Diagnosis and surgical outcome of diaphragmatic herniorrhaphy in cows

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SUMMARY

The study describes the clinical, radiographic and ultrasonographic features, surgical treatment and outcome of cows suffering from diaphragmatic hernia. A total of eight cows (2 Sahiwal, 4 Holstein Friesian crossbred and 2 Jersey crossbred) were diagnosed for diaphragmatic hernia using radiography and / or ultrasonography during a study period of 30 months. The cows were aged 4 to 10 years. Only 62.5% (n=5) cows had the history of bloat and 25% (n=2) were 4 and 7 months pregnant. The 50% cows had a common history of melena since varying days. All the cows were anaemic with average haemoglobin of 8.87g/dL. Radiography was confirmatory in the diagnosis of diaphragmatic hernia in 7 cows while in one cow only ultrasonography was used to diagnose this condition. Ultrasonography was done in 75% of the cows from both right and left side at 4th Intercostal space at the level of elbow. Linear metallic foreign bodies of more than 2cm length were detected in the reticulum of 50% (n=4) cows on radiography.

Out of 8, only 4 cows (50%) were operated for diaphragmatic hernia repair as per the owner's consent. The surgery was done in 2 stages; on day 1, rumenotomy was done with complete emptying of ruminal contents along with retrieval of foreign bodies from the reticulum in standing local anaesthesia through left flank and on day 2, herniorrhaphy was done under inhalant general anaesthesia (midazolam, propofol and Isoflurane) through ventral cranial midline approach in dorsal position. Three out of 4 cows (75%) showed excellent surgical outcome on short term follow up, while one died during surgery. The cow that died during surgery had severe reticular adhesions with multiple tears in the diaphragm and the reticulum got ruptured during the act of breaking of adhesions. In one survived cow the reticular foreign body visible on radiograph was retrieved during herniorrhaphy. Another survived cow had reticular tear while breaking adhesions during herniorrhaphy and was presented with peritonitis after one month and was euthanized. The overall long term surgical outcome of diaphragmatic herniorrhaphy in cows was 50%.

In conclusions, a hospital occurrence of 8 cows suffering from diaphragmatic hernia is presented with Sahiwal breed suffering from this condition being reported for the first time. Radiography and ultrasonography complement each other in the diagnosis of diaphragmatic hernia and foreign bodies in cows. Low hemoglobin and reticular tear during herniorrhaphy are poor prognostic indicators for surgery in cows.

KEY WORDS

Bovine, cattle, diaphragmatic hernia, radiography, reticular hernia, ultrasonography.

INTRODUCTION

Acquired diaphragmatic hernia (DH) is a common condition of buffaloes [1] but is less reported in cows [2]. Reticulum is the most common organ found herniated in this disease condition. Advanced pregnancy, potential foreign body, reduced vascularity and elasticity of the diaphragm have been reported to be the possible etiologies for DH in buffaloes [3].

There is scanty literature on the occurrence and surgical outcome of cows operated for diaphragmatic herniorrhaphy [4-5]. The present report describes the clinical features, diagnosis (radiography and ultrasonography) and surgical outcome of cows suffering from diaphragmatic hernia.

CASE HISTORY AND PRESENTATION

Holstein Friesian crossbred cows were the most presented (50%), followed by 2 Sahiwal (Indigenous pure bred) and 2 Jersey crossbred cows. The average age of cows presented was 6.5 years, ranging from 4-10 years. Only 25% of cows (2/8) were pregnant while the rest were non-pregnant. One cow had a recent history of calving. The body condition score (BCS) of the cows ranged from 2.0 to 3.5. The average body weight of the cows was 339.25 Kgs (270-400Kgs). Except for the recently calved cow, all other were reported ill from 20-30 days. The recent parturited cow became ill only after parturition. One cow

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Table 1 - Table showing the detailed signalment and clinical findings of the DH cows.

