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DIAGNOSTIC UTILITY OF ECHOCARDIOGRAPHY AND ULTRASONOGRAPHY IN BUFFALOES SUFFERING FROM PERICARDITIS

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ABSTRACT

Pericarditis remains a serious problem faced by bovine producers in the developing countries. This study was designed to evaluate the echocardiographic and ultrasonographic changes in dairy buffaloes affected with pericarditis presented to Large Animal Clinic, Teaching Veterinary Hospital of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, India. 49 buffaloes were included and selected on the basis one or more of the clinical signs viz., brisket edema, dyspnoea, muffled heart sounds and distended jugular veins. Animals were subjected to clinical examination, thoracic and abdominal ultrasonography and M-mode echocardiography. The CVS examination revealed normal intensity of heart sounds in 17 and muffled in 32 cases with splashing/pericardial rub in 9 cases. Ultrasonography revealed spleenic congestion, liver was congested in majority of the cases with visible dilatation of the caudal vena cava. Heart was normal in 7 and visibly compressed in 42 cases due to the pericardial fluid. Massive pleural fluid was seen in 28 cases. Buffaloes in our study had pericardial effusions (n=49), pleural and pericardial effusions (n=45) and pleural, pericardial and peritoneal effusions (n=19). The predominant echocardiographic findings were significantly decreased dimensions of the heart chambers in both systole and diastole. The left ventricular contractility indices (FS% and EF%) were significantly high. The clinical findings alone do not allow a definitive diagnosis of pericarditis as characteristic signs were not present in all the cases. The combined use of ultrasonography and echocardiography provides a comprehensive idea about such cases and aids in early diagnosis of pericarditis.

Keywords: *Bubalus bubalis*, buffaloes, echocardiography, heart, pericarditis, ultrasonography

INTRODUCTION

The bovine heart comprises of three major structures i.e. pericardium, myocardium, endocardium and conductive tissue. The diseases of pericardium are commonly reported. Pericardial

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diseases in decreasing order of occurrence are traumatic reticulopericarditis, pericarditis secondary to pleural or lung infection, neoplastic effusion secondary to a lymphoma/ mesothelioma and idiopathic aseptic hemorrhagic pericarditis (Firshman *et al*., 2006). Heart failure (HF) is the end stage event in a cardiac disease and occurs when initial cardiac and neuro-hormonal compensatory mechanisms are overwhelmed (Colucci and Braunwald, 2005) and on failure of this mechanism, the heart fails (Givetz *et al*., 2001). Congestive heart failure (CHF) results in increased hydrostatic pressure and retention of fluid (Reef and McGuirk, 2009). Traumatic pericarditis in bovines leads to right-sided heart failure which is attributable to cardiac tamponade that hinders proper cardiac functioning. Ultrasonography as compared to other diagnostic techniques is cost effective and has evolved as a valuable imaging tool in almost all species of animals. A number of thoraco-abdominal affections can be diagnosed through ultrasonography *viz*; reticulitis, extra-reticular abscess (Kumar *et al*., 2012), diaphragmatic hernia (Kumar and Saini 2012), omasal and abomasal distention (Mohindroo *et al*., 2008), peritonitis (Kumar *et al*., 2008), liver abnormalities, intestinal, ceacal, kidney affections, pericarditis, pleural effusion, lung cyst, cardiac abscess and lung abscessation, etc. (Kumar and Saini, 2012). The present study was designed to see the efficacy of USG and echocardiography in diagnosis of pericarditis as so far, no studies have been conducted on these aspects in buffaloes.

MATERIALS AND METHODS

Buffaloes showing one or more clinical signs of brisket edema, jugular distention and pulsation, muffled heart sounds, tachycardia were selected for further detailed clinical examination and diagnostic procedures. 24 healthy buffaloes were selected for comparison with diseased animals. The final diagnosis was made on the basis of ultrasonography which confirmed pericarditis in 49 buffaloes. Transcutaneous ultrasonography was performed in standing buffaloes (n=49) as described by Braun (2003). A portable ultrasound scanner (SonoSite, USA) equipped with 3.5 to 5 MHz convex sector with penetration of depth 30 cm was used. Reticular shape and contour were assessed. All abnormal ultrasonographic findings of the neighbouring organs were also recorded including spleen, liver, caudal vena cava, amount and type of peritoneal reaction (Figure 1). For scanning the thoracic cavity, the area between the fifth and twelfth intercostal spaces is shaved on the right and left sides in the shape of a triangle that spans the caudal edge of the thoracic limb, the transverse vertebral processes, and a line stretching from the elbow to the dorsal corner of the thirteenth and following the diaphragm for assessment of lung area, amount and type of pleural effusions if any. Echocardiography was performed as described by Braun *et al*., (2001) using Sonosite M-turbo portable ultrasound machine (FUJIFILM SonoSite, Inc. USA) using a 1 to 5 MHz sector cardiac probe in all the patients for cardiac evaluation. The patients were prepared by shaving 25x25 cm area over the third, fourth and fifth intercostal spaces in the cardiac region on both left and right side. Ultrasound gel was applied to make good contact with the surface, 2-D and M mode images were recorded. 2-D image was used to correctly place the cursor of the M-mode for measurement of left ventricle indices. All M-mode dimensional measurements were obtained in centimetres from the right parasternal short axis

