



Comprehensive approaches to diagnose thoracic cavity disorders (TCD) in cattle

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ABSTRACT

The aim of the study was to document the prevalence and diagnosis of thoracic cavity disorders (TCD) in cattle. All the selected animals subjected to detailed anamnesis; physical, clinical haemato-biochemical, electrolytes, cardiac biomarker, thoracic radiography and ultrasonographic examination were performed. The prevalence of TCD was 0.76%, among these; cardiac disorders (CD) was in 37.0%, lung disorders (LD) in 22.0%, lung and cardiac disorders (LCD) in 22.0% and diaphragmatic hernia (DH) in 19.0%. Highest prevalence of thoracic cavity disorders was recorded in Jersey cross bred cattle (62.0%). More than 3 years of age and pregnant animals were the mostly affected. The most predominant clinical signs was recorded in the order of grunting, dyspnea, abduction of elbow, brisket edema, jugular vein engorgement, jowl edema, rumen hypo-motility and muffled heart sound. Haematology revealed significant reduction of Hb, PCV and RBC. Significant decrease in the mean values of serum TP, albumin, glucose, cholesterol and increases in ALP and AST levels were observed. Significant increase in the cardiac biomarkers (CK-MB, LDH and cTnI) was noticed. The presences of foreign body, DH and pericardial effusion were in radiographic examination. Ultrasound examination revealed anechoic fluid (37.50%), mixed echogenic fluid (18.75%), echogenic fibrinous strands (21.85%) on both of respiratory and cardiac disorders. Comprehensive approaches could facilitate early diagnosis of thoracic cavity disorders, as well as to assess the diseases status and to initiate appropriate therapeutic protocols in cattle.

Keywords: Cardiac biomarkers, Cattle, Disorders, Radiography, Thoracic cavity, Ultrasonography

Bovine thoracic disorders are potentially life-threatening conditions, which requires early diagnosis for intervening treatment protocols (Braun 2004). Thoracic radiography and ultrasonography provide useful information regarding thoracic lesions and supportive diagnostic methods like haemato-biochemical and cardiac profiling will further helps to assess disease severity. Ultrasound guided, thoracic and pericardial drainage not only provides diagnosis as well as palliative care and management of animals with advance pregnancy (Venkatesan *et al.* 2019). The clinical signs of thoracic cavity disorders are quite similar and it make difficulties in the differentiating the disorders in cattle. To overcome these limitation detailed studies on lung and cardiac disorders is required. The comprehensive studies related to thoracic cavity disorders were meager and it makes difficulties in the decision on treatment strategies and impart prognosis to the affected animals. Therefore, this study was aimed to provide comprehensive information on thoracic cavity disorders in cattle by clinical, haemato-biochemical, electrolyte, cardiac biomarkers,

radiography and ultrasonographic evaluation of thoracic cavity disorders in cattle.

MATERIALS AND METHODS

The study consisted of apparently healthy cattle and clinical cases. The clinical study was carried out at Large Animal Medicine Outpatient Unit, Veterinary Clinical Complex, Veterinary College and Research Institute, Thanjavur. Total number of cattle that were brought to VCRI, Orathanadu during the study period of 2021-2022 was 4182.

Selected cases were subjected to physical and clinical examination as described by Jackson and Cockcroft (2002). Haematology (Hb, PCV, RBC, erythrocytic indices, WBC, DLC and platelet count), serum biochemistry (total protein, albumin, globulin, A/G ratio, BUN, creatinine, glucose, cholesterol ALP and AST), serum electrolytes (Sodium, potassium, chloride, total calcium, phosphorus and magnesium) and serum biomarkers (CK-MB, LDH and CTnI) were analyzed by using Selectra PRO XS auto biochemistry analyzer and i-STAT analyzer standard protocols.

Thoracic radiography was performed in standing animals to identify the presence of foreign body and its location and size, the diaphragmatic border, effusion and

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organ location (Athar *et al.* 2010).