	COW 1	COW 2	COW 3	COW 4	COW 5	COW 6	COW 7	COW 8
				SIGNALMENT AND CLINICAL SIGNS				
Breed	Sahiwal	Sahiwal	Jersey Cross	Holstein Friesian cross	Jersey Cross	Holstein Friesian cross	Jersey Cross	Holstein Friesian cross
Age in years	10	4	4	6	7	7	6	8
Pregnancy status	No	No	4 month	7 month	No	No days back	Parturited 7	Parturited 30days back
Body condition score	2.0	3.5	2.0	3.0	2.0	2.0	2.5	2.5
Body weight in Kgs	325	350	304	400	270	380	365	320
History Age of illness	20 days	20 days	30days	30 days	30 days	90 days	5 days	30 days
of bloat	No bloat	Recurrent bloat	No bloat	Recurrent bloat	Recurrent bloat	Recurrent bloat	One time bloat	Recurrent Bloat
Faeces	Black hard	Diarrhoea	Diarrhoea	Black hard	Black diarrhoea	Black diarrhoea	Normal	Black hard
Feeding status	Partial anorexia	Partial anorexia	Severe anorexia	Partial anorexia	Partial anorexia	Partial anorexia	In- appetence	Partial anorexia
				HAEMATOLOGY				
Haemoglobin (g%)	8.7	6.8	12.2	10.1	6.5	9.8	9.7	7.2
Total leucocyte count	7940	6180	9800	5400	5800	8000	9100	3700
Neutrophils %	30	58	26	48	60	30	62	40
Limphocyte%	70	42	74	52	40	68	38	60
Packed cell volume	26.8	25.2	37.2	27.9	21.0	28.6	28.9	21.9
Platelet ($X10^3$)	375	457	Adequate	450	595	635	430	387
				BIOCHEMISTRY				
Serum Creatinine (mg/dl)	1.0	0.9	1.0	1.0	0.8	1.0	0.8	1.0
Blood urea nitrogen mg/dl	16	13	19	18	12	17	17	13.5
Glucose mg/dl	110	-	-	106	-	112	66	-

was showing in-appetence from the last 3 months but the bloat started appearing from the last 30 days. The 62.5% cows (5/8) had the history of recurrent bloat while 2 had no bloat while one had single episode of bloat at the start of the illness. The 50% (4/8) cows had the history of black diarrhoea, while 3 had hard black faeces and one had normal faeces. Most of the cows had partial anorexia (7/8=87.5%), while one had complete anorexia. There was no history of fever in any of the cows.

All the cows presented for DH were anaemic with a few were severely anaemic. The mean haemoglobin of the cows was 8.87g% (6.5-12.2). The total leucocyte count was very low to normal in range. The platelets were mostly on the higher side. Among biochemistry values, the serum creatinine, BUN and glucose were within the normal range.

The detailed history and clinical signs of cows suffering from diaphragmatic hernia are presented in Table 1.

Diagnosis of Diaphragmatic hernia in cows

Radiography

Except for one cow, all were subjected to reticular radiography using a ceiling mounted X-ray machine (ProRad) of Prognosis make with 1000mA and 125 kVp. The factors used for radiography were 90-113 kVp, 53mAs and 90-110 FFD for Kodak computerized radiography system or 30mAs, 70 kVp and 90-110FFD for digital radiography system. All the radiographs were made in standing position with both forelimbs slightly stretched forward with the help of a rope. The centring was done at 5th ICS and at the point of elbow.

The characteristic radiographic features for the diagnosis of DH included; unclear diaphragm line with a sac like soft tissue round/oval opacity cranial to the diaphragm and presence of potential and/or non-potential foreign bodies in that sac. The

Table 2 - Table showing the Radiography and Ultrasonography findings of DH cows.

	Cow 1	Cow 2	Cow 3	Cow 4	Cow 5	Cow 6	Cow 7	Cow 8
Radiography	Diaphragm line was not clear. A large soft tissue sac was seen cranial to diaphragm. Two potential linear foreign bodies of 3 and 4.7cm were seen in the sac. Heart was not visible. **DH confirmed**	Diaphragm line was clear. No clear sac like structure was seen cranial diaphragm. Multiple non-potential metallic foreign bodies were seen cranial to diaphragm. Heart was clearly visible. **DH confirmed**	Not done	Diaphragm line was not clear. No clear sac like structure was seen cranial to diaphragm but few non-potential foreign bodies were seen. Heart was not visible. **DH Confirmed**	Diaphragm line was partially clear. No clear sac like structure was seen cranial to diaphragm but few non-potential foreign bodies were seen. Heart was partially visible. Alveolar pattern was seen in ventral lungs. **DH Confirmed**	Diaphragm line was not clear. A 4cm potential linear foreign body was seen at the diaphragm. A large soft tissue sac (with multiple non-potential sand like opacities at floor) was seen cranial to diaphragm. Heart was not visible. **DH Confirmed**	Diaphragm line was not clear partially. A soft tissue sac with multiple non-potential (sand like) opacities and a potential (hook shaped) foreign body (of length 6cm) was seen cranial to diaphragm. Heart was partially visible. **DH Confirmed**	Diaphragm line was not clear. A large soft tissue sac was seen cranial to diaphragm. Large amount of sand like radio-opaque opacity was seen on the floor of sac and the abdominal reticular region. No Potential foreign body seen. Heart was not visible. **DH confirmed**
Ultrasonography	Not done	Not done	**Rt side**: Reticulum was seen close to the thoracic wall at 4th ICS with biphasic motility. **Left side**: Reticulum was seen medial to heart at 4th ICS with biphasic motility.	**Rt side**: Reticulum was seen close to the thoracic wall at 4th ICS with biphasic motility. **Left side**: Reticulum was seen medial to heart at 4th ICS with biphasic motility. Mild free fluid was seen in chest on right side.	**Rt side**: Reticulum was seen close to the thoracic wall at 4th ICS with biphasic motility. **Left side**: Reticulum was seen close to thoracic wall at 4th ICS with no motility.	**Right side:** Reticulum was seen close to thoracic wall at 4th ICS with biphasic motility. **Left side:** Reticulum was seen medial to heart at 4th ICS with no motility.	**Rt side**: Reticulum was seen close to the thoracic wall at 4th ICS with biphasic motility. The heart was seen when reticulum moved deeper with motility. **Left side**: Reticulum was seen medial to heart at 4th ICS with no motility.	**Rt side**: Reticulum was seen close to the thoracic wall at 4th ICS with biphasic motility. **Left side**: Reticulum was seen medial to heart at 4th ICS with no motility.