view of the left ventricle as described by Boon (2011) in accordance with the guidelines of the American Society of Echocardiography by using the leading-edge-to-leading-edge method of measurement. Measurement of the cardiac structures was made from the frozen M-mode images on the screen. The M-mode has a right ventricle at the top of the image, followed by the interventricular septum, the left ventricular chamber and then the left ventricular free wall at the bottom of the image (Figure 7). The pericardium on an M-mode image is always seen as a very bright line just below the left ventricular free wall.

RESULTS AND DISCUSSIONS

History and Signalment

The detailed history and signalment of the present study are entabulated in Table 1. Ghanem (2010) reported 15±2.6 as mean days of sickness in five animals suffering from pericarditis. Hussein and Staufenbiel (2014) reported 1 to 2 weeks of duration of illness in 53 buffaloes suffering from congestive heart failure. Sangwan *et al.* (2018) reported mean age as 6.27±2.19 years (3 to 9) and 5.46±1.99 year (3 to 10) in pericarditis affected cattle and buffaloes, respectively. Fubini and Divers (2007) reported that anorexia is a common part of history in animals suffering from heart diseases. Braun *et al.* (2007) also reported decreased appetite in 23/28 (82.14%) and anorexia in 5/28 (17.86%) cattle suffering from pericarditis. Hussein and Staufenbiel (2014) also reported either anorexia (57%) or inappetence (43%) in 53 buffaloes suffering from congestive heart failure (CHF). Bexiga *et al.* (2008) reported that majority of animals suffering from pericarditis passed either diarrheic (36%), scant (21%) or normal feces in 33%. Hepatic congestion due to venous congestion in the portal system is accompanied by impaired digestion and absorption, which later leads to diarrhea (Radostits *et al*., 2007). Few other workers have reported sudden reduction in milk yield in majority of animals (Hussain 2014 and Ghanem, 2010) which may be attributed to acute development of pericarditis or pain due to penetration of foreign body. So, drops in milk yield can be sudden or gradual in animals with pericarditis depending on the course of disease. Hussain (2014) reported higher incidence of pericarditis in pregnant (64.28%) animals as compared to non-pregnant animals. However, Hussein and Staufenbiel (2014) reported higher incidence in non-pregnant (44/53) as compared to pregnant buffaloes (9/53). The incidence of traumatic pericarditis is greater during the last trimester of pregnancy and at parturition than at other times due to increased intra-abdominal pressure that pushes the foreign body towards the thorax. (Desiye and Mersha 2012). An interesting finding in the present study is one buffalo heifer had pericarditis. However, no previous study reports occurrence of pericarditis in heifers.

Clinical examination

A thorough clinical examination pertaining to the cardiovascular system was carried out in all the animals. The findings are listed in Table 2. According to Braun *et al.* (2007), 75% of the cattle with pericarditis have the same audibility of heart sounds on both sides of the chest. Bexiga *et al.* (2008); Buczinski *et al.* (2010); Hussein and Staufenbiel (2014) have reported muffling, systolic, diastolic or systole-diastolic murmur, splashing or pericardial frictional sounds in cattle with signs of congestive heart failure or pericarditis. Muffling occurs because of pericardial effusions

and fibrinous changes in the pericardial sac. This suggests an increase in tissue and tissue interfaces between the heart and the stethoscope (Radostits *et al*., 2007). The presence of characteristic asynchronous abnormal heart sounds depends on the type of lesions. If the changes are predominantly fibrinous, the sounds are rubbing, squeaking or scratching in nature. If the fluid predominates, there are splashing or gurgling sounds, which vary continuously in pitch, loudness, duration and point of maximal intensity (Athar *et al*., 2012).