Ultrasonographic examination: All the selected animals were subjected to trans-thoracic ultrasound examination for the evaluation of heart, lung and diaphragm according to Braun *et al.* (2007). Trans-thoracic ultrasound examination was performed in standing animals without any sedation. Colour Doppler ultrasound My Lab one Vet (Esaote) with 2.5 to 5 MHz convex probe was used for this study. For the transthoracic cardiac ultrasound examination fourth and fifth intercostal space (ICS) was selected, whereas 6th to 11th ICS was selected for the transthoracic lung examination of both sides. The ultrasound parameters like organ location, echogenicity, motility, presence of foreign body and growth, if any were assessed in all the selected cases according to Braun *et al.* (2007) and Braun (2009).

Statistical analysis: The values of haematology, serum biochemistry, electrolytes, and cardiac biomarkers of the TCD groups were analyzed statistically by using SPSS software. All data are expressed as mean±standard error. One-way analysis of variance (ANOVA) and post hoc turkey's test, multiple comparisons was done between the groups of TCD. A value of $P < 0.05$ was considered as significant in all statistical analyses.

RESULTS AND DISCUSSION

A total of 4182 cattle were presented to the Large Animal Medicine Outpatient Unit of VCC, VCRI, Orathanadu during the study period (2021-2022) out of which 159 animals exhibited clinical signs of respiratory and cardiac issues. Among these 32 cases confirmed as various thoracic cavity disorders (0.76%), viz. CD (37.0%) followed by LD (22.0%), LCD (22.0%) and DH (19.0%). Common thoracic cavity disorders of cattle includes traumatic pericarditis, diaphragmatic hernia, lung abscess, pericardial effusion and pleural effusions (Flock 2004, Buczinski *et al.* 2014). Presence of metallic foreign body within the reticulum which penetrate into heart and lungs by reticular contraction and also pushing the metallic foreign bodies towards thorax by increased intra-abdominal pressure in pregnant animals. This could be major risk factors for the occurrence of lung and cardiac disorders in cattle. Similarly, trauma, weak diaphragmatic muscles and penetration of metallic foreign body could be the possible cause for diaphragmatic hernia (Premkumar *et al.* 2019). In the present study the prevalence of TCD were high in Jersey cross bred (62.5%), Non-descript (ND), Holstein Friesian cross (HFX) and Umblachery were 18.75%, 15.63% and 3.13%, respectively. These findings were accorded with previous reports by Radostits *et al.* (2007), Hajighahramani and Ghane (2010) and Buczinski (2010).

Radostits *et al.* (2007) reported that middle aged animals were more susceptible for thoracic disorders. Sex wise incidence of TCD was higher in female animals (88.0%). Among these DH, LD, CD and LCD exhibited higher rate of incidence 83.30, 85.71, 91.67 and 85.71 per cent, respectively. Roth and king (1991) and Athar *et al.* (2012) also reported that higher incidences of cardiac diseases in females. The reproductive status, pregnancy, calving status, nutritional levels and immune status might have attributed to the increased incidence in female animals (Braun *et al.* 2018).

Among the 28 females, 13 were pregnant, 9 were recently calved and 6 were heifers. Among the 13 pregnant animals which were in last trimester, seven exhibited CD, two animals were found with LCD, two animals were affected with DH and two animals showed LD. With respect to calving status of TCD, nine animals were recently calved (15d-120d). Out of nine animals in DH one animal (60d), in LD two animals (60d and 120d), CD with four animals (15d, 20d, 60d and 60d) and two animals with LCD (30d and 40d) were reported. Similarly, Elhanafy and French (2012) who reported in his study the pregnant animals in the last trimester were more commonly affected with TCD including TRP, pericarditis, reticular abscess and pleural effusion. The combination of weight and size of the gravid uterus in pregnant animals that probably allowed the organ to act like pendulum as a cow gets up and down would have exerted physical pressure on rumen and reticulum, leading to movement of metallic foreign bodies which penetrated in thoracic cavity (Divers and Peek 2008).

The temperature, heart rate and respiratory rate were within the normal range in traumatic pericarditis (Khalpallah *et al.* 2017), diaphragmatic hernia (Abdelaal *et al.* 2014) and thoracic cavity disorders (Athar *et al.* 2012). Similarly in the present study vitals were within the normal.