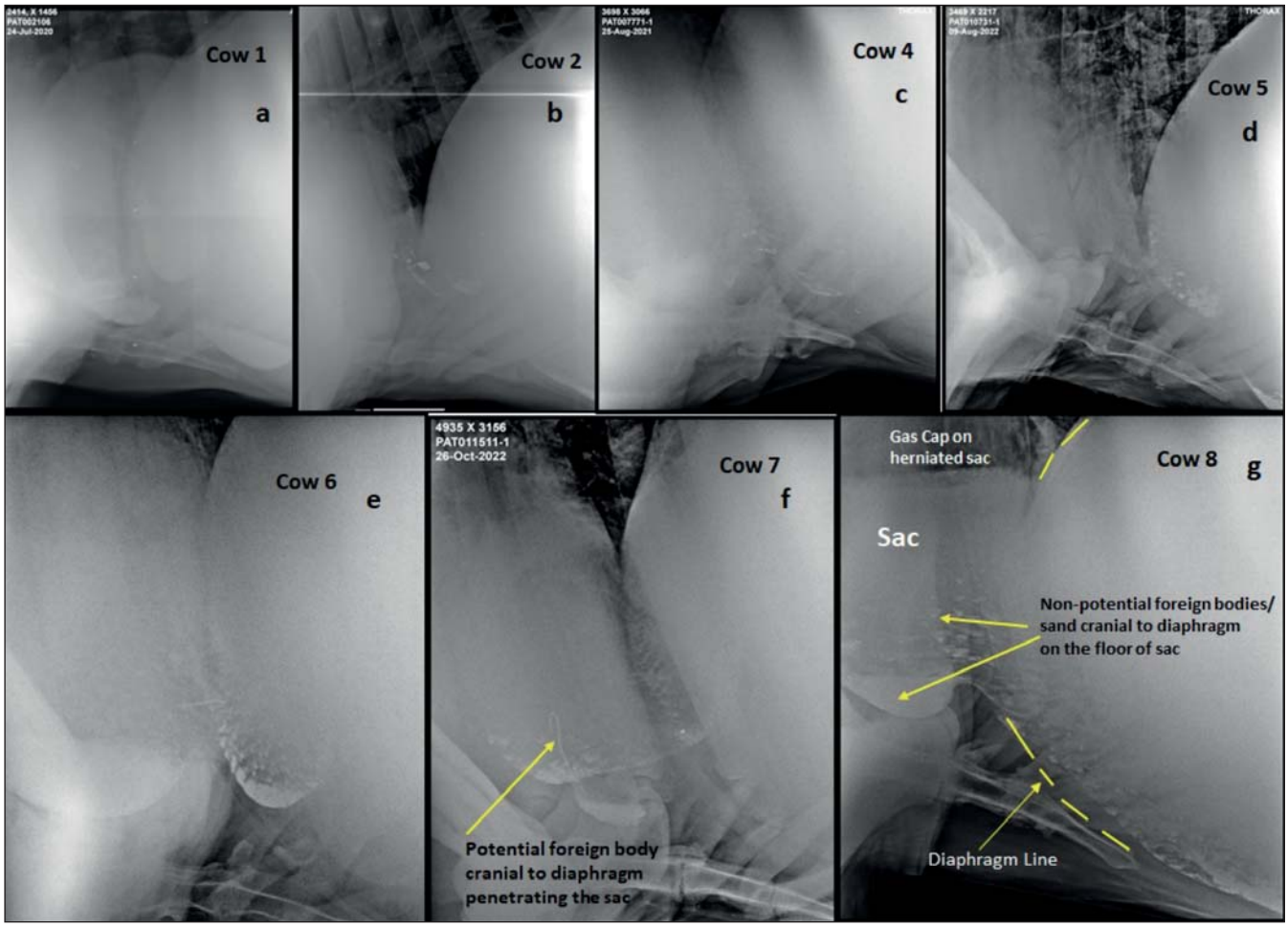

Figure 1 - Reticular radiographs of cows diagnosed for diaphragmatic hernia. **a**: The diaphragm line is not clear. A soft tissue sac opacity is seen cranial to diaphragm with some non-potential/sand like opacity seen on the floor of the sac. The caudal cardiac silhouette is seen overlapped by the sac opacity. **b**: The diaphragm line is not clear ventrally. Few non-potential foreign bodies are seen cranial to diaphragm, which appears to be a small sac opacity. **c:** The diaphragm line is not clear and the caudal cardiac silhouette is not defined. Few non-potential foreign bodies are seen cranial to diaphragm. **d**: The diaphragm line is not clear ventrally. Few non-potential foreign bodies are seen cranial to diaphragm. The ventral lungs show alveolar pattern. **e**: The diaphragm line is not clear. Few non-potential foreign bodies are seen cranial to diaphragm. The heart is not visible. A linear potential foreign body is seen horizontally placed at the interface of chest and abdomen. **f**: The diaphragm line is not clear. A soft tissue sac with honey comb appearance is seen cranial to diaphragm. A linear potential foreign body along with multiple non-potential foreign bodies is seen on the floor of the sac. **g**: The diaphragm line is not clear. A soft tissue sac opacity is seen cranial to diaphragm masking the heart and showing some honey comb like opacity. Multiple non-potential foreign bodies are seen cranial to diaphragm.

potential foreign bodies were defined as the sharp metallic foreign bodies, mostly linear which have the potential to penetrate while the non-potential included opacities of sand and small iron non-linear particles. In one cow the ventral lungs showed alveolar pattern as well (**Figure 1**). The details of the radiographic and ultrasonographic findings of each cow are depicted in Table 2.

