb	Kg
Birth	3.3-4.4	1.5-2.0
Weaning	7.7	3.5
	11	5
	22	10
Nursery	33	15
	44	20
	55	25
	66	30
Grower	99	45
	110	50
	132	60
Finisher	198	90
	220	100
	231	105
	242	110
	253	115
Sow	300	136
	661	300
Boar	794	360
	800	363

1 tonne = 1000 kg
1 ppm = 0.0001% = 1 mg/kg = 1 g/tonne
1 ppm = 1 mg/L