Presurgical ultrasonographic evaluation of omasum in bovines suffering from foreign body syndrome and diaphragmatic hernia in comparison to apparently healthy bovines

MANJEET KUMAR[1]*, HARMANPREET SINGH SODHI[1], NU DEVI[1], KRITIMA KAPOOR[2], MANDEEP SINGH BAL[3]

[1] Department of Veterinary Surgery and Radiology, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India, 141004
[2] Department of Veterinary Anatomy, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India, 141004
[3] Animal Disease Research Centre, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, India, 141004

SUMMARY

This study was conducted in 3 groups where Group I consisted of 6 apparently healthy bovines (4 buffaloes and 2 cattle), Group II included 22 bovines (18 buffaloes and 4 cattle) suffering from foreign body syndrome and Group III comprised 28 bovines (25 buffaloes and 3 cattle) suffering from diaphragmatic hernia. This study aimed to ultrasonographically evaluate the position of omasum in relation to anatomical landmarks in cattle and buffaloes. Ultrasonographically, the distance from dorsal spine to dorsal most part of omasum, the point of elbow to cranial most part of the omasum, the distance from last rib to caudal most part of omasum and the distance from ventral midline to ventral most part of omasum were recorded to evaluate the size of omasum. Ultrasonographic findings were correlated with intraoperative findings during rumenotomy in bovines suffering from foreign body syndrome and diaphragmatic hernia. Cranial wall of omasum was identified closer to point of elbow in bovines suffering from diaphragmatic hernia as compared to apparently healthy bovines and those suffering from foreign body syndrome. Caudal wall of omasum was located farthest from last rib in bovines suffering from diaphragmatic hernia as compared to apparently healthy bovines and those suffering from foreign body syndrome. No statistically significant difference were observed in the mean distance from dorsal to ventral wall and from cranial to caudal wall of omasum among the three groups The omasal motility was absent in all 3 groups.

In conclusions, ultrasonographic assessment of omasum in relation to anatomical landmarks was useful to evaluating the size and position of omasum in bovines suffering from foreign body syndrome and diaphragmatic hernia. The size of omasum in apparently healthy bovines and those suffering from foreign body syndrome and diaphragmatic hernia was found to be similar. However, location of the omasum is seen significantly cranially in bovines suffering from diaphragmatic hernia as compared to apparently healthy bovines and those suffering from foreign body syndrome.

KEY WORDS

Bovine, Omasum, Ultrasonography, Anatomical landmarks.

INTRODUCTION

Foreign body syndrome and diaphragmatic hernia are common conditions of cattle and buffaloes. Foreign body syndrome arises from the ingestion of indigestible materials, including both metallic and non-metallic sharp or blunt objects [1,2]. This condition significantly impacts the dairy industry by causing substantial production losses and increased mortality rates [3]. Reticular diaphragmatic hernia is a congenital or acquired defect in which the reticulum protrudes into the thoracic cavity, often resulting from penetrating foreign bodies [4]. Radiography is a effective method for visualizing metallic foreign bodies, whereas ultrasonography is a excellent technique for evaluating fibrinous deposits [5]. The incidence of right side diaphragmatic hernia is more compared to left side because right lower half of musculotendinous junction of diaphragm was thinner than left lower half [6]. Ultrasonographic detection of reticulum cranial to 5th intercostal space is considered a definitive indicator for diagnosing diaphragmatic hernia [7].

The omasum is located on the right side between 7th to 11th ICS [8]. Omasal leaves offer a large surface area necessary for the absorption of volatile fatty acids, electrolytes and water [9]. The omasum examination cannot be directly in adult animals using auscultation, palpation, per rectal and through radiography [10]. In healthy buffaloes, the omasum typically appears between 8th and 9th intercostal space as a round structure with thick wall and echogenic leaves [11]. The omasum is influenced by various gastrointestinal illness including reticulo-omasal stenosis, TRP, abomasal displacement/volvulus, pyloric stenosis and ileus [12]. Clinical examination provides subjective evaluation of omasal impaction but for definitive diagnosis often requires exploratory laparotomy [13]. This procedure inappropriate for critically ill patients. Ultrasound is a non-inva-

*Corresponding Author:
Manjeet Kumar (manjeetsama246@gmail.com)

sive diagnostic tool for the evaluation of the omasum in animals 14]. Some report suggest that ultrasonography cannot be reliably used to diagnosed omasal impaction in cows [15]. Omasal impaction is reported higher in buffaloes, primarily due to the consumptions of wheat straw and may also arise from conditions such as TRP/pericarditis, intestinal obstruction and peritonitis [16]. The clinical signs are generally nonspecific and may include anorexia, reduced defecation, ruminal distension, dehydration, mucosal congestion, and decreased milk yield [17]. Omasal dilation or displacement can occur secondary to vagal indigestion or simple indigestion [18].

The objective of the study was to evaluate the omasum in bovines suffering from foreign body syndrome and diaphragmatic hernia in comparison to apparently healthy bovines.