Ultrasonography

Ultrasonography was done using 5 MHz curvilinear transducer from Logic F8 of GE make. In six out of 8 cows ultrasonography was done at 4th ICS from both sides (left and right), caudal to elbow by pulling that side of forelimb forward [6-7] in a standing position without sedation. In right sided herniation, the reticular wall was seen close to the thoracic wall from right side and the heart may or may not be visible completely medial to the reticular wall while from the left side, the heart was seen close to the thoracic wall and the reticular wall was seen medial to it (**Figure 2**).

Surgical Treatment

Only 4 cows underwent surgical intervention for the correction of hernia as per the consent of the owner. The surgery for diaphragmatic herniorrhaphy was done in two stages (Table 3).

The stage 1; It included the left flank rumenotomy in standing position under local infiltration (2% lignocaine hcl) anesthesia. All the ruminal contents were evacuated and the palpable foreign bodies were removed from the herniated and abdominal parts of the reticulum. The size of the hernia ring was measured in fingers kept broad. The location of hernia ring in relation to cardia was also assessed and recorded. The cows were administered intravenous fluids (injection normal saline solution, 30ml/Kg body weight), antibiotics (injection Ampicillin Cloxacillin, 10mg/kg) and analgesic (injection Meloxicam, 0.2mg/Kg). The cows were kept without food and water till next day when herniorrhaphy was done under general anesthesia.