The major clinical signs recorded in the thoracic cavity disorders were grunting (71.88%), respiratory dyspnea (65.63%), brisket edema (62.5%), abducted elbow (62.5%), jugular vein engagement (56.25%) and suspended ruminal motility (53.13%). Similarly, the clinical signs of DH, LD, CD and LCD are given in Supplementary Table 1 and Supplementary Fig. 1 A-F. In the present study the recorded clinical signs of various thoracic cavity disorders are accorded with the previous researchers viz lung disorder (Radostits *et al.* 2007, Braun 2009, Torki *et al.* 2010 and Buczinski *et al.* 2014), cardiac disorders (Sasikala *et al.* 2018, Saravanan *et al.* 2018 and Singh *et al.* 2019), and DH (Divers and Peek 2008) and Abdelaal *et al.* 2014).

A highly significant ($P < 0.01$) reduction in the mean

Table 1. Cardiac biomarkers (Mean±S.E) of healthy and diseased cattle

Parameter	Control (n=6)	DH(n=6)	LD (n=7)	CD (n=12)	LCD(n=7)	F-value
CK-MB (IU/L)	70.25±10.08 ^a	66.32±11.18 ^a	166.14±11.30 ^b	263.91±35.94 ^c	100.67±16.20 ^{ab}	10.82**
LDH (U/L)	572.80±14.86 ^a	1166.68±50.33 ^b	1884.99±109.69 ^c	1804.46±202.06 ^c	1646.80±151.58 ^{bc}	9.66**
cTnI (ng/ml)	0.01±0.00 ^a	0.02±0.01 ^a	0.04±0.02 ^a	0.56±0.27 ^b	0.06±0.01 ^a	4.13**

Where, CK-MB, Creatine kinase-MB; LDH, Lactate dehydrogenase; cTnI, Cardiac troponin I.

Table 2. Trans-thoracic ultrasonographic findings of various thoracic cavity disorders in cattle

USG appearance of thoracic pathologies	Number of cases (n=32)				
	DH (n=6)	LD (n=7)	CD (n=12)	LCD (n=7)	Total (n=32)
Reticular wall in thoracic cavity	4 (12.50%)	-	-	-	4 (12.50%)
Anechoic fluid	-	4 (12.50%)	3(9.37%)	5 (15.65%)	12 (37.50%)
Mixed echogenic fluid	-	1 (3.12%)	4 (12.50%)	1 (3.12%)	6 (18.75%)
Echogenic fibrinous strands	-	2 (6.25%)	4 (12.5%)	1 (3.12%)	7 (21.85%)
Vegetative growth in mitral valve	-	-	1 (3.12%)	-	1 (3.12%)

values of Hb and PCV were recorded in cardiac disorders, diaphragmatic hernia and lung with cardiac disorders (Supplementary Table 2). Similar findings were reported by Peek *et al.* (2012), Khalphallah *et al.* (2017) and Venkatesan (2020), where normal erythrocyte counts were observed in bovine endocarditis (Mohamed and Buczinski 2011), respiratory disorders (Tharwat and Oikawa 2011) and Diaphragmatic hernia in Egyptian buffaloes (Abdelaal *et al.* 2014). Highly significant ($P<0.01$) increase in the mean values of WBC and neutrophil counts were recorded in lung disorders and cardiac disorders. There was highly significant decrease in the mean values of lymphocyte and platelet count of lung with cardiac disorders and cardiac disorders than diaphragmatic hernia and lung disorders. Leucocytosis was commonly observed in animals with pericarditis, TRP and pleuritis (Radostits *et al.* 2007, Braun *et al.* 2018; Sasikala *et al.* 2018). Braun *et al.* (2018) who reported that neutrophilia was observed in 92% of TRP animals. Neutrophilia with a left shift was the primary laboratory findings observed in animals with cardiac diseases in cattle (Buczinski 2010, Abu-Seida and Al-Abbadi 2016).

