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TATIANE VITOR DA SILVA

Estudo clínico da reticuloesplenite traumática e hérnia reticular diafragmática
em bovinos com foco na ultrassonografia

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Tatiane Vitor da Silva

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Dissertação submetida ao Programa
de Pós-Graduação em Ciência e
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requisito parcial para obtenção do
grau de Mestre em Ciência e Saúde
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*“A tarefa não é tanto ver aquilo que ninguém viu, mas pensar o que ninguém ainda pensou
sobre aquilo que todo mundo vê”.*

RESUMO

O objetivo desse trabalho foi descrever os achados clínicos, laboratoriais, ultrassonográficos e anatomopatológicos de 30 bovinos acometidos com retículo esplenite traumática e cinco com hérnia reticular diafragmática atendidos na Clínica de Bovinos de Garanhuns da Universidade Federal Rural de Pernambuco (CBG/UFRPE). Todos os bovinos foram submetidos a exames clínico e ultrassonográfico. Amostras de sangue foram coletadas dos animais em tubos a vácuo com anticoagulante para a determinação de hemograma, proteína plasmática total e fibrinogênio plasmático. Os bovinos cujo prognóstico era desfavorável foram eutanasiados e necropsiados. Os resultados referentes ao exame clínico, de ultrassom e anatomopatológicos foram analisados por meio de estatística descritiva e para os dados hematológicos foram utilizadas média e desvio padrão. Os animais diagnosticados com retículo esplenite traumática clinicamente apresentaram desidratação e alterações no comportamento, apetite e na motilidade ruminal. Os achados hematológicos revelaram leucocitose (37.077 cel/ μ L) por neutrofilia com desvio a esquerda regenerativo e hiperfibrinogenemia (1.130 mg/dL). O exame ultrassonográfico possibilitou a visualização de aderências fibrinosas, observou-se também, deslocamento do retículo e irregularidade no seu contorno além das alterações na quantidade, padrão e amplitude das contrações reticulares. Permitiu ainda, a constatação de alterações esplênicas como abscessos, trombose da veia esplênica e dobramento do baço. Já os bovinos acometidos com hérnia reticular diafragmática exibiam desidratação em variados graus, distensão abdominal, timpania e alterações na motilidade ruminal. Além de alterações cardiorrespiratórias como sopro, dispneia e abafamento dos sons pulmonares. O exame laboratorial revelou discreta leucocitose por neutrofilia e hiperfibrinogenemia. E as imagens ultrassonográficas revelaram retículo no interior da cavidade torácica próximo ao pulmão e coração, porém nenhuma motilidade reticular foi observada. As lesões anatomopatológicas ratificaram os achados de imagem para ambas as enfermidades. Diante dos resultados constatamos que o exame ultrassonográfico foi eficaz para o diagnóstico da retículo esplenite traumática e da hérnia reticular diafragmática.

PALAVRAS-CHAVE: Reticulite; Ruminante; Ultrassonografia.

ABSTRACT

The purpose of this study was to describe the clinical, laboratory, ultrasonographic, and pathological findings of 30 adult cattle diagnosed with traumatic reticulo splenitis and five adult cattle diagnosed with diaphragmatic reticular hernia attended at the Clínica de Bovinos de Garanhuns of the Universidade Federal Rural de Pernambuco. All cattle underwent clinical and ultrasound examinations. Blood samples were collected from all animals, into siliconized vacutainer tubes containing EDTA anticoagulant (10%) to determine hematological variables (blood count, total plasma protein, and plasma fibrinogen). Cattle whose prognosis was unfavorable were euthanized and necropsied. Clinical, ultrasound, and anatomopathological findings were analyzed using descriptive statistics and laboratory data were evaluated using mean and standard deviation. Clinically the animals diagnosed with traumatic reticulo splenitis presented dehydration and alterations in behavior, appetite, and ruminal motility. Hematological findings revealed neutrophilic leukocytosis ($37,077\text{cell}/\mu\text{L}$) with regenerative left shift and hiperfibrinogenemia ($1,130\text{mg/dL}$). The ultrasound examination enabled visualization of fibrin adhesions, displacement of the reticulum and irregularity in its contour, in addition alterations in the quantity, pattern, and amplitude of reticular contractions. It also allowed to find splenic alterations such as abscesses, splenic venous thrombosis and spleen bowed. Cattle affected with diaphragmatic reticular hernia exhibited varying degrees of dehydration, abdominal distension, tympania and changes in ruminal motility. In addition to cardiorespiratory changes such as heart murmur, dyspnea, and muffling of lung sounds. Laboratory examination revealed mild neutrophilic leukocytosis and hyperfibrinogenemia. And the ultrasound images revealed reticulum inside the thoracic cavity near the lung and heart, but no reticular motility was observed. The anatomopathological lesions confirmed the imaging findings for both diseases. Given the results we found that the ultrasound examination was effective for the diagnosis of reticulum traumatic splenitis and diaphragmatic reticular hernia.

KEY WORDS: Reticulitis; Ruminant; Ultrasonography.

LISTA DE FIGURAS

CAPITULO I		Pagina
Figure 1 (A e B):	(A) Ultrasound image of the left ventral cranial of the bovine abdomen: visualizing a nonsupported reticulum over the diaphragm, displaced dorsally by hypoechoic effusion and deposits of echogenic material, which was also adhered to the reticular and ruminal serosa. (B) Serofibrinous peritonitis with adhesions between the organs of the abdominal cavity.	37
Figure 2 (A e B):	(A) Ultrasonographic image of the left ventral cranial of the bovine abdomen: visualizing non-supported reticulum on the dorsally displaced diaphragm, by the spleen with heterogeneous and hypoechoic parenchyma and heterogeneous material adhered to the reticular and ruminal serosa. (B) Spleen with lesion.	37
Figure 3 (A, B e C):	(A) Ultrasound image of the 8th left intercostal space of the bovine abdomen: visualizing the rumen, supported on the spleen whose parenchyma is heterogeneous, suggesting abscess lesions. (B) Ultrasound image of the 8th left intercostal space of a bovine: part of the spleen without alterations, with homogeneous parenchyma well delimited by a thin and hyperechoic capsule. (C) Spleen showing part of normal parenchyma and altered part with abscess lesion.	38
Figure 4 (A e B)	(A) Ultrasound image of the 8th left intercostal space of a bovine: visualizing spleen with splenic vein lumen partially filled with echogenic structure, suggestive of thrombosis, and deposition of echogenic and heterogeneous material adhering the rumen serosa to the splenic capsule. (B) Splenic thrombosis.	38
Figure 5 (A, B e C)	(A) Ultrasound image of the left ventral cranial region of the bovine abdomen: visualizing the reticulum supported over the spleen and thus displaced dorsally. Spleen torsion, plus circular hyperechoic areas corresponding to the fixation site of the metallic foreign body. (B) Splenic bowed. (C) Abscess lesion caused by metallic foreign body.	38

LISTA DE FIGURAS

CAPITULO II		Pagina
Figure 1	Ultrasound image of the third left intercostal space of a bovine: visualizing the reticular wall resting on the heart and compressing it.	54
Figure 2 (A, B e C):	(A) Ultrasound image of the 5th left intercostal space of a bovine: visualizing the reticular wall caudal to the lung. (B) reticulum attached to the lung. (C) reticular mucosa. B and C corresponding to figure 2A.	55
Figure 3 (A e B):	(A) Ultrasound image of the 5th left intercostal space of a bovine: visualizing the reticular wall caudal to the lung. (B) Pocket of inflammatory fluid and Reticular wall corresponding to figure 3A.	56

LISTA DE TABELAS

CAPITULO I		Pagina
Table 1	Absolute (n) and relative (%) frequency of major clinical signs of 30 cattle diagnosed with traumatic reticulo splenitis	33
Table 2	Hematological values, total plasma protein, and plasma fibrinogen obtained from cattle with traumatic reticulo splenitis.	34
Table 3	Main ultrasound findings related to the reticulum of 30 cattle affected by traumatic reticulo splenitis.	35
Table 4	Correspondence between sonographic findings and anatomopathological lesions of cattle affected with traumatic reticulo splenitis.	36
CAPITULO II		
Table 1	Absolute (n) and relative (%) frequency of the main clinical signs of five cattle diagnosed with reticular diaphragmatic hernia.	50
Table 2	Hematological values, total plasma protein, and plasma fibrinogen obtained from four cattle with reticular diaphragmatic hernia.	51
Table 3	Ultrasound findings of the abdominal and thoracic cavity of five cattle with reticular diaphragmatic hernia.	52
Table 4	Correspondence between ultrasound findings and anatomopathological lesion of cattle with reticular diaphragmatic hernia.	53

SUMÁRIO.

AGRADECIMENTOS	.....	V
RESUMO	.....	VII
ABSTRACT	.....	VIII
LISTA DE FIGURAS	.....	IX
LISTA DE TABELAS	.....	XI
1.INTRODUÇÃO GERAL	.....	12
REFERÊNCIAS	.....	15
2.CAPÍTULO 1	.....	17
ABSTRACT	.....	18
RESUMO	.....	19
INTRODUCTION	.....	20
MATERIAL and METHOD	.....	21
Location and date	.....	21
Animals	.....	21
Physical examination	.....	21
Laboratory test	.....	21
Ultrasound examinations	.....	21
Euthanasia	.....	21
Statistical analysis	.....	22
Ethics committee approval	.....	22
RESULTS	.....	22
History	.....	22
Epidemiological observations	.....	22
Clinical observations	.....	23
Laboratory results	.....	23
Ultrasonographic aspects	.....	23
Necropsy findings	.....	23
DISCUSSION	.....	24
CONCLUSION	.....	26
References	.....	28
3.CAPÍTULO II	.....	39
HIGHLIGHTS	.....	40
ABSTRACT	.....	40
RESUMO	.....	41
INTRODUCTION	.....	42
MATERIAL and METHOD	.....	43
Location and date	.....	43
Animals	.....	43
Physical examination	.....	43
Laboratory examinations	.....	43
Ultrasound examinations	.....	43
Euthanasia	.....	43
Statistical analysis	.....	44

Ethics committee approval	.....	44
RESULTS	.....	44
History	.....	44
Epidemiological observations	.....	44
Clinical observations	.....	44
Laboratory findings	.....	44
Ultrasound findings	.....	45
Necropsy findings	.....	45
DISCUSSION	.....	45
CONCLUSION	.....	47
References	.....	48
CONSIDERAÇÕES FINAIS	.....	57

INTRODUÇÃO

Atualmente, o Brasil ocupa o segundo lugar no ranking mundial da criação de bovinos, com efetivo estimado em 232 milhões de animais ficando atrás somente da Índia com 305 milhões (USDA, 2018). A criação desses animais é o destaque no mundo do agronegócio que através dos seus dois segmentos, a bovinocultura de corte e leiteira, gera lucratividade para o país. Do total de bovinos do país, cerca de 27.736.607 estão concentrados na região nordeste e desse total, 1.862,181 estão no estado de Pernambuco que ocupa o primeiro lugar como produtor de leite contribuindo com 900 milhões de litros/ano, onde, 75% da produção total de leite do estado é proveniente da bacia leiteira do Agreste Meridional (IBGE, 2018).