In the present study, visible distension of the jugular veins was observed in the majority of the pericarditis affected animals. However, normal jugular veins were observed in eight buffaloes. No brisket edema was observed in 11 buffaloes, whereas variable number of animals had different degrees of brisket, throat, ventral and limb edema (Table 2). Cattle suffering from heart diseases show variable clinical signs (Radostits *et al*., 2007; Imran *et al*., 2011). The pathognomonic clinical signs of traumatic pericarditis are tachycardia, muffled heart sounds, asynchronous heart sounds, jugular vein distension and edema. Jugular engorgement is reportedly the most consistent finding in cases of pericarditis (Saleh *et al*., 2008) even if brisket edema is not present. Bexiga *et al*. (2008) observed jugular engorgement in 97% of animals suffering from pericarditis. However, Braun *et al*. (2007) reported jugular engorgement in 25/28 (89.2%) cattle with traumatic pericarditis. Ghanem (2010) studied 40 buffaloes suffering from traumatic pericarditis which had non-inflammatory presternal edema (73%), and jugular & mammary vein distension and pulsation (88%). Brisket edema development usually follows jugular engorgement. Venous distention and pulsation coupled with abnormal heart sounds or rhythm are the key signs to diagnose heart failure in dairy cattle (Peek and McGuirk, 2008). However, many cases do not show all these signs. Respiratory manifestations like cough, dyspnoea and abnormal lung sounds are also found in most cows and buffaloes with thoracic abscesses as well as in few cases with pericarditis. It is difficult to differentiate involvement of heart, lung or mediastinal region by clinical examination alone. Therefore, additional diagnostic techniques are necessary for diagnosis and differentiation of these diseases (Abdelaal *et al*., 2009).

B-mode Ultrasonography

Presence of abnormal amount of fluid around the heart was considered diagnostic for pericarditis in buffaloes (n=49). Various B-mode ultrasonographic findings in cardiac affections are given in Table 3.

Thoracic lesions

Heart and Pericardial cavity

In the present study, ultrasonography of cases suspected of pericarditis revealed increased pericardial contents in 100% of the animals. Heart was visibly compressed due to excessive pericardial fluid accumulation in 42/49 buffaloes. Rest of the animals had less accumulation of pericardial fluid (less than 3 cm) which did not cause the visible compression of heart. Majority of the animals (33/49 buffaloes) had echogenic deposits in the pericardial sac as compared to anechoic pericardial fluid contents in 16/49 buffaloes (Table 3) (Figure 2).

Previous workers also reported hypoechoic materials with echogenic fibrin interspersed in between the pericardial sac in pericarditis affected animals (Gouda, 2015). Ghanem (2010) found hypoechoic pericardial effusion interspersed with echogenic deposits, representing a fibrin mesh with medial displacement of the heart chambers

away from the thoracic wall. Similarly, Tharwat (2011) reported mild or massive anechoic fluid with fibrin threads (fibrinous pericarditis) pericardial effusions or homogenous echogenic pericardial effusions. Athar (2009); Hussain (2014) also reported findings similar to the present study.

Lungs and pleural cavity

Upon scanning of the lung area, marked pleural effusions were evident in 41/49 buffaloes. Both anechoic and echogenic accumulation of the pleural fluid was observed in our study i.e. anechoic in 28/49 buffaloes and echogenic in 13/49 buffaloes (Table 3) (Figure 3).

According to Hussein and Staufenbiel (2014), lung consolidation can be seen in buffaloes with pericarditis. Reverberation artifact of a normal lung is replaced by hypoechoic structure and echogenic debris with distal comet tail artefacts along with anechoic pleural effusion and echogenic fibrin in pleural sac as a feature of pleuropneumonia in buffaloes with pericarditis (Gouda, 2015). Traumatic pleuropneumonia is a rare complication of hardware disease in buffaloes and ultrasonography shows hypoechoic exudates in the pleural cavity, absence of reverberation artifacts, presence of comet tail artifacts and hepatized lung (Abu-Seida and Al-Abbadi, 2016) Pleural effusions can occur because of pathology of the pleura itself or a condition affecting the surrounding organ structures (particularly heart) that leads to passive venous congestion (Babkine and Blond, 2009). So, this fact efficiently explains the excessive accumulation of pleural fluid in pericarditis affected buffaloes in our study.