Statistically highly significant ($P<0.01$) decrease in the mean values of total protein was noticed in cardiac disorders and lung with cardiac disorders, where there were no significant difference between diaphragmatic hernia and lung disorders as compared to the control group. The mean values of albumin were significantly decreased ($P<0.01$) in the TCD groups when compared to the control group (Supplementary Table 3). The hypoproteinemia and hypoalbuminemia were due to inflammatory cellular destruction secondary to various thoracic cavity disorders (Dubensky and White 1983). The sequestration of protein in the extra vascular spaces as an inflammatory response and malnutrition could leads to hypoalbuminemia which causes a change in the albumin and globulin ratio (Lakhpatri

et al. 2019). These findings were also observed in the present study. Highly significant reduction in the mean values of glucose and cholesterol and increases in ALP and AST levels were observed in lung and cardiac disorders than other thoracic cavity disorders. Increases in AST and ALP were considered as more reliable indicator for muscle damage and liver diseases. An increase of AST was reported with cardiac diseases (Sasikala *et al.* 2018). Lakhpatri *et al.* (2019) also recorded elevated AST, ALP and LDH in animals with foreign body syndrome.

Elhanafy and Fernch (2012) who observed decreased calcium and phosphorus in animals affected with pericarditis. Reduction in the calcium, phosphorus, magnesium and potassium in the affected cow could be associated with management conditions and immune status of animals as well as differences in their feeding patterns. Similarly in the present study also reduction in calcium, phosphorus and magnesium were noticed (Supplementary Table 4). Moreover, the animals of present study group were lactating cows (60d-120d) which were at highest risk for hypokalemia due to anorexia with concurrent cardiac and respiratory diseases.

Statistically highly significant ($P<0.01$) increases in the mean values of CK-MB and LDH were noticed in lung and cardiac disorder (Table 1). Sasikala *et al.* (2018) and Singh *et al.* (2019) reported that the elevation of CK-MB in animals with cardiac and cardiac associated diseases like traumatic reticulo-pericarditis in cattle. Lactate dehydrogenase (LDH) was a ubiquitous cytosolic enzyme, which present in muscle, liver, and erythrocyte damages and it increases during inflammation. In cattle, increases LDH level was observed in the cardiac muscle, liver and kidneys (Sobiech *et al.* 2002). The mean values of cTnI were significantly ($P<0.01$) increased in cardiac disorders when compared with other groups. Cardiac troponin I was uniquely expressed in the myocardium and it could

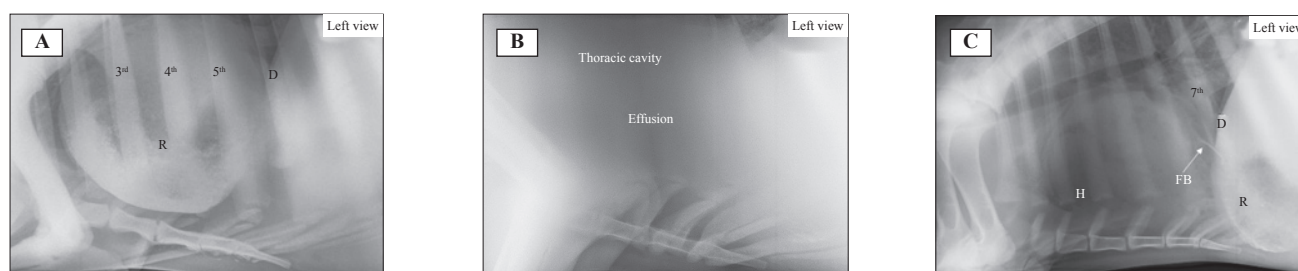


Fig. 1. A. X Ray: Cattle: Thorax lateral view - Diaphragmatic hernia (DH)- Reticulum (R) herniated into the thoracic cavity; B. X Ray: Cattle: Thorax lateral view - Fluid opacity in the thoracic cavity masking the heart and lung; C. X Ray: Cattle: Thorax lateral view - Linear foreign body (FB) piercing heart (H) from reticulum (R).