MATERIAL AND METHODS

The study was conducted in 3 groups where Group I consisted of 6 apparently healthy bovine (4 buffaloes and 2 cattle), Group II included 22 bovines (18 buffaloes and 4 cattle) diagnosed with foreign body syndrome and Group III comprised of bovines (25 buffaloes and 3 cattle) suffering from diaphragmatic hernia. Ultrasonography was used to record the dimensions of omasum in cattle and buffaloes in relation to anatomical landmarks. Ultrasonography was performed on standing bovine secured in a travis without sedation. The right lateral side of the thoracoabdominal wall (6^{th} to 12^{th} intercostal spaces) was shaved and cleaned with water. The bovine was examined using a 2.5–5.0 MHz convex transducer after applying transducer gel. Chalk was used to mark the dorsal, ventral, cranial and caudal boundaries of the omasum at each intercostal space. The transducer was held parallel to the ribs while scanning each intercostal space, starting from dorsally and moving toward ventrally. The dorsal and ventral walls of the omasum was identified using ultrasonography and marked with chalk at each intercostal space on the body of the bovine (Fig. 1). The transducer was held perpendicular to the ribs and each intercostal space was scanned again, starting cranially and moving toward caudally. The cranial and caudal walls of omasum were identified ultrasonographically and marked with chalk at each ICS on the body of the bovine.

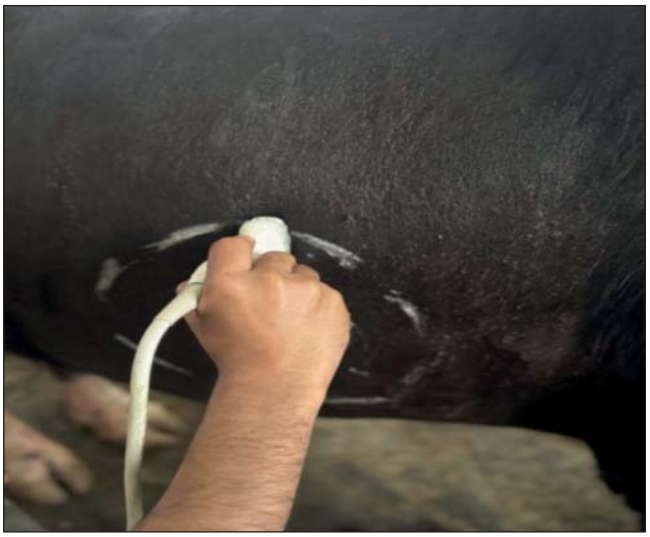

Figure 1 - Photograph showing the position of omasum outlined with a chalk.

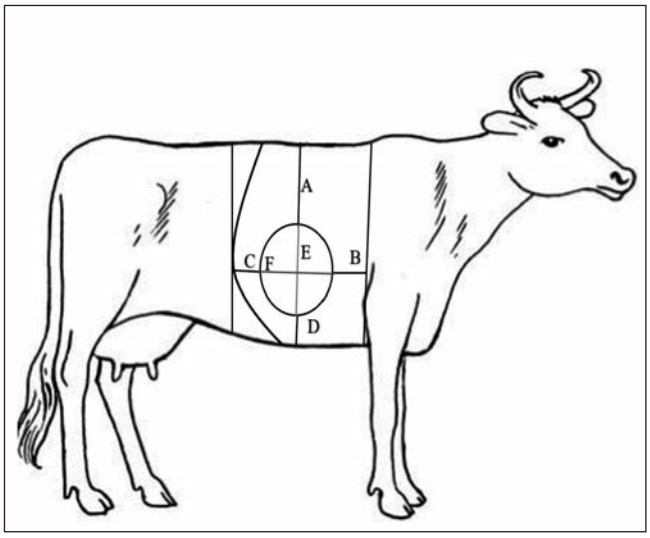

Figure 2 - Sketch showing the measurements of omasum in relation to anatomical landmarks.

Position of omasum in relation to anatomical landmarks was determined as follow (Fig. 2):

A. Distance from dorsal spine to dorsal most aspect of omasum in centimetres (A).
B. Distance from point of elbow in squarely standing bovine to cranial most part of omasum. In case omasum was dorsally / ventrally placed an imaginary line perpendicular to point of elbow was drawn and used to measure the distance of cranial most wall of omasum from the point of elbow in centimetres (B).
C. Distance from last rib to caudal most part of omasum. In case omasum was dorsally / ventrally placed an imaginary line perpendicular to the caudal most part of last rib was drawn and used to measure the distance of caudal most wall of omasum from last rib in centimetres (C).
D. Distance from ventral midline to ventral most part of omasum was recorded in centimetres (D).
E. Distance from the dorsal to ventral wall of omasum was recorded in centimetres (E). (Green line)
F. Distance from the cranial to caudal wall of omasum was also recorded in centimetres (F). (Blue line)

The wall thickness of omasum was measured in centimetres using ultrasonography calliper. The visibility of omasal leaves was recorded as visible or not visible upon ultrasonography. The transducer was maintained 3-5 min after identified the dorsal wall of omasum to record the omasal motility, if any present.