Abdominal lesions

Spleen, reticulum and peritoneal cavity

Normal spleen and reticulum were observed in 32/49 (65%) buffaloes and 28/49 (57%) buffaloes, respectively and rest of the animals had variable degree of splenic congestion and peritoneal reaction (Table 3) (Figure 4). Abdominal ultrasonography revealed ascites and hepatomegaly in the majority (4/5) of the cows suffering from idiopathic pericarditis (Firshman *et al*., 2006). Tharwat (2011) in a previous study reported perireticular and splenic abscessation, echogenic deposits between reticulum and spleen in pericarditis affected cattle. In a recent study on buffaloes with congestive heart failure, abdominal ultrasonography revealed, moderate corrugations of the reticular wall with echogenic constrictive adhesions between the spleen and dorsal ruminal sac in 9 buffaloes. In cases where reticular adhesions were noticed, no reticular contractions were imaged, while in buffaloes with mild reticular lesions, the frequency of reticular contractions was 1 to 2 contractions/ 2 mins. Fibrinous tissue deposits were imaged between the reticulum, dorsal ruminal sac, and diaphragm in 13 buffaloes. Perireticular abscesses were also seen in 5 buffaloes with traumatic pericarditis (Hussein and Staufenbiel, 2014).

Liver and caudal vena cava

Majority of the pericarditis affected animals in the present study had hyperechoic liver (41/49 buffaloes) followed by liver floating in fluid (6/49 buffaloes) indicative of ascites (Figure 5). The caudal vena cava was dilated and oval in 43/49 buffaloes as compared to normal triangular shape in 6/49 buffaloes (Table 3) (Figure 6).

The caudal vena cava has a characteristic triangular shape on cross-section because it is embedded in the sulcus of vena cava in the liver (Plate 3s). The diameter of the caudal vena cava does not change from 12th to 10th ICS and mean diameter

measures 3.6±0.6 cm (2.2 to 5.0) (Braun, 2008). Congestion in the systemic circulation results in dilation of the caudal vena cava. The causes can be right-sided cardiac insufficiency, caudal vena cava thrombosis and compression in the thorax or subphrenic region by space occupying lesions. The caudal vena cava loses its normal triangular shape when congested and becomes round to oval on sonography. At the same time, the diameter of the vein also increases (Braun, 2009).

In the pericarditis affected animals, pericardial effusions were observed in 49/49 buffaloes. Both pericardial and pleural effusions were observed in 45/49 buffaloes. Effusions in pericardium, pleura and peritoneum were observed in 19/49 buffaloes. Similar to our findings, Puri (2016) also reported combined pericardial, pleural and peritoneal effusions in majority of the animals suffering from pericarditis. Abdominal ultrasonography in animals with traumatic pericarditis shows reticular changes typical of TRP, hepatomegaly and moderate to severe ascites (Abu-Seida and Al-Abbadi, 2016).

M-mode echocardiography

The M-mode echocardiographic parameters were measured in 29 percarditis affected buffaloes as heart was not visible enough for measurements in rest of the cases due to massive accumulation of the pericardial fluid. The measurements of right ventricle internal diameter (RVIDd and RVIDs) were non-significantly different between healthy, and pericarditis affected buffaloes. The measurements of interventricular septum during systole and diastole were significantly lower in pericarditis buffaloes as compared to healthy animals. Puri (2016) reported significantly reduced IVS (systole and diastole) in pericarditis affected cattle. The left ventricular dimensions during systole and diastole, were significantly ($P<0.05$) reduced in pericarditis affected buffaloes as compared to healthy buffaloes (Table 4) (Figure 7 and 8). As there was diastolic failure in pericarditis i.e. ventricles and atrium did not fill completely during diastole, so LVID decreased in the affected animals, which accounted for the decrease in other parameters. Left ventricle posterior wall thickness during diastole and systole (LVPWd and LVPWs) of pericarditis affected buffaloes showed significant ($P<0.05$) decrease as compared to the healthy group. Left ventricular volumes (EDV and ESV) were significantly lower ($P<0.05$) in pericarditis affected animals was observed as compared healthy buffaloes. Here it is important to note that EDV and ESV are the derived values from left ventricular dimensions, so any change in the LV dimensions will subsequently lead to the changes in values of EDV and ESV. Similarly, the results of our study showed significantly ($P<0.05$) higher contractility indices i.e. FS% and EF% in pericarditis group as compared to healthy animals. The increase in FS% and EF% may be attributed to the fact that as the size of heart decreases, it puts more effort to pump maximum blood into the systemic circulation as a result there is relative increase in FS% and EF%.