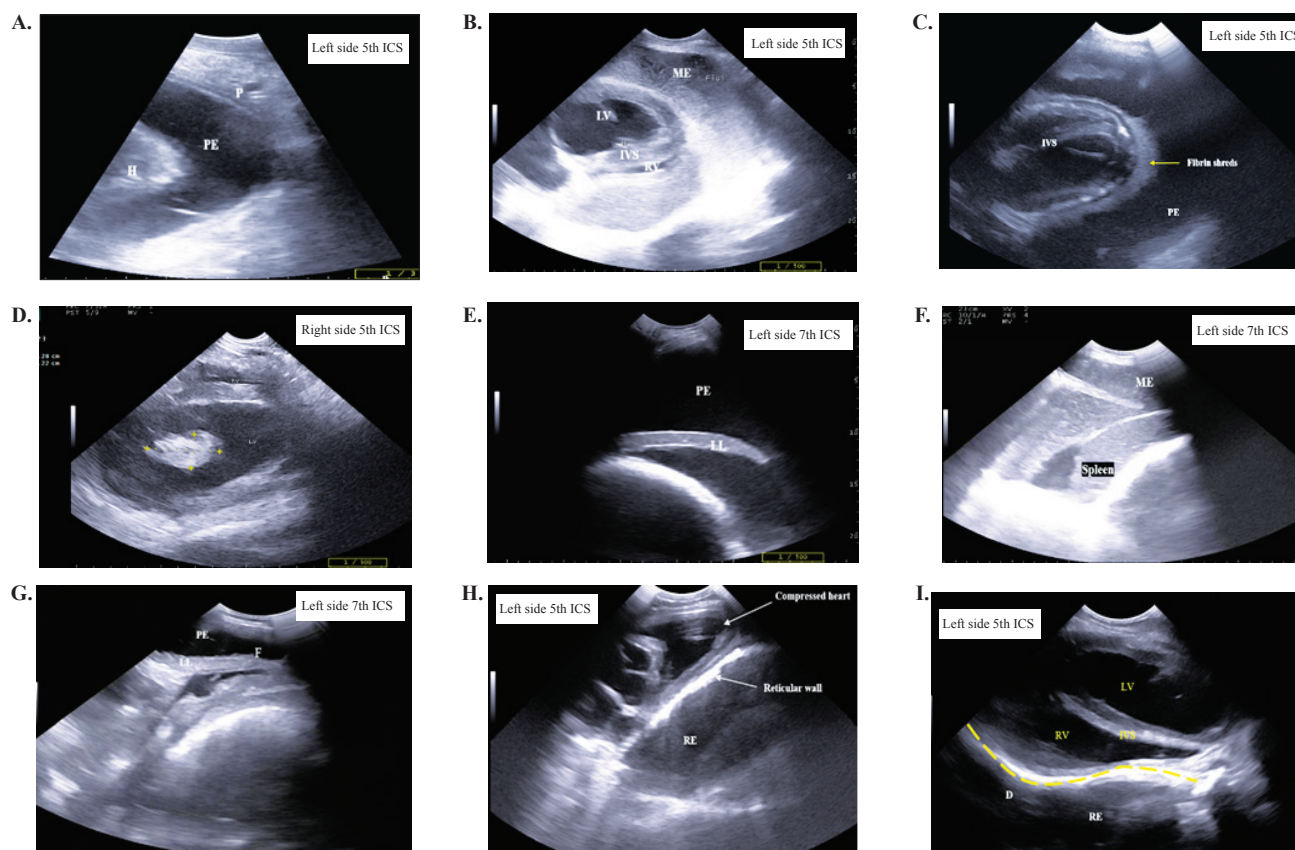


Fig. 2. A.USG: Cattle - Anechoic fluid between pericardium (P) and epicardium. PE - Pericardial effusion, H-Heart; B. USG: Cattle - Mixed echogenic (ME) fluid filled area between pericardium and epicardium; C. USG: Cattle - Pericardial effusion (PE) with fibrin shreds; D. USG: Cattle Hyperchoic mass on the mitral valve (Vegetative endocarditis); E. USG: Cattle - Lung lobe floating in the pleural effusion; F. USG: Cattle - Mixed echogenic effusion in the pleural cavity; G. USG: Cattle - Anechoic effusion with fibrin deposition on the lung lobe; H. USG: Cattle - Herniation of reticulum in to the thoracic cavity at the level of 5th ICS; I. USG: Cattle - Herniated reticulum compressing the ventricular apex and curvature of diaphragmatic border suggestive of DH.