The stage 2; The diaphragmatic herniorrhaphy was done un-

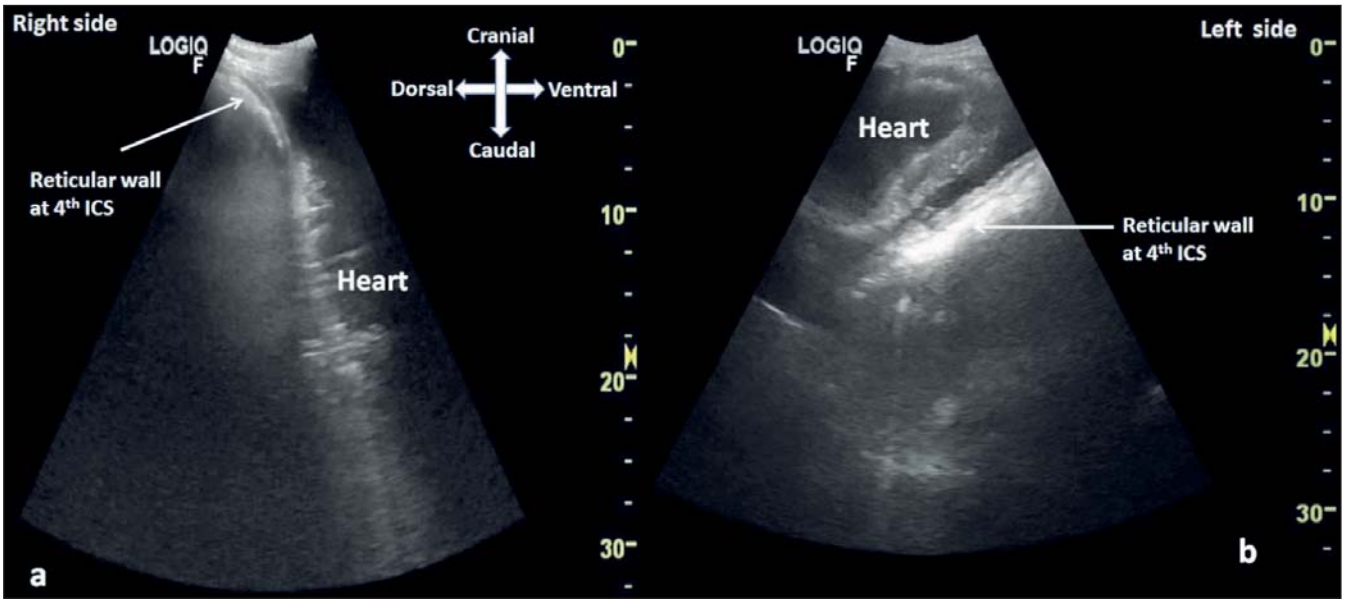

Figure 2 - Ultra-sonograms of a cow with diaphragmatic hernia and the ring on the right side. The reticular wall is seen close to the thoracic wall from the right side at 4th ICS along with the heart seen medially (a) whereas, from the left side again the heart and reticular wall are seen in one view but the heart is seen close to the thoracic wall while the reticular wall is seen medial to it (b).

der general anaesthesia and 16-20 hours after rumenotomy. The cows were casted in right lateral recumbency and were started with intravenous fluid therapy.

Injection midazolam at the rate of 0.2mg/kg was given intravenous as a pre-anaesthetic. Five minutes later the anaesthesia was induced with injection Propofol at the rate of 1.2-1.5mg/Kg, slow intravenous. Endotracheal intubation was done using ID 20-22 by applying Butler mouth gag. The 100% oxygen was attached along with Isoflurane anaesthesia (1.5-2%). The SpO_2 and heart rate were regularly monitored during surgery by applying the probe on the vulvar lip. The antibiotic Ampicillin Cloxacillin, 10mg/Kg body weight was administered intravenous.

The cows were positioned in ventro-dorsal position and the cranial midline abdomen was prepared for surgery. The cranial midline linea Alba incision (approximately 6-8 inches in length) was made just caudal to the xiphoid. The position of the ring was located and reticular adhesions with the diaphragm were carefully dissected to avoid reticular tear or pleura rupture. Once separated, the reticulum was brought back in the abdomen and the ring **(Figure 4a)** was sutured using continuous lock stitch pattern starting from the dorsal most point of the ring and using sterilized braided silk no. 2 (made double). The positive pressure ventilation was given during the surgery. Hyper-ventilation of the lungs was done at the last stitch applied on the diaphragm. The free air in the pleural space was suctioned by applying a 4inch sterilized needle at 4th ICS near elbow on the right side in ventro-dorsal position itself as and when required.

The linea alba was closed using polydiaxanone no. 1 (loop) in simple continuous and lock stitch pattern. The skin was closed using cross mattress sutures using silk no. 2. If, the reticulum got torn during the act of breaking the adhesions, it was sutured using catgut no. 2 in inversion pattern (lambert/cush-