Porém, os períodos de seca que atingem essa região levam os produtores de gado a recorrerem a alternativas baratas de alimentação. As mais comuns delas são os subprodutos da agroindústria como a casca de mandioca (*Manihot esculenta*) e a cama de frango que podem conter objetos perfurantes os quais podem afetar a saúde dos bovinos desencadeando a reticulite traumática (ASSIS, 2018).

Além dos fatores relacionados ao manejo, deve-se considerar também a anatomia e fisiologia dos pré-estômagos dos bovinos uma vez que os ciclos de contração do retículo aliado a sua conformação anatômica e sua proximidade com os demais órgãos da cavidade abdominal podem diante da presença de um corpo estranho metálico e pontiagudo resultar em várias sequelas dessa enfermidade (DIRKSEN, 1993; DIRKSEN, 2005).

A depender do direcionamento do corpo estranho metálico, podem surgir casos de reticuloperitonite traumática, reticulopericardite traumática, abscessos hepáticos, jejunitis traumática, reticuloesplenite traumática e hérnia diafragmática (SILVA, 2011; TRECENTI et al. 2015; SOUZA et al. 2016; KUMAR et al. 2017).

Dos bovinos acometidos por reticuloperitonite traumática apenas uma pequena porção, cerca de 2 a 14% desenvolvem a reticulo esplenite como seqüela. E apesar dessa baixa ocorrência, a mortalidade ocasionada por essa enfermidade é elevada (SILVA et al., 2017). Outra seqüela não muito comum de ser observada na rotina clínica de ruminantes é a hérnia reticular diafragmática a qual tem sido relatada principalmente nos animais da espécie bubalina (ABDELAAL et al. 2014; ATTIA, 2016).

Os animais acometido pelas sequelas da reticulite traumática apresentam sintomatologia clínica inespecífica, dessa maneira, o diagnóstico exato e precoce torna-se difícil e em função disso, prejuízos econômicos são gerados devido a gastos com tratamentos clínicos e cirúrgicos,

além de muitas vezes resultar no óbito em decorrência do diagnóstico tardio (RAVINDRA; ASHA; SANDEEP, 2014).

Por este motivo, torna-se necessário a realização de exames complementares, como os de laboratório e de imagem, como ultrassonografia, radiografia e videolaparoscopia que além de contribuírem para confirmação de uma suspeita, ajudam também no estabelecimento do prognóstico (BRAUN; GÖTZ; MARMIER, 1993; BRAUN et al. 2018; SILVA, 2018).

A ultrassonografia tem sido o método mais empregado em ruminantes especialmente nos bovinos acometido pelas sequelas da reticulite (SILVA, 2011; ASSIS, 2018; BRAUN et al. 2018). Dentre as opções de diagnóstico por imagem, a ultrassonografia apresenta vantagens sobre a videolaparoscopia que tem um custo mais elevado para ser realizada e por ser considerada um procedimento cirúrgico, envolve o tempo de recuperação dos animais. E também apresenta maior facilidade de execução quando comparada a radiografia além de ser menos estressante para os animais (ATHAR et al. 2010; SILVA, 2018).

A técnica para realização do exame ultrassonográfico em bovinos com reticulite traumática e outras desordens digestivas foi descrita por (BRAUN; GÖTZ; MARMIER, 1993) e consiste inicialmente em remover os pelos da região ventral do tórax e também do antímero direito e esquerdo até a articulação do cotovelo. Em seguida com um transdutor linear de 3 – 5 MHz posicionado sobre a região torácica ventral esquerda e direita visualiza-se a parede abdominal, veia musculo frênica, contorno do reticulo cuja aparência é de “meia-lua” e avalia-se a atividade reticular por três minutos. Posteriormente os espaços intercostais de ambos os antímeros também são examinados com o transdutor paralelo as costelas. Progredindo caudalmente no lado esquerdo observa-se transição do reticulo para o saco seco dorsal do rúmen, sulco ruminoreticular e parte cranial do saco ventral do rúmen. A porção distal do baço é vista lateralmente e avançando caudalmente com o transdutor à direita da linha média, é possível visualizar partes do fígado, omaso e abomaso. Em algumas situações é necessário que a área de exame seja ampliada.

Para realizar o exame ultrassonográfico do baço, cada espaço intercostal do antímero esquerdo é avaliado começando dorsalmente e progredindo até a região ventral com o transdutor mantido na posição paralelo as costelas. O baço é visualizado entre a parede abdominal e rúmen e/ou reticulo e as vezes pode ser visto na região ventral do tórax. A aparência ultrassonográfica do parênquima esplênico saudável consiste em vários ecos homogêneos e a capsula é vista como uma linha fina e hiperecoica. (BRAUN; SICHER, 2006; BRAUN; STEININGER, 2010; FLOECK et al. 2013).

Portanto, tendo em vista a importância do impacto econômico gerado pelas sequelas da reticulite traumática, este estudo teve como objetivo avaliar a utilização da ultrassonografia no diagnóstico reticuloesplenite traumática e da hérnia reticular diafragmática em bovinos.

Desta maneira, este trabalho é composto por dois capítulos formados por artigos científicos intitulados: Clinical, laboratory, ultrasonographic, and anatomopathological aspects in 30 cattle with traumatic reticulo splenitis e Ultrasound Diagnosis of Reticular Diaphragmatic Hernia in Bovines. Respectivamente.

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CAPITULO I

**Clinical, laboratory, ultrasonographic, and anatomopathological aspects in 30 cattle
with traumatic reticulo splenitis**

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Clinical, laboratory, ultrasonographic, and anatomopathological aspects in 30 cattle with traumatic reticulo splenitis

Abstract

Silva, T.V.,^{1*} Cajueiro, J.F.P.,² Silva, N.A.A., Souto, Rodolfo J.C.,² Coutinho, L.T.,² Mendonça, C.L.,² Afonso, J.A.B.,² Miranda Neto, E.G³ [Clinical, laboratory, ultrasonographic, and anatomopathological aspects in 30 cattle with traumatic reticulo splenitis] *Clínica de Bovinos de Garanhuns, Universidade Federal Rural de Pernambuco (UFRPE), Avenida Bom Pastor, s/n, Boa Vista, Garanhuns, Caixa postal 152. CEP: 55292-272, Pernambuco, Brasil.*

Ingestion of metallic and/or pointed foreign bodies triggers a framework of traumatic reticuloperitonitis and its sequelae in cattle. Among these sequelae, we can highlight traumatic reticulo splenitis with high mortality, although its frequency in the clinical of ruminants is low. Therefore, based on the scarcity of information on this disease, the current study aimed to evaluate the clinical, laboratory, ultrasonographic, and pathological findings of 30 adult cattle diagnosed with traumatic reticulo splenitis. Clinical, ultrasound, and anatomopathological findings were analyzed using descriptive statistics and laboratory data were evaluated using measures of central tendency. Clinically the animals presented dehydration and alterations in behavior, appetite, and ruminal motility. Hematological findings revealed neutrophilic leukocytosis (37,077cell/ μ L) with regenerative left shift and hyperfibrinogenemia (1,130mg/dL). The ultrasound examination enabled visualization of mobile and echogenic filaments that corresponded to the presence of fibrin adhesions. Displacement of the reticulum and irregularity in its contour, as well as alterations in the quantity, pattern, and amplitude of reticular contractions were also observed. Splenic alterations such as abscesses were found,

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characterized as circular structures of varying sizes delimited by capsules containing variable echogenicity. Splenic vein thrombosis and spleen bowed were also observed. The results obtained in the current study indicated that traumatic reticulo splenitis causes nonspecific clinical signs, severe laboratory alterations and, mainly, that ultrasound is an efficient method for the diagnosis of this disease, since the anatomopathological lesions confirmed the ultrasound findings.

Index Terms: Diagnostic imaging, Foreign body syndrome, Spleen, Traumatic reticulo splenitis

Resumo

A ingestão de corpos estranho de origem metálica e/ou pontiagudos desencadeia em bovinos, quadros de Reticuloperitonite Traumática e suas sequelas. Dentre as quais podemos destacar a reticulo esplenite traumática cuja letalidade é elevada, embora a mesma apresente uma baixa frequência na clínica de ruminantes. Portanto, baseado na escassez de informações sobre esta enfermidade, este trabalho teve por objetivo avaliar os achados clínicos, laboratoriais, ultrassonográficos e anatomopatológicos de 30 bovinos adultos diagnosticados com reticulo esplenite traumática. Os achados clínicos, ultrassonográfico e anatomopatológico foram analisados por meio de estatística descritiva, e os dados laboratoriais foram avaliados utilizando-se as medidas de tendência central. Clinicamente os animais apresentaram desidratação e alterações no comportamento, apetite e na motilidade ruminal. Os achados hematológicos revelaram leucocitose (37.077 cel/ μ L) por neutrofilia com desvio a esquerda regenerativo e hiperfibrinogenemia (1.130 mg/dL). O exame ultrassonográfico possibilitou a visualização de filamentos móveis e ecogênicos que corresponderam à presença de aderências fibrinosas, observou-se também, deslocamento do reticulo e irregularidade no seu contorno além das alterações na quantidade, padrão e amplitude das contrações reticulares. Permitiu ainda, a constatação de alterações esplênicas como abscessos que foram caracterizados como estruturas circulares de variados tamanhos delimitada por capsula contendo no seu interior conteúdo de ecogenicidade variável. Trombose da veia esplênica e dobramento do baço. Os resultados obtidos nesse trabalho, indicaram que a reticulo esplenite traumática causa sinais clínicos inespecíficos, severas alterações laboratoriais e principalmente que a ultrassonografia é um método eficiente para o diagnóstico dessa enfermidade uma vez que as lesões anatomopatológicas confirmaram os achados ultrassonográficos.