Puri (2016) performed M-mode echocardiographic measurements in 11 pericarditis affected cattle. He observed significantly decreased LVIDs, LVIDd, IVSs, IVSd, LVEDV and LVESV in pericarditis affected cattle as compared to healthy control whereas FS% (51.56±3.05%) and EF% (81.45±2.55%) were significantly higher in pericarditis affected cattle as compared to healthy control.

As per the knowledge of the authors, no studies are available on M-mode echocardiographic findings in pericarditis affected buffaloes, so this

Table 1. History and signalment of pericarditis affected buffaloes.

Variable			Number
Age (years)			6.01±0.3 (2.5-15)
Duration of illness (days)			10.9±0.1 (5-20)
Feed intake	Normal		3
	Inappetence		5
	Anorexia		41
Water intake	Normal		10
	Reduced		39
Fecal output	Normal		22
	Hard/Scanty		20
	Diarrheic		7
Posture	Normal		27
	Arched		22
Milk yield reduction	Gradual		13
	Sudden		8
Parturition history	Calved (months)	<1	11
		>1	8
	Pregnant (months)	<4	2
		4-7	14
		>7	14

Table 2. Clinical examination (CVS) findings of pericarditis affected buffaloes.

Variable	Finding	Number
Intensity of heart sounds	Normal	17
	Muffled	32
Audibility of heart sounds	Same on both sides	17
	Louder on left	32
	Louder on right	0
Pericardial sounds	Splashing	5
	Rubbing	4
Jugular veins	Normal	11
	Bilateral distension	38
	Jugular pulse	12
Edema	No edema	11
	Throat	4
	Brisket	38
	Ventral	7
	Limb	0
Posture	Normal	26
	Abducted elbows	23
Respiration	Normal	20
	Dyspnoea	20
	Open mouth breathing	10
	Coughing	4

Table 3. B mode ultrasonographic findings of pericarditis affected buffaloes.

Organs/ Area involved	Findings	No. of buffaloes (%)
Heart	Normal	7 (14.3)
	Compressed	42 (85.7)
Pericardial cotent	Anechoic	16 (32.6)
	Echogenic	33 (68.7
Lungs	Normal	6 (11.7)
	Consolidated	9 (17.6)
Pleural content	Anechoic	28 (54.9
	Echogenic	13 (26.5)
Spleen	Normal	32 (65.6)
	Hyperechoic	12 (24.4)
	Floating in fluid	5 (10.2)
Reticulum	Normal	28 (57.1)
	Peri-reticular adhesions	21 (42.8)
Peritoneal content	Anechoic	12 (57.1)
	Echogenic	9 (42.8)
Liver	Normal	8 (16.3)
	Hyperechoic	41 (83.6)
	Floating in fluid	6 (12.2)
Caudal vena cava	Normal	6 (12.2)
	Dilated	43 (87.8)

Table 4. M-mode echocardiographic findings of pericarditis affected buffaloes.

M-mode echocardiographic parameters		Control (n=24)	Pericarditis affected (n=29)
Right ventricle wall	RVWd (cm)	1.43±0.03[1]a[2] (1.06-1.78)[3]	1.98±0.11a (0.93-3.65)
	RVWs (cm)	2.23±0.07a (1.61-2.91)	2.07±0.12a (0.96-3.23)
Right ventricle internal diameter	RVIDd (cm)	2.85±0.15a (2.03-3.86)	2.44±0.17a (0.18-4.7)
	RVIDs (cm)	1.93±0.16a (1.01-3.22)	2.06±0.18a (0.32-4.06)
Interventricular septum	IVSd (cm)	2.16±0.04a (1.67-2.55)	1.83±0.06b (1.21-3.01)
	IVSs (cm)	2.88±0.04a (2.4-3.48)	2.52±0.08b (1.95-3.93)
Left ventricle internal dimension (cm)	LVIDd	7.56±0.18a (6.43-8.58)	4.96±0.26b (2.15-8.58)
	LVIDs	4.60±0.15a (3.65-5.82)	2.34±0.17b (0.98-5.77)
Left ventricle posterior wall (cm)	LVPWd	2.30±0.11a (1.25-3.10)	1.87±0.09b (0.96-3.22)
	LVPWs	3.05±0.10a (2.21-3.81)	2.59±0.11b (1.25-3.99)
Volume (mL)	LVEDV	309.77±16.15a (210.75-402.67)	130.37±16.18b (15.28-402.67)
	LVESV	101.30±7.79a (56.26-167.87)	24.35±5.47b (1.94-164.59)
Contractility indices (%)	FS	39.35-1.02a (30.65-49.7)	53.22±1.18b (32.75-74.5)
	EF	67.91±1.26a (56.43-79.25)	83.63±1.09b (59.12-96.63)

[1]Mean±SEM; [2]Values with different lower cases alphabet differ significantly (P<0.05) between the columns; [3]Range.