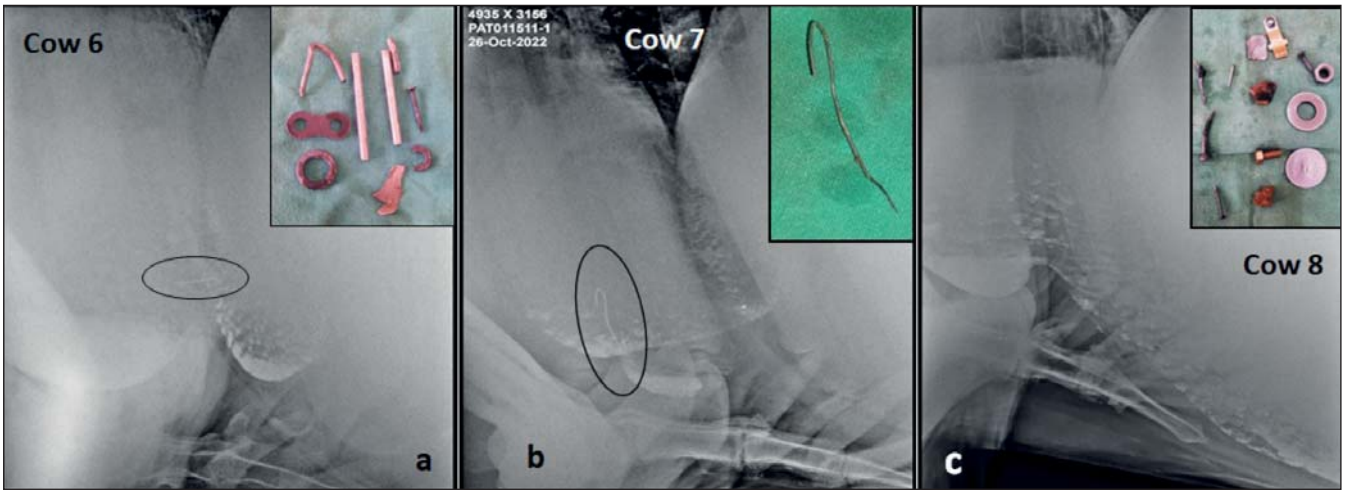

Figure 3 - Photographs showing the comparison between radiographic visualization of the foreign bodies to those retrieved during rumenotomy in the cows operated for herniorrhaphy. **a**: Many foreign bodies were removed during rumenotomy but the one visible on radiograph was not found. **b**: The potential linear foreign body was retrieved during rumenotomy. **c**: Multiple foreign bodies were removed but these were not visualized on radiograph.

Table 3 - Table showing the surgical findings and follow up outcome of cows operated for herniorrhaphy.

		Cow 2	Cow 6	Cow 7	Cow 8
Surgical findings	Rumenotomy	No potential foreign body was visible on radiograph and none was found on rumenotomy	Multiple potential and non-potential foreign bodies removed during rumenotomy but the one linear potential foreign body seen on x-ray was not found during rumenotomy **(Figure 3a)**	The hook shaped potential foreign body seen on x-ray was removed during rumenotomy **(Figure 3b)**	8 non-potential and 5 potential foreign bodies were removed from the herniated sac. One potential foreign body was found penetrating the reticular wall (Figure 3c)
		4 finger ring size felt on the right side in reference to cardia.	7 finger ring size felt on the right side in reference to cardia.	6 finger ring felt ventral to cardia	3 finger ring felt on the right side in reference to cardia.
	Herniorrhaphy	Pleura intact throughout surgery	Pleura was intact throughout surgery	Pleura was intact throughout surgery	Pleura was intact throughout surgery
			The foreign body seen on x-ray and not found on rumenotomy was found in chest within the reticular adhesions **(Figure 4b)**.	Severe adhesions of reticulum. The reticulum got ruptured while breaking adhesions, which was sutured with catgut no. 2.0 **(Figure 4c).**	Severe adhesions of reticulum. The ring was huge with multiple tears in the diaphragm **(Figure 4d)**. The reticulum got ruptured while breaking adhesions, which was sutured with catgut no. 2.0.
Follow up outcome	Short term	The cow recovered well from anaesthesia	The cow recovered well from anaesthesia	The cow recovered well from anaesthesia	The cow collapsed during surgery.
		Taking fodder and water. Rumination present	Taking fodder and water. Rumination present	Taking fodder and water. Rumination present	
	Long term	Healthy and fine	Healthy and fine	At one month reported with peritonitis and recumbency. Euthanized	

ing). The findings of the surgery were recorded as mentioned in Table 3. Analgesic, meloxicam (dose rate 0.2mg/Kg, IV) was administered at the end of surgery. The cows were brought to lateral recumbency. The oxygen was detached if the cows had spontaneous respiration and were moved to recovery room. The cows were brought to sternal position and the endotracheal tube was removed.

Post-operative care and follow up outcome

All the cows were fed small amount of jaggery, once the swallowing reflex was obtained. A small portion of green fodder and water was allowed in sitting position. Once the cows stood up, the abdominal bandaging was done with a thick cotton tape and a cotton pad (**Figure 5**).

The cows were discharged on the next morning. The owners were advised antibiotics injection Ampicillin cloxacillin at the rate of 10mg/Kg, BID for 5 days and Injection Gentamicin at the rate of 4mg/kg divided in two doses for 3 days, IM. Analgesic meloxicam was advised once a day for 2 more days, IM. Rumenotorics (Yeesac Bolus) were advised twice daily for at least 5 days. The suture line was advised for cleaning using Povidone iodine solution and fly repellant cream. The skin sutures were removed between 14-16 days post-operatively.