Termo de Índice: Baço, Diagnóstico por imagem, Reticulo esplenite traumática, Síndrome do corpo estranho.

Introduction

The feeding habits of cattle, combined with the low sensitivity of taste organs, nutritional deficiencies, permanence in pastures containing pointed foreign bodies, and the supply of agribusiness residues in regions where food is scarce are considered the main factors responsible for ingestion of foreign bodies (Anteneh & Ramswamy 2015; Mulatu et al. 2018).

Among these foreign bodies, it is worth mentioning metallic and pointed objects which, when ingested, tend in most cases to stick to the reticulum mucosa where they trigger cases of Traumatic Reticuloperitonitis (TRP) and its sequelae (Braun et al. 2018).

These objects may remain free within the reticulum or transfix its wall and continue in various directions causing a framework of focal or diffuse peritonitis, traumatic pericarditis, diaphragmatic hernia, hepatitis, and traumatic splenitis (Assis 2019; Balasundara et al. 2012; Silva 2011).

It is estimated that only 2 to 14% of animals diagnosed with traumatic reticuloperitonitis develop splenitis as a sequela (Dirksen 2005), the clinical presentation of which is characterized by fever, tachycardia, decreased appetite and milk production, and increased pain sensitivity to palpation of the spleen (Radostits 2002). However, due to the scarcity of reports of splenic disease diagnosed in live cattle, these clinical signs may be attributed to traumatic reticuloperitonitis.

In addition to the above clinical signs, the affected animals also present significant laboratory alterations such as expressive neutrophilia leukocytosis and hyperfibrinogenemia due to the formation of abscesses in the spleen (Silva et al. 2017).

Although this disease presents low frequency in the clinical of ruminants, its lethality is 100% and the economic losses begin with impairment of the productive life of the animal (Silva et al. 2017).

Therefore, due to the lack of information about this disease, especially regarding early diagnosis and its relevance to cattle ranching arising from the economic losses generated, the current study aimed to address the main clinical and laboratory findings, as well as the sonographic and anatomopathological observations and to evaluate the effectiveness of ultrasound in the diagnosis of traumatic reticulo splenitis.

Material and methods

Location and date

The study was conducted in the Clínica de Bovinos de Garanhuns (CBG) *Campus* of the Universidade Federal Rural de Pernambuco (UFRPE) by analyzing the clinical follow-up records (including laboratory information) of the ultrasound and necropsy reports of animals attended in the period from May 2009 to May 2019 diagnosed with traumatic reticulo splenitis.

Animals

Thirty purebred or crossbred dairy cattle, male and female, from dairy farms located in the Southern Agreste region of Pernambuco were studied.

Physical examination

All animals were clinically examined following the recommendations of (Dirksen, 1993).

Laboratory tests

Blood samples were collected from all animals by venipuncture of the jugular, using a 21G needle, into siliconized vacutainer tubes containing EDTA anticoagulant (10%) to determine hematological variables (blood count, total plasma protein, and plasma fibrinogen) according to the methodology proposed by (Jain, 1993).

Ultrasound examinations

Ultrasounds were performed using two Mode B devices (Logic 100 Pro, GE Medical Systems Co. Ltd., Wuxi China and Z6 Vet, Mindray Bio-Medical Eletronics Co. Ltd., Shenzhen China) and convex transducers with frequencies of 3.5 MHz (Logic 100 Pro) and 5.0 MHz (Z6 Vet) according to the methodology used by (Braun, 1993) for the reticulum examination (Braun and Sicher, 2006) and spleen evaluation.

Euthanasia

Euthanasia of the animals followed the technical recommendations of (Luna and Teixeira, 2007).

Statistical analysis

Results obtained from the clinical, ultrasound, and pathological findings were analyzed using descriptive statistics. Laboratory data were evaluated using measures of central tendency, mean, and standard deviation (Curi, 1997). For the purpose of evaluating the correspondence between the sonographic findings and the pathological lesions, reports of 20 necropsied animals were used.

Ethics committee approval

This study was approved by the Animal Use Ethics Commission (CEUA) of UFRPE under No. 105/2018 according to the rules of the Brazilian College of Animal Experimentation (COBEA) and *National Institute of Health Guide for Care and Use of Laboratory Animals*.

History

The main complaints reported by the owners were reduced appetite, weight loss, and decreased milk production of the animals. In some cases, information was given on the introduction of agribusiness residues such as poultry litter and cassava bark in the animal feed.

Results

Epidemiological observations

During the study period, 7,353 cattle were treated in the Clínica de Bovinos de Garanhuns (CBG) *Campus* of the Universidade Federal Rural de Pernambuco (UFRPE) of which 1,361 (18.50%) were diagnosed with digestive problems. Of these, 229 (16.82%) corresponded to cases of traumatic reticuloperitonitis and 30 (13.10%) presented cases of traumatic reticulo splenitis.

The cattle in this study, 6 were bred in intensive systems (20%) and 24 in semi-intensive systems (80%), all aged between two and 15 years. Eight of the animals were Holandes breed, one Girolando, and 21 were crossbred Holandes-Zebu cattle. Of the 30 animals two were males and 28 were females, among which six were pregnant, one nulliparous, 12 had calved more than 100 days previously, and in nine cases the person responsible did not know if the animal was pregnant.

Clinical observations

Clinically the animals exhibited alterations in appetite, varying degrees of dehydration and ruminal hypomotility. In table 1 presents the absolute (n) and relative (%) values of the main clinical findings of cattle with traumatic reticulo splenitis.

Laboratory results

The results of the hematological exams demonstrated slight alterations in the red blood cells and intense alterations in the white blood cells. The values are specified in table 2.

Ultrasonographic aspects

The ultrasound findings in the ventral cranial region of the abdomen were characterized by the presence of heterogeneous echogenic filamentous material on the surface of the organs, suggesting fibrin and/or adhesions, figure 1A. In addition, circular structures of varying sizes were observed, delimited by capsules with content of variable echogenicity, indicating fibrin abscesses or pockets.

Visualization of the reticulum was possible in all cases, however, in three animals it was not clearly observed due to the presence of a large amount of inflammatory deposit. Table 3 shows the absolute and relative frequencies of the main reticulum-related ultrasound findings as well as the frequency, amplitude, and pattern of reticular contractions in cattle affected by traumatic splenitis.

The ultrasound examination of the splenic region revealed marked alterations in all animals. The images commonly observed in the spleen were characterized by two thin or thick hyperechoic lines delimiting a heterogeneous echotexture parenchyma, figure 2A. In all cases, circular and capsule-bounded structures were visualized. These alterations sometimes extended throughout the organ, while in other cases part of the splenic parenchyma maintained its normal echotexture, figure 3A. It is worth mentioning the presence of echogenic images partially filling the lumen of the splenic vein, indicating the existence of thrombosis, figure 4A. One case of spleen bowed were characterized by the visualization of two thin and hyperechoic lines in the center of the image of the spleen, figure 5A.

Necropsy findings

Of the 30 cattle with traumatic reticulo splenitis, 19 were euthanized and one died naturally, therefore 20 necropsy were available. The lesions found in the abdominal cavity were

characterized by the presence of fibrin and adhesions between the organs (rumen, reticulum, diaphragm, spleen, liver) and increased peritoneal fluid. Table 4 presents information on the main anatomopathological findings of the abdominal cavity, reticulum, and spleen, as well as the correspondence between these findings and the ultrasound observations of the lesions. In figures 1B, 3C, 4B, and 5B, it is also possible to observe the correspondence between ultrasound and anatomopathological findings.

Regarding the presence of foreign bodies, a total of 20 metal objects with perforating characteristics (wires) were recovered from 16 animals, with lengths ranging from (4 to 15 cm). These were located free or attached to the reticulum, rumen, or abomasal mucosa and inside fistulas and splenic parenchyma.

Discussion

The higher occurrence of cases of traumatic reticulo splenitis in adult crossbred females observed in this study is attributable to the predominance of dairy cattle farming in the region where the Pernambuco dairy basin is located (Silva 2011). A contributing factor to the development of this disease is the supply of feed in the troughs, which is highly manipulated by man in intensive and semi-intensive rearing systems, causing the accidental addition of metallic objects during the processing and/or storage stages (Fubine & Divers 2008). In the region studied, mainly on dry period season it is common to offer animals by-products from the local agro-industry, such as poultry litter and cassava bark, which in some situations may contain perforating materials that contribute to the appearance of splenitis and other sequelae of TPR (Assis 2019).

The clinical expression of this disease in pregnant and recently calved animals occurs due to the expansion of the uterus and the effort generated at the time of calving, which causes the uterus to exert physical pressure on the reticulum, possibly due to the existence of an metallic foreign body, causing perforation of this organ and resulting in TRP sequelae (Anteneh & Ramswamy 2015; Assis 2019; Fubine & Divers 2008; Silva 2011). Clinical signs characterized by apathy, appetite alteration, varying degrees of dehydration, and ruminal hypomotility were also reported by Trecenti et al. (2015). However, due to the scarcity of reports on splenic disease diagnosed in live cattle, clinical signs resembled those observed by Assis (2019) in cases of traumatic reticuloperitonitis.