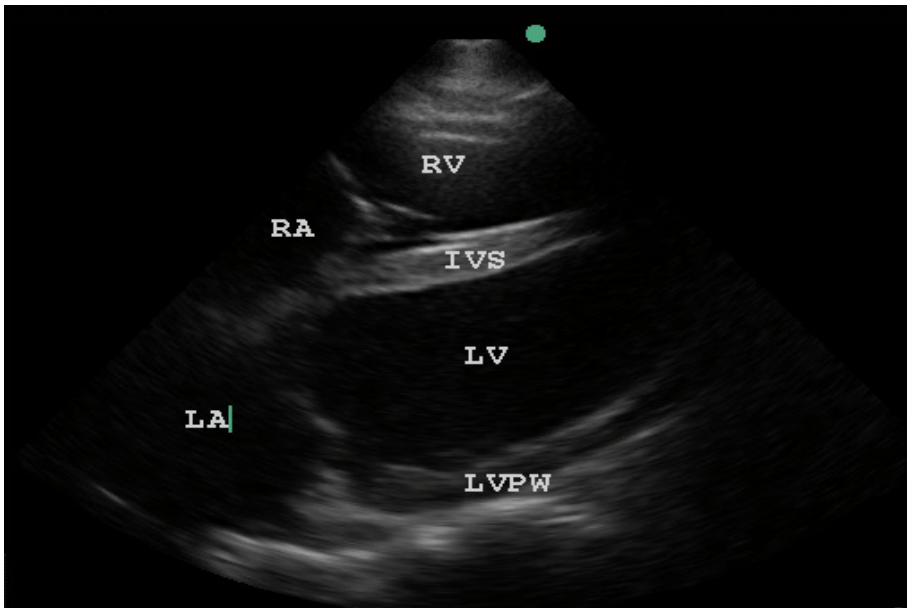

Figure 1. Appearance of heart on ultrasonogram in a healthy animal.

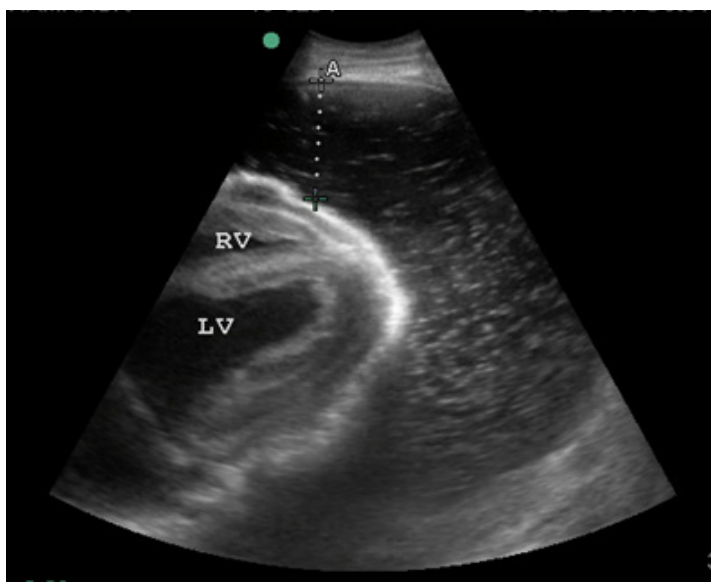

Figure 2. Massive accumulation of purulent pericardial fluid.