The cow no.8 died during surgery. Rests of the 3 cows (75%) were healthy with normal feed and water intake for next one month. However, cow no. 7 was reported after 46 days with recumbency and anorexia. Peritonitis was diagnosed and the cow was euthanized on owner's request. The other 2 cows were reported healthy with the long term successful outcome of 50%.

DISCUSSION

Reticulum is the most common organ reported to be herniated in DH in buffaloes [8] and that is why this condition is also referred to as reticular diaphragmatic hernia [7]. Multiple etiologies; potential linear foreign bodies in the reticulum, advanced pregnancy or recently calved, some anatomical weakness of the diaphragm, wallowing nature of the buffaloes have been reported for the occurrence of DH in buffaloes [3]. Presence of potential linear metallic foreign bodies is mostly reported in cows suffering from DH [4] but reports of absence or 50-70% occurrence of potential foreign bodies has also been reported in buffaloes [9-11]. Most of the cows suffering from DH are either recently calved or in the advanced stage of pregnancy [4-5] however, in the present study 62.5% cows were not recently calved or in advance stage of pregnancy.

Sahiwal, an indigenous breed is never been reported with DH and it was successfully operated though with less hemoglobin. Buffaloes are reported with long standing cases of DH as they usually have partial anorexia leading to low BCS, and dehydration [1]. The cows are mostly reported with very low hemoglobin leading to dull, depressed and even recumbent presentation compared to buffaloes which are hyper but dehydrated. Most of the DH buffaloes have scanty dry black feces [12] while the cows in this study mostly had melena which could be correlated to the bleeding abomasal ulcers and could also be one of the reasons for fairly low hemoglobin in these cows. The low hemoglobin might be the reason for high mortality in cows suffering from DH [2, 4]. The serum creatinine and the random blood glucose of the cows was within the normal range, however the creatinine is reported on the higher side in DH buffaloes [13].

The entrapment of reticulo-omasal groove in the hernia ring and deviation of cardia hampers eructation process leading to recurrent bloat in bovines suffering from DH [14] however; a few cases are reported with a history of once or no bloat as well [12] which need to be correlated with the position of ring in relation to cardia and reticulo-omasal groove. Fever is rarely reported clinical sign in bovines suffering from DH [1].

The radiography of reticulum may not always be diagnostic for DH in buffaloes in standing position as they sometime do not allow the forward stretching of forelimb and may require recumbent radiography [15-17] or ultrasonography to confirm this condition. However, the cows mostly allow standing reticular radiography for the diagnosis of DH [1-2] unless there are some other complications of fluid/cyst in the chest, which make the radiograph non-diagnostic. Otherwise also, the thoracic width of the buffaloes at the site of radiographic cen-