Regarding hematological alterations, the neutrophilic leukocytosis with regenerative left shift found in the animals of this study characterizes the severity of the inflammatory

process. Such conditions are similar to those observed by Nuss et al. (2009) and Trecenti et al. (2015) in cattle affected by traumatic splenitis. This type of response occurs through abscesses and chronic lesions that continue to stimulate the bone marrow to produce neutrophils. On the other hand, even in prolonged inflammatory processes the acute inflammatory pattern may be present and maintain activation of neutrophil demand (Jain 1993; Weiser 2015). Hyperfibrinogenemia was also present in the current and other studies involving traumatic digestive disorders in cattle and buffaloes (Assis 2019; Athar et al. 2010; Silva 2011; Silva 2018). Although fibrinogen is a positive acute phase protein, its concentration also remains high in chronic disease as long as liver synthesis capacity is not affected and there is an antigenic stimulus for its production (Allison 2015). The chronicity of the inflammatory process also results in an increase in total plasma protein concentration due to clinical dehydration (Allison 2015; Assis 2019; Braun et al. 2018).

The ultrasound results demonstrated impairment in the reticular activity, which may occur due to stimuli of inhibitory mechanisms caused by pain or fever which affect the gastric center of the vagus nerve, generating a decrease in rumen-reticulum motility due to the formation of fibrin adhesions (Braun et al. 1993a). In a more recent study Braun et al. (2018), attributed this decrease in reticular motility to mechanical factors associated with peritonitis, since cattle with or without discrete lesions presented normal reticular contractions.

In addition to alterations in the motility pattern of the reticulum, due to adhesions, it was distanced from the diaphragm and had an irregular contour. Corroborating with Abdelaal et al. (2009); Braun et al. (1993a); Khalphallah et al. (2015); Braun et al. (2018) who also observed these lesions when evaluating cattle and buffaloes affected with traumatic reticuloperitonitis. This finding opposes that found in healthy animals, whose the ultrasound aspect of the reticulum appears as a half-moon-shaped structure with a smooth contour supported by the diaphragm or ventral abdominal wall (Braun et al., 1993a; Braun & Götz, 1994; Braun 2009).

The ultrasound images that defined the traumatic splenitis framework in the animals of this study were similar to those observed by Nuss et al. (2009); Silva et al. (2017), who reported alterations in the echogenicity pattern of the splenic parenchyma as a consequence of abscesses. These were characterized as circular structures delimited by a hyperechogenic capsule with content of variable echogenicity, similar to that described by Braun et al. (1993a). In healthy cattle, the splenic parenchyma presents a homogeneous echogenicity pattern and its capsule can be seen as a thin and echogenic line (Braun & Sicher 2006).

In addition to the alterations observed in the spleen parenchyma, the ultrasound was also efficient for identifying the splenic bowed that occurred in one of the animals in this study, the cause of which is not clear, but may be related to the rupture of the ligaments responsible for the spleen fixation due to the inflammatory process. This type of injury is widely reported in dogs, with the main reason being gastric dilation in this species (Gomes et al. 2017; Ortiz et al. 2016).

The majority of the ultrasound findings observed in the current study were confirmed in the *postmortem* examination of the animals, similar to that verified by (Assis 2019; Silva 2011). However, the non-visualization of adhesions by ultrasound in some cases is due to the internal location of these lesions, making it impossible to access them through absorbing ultrasound waves (Braun & Götz 1994).

The inflammatory lesions of the peritoneum observed in the ventral cranial region of the abdomen indicate foreign body perforation of the reticular wall (Braun et al. 2018). However, these objects were not visualized by ultrasound, since this diagnostic method enables evaluation of the scale and location of inflammatory alterations to the peritoneum while radiography provides visualization of metallic foreign bodies (Athar et al. 2010; Braun et al. 1993a; Braun et al. 1993b; Braun et al.,2002; Braun et al. 2018).

The metallic foreign bodies recovered during necropsy resembled those observed by Braun et al. (2018) in radiographic surveys and by Mulatu et al. (2018) in slaughterhouse cattle. However, the oxidation process suffered by the metallic objects as well as the extent of inflammatory lesions may have contributed to the non-visualization of MFB in some of the animals, which was also observed by (Braun et al. 2018).

Conclusion

Clinical examination alone did not allow the definitive diagnosis of traumatic reticulo splenitis since the clinical signs seen in the animals of this study resemble those observed in cattle with other sequelae of traumatic reticuloperitonitis. However, the complementary laboratory exams demonstrated severe alterations, which may indicate the possibility of a suppurative disease to the clinician. Therefore, laboratory findings combined with ultrasound contributed to the establishment of definitive diagnosis and prognosis, since splenic abscesses seen through ultrasound and confirmed at necropsy ratified the significant leukocytosis of the animals. Thus, the results of the current study indicated that ultrasound proved to be an efficient method for the diagnosis of traumatic reticulo splenitis.

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Conflict of interest statement

None of the authors have financial or personal relationships that may influence or distort the content of the article.

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Figure legends

Fig.1 (A) Ultrasound image of the left ventral cranial of the bovine abdomen: visualizing a non-supported reticulum over the diaphragm, displaced dorsally by hypoechoic effusion and deposits of echogenic material, which was also adhered to the reticular and ruminal serosa. (B) Serofibrinous peritonitis with adhesions between the organs of the abdominal cavity, corresponding to Figure 1A. 1. Abdominal wall; 2. Muscle-phrenic vein; 3. Diaphragm; 4. Reticulum; 5. Blind base of ruminal dorsal sac; 6. Hypoechoic effusion; Arrows: Fibrinous material; Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal

Fig.2 (A) Ultrasonographic image of the left ventral cranial of the bovine abdomen: visualizing non-supported reticulum on the dorsally displaced diaphragm, by the spleen with heterogeneous and hypoechoic parenchyma and heterogeneous material adhered to the reticular and ruminal serosa. (B) Spleen with lesion corresponding to figure 2A. 1. Abdominal wall; 2. Diaphragm; 3. Spleen; 4. Reticulum; 5. Blind base of ruminal dorsal sac; 6. Fibrinous material; Arrow: Splenic capsule. Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal

Fig.3 (A) Ultrasound image of the 8th left intercostal space of the bovine abdomen: visualizing the rumen, supported on the spleen whose parenchyma is heterogeneous, suggesting abscess lesions. (B) Ultrasound image of the 8th left intercostal space of a bovine: part of the spleen without alterations, with homogeneous parenchyma well delimited by a thin and hyperechoic capsule. (C) Spleen showing part of normal parenchyma and altered part with abscess lesion, corresponding to figures 3A and 3B. 1. Abdominal wall; 2. Spleen; 3. Blind base of rumen dorsal sac; Arrow: abscess; Arrow Head: Splenic capsule; Vt. Ventral; Ds. Dorsal

Fig.4 (A) Ultrasound image of the 8th left intercostal space of a bovine: visualizing spleen with splenic vein lumen partially filled with echogenic structure, suggestive of thrombosis, and deposition of echogenic and heterogeneous material adhering the rumen serosa to the splenic capsule. (B) Splenic thrombosis, corresponding to figure 4A. 1. Abdominal wall; 2. Spleen; 3. Rumen; 4. Echogenic material; Arrow. Splenic vein thrombus; Arrowhead. Thickened splenic capsule; Vt. Ventral; Ds. Dorsal

Fig.5 (A) Ultrasound image of the left ventral cranial region of the bovine abdomen: visualizing the reticulum supported over the spleen and thus displaced dorsally. Spleen torsion, plus circular hyperechoic areas corresponding to the fixation site of the metallic foreign body

(MFB). (B) Splenic bowed corresponding to figure 5A. (C) Abscess lesion caused by MFB corresponding to Figure 5A. 1. Abdominal wall; 2. Spleen; 3. Irregularly contoured reticulum; 4. Echogenic deposits; 5. Omentum; Fine arrow: splenic capsule; Thick arrow: thin and hyperechoic lines indicating spleen torsion; Arrowhead: abscesses. Vt. Ventral; Ds. Dorsal

Table 1. Absolute (n) and relative (%) frequency of major clinical signs of 30 cattle diagnosed with traumatic reticulo splenitis

Characteristics	Clinical findings	Number of animals	
		Absolute value	Relative value
Posture	Standing	27	90%
	Decubitus	3	10%
Appetite	Present	15	50%
	Absent	6	20%
	Capricious	9	30%
Behavior	Calm	15	50%
	Apathetic	15	50%
Rectal temperature (°C)	Normal (37– 39 °C)	19	63.33%
	Fever (>40 °C)	11	36.67%
Dehydration	Absent	2	6.67%
	Mild (5-8%)	10	33.33%
	Moderate (9-12%)	11	36.67%
	Severe (> 12%)	7	23.33%
Heart rate	Normal (60-80)	18	60%
	Low (<60)	1	3.33%
	Accelerated (>80)	11	36.66%
Respiratory frequency	Normal (24 - 36)	15	50%
	Low (<24)	6	20%
	Accelerated (>40)	9	30%
Venous stasis	Positive	3	10%
	Negative	25	83.33%
	Not informed	2	6.67%
Ruminal motility	Physiological	2	6.67%
	Hypermotility	5	16.67%
	Hypomotility	22	73.33%
	Atony	1	3.33%
Ruminal tympany	Present	4	13.33%
	Absent	26	86.67%
Ruminal stratifications	Defined extracts	20	66.67%
	Undefined extracts	8	26.67%
	Not informed	2	6.67%
Evidence of pain	Positive (in a test)	4	13.33%
	Negative	24	80%
	Not informed	2	6.66%
Abdominal tension	Physiological	21	70%
	Increased	8	26.66%
	Not informed	1	3.33%

Table 2. Hematological values, total plasma protein, and plasma fibrinogen obtained from 30 cattle with traumatic reticulo splenitis.