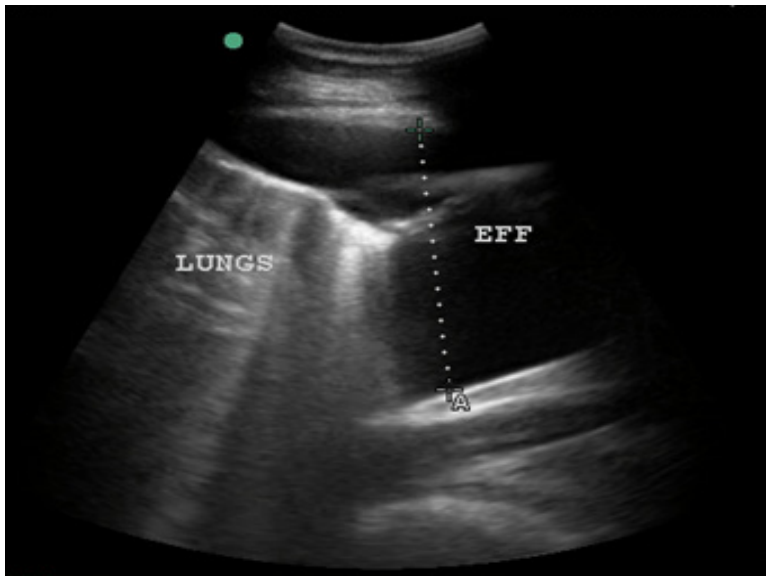

Figure 3. Ventral displacement of the lung parenchyma due to massive pleural effusions.

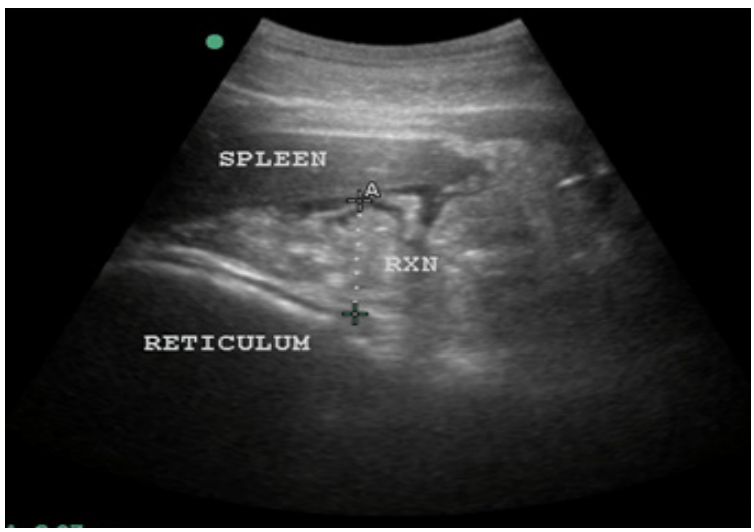

Figure 4. Massive fibrinous reaction in between spleen and reticulum.

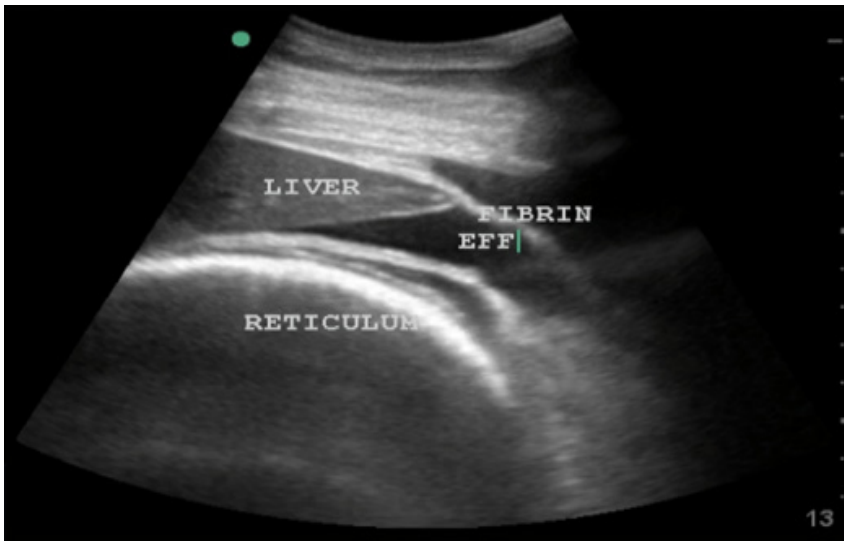

Figure 5. Appearance of liver floating in fluid at right 7th ICS.