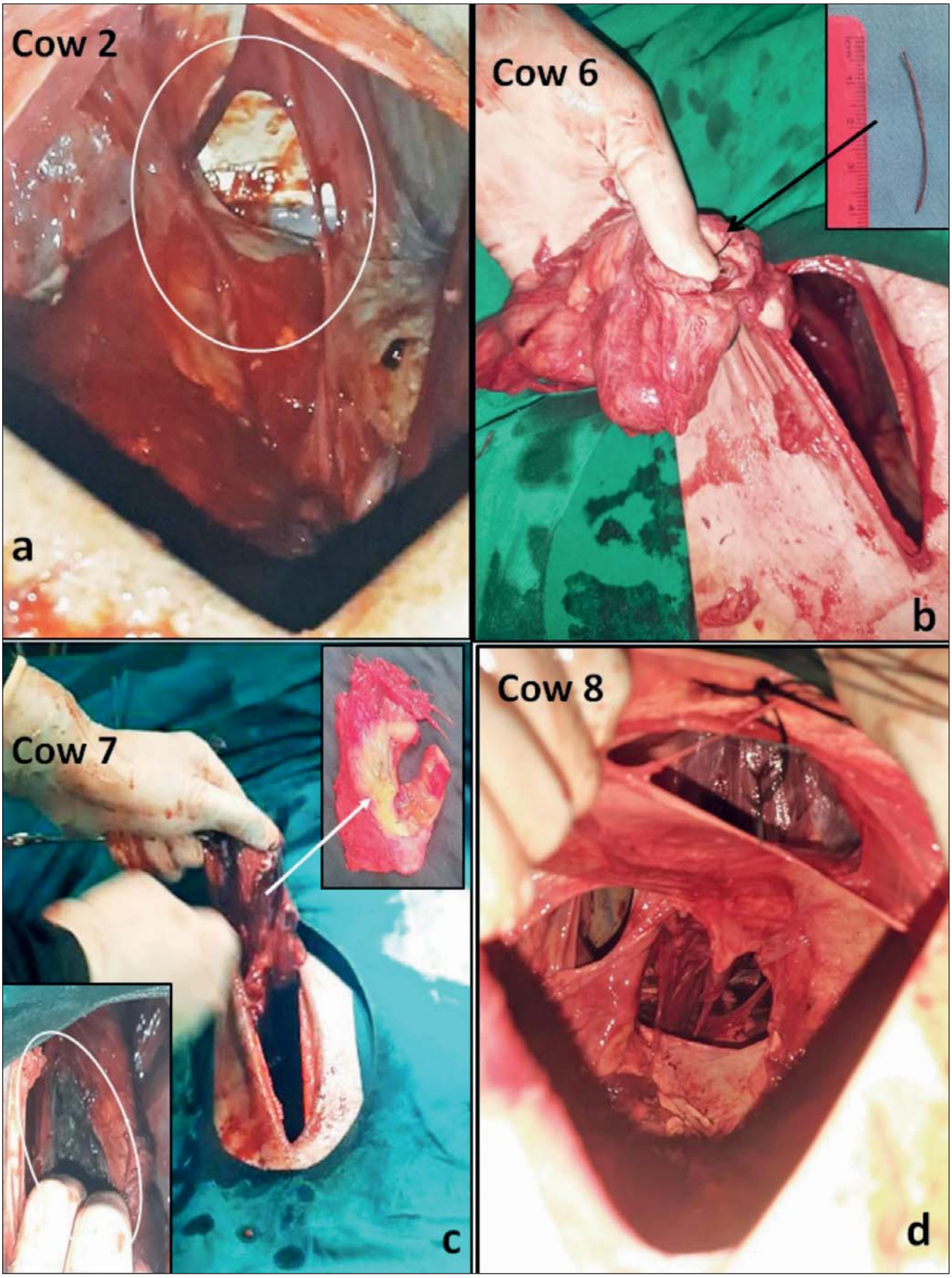

Figure 4 - Herniorrhaphy findings of the cows. The visualization of hernia ring after breaking the adhesions and freeing the reticulum in a cow (a). The potential foreign body visualized on the radiograph of cow 6 but was not found on rumenotomy was retrieved during herniorrhaphy in a tract surrounded by adhesions (b inset). The tract of the foreign body removed during rumenotomy in cow 7 was removed during herniorrhaphy but the reticulum got torn (inset with white circle) during the act of break adhesions (c). The severely ruptured diaphragm with sort of multiple rings in cow 8 (d).

Figure 5 - Photographs of the cows which survived the herniorrhaphy surgery after anesthetic recovery. A broad thick cotton tape was used for the bandaging of the chest.

tering of reticulum is higher than that of cows, leading to higher clarity of radiograph in cows compared to buffaloes in standing position [18]. However, radiography sometimes fails to diagnose a potential foreign body and many times the foreign body would be recovered on rumenotomy or herniorrhaphy which otherwise was not visible on the radiograph [16]. Ultrasonography is a safer technique to diagnose DH in bovines [2, 7, 19] but it fails to diagnose foreign bodies.

The DH in buffaloes is reported to be done in 2 stages. The rumenotomy is done to remove the foreign bodies from the reticulum and to completely empty the rumen and reticulum so that the bovine can be prepared for the next day general anesthesia and to create space for suturing of the diaphragm [20]. The suturing of rumen and muscles is done using catgut no. 2 and no complication related to it has been reported in literature [20]. The rupture of pleura [1-2, 21] and or reticulum [10] were reported to be poor prognostic parameters for DH. The rupture of pleura, while breaking adhesions lead to entrapment of air in pleural space, which sometimes is not possible to remove from various pockets and lead to respiratory distress in recovery phase. The reticular rupture while breaking adhesions or the removal of foreign body during herniorrhaphy may lead to infection in the peritoneum leading to peritonitis and thus poor prognostic outcome [20]. The suturing of diaphragm has been reported with braided silk no. 2 or 3 made double and using continuous lock stitch pattern starting from the dorsal end of the ring. This suture pattern is air leak proof and is also tested at the last stitch by hyperventilating the lungs.

Variable surgical outcomes have been reported for DH in bovines [9, 22] and are mostly fair in cows [2, 4-5].

CONCLUSION

The study reports a hospital occurrence of 8 cows suffering from DH in a period of 30 months with Sahiwal breed being reported for the first time. Radiography and ultrasonography complement each other in the diagnosis of DH and foreign bodies in cows. Low hemoglobin and reticular tear during herniorrhaphy are poor prognostic indicators for surgery in cows.

Conflicts of interest

The authors have no conflicts of interest with anyone.

Authors contribution

Author 1 is the PhD scholar and is the part of his research; Author 2 is the anaesthesiologist and scrutinized the manuscript; Author 3, 4, 5 and 6 are the surgeons for the 4 cases operated.

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