Parameters	Maximum value	Minimum value	Mean/SD	Reference value ^a
Hematocrit	31	9.00	23.10±4.51	24 – 46
Erythrocytes (10 ⁶)	6.8	1.68	5.00±1.04	5.0 - 10.0
Hemoglobin (g/dL)	11.2	2.66	7.44±1.81	8.0 – 15.0
MCV ^b (fL)	58	36.48	46.69±4.92	40.0 - 60
MCHC ^c (%)	44	22.47	32.12±4.06	30.0 – 36.0
Total leukocytes (μL)	123,150	6,900	37,077±25004	4.0 – 12.0
Lymphocytes (μL)	24,486	1,800	6,023±4587	2500 -7500
Neutrophils (mature) (μL)	103,446	4209	30,138±21741.47	600 - 4000
Neutrophils (band cell) (μL)	7,339	0	789±1503.58	0 – 120
Eosinophils (μL)	567	0	89±169.75	0 – 2400
Monocytes (μL)	2,735	0	353±547.65	25 – 840
Basophils (μL)	235	0	26±70.81	0 – 200
TPP ^d (g/dL)	11.6	6.3	9.33±1.19	7.0 – 8.5
PF ^e (mg/dL)	1,800	600	1,130±365.00	300 - 700

^bMCV: mean corpuscular volume; ^c MCHC: mean corpuscular hemoglobin concentration; ^dTPP: total plasma protein; ^ePF: plasma fibrinogen. ^aJAIN, 1993

Table 3. Main ultrasound findings related to the reticulum of 30 cattle affected by traumatic reticulo splenitis.

Characteristics	Ultrasound findings	Number of animals	
		Absolute value	Relative value
Reticular Contour	Smooth	4	13.33%
	Irregular	20	66.67%
	Not informed	6	20%
Reticular Positioning	Supported by diaphragm	0	-
	Dorsally displaced	28	93.33%
	Not informed	2	6.66%
Number of contractions in 3 minutes	3-4 (normal)	7	23.33%
	1-2 (reduced)	4	13.33%
	5-9 (hypermotile)	1	3.33%
	0 (atonic)	6	20%
	Attempt at contraction ^a	10	33.33
	Not informed	2	6.66
Contraction pattern	Biphasic	7	23.33%
	Triphasic	1	3.33%
	Atony	6	20%
	Attempt at contraction ^b	10	33.33
	Not informed	6	20%
	Not informed	6	20%
Contraction range	Normal	6	20%
	Reduced	14	46.66%
	Atony	6	20%
	Not informed	4	13.33%

^{a,b} contraction attempts were considered when there was a very small reticular displacement (<3cm) due to the adhesions of the organ wall.

Table 4. Correspondence between sonographic findings and anatomopathological lesions of cattle affected with traumatic reticulo splenitis

Affected organ	Ultrasound findings	Animal (n)	Anatomopathological findings	Animal (n)	Correspondence (%)
Abdominal cavity	Large quantity of anechoic content	1	Increased peritoneal fluid	1	100%
	Filamentous content of hyperechoic/hypoechoic echogenicity	11	Fibrin/adhesions between organs	17	60%
	Impaired motility	16	Adhesions	16	100%
Reticulum	Fistulas	0	Fistulas	9	0
	Presence of MFB	0	Presence of MFB	16	0
Spleen	Circular structures of varying sizes enclosed by capsules containing variable echogenicity content.	20	Abscesses	20	100%
	Thin, hyperechoic lines in the center of the spleen image.	1	Splenic bowed	1	100%
	Echogenic image filling the lumen of the splenic vein	1	Splenic vein thrombosis	2	50%

Figure

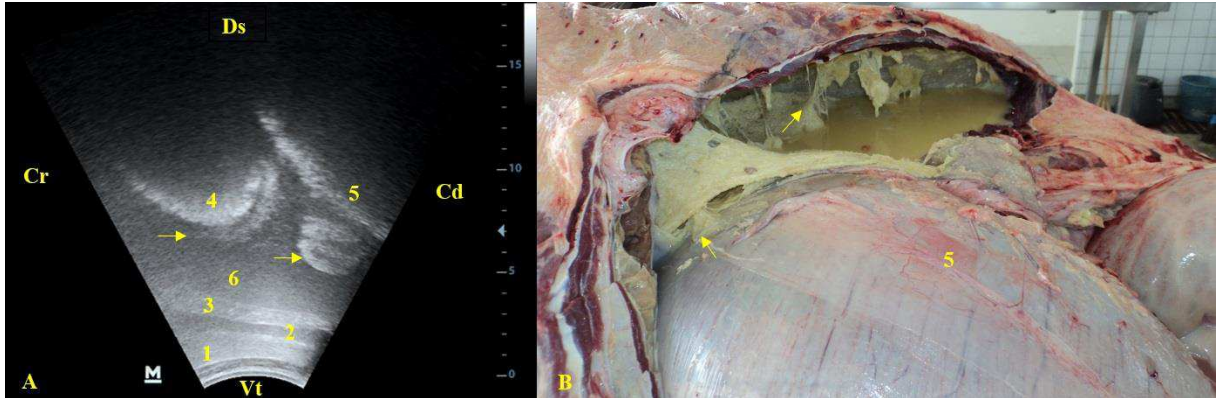


Fig.1 (A) Ultrasound image of the left ventral cranial of the bovine abdomen: visualizing a non-supported reticulum over the diaphragm, displaced dorsally by hypoechoic effusion and deposits of echogenic material, which was also adhered to the reticular and ruminal serosa. (B) Serofibrinous peritonitis with adhesions between the organs of the abdominal cavity, corresponding to Figure 1A.1. Abdominal wall; 2. Muscle-phrenic vein; 3. Diaphragm; 4. Reticulum; 5. Blind base of ruminal dorsal sac; 6. Hypoechoic effusion; Arrows: Fibrinous material; Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal

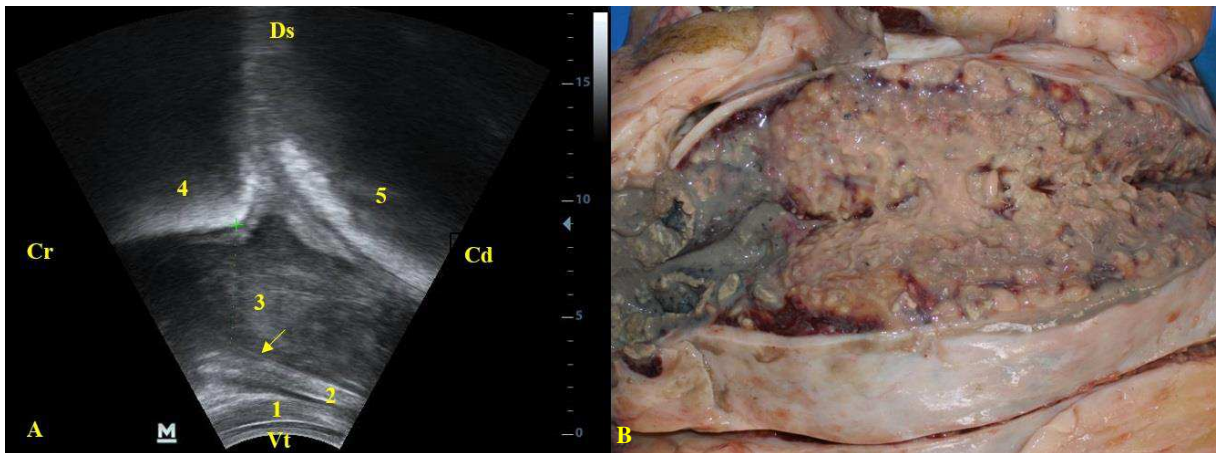


Fig.2 (A) Ultrasonographic image of the left ventral cranial of the bovine abdomen: visualizing non-supported reticulum on the dorsally displaced diaphragm, by the spleen with heterogeneous and hypoechoic parenchyma and heterogeneous material adhered to the reticular and ruminal serosa. (B) Spleen with lesion corresponding to figure 2A. 1. Abdominal wall; 2. Diaphragm; 3. Spleen; 4. Reticulum; 5. Blind base of ruminal dorsal sac; 6. Fibrinous material; Arrow: Splenic capsule. Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal

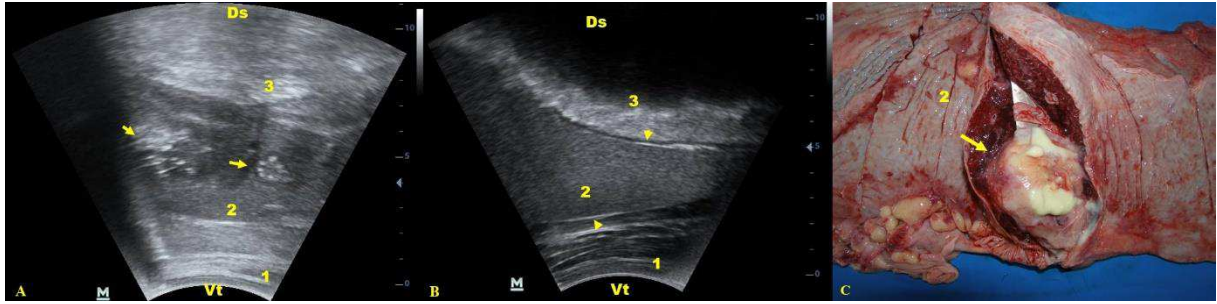


Fig.3 (A) Ultrasound image of the 8th left intercostal space of the bovine abdomen: visualizing the rumen, supported on the spleen whose parenchyma is heterogeneous, suggesting abscess lesions. (B) Ultrasound image of the 8th left intercostal space of a bovine: part of the spleen without alterations, with homogeneous parenchyma well delimited by a thin and hyperechoic capsule. (C) Spleen showing part of normal parenchyma and altered part with abscess lesion, corresponding to figures 3A and 3B. 1. Abdominal wall; 2. Spleen; 3. Blind base of rumen dorsal sac; Arrow: abscess; Arrow Head: Splenic capsule; Vt. Ventral; Ds. Dorsal