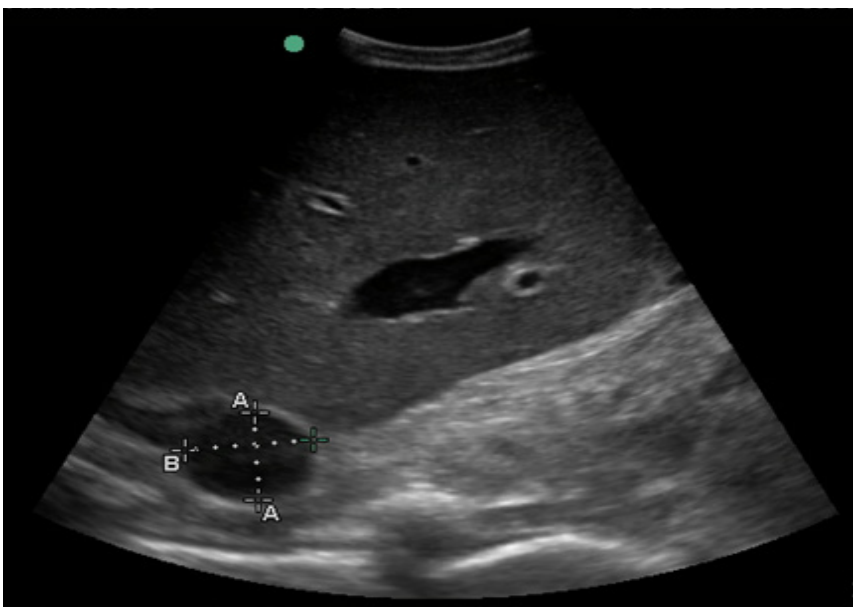

Figure 6. Appearance of congested liver, dilated CVC and other hepatic blood vessels.

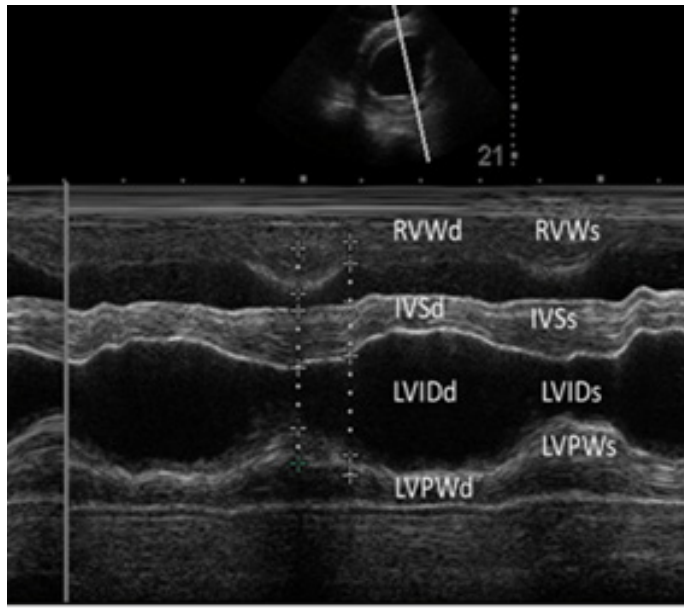

Figure 7. M-mode echocardiographic image in a healthy animal (Rt parasternal short axis view).

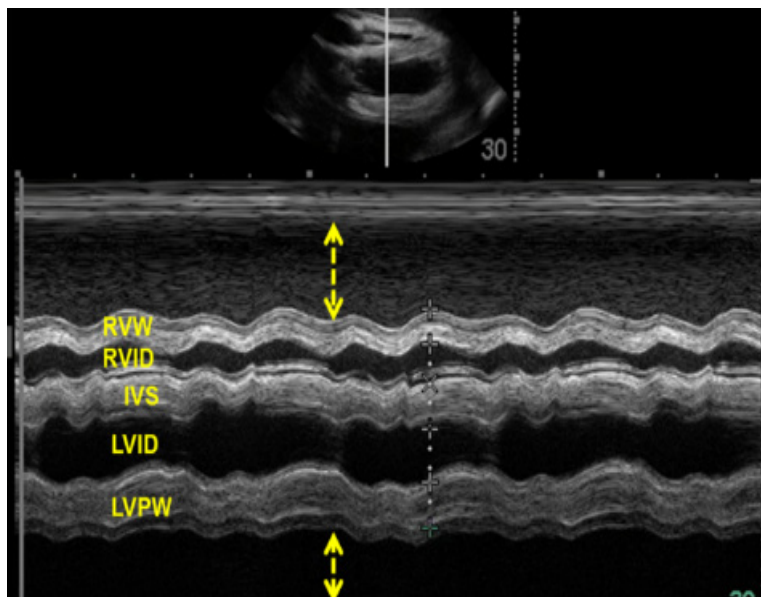

Figure 8. M-mode image showing visibly reduced lumen of ventricles with purulent pericardial reaction.

study is unique and first of its type. Also combined utility of USG and echocardiography has so far not been explored for diagnosis of pericarditis. The present study emphasizes on the combined use of these two modalities for diagnosis of pericarditis as some cases may not always be presented with typical signs.

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