recognize as a highly sensitive and specific cardiac marker for diagnosis of cardiac disease in humans and domesticated animals (Undhad *et al.* 2012). Detection of cTnI was very useful tool for the diagnosis, prognosis and monitoring of cardiac diseases by veterinary professionals (Mellanby *et al.* 2007). Cardiac troponin I concentration of cattle affected with idiopathic pericarditis was reported as 0.89 ng/ml as found in this study (Jesty *et al.* 2005).

Thoracic radiography revealed the presences of metallic foreign body (FB), diaphragmatic hernia, pleural effusion and pericardial effusions were observed in 21.87%, 18.75%, 18.75% and 6.25%, respectively (Fig. 1A-C). Similarly, combination of pleural and pericardial effusion was observed in 6.25% of the animals. Radiography examination was widely used for diagnosis of various TCD in animals and humans (Misk and Semieka 2001). Similarly, Sasikala *et al.* (2018) who found radiopaque foreign bodies in 44.64% of cases and the authors further stated that poor imaging of radiography were observed due to insufficient density of the foreign bodies and also increased thickness of thorax/abdomen of the cattle. The loss of details in radiography of cattle with TRP due to

the presence of large amounts of fibrinous exudates in the pericardial sac (Singh *et al.* 2019).

Ultrasonography (USG) was performed in all the 32 animals, out of this anechoic fluid was noticed in 37.50% of animals (i.e. 15.65% around lungs with cardiac disorder, 12.50% in animals with lung disorders, 9.37% in animals with cardiac disorders) 12.5% of the animals were diagnosed with diaphragmatic hernia (Table 2 and Fig 2A-I). Grunder (2002), Braun (2009) and Ibrahim and Gomaa (2016) reported that floating of fibrin in the fluid between epicardium and pericardium and large amount of hypo echogenic to echogenic pericardial fluid in cardiac diseases. Mixed echogenic fluid was noticed in 18.75% animals. Fibrin strands were visualized in 21.87% of the animals (12.5% cardiac disorders, 6.25% lung disorders and 3.12% lung and cardiac disorders). Vegetative endocarditis was identified in 3.12% of the animals. Danjuma *et al.* (2014) reported that ultrasound examinations revealed the fibrin, fibrinous exudates and fluid in the pericardial sac in the TRP case affecting the cardiac function.

In comparison between the radiography and ultrasonography, all the diaphragmatic hernia cases were

diagnosed by radiography (100%), where only 66.67% cases were diagnosed by ultrasonography. Similarly metallic FB was better identified using thoracic radiography than ultrasonography. But in case of effusions and vegetative endocarditis. USG diagnosed 81.25% of the cases when compared with radiograph which diagnosed only 31.25 per cent cases.

Braun (2009) stated that radiography detects the metallic foreign bodies, where the effusion could be detected by ultrasonography. Saravanan *et al.* (2018) reported the hyperechoic homogenous granular structures along with the cardiac contraction in pericardial effusion.

In the present study recorded various thoracic cavity disorders in cattle, viz. cardiac (37.0%), lung (22.0%), lung with cardia (22.0%) and diaphragmatic hernia (19.0%). Serum biomarkers, viz. CK-MB, cTnI and LDH could be used as prognostic indicators for thoracic cavity disorders (TCD) in cattle.

Thoracic radiography and ultrasound examinations were found to be very much useful in the diagnosis of various thoracic cavity disorders, whereas combination of these two diagnostic imaging further strengthening the diagnosis as well as to decide appropriate treatment protocol and prognosis.

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