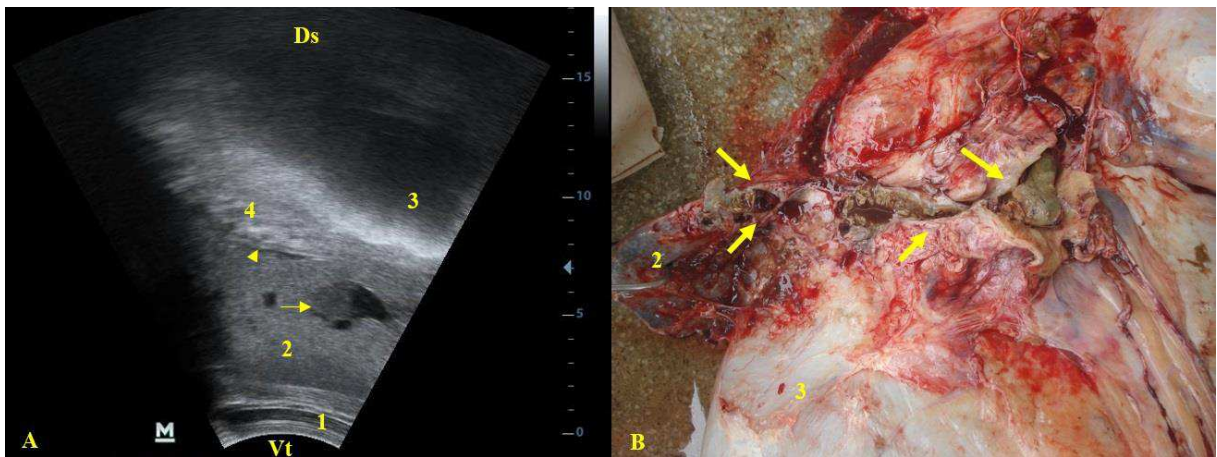


Fig.4 (A) Ultrasound image of the 8th left intercostal space of a bovine: visualizing spleen with splenic vein lumen partially filled with echogenic structure, suggestive of thrombosis, and deposition of echogenic and heterogeneous material adhering the rumen serosa to the splenic capsule. (B) Splenic thrombosis, corresponding to figure 4A. 1. Abdominal wall; 2. Spleen; 3. Rumen; 4. Echogenic material; Arrow. Splenic vein thrombus; Arrowhead. Thickened splenic capsule; Vt. Ventral; Ds. Dorsal



Fig.5 (A) Ultrasound image of the left ventral cranial region of the bovine abdomen: visualizing the reticulum supported over the spleen and thus displaced dorsally. Spleen torsion, plus circular hyperechoic areas corresponding to the fixation site of the metallic foreign body (MFB). (B) Splenic bowed corresponding to figure 5A. (C) Abscess lesion caused by MFB corresponding to Figure 5A. 1. Abdominal wall; 2. Spleen; 3. Irregularly contoured reticulum; 4. Echogenic deposits; 5. Omentum; Fine arrow: splenic capsule; Thick arrow: thin and hyperechoic lines indicating spleen torsion; Arrowhead: abscesses. Vt. Ventral; Ds. Dorsal

CAPÍTULO II
Ultrasound Diagnosis of Reticular Diaphragmatic Hernia in Bovines.

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Trabalho a ser submetido à revista

(Qualis B1)

Ultrasound Diagnosis of Reticular Diaphragmatic Hernia in Bovines

Diagnóstico Ultrassonográfico de Hérnia Reticular Diafragmática em Bovinos

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Highlights

The clinical exam alone did not allow the definite diagnosis of reticular diaphragmatic hernia once the clinical signs seen in the animals of this study were similar to those observed in cattle with other sequelae of traumatic reticuloperitonitis.

The laboratorial exams revealed presence of an inflammatory process, having little value for the exact diagnosis of the disease.

Ultrasonography was determinant for the diagnosis reticular diaphragmatic hernia in bovines since the necropsy findings were compatible with the ultrasonographic images.

Abstract

A reticular diaphragmatic hernia is a congenital or acquired alteration resulting from protrusion of the reticulum into the thoracic cavity. In ruminants, lesions to the diaphragmatic muscle, due to penetration of sharp metallic objects, is the most common cause of this disease. Therefore, given the low number of reports on this disease in the bovine species, the current study aims to describe the clinical, laboratory, and anatomopathological findings, with special emphasis on the ultrasound diagnosis of five cattle suffering from reticular diaphragmatic

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hernia. The laboratory data were analyzed using mean and standard deviation, and clinical, ultrasound, and pathological findings were evaluated using descriptive statistics. Clinically the animals exhibited varying degrees of dehydration, abdominal distension, tympania, and alterations in ruminal motility, in addition to cardiorespiratory alterations such as murmur, dyspnea, and muffling of lung sounds. The laboratory examination showed neutrophilic leukocytosis and hyperfibrinogenemia. The sonographic images demonstrated reticulum inside the thoracic cavity adjacent to the lung and heart, although no reticular motility was observed. The pathological lesions confirmed the findings of the ultrasound exams. Thus, the current study demonstrated that ultrasonography was efficient in diagnosing reticular diaphragmatic hernia in the bovine species.

Key-words: Diagnostic imaging, Foreign body syndrome, Reticulum

Resumo

A hérnia reticular diafragmática é uma alteração congênita ou adquirida resultante da protrusão do retículo para o interior da cavidade torácica. Em ruminantes, lesões no músculo diafragmático devido a penetração de objetos metálico pontiagudos constitui a causa mais comum dessa enfermidade. Portanto, diante dos poucos relatos a cerca dessa enfermidade nos animais da espécie bovina, este estudo tem como objetivo descrever os achados clínicos, laboratoriais, anatomopatológicos e dar ênfase especial no diagnóstico ultrassonográfico de cinco bovinos acometidos com hérnia reticular diafragmática. Os dados laboratoriais foram analisados utilizando-se média e desvio padrão e os achados dos exames clínico, ultrassonográfico e anatomopatológicos foram avaliados através de estatística descritiva. Clinicamente os animais exibiam desidratação em variados graus, distensão abdominal, timpania e alterações na motilidade ruminal. Além de alterações cardiorrespiratórias como sopro, dispneia e abafamento dos sons pulmonares. O exame laboratorial revelou leucocitose por neutrofilia e hiperfibrinogenemia. As imagens ultrassonográficas revelaram retículo no interior da cavidade torácica adjacente ao pulmão e coração, porém nenhuma motilidade reticular foi observada. As lesões anatomopatológicas confirmaram os achados dos exames ultrassonográficos. Dessa maneira, este trabalho demonstrou que a ultrassonografia foi eficiente no diagnóstico da hérnia reticular diafragmática nos animais da espécie bovina.

Palavras-chave: Diagnóstico por imagem, Reticulo, Síndrome do corpo estranho

Introduction

Congenital or acquired failures in the diaphragmatic muscle result in diaphragmatic hernia in which protrusion of the organs of the abdominal cavity into the interior of the thorax is observed. In ruminants, the reticulum is the most commonly herniated organ, resulting in a condition known as reticular diaphragmatic hernia, which has been reported in calves, goats, cattle, and buffaloes (Dirksen, 2005; Mohindroo, et al 2007; Netto, et al 2008; Bellavance et al., 2010; Marques et al., 2014).

Generally, the most common causes of this disease are external trauma due to falls and blows, increased intra-abdominal pressure caused by bloating or advanced pregnancy, and weakening of the diaphragm through traumatic reticuloperitonitis lesions (Dirksen, 2005; Netto, et al 2008; Marques et al., 2014).

Clinically, reticular diaphragmatic hernia is most commonly manifested through recurrent tympanism, regurgitation, inappetence, and sparse stools. These signs might be accompanied by dyspnea, cough, and predominantly abdominal breathing. Chest auscultation in the cardiac region may reveal sounds of reticular contractions and muffled heart sounds (Dirksen, 2005; Constable et al., 2017).

The definitive diagnosis of this disease is obtained through exploratory laparotomy (Netto, et al 2008; Talekar, et al 2018) or through ultrasound visualization of the wall and reticular motility in the fourth right intercostal space of the thorax in bovines and buffaloes (Kumar and Saini, 2011). In situations where imaging equipment is not available, thoracentesis has been described as an alternative diagnostic method (Misk, 2015).

Although the indicated treatment for reticular diaphragmatic hernia is surgical correction, due to the severe impairment in the general condition observed in most affected animals, the best option in these conditions is slaughter or euthanasia of the animals (Constable et al., 2017).

Researchers from India and Egypt have reported the use of ultrasound to diagnose reticular diaphragmatic hernia, mainly in buffaloes (Mohindroo, et al 2007; Abouelnasr et al 2012; Abdelaal et al 2014; Attia, 2016). However, there is little information about the use of this imaging method for the diagnosis of diaphragmatic reticular hernia in the bovine species. Therefore, the current paper proposes to present the clinical, laboratory, and anatomopathological findings with special emphasis on the ultrasound diagnosis of five cattle suffering from reticular diaphragmatic hernia.

Material and method

Location and date

The study was carried out at the Clínica de Bovinos de Garanhuns (CBG) *Campus* of the Universidade Federal Rural de Pernambuco (UFRPE) through analysis of the clinical follow-up records, which also included the laboratory information, and ultrasound and necropsy reports of the cattle that were attended between the years 2016 and 2018.

Animals

Five crossbreed female dairy cattle from dairy farms located in the Southern Agreste region of Pernambuco were studied.

Physical examination

All animals were clinically examined following the recommendations of Dirksen (1993).

Laboratory examinations

Blood samples were collected from four animals using a 21G needle through jugular venipuncture into vacutainer-type siliconized tubes containing EDTA anticoagulant (10%) to determine hematological variables (blood count, total plasma protein, and plasma fibrinogen), according to the methodology proposed by Jain (1993).

Ultrasound examinations

Reticulum ultrasound examinations were performed using Mode B apparatus (Z6 Vet, Mindray Bio-Medical Electronics Co. Ltd., Shenzhen China) and a 5.0 MHz convex transducer (3C5P), according to the methodology used by Braun (1993).

Euthanasia

In animals euthanized with the permission of the owners, the technical recommendations of Luna and Teixeira (2007) were followed.

Statistical analysis

Results pertaining to clinical, ultrasound, and anatomopathological findings were analyzed using descriptive statistics. Laboratory data were evaluated using measures of central tendency, mean, and standard deviation (Curi, 1997).

Ethics committee approval

This work was approved by the Animal Use Ethics Committee (CEUA) of UFRPE under No. 105/2018 according to the standards of the Brazilian College of Animal Experimentation (COBEA) and the *National Institute of Health Guide for Care and Use of Laboratory Animals*.

Results

History

The animals presented a history of 2 to 4 weeks of clinical evolution, with complaints of reduced appetite, weight loss, decreased milk production, episodes of recurrent tympanism, and, in two cases, reflux of food content through the nostrils. Two of the affected cattle presented clinical signs between 15 and 30 days after calving.

Epidemiological observations

The affected cattle were five Dutch-Zebu crossbreed females, aged 3 to 14 years, one of which was reared in an extensive system and four semi-intensively. Only one was pregnant.

Clinical observations

Clinically the animals exhibited varying degrees of dehydration, abdominal distension, tympania and alterations in ruminal motility. Table 1 presents the absolute (n) and relative (%) values of the main clinical findings of the cattle suffering from reticular diaphragmatic hernia.

Laboratory findings

The results of the hematological exams demonstrated alterations the white blood cells such as leukocytosis due to neutrophilia and hiperfibrinogenemia. The results of the laboratory examinations are shown in table 2.

Ultrasound findings

The ultrasound findings that indicated the presence of reticular diaphragmatic hernia consisted of the visualization of the reticular wall in the third and fifth left intercostal space of the thorax and in the proximity of the reticulum with the organs of the thoracic cavity (figures 1A, 2A, and 3A). The reticular diaphragmatic hernia was not visualized through the ultrasound examination in only one of the five animals. These findings are described in table 3.

Necropsy findings

Of the five cattle suffering from reticular diaphragmatic hernia, only one was not authorized to be euthanized and in this case the diagnosis was obtained based on ultrasound examination only. Information related to the lesions found in the thoracoabdominal cavity of the necropsied animals, as well as the correlation with the sonographic findings, are described in table 4. In figures 2B, 3B, and 3C it is also possible to observe the correspondence between ultrasound and anatomopathological findings.

Discussion

The occurrence of reticular diaphragmatic hernia observed only in dairy cows could be attributed to the composition of the herd in the region, where there is a predominance of dairy cattle, in addition to the greater exposure of female dairy cattle to sharp metallic foreign bodies due to their higher productive longevity (Netto et al, 2008; Anteneh and Ramswamy, 2015).

The occurrence of this disease in animals that have recently calved and in the final third of gestation was attributed to increased intra-abdominal pressure resulting in diaphragm rupture due to diaphragm fragility caused by trauma from penetration of foreign bodies from the reticulum (Dirksen, 2005; Netto et al, 2008).

According to Netto et al, (2008), Athar et al (2010), Kumar and Saini (2011) clinical signs of reticular diaphragmatic hernia involve alterations in the digestive tract and cardiorespiratory system, as found in the animals of the current study. The presence of tympanism, reflux of food content, and inappetence can be attributed to entrapment of the reticulum inside the chest.

Cardiac murmur, dyspnea, and muffling in the auscultation of the pulmonary fields, as evidenced in some of the cattle, occur because the herniated reticulum causes the heart to shift and changes in intrathoracic pressure, resulting in cardiorespiratory alterations (Dirksen, 2005; Abdelaal et al 2014; Constable et al., 2017).

The laboratory alterations observed only suggest the presence of an inflammatory process, having little value for the exact diagnosis of the disease (Allison, 2015; Constable et al., 2017). However, leukocytosis accompanied by hyperfibrinogenemia, as found in the current study, is the most frequent hematological finding in cases of reticular diaphragmatic hernia, which was also reported by Abdelaal et al (2014) and Attia (2016) in Egyptian buffaloes.

The ultrasound findings of this disease in the animals of the current study were similar to those verified by Attia, (2016) who observed the reticular wall and lack of motility in the fifth left intercostal space of the thorax in buffaloes affected by reticular diaphragmatic hernia. However, a previous study has shown that the fourth intercostal space of the right antimere is the most reliable site for demonstrating reticular diaphragmatic hernia (Kumar and Saini, 2011).

The absence of a reticulum motility pattern within the thoracic cavity could be attributed to reticulum entrapment or the presence of strong peri-reticular adhesions (Athar et al 2010; Kumar et al 2017). However, although some authors consider that reticular motility within the chest is a decisive finding for the correct diagnosis of reticular diaphragmatic hernia (Mohindroo et al 2007; Athar et al 2010; Kumar and Saini, 2011), false positive diagnoses were reported by (Athar et al 2010) in animals that presented reticular motility at the level of the fifth intercostal space due to cranial displacement of the reticulum caused by abdominal distension.

On the other hand, a false negative diagnosis may occur when only a small portion of the reticulum is herniated, thus, ultrasound visualization of the viscera inside the chest is not possible and in the current study this prevented the ultrasound diagnosis in one of the cattle. In addition, when the reticulum is located far from the chest wall, out of the transducer range, and covered by the lungs, a diagnosis of diaphragmatic reticular hernia is not possible (Kumar and Saini, 2011; Constable et al., 2017).

Although no reticular motility within the chest was observed, visualization of the reticulum adjacent to the heart and lung was a determining finding for the diagnosis of reticular diaphragmatic hernia. These findings were similar to those observed by (Abdelaal et al 2014; Kumar et al 2017).

The necropsy findings corroborated the ultrasound examinations of the animals. This is the first study to confirm the ultrasound images of cattle with reticular diaphragmatic hernia through the observation of anatomopathological lesions, since in the few reports of ultrasound diagnosis of this disease in the literature, such as those of Kumar and Saini (2011) and Kumar et al. (2017), confirmation of the ultrasound diagnosis was given through exploratory laparotomy of cattle and buffaloes.

Conclusion

Visualization of the reticular wall in the fifth and third intercostal spaces of the left antimeres as well as the finding of the proximity of the reticulum to the organs of the thoracic cavity were decisive findings for the diagnosis of reticular diaphragmatic hernia in cattle, since these findings were confirmed in the necropsy of the animals. Therefore, visualization of motility of the herniated portion of the reticulum was not necessary for the diagnosis of this disease, since adhesions on thoracic organs may prevent this function.

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Table 1. Absolute (n) and relative (%) frequency of the main clinical signs of five cattle diagnosed with reticular diaphragmatic hernia.

Characteristics	Clinical findings	Number of animals	
		Absolute value	Relative value
Attitude	Standing	5	100%
	Decubitus	-	-
Appetite	Present	2	40%
	Absent	2	40%
	Finicky	1	20%
Behavior	Calm	5	100%
	Apathetic	-	-
Rectal temperature (°C)	Normal (37– 39 °C)	4	80%
	Fever (>40 °C)	1	20%
Dehydration	Absent	-	-
	Mild (5-8%)	1	20%
	Moderate (9-12%)	2	40%
	Severe (> 12%)	2	40%
Heart rate	Normal (60-80)	4	80%
	Low (<60)	-	-
	Increased (>80)	1	20%
Cardiac alteration	Murmur	2	40%
	Pre-stomach peristalsis	2	40%
	No alteration	1	20%
Respiratory frequency	Normal (24 - 36)	4	80%
	Low (<24)	-	-
	Increased (>40)	1	20%
Respiratory alteration	Dyspnea	2	40%
	Muffled auscultation	2	40%
	No alteration	1	20%
Venous stasis	Positive	2	40%
	Negative	3	60%
Ruminal motility	Physiological	2	40%
	Hypermotility	-	-
	Hypomotility	2	40%
	Atonia	1	20%
Ruminal tympania	Present	4	80%
	Absent	1	20%
Ruminal stratifications	Defined extracts	1	20%
	Undefined extracts	4	80%
Evidence of pain	Positive (in a test)	2	40%
	Negative	3	60%
Abdominal tension	Physiological	2	40%
	Increased	3	60%

Table 2. Hematological values, total plasma protein, and plasma fibrinogen obtained from four cattle with reticular diaphragmatic hernia.

Parameters	Animals				Mean/SD	Reference value ^a
	1	2	3	4		
Hematocrit	21	31	34	35	30.25±6.40	24-46
Erythrocytes (10 ⁶)	4.15	5.13	6.46	6.5	5.56±1.14	5-10
Hemoglobin (g/dL)	5.66	10.75	11.29	10.57	9.57±2.62	8-15
MCV (fL)	50.60	60.40	52.63	53.84	55.63±4.19	40-60
MCHC (%)	26.9	34.67	33.2	31.34	31.53±3.37	30-36
Total leukocytes (μL)	15350	14800	11050	10000	12800±2671	4000-1200
Lymphocytes (μL)	3070	5328	8067	6800	5816±2146	2500-7500
Segmented neutrophils (μL)	11820	9176	2320	3100	6604±4675	600-4000
Neutrophil rods (μL)	0	148	0	0	37±74	0-120
Eosinophils (μL)	0	0	663	0	166±332	0-2400
Monocytes (μL)	460	148	0	100	177±198	25-840
Basophils (μL)	0	0	0	0	0±0	0-200
TPP (g/dL)	8.8	6.8	7.8	7.4	7.7±0.84	7-8.5
PF (g/dL)	1800	400	800	600	900±622	300-700

MCV: mean corpuscular volume; MCHC: mean corpuscular hemoglobin concentration;

TPP: total plasma protein; PF: plasma fibrinogen. ^a JAIN, 1993

Table 3. Ultrasound findings of the abdominal and thoracic cavity of five cattle with reticular diaphragmatic hernia

Parameters	Abdominal cavity		Parameters	Thoracic cavity	
	Number of animals			Number of animals	
	Absolute value	Relative value		Absolute value	Relative value
Reticular contour			Reticular contour		
Smooth	-		Smooth	-	
Irregular	5	100%	Irregular	4	80%
Reticular positioning			Reticular positioning		
Supported by the diaphragm	3	60%	Supported by the heart	1	20%
Dorsally displaced	2	40%	Caudal to the lung	3	60%
Number of contractions in 3 minutes			Number of contractions in 3 minutes		
3-4 (normal)	2	40%	3-4 (normal)	-	
1-2 (reduced)	-		1-2 (reduced)	-	
5-9 (hypermotile)	-		5-9 (hypermotile)	-	
0 (atonic)	-		0 (atonic)	4	80%
No information	3	60%	No information	-	
Contraction pattern			Contraction pattern		
Biphasic	2	40%	Biphasic	-	
Triphasic	-		Triphasic	-	
No information	3	60%	No information	-	
			Reticulum not visualized in the chest	1	20%

Table 4. Correspondence between ultrasound findings and anatomopathological lesion of cattle with reticular diaphragmatic hernia

Affected organ	Ultrasound findings	Animal (n)	Anatomopathological findings	Animal (n)	Correspondence
	Motility absent	5	Adhesions	4	80%
Reticulum	Reticulum caudal to the lung	3	Reticulum adhered to the lung	3	100%

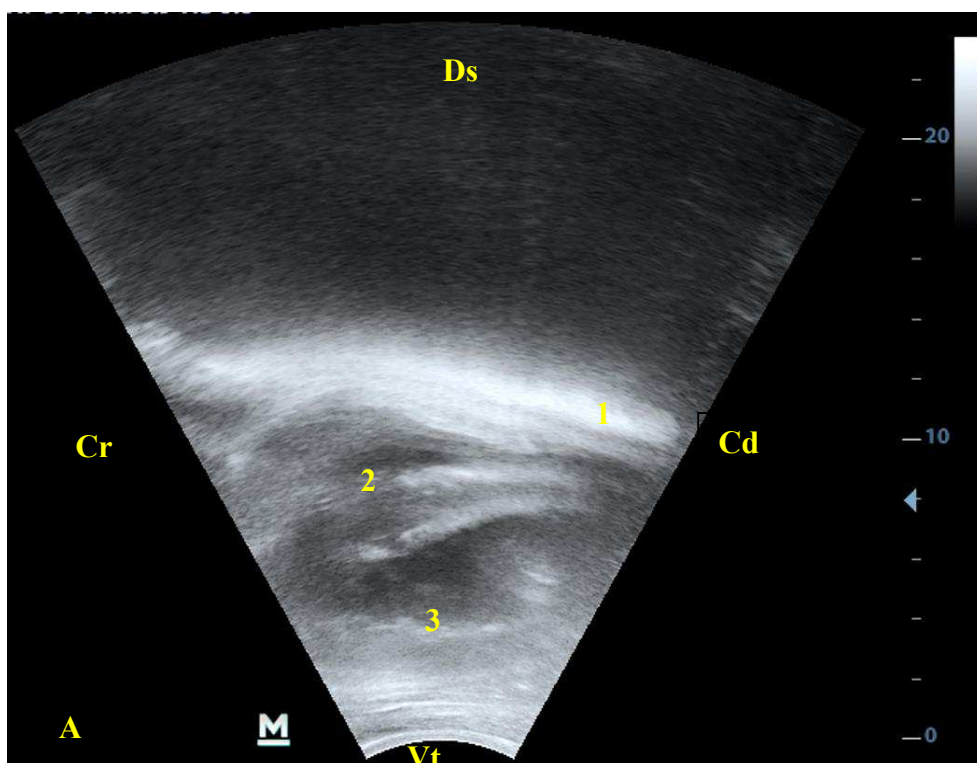


Figure 1: (A) Ultrasound image of the third left intercostal space of a bovine: visualizing the reticular wall resting on the heart and compressing it. 1. Reticular wall; 2. Right ventricle; 3. Left ventricle; Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal.

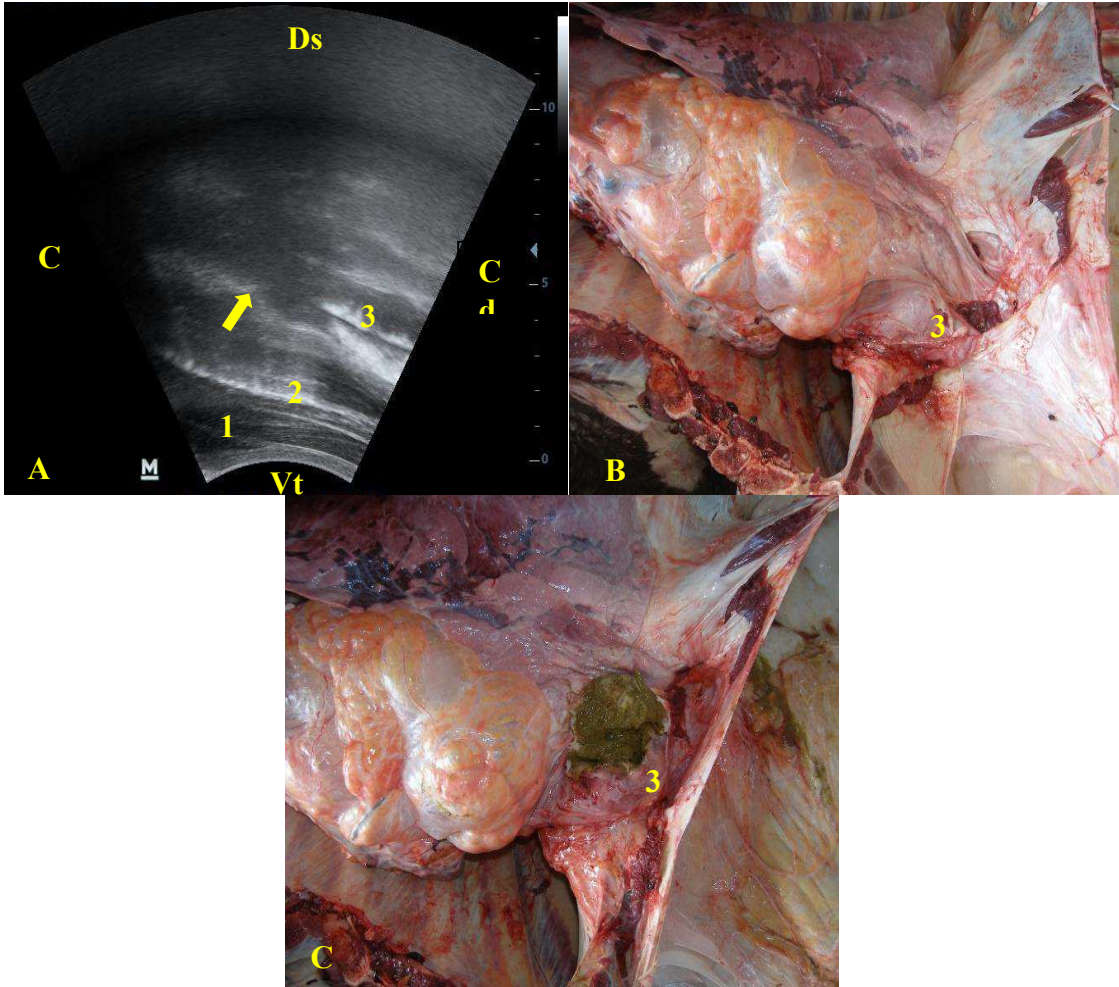


Figure 2: (A) Ultrasound image of the 5th left intercostal space of a bovine: visualizing the reticular wall caudal to the lung. (B) reticulum attached to the lung. (C) reticular mucosa. B and C corresponding to figure 2A. 1. Chest wall; 2. Lung (reverberation); 3. Reticular wall; Arrow. reticular wall contour within the chest. Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal.

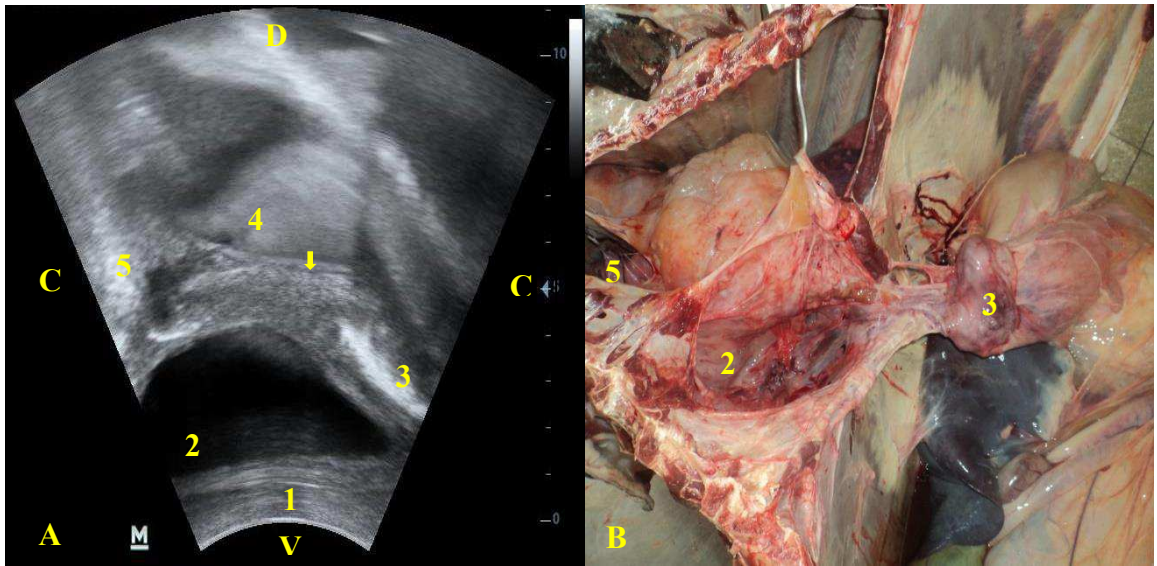


Figure 3: (A) Ultrasound image of the 5th left intercostal space of a bovine: visualizing the reticular wall caudal to the lung. (B) Pocket of inflammatory fluid and Reticular wall corresponding to figure 3A. 1. Chest wall; 2. Pocket of inflammatory fluid; 3. Reticular wall; 4. Left ventricular wall; 5. Lung; 6. Left atrium; Arrow. Ventricular wall with adhered inflammatory material (fibrin); Cr. Cranial; Cd Caudal; Vt. Ventral; Ds. Dorsal.

CONSIDERAÇÕES FINAIS

O exame clínico aliado aos exames laboratoriais são etapas imprescindíveis para se alcançar o diagnóstico das enfermidades. Contudo, a inespecificidade dos sinais clínicos que os animais podem exibir diante de algumas doenças, e como foi constatado nos bovinos deste estudo. Torna necessário a utilização de outros métodos complementares de exame para o alcance de um diagnóstico correto e definitivo. Nestas situações, a ultrassonografia mostrou ser um método eficiente no diagnóstico definitivo das duas entidades estudadas além de proporcionar um diagnóstico mais rápido, mais viável economicamente e menos estressante para os animais.