Ultrasonographic findings in bovines suffering from foreign body syndrome (Group II) and diaphragmatic hernia (Group III) were confirmed through rumenotomy. Rumenotomy was performed in the standing position with the left paralumbar fossa desensitized using local anaesthesia [19]. During rumenotomy, two third of rumen contents were emptied to facilitate palpation of rumen, reticulum and omasum.The presence of penetrating and non-penetrating foreign bodies was carefully examined in the rumen and reticulum. Omasal health was evaluated by assessing the size and consistency of the organ through palpation of rumen wall during rumeno-

tomy. Before suturing the rumen, it was filled up to one third with water, 4 boluses of ecotas and 100g of Liv. 52 was put inside the rumen in cases of foreign body syndrome. In cases of diaphragmatic hernia, the contents of the rumen and reticulum were completely evacuated. In cases of slightly hard omasum, the omasum was filled with water and 500ml of liquid paraffin was filled using a soft pipe having small diameter. Rumenotomy wound was closed in a routine manner. Intra-operatively the size of the omasum was examined subjectively by the same person in all the bovines (Group II and Group III) as: small / normal/ distended. The consistency of omasum was examined as: Doughy/ hard/ watery. The size of omasum observed upon rumenotomy was correlated with ultrasonographic findings in Group II and Group III.

SATISTICAL ANALYSIS

The parametric data obtained in this study were analysed statistically through one way analysis of varience, utilizing SPSS software for data evaluation.

RESULTS AND DISCUSSION

The dorsal wall of the omasum was seen as a crescent-shaped and thick echogenic line. The dorsal limit of the omasum appeared as a semicircle running from cranial to caudal direction [20]. The dorsal wall of the omasum was visible medial to the liver (Fig.3). Ultrasonographic examination of the omasum was conducted in all animals at the 8th to 9th intercostal spaces, irrespective of pregnancy [19]. The omasum closest to the right abdominal wall was seen at the 8th to 9th intercostal space [20]. The dorsal wall of omasum was seen closest to the dorsal spine in bovines suffering from foreign body syndrome (Group II, 50.22±2.45 cm), followed by bovines suffering from diaphragmatic hernia (Group III, 50.46±2.17 cm) and was seen farthest from dorsal spine in apparently healthy bovines (Group I, 54.00±4.70 cm) (Table 1). There was no statistically significant variation was observed in the distance from dorsal wall of omasum to dorsal spine among the three groups. Bovines were made to stand in travis squarely before taking measurement of cranial wall of omasum. The cranial limit appeared as a semicircle running from dorsal to ventral direction.

Figure 3 - Ultrasonogram showing the dorsal wall of omasum at 9th ICS medial to liver.

Cranial wall of omasum was lying adjacent to the abdominal wall in majority of bovines. The cranial wall of omasum (Fig. 4) was seen closest to the point of elbow in squarely standing in bovines suffering from diaphragmatic hernia (Group III, 14.78±0.86 cm), followed by apparently healthy bovines (Group I, 15.17±1.87cm) and the farthest from point of elbow was seen in bovines suffering from foreign body syndrome (Group II, 15.81±0.97 cm) (Table 1). Cranial wall of omasum was found to be significantly ($P<0.05$) closer to point of elbow in bovines suffering from diaphragmatic hernia as compared to apparently healthy bovines and those suffering from foreign body syndrome. The distance from the cranial wall of omasum to the point of the elbow was observed 13.70 ± 1.24 cm in animals suffering from foreign body syndrome and 14.14 ± 1.92 cm in those suffering from diaphragmatic hernia [19]. The omasum was located more cranially (6th to 10th ICS) in cattle as compared to buffaloes (7th to 11th ICS) [21]. The dimensions of the omasum remained almost unchanged during advanced pregnancy with exception of the 10th intercostal space and it displaced dorsally and cranially throughout advanced gestation [22].

The caudal wall of the omasum (Fig. 5) appeared as a semicircle running from the dorsal to ventral direction. The caudal wall

Table 1 - Table showing the statistical values.

Groups	Mean ± SE of the distance from dorsal spine to dorsal most aspect of omasum (cm) (A)	Mean ± SE of the distance from point of elbow in squarely standing bovine to cranial most part of omasum (cm) (B)	Mean ± SE of the distance from last rib to caudal most part of omasum (cm) (C)	Mean ± SE of the distance from ventral midline to ventral most part of omasum (cm) (D)	Mean ± SE of the distance from dorsal to ventral wall of omasum (cm) (E)	Mean ± SE of the distance cranial to caudal wall of omasum (cm) (F)
I (Apparently healthy bovines)	54.00±4.70[a]	15.17±1.87[a]	20.66±3.12[a]	37.16±4.45[a]	17.83±2.33[a]	22.50±2.55[a]
II (FBS)	50.22±2.45[a]	15.81±0.97[a]	22.27±1.63[a]	37.86±2.32[a]	19.59±1.21[a]	22.77±1.33[a]
III (DH)	50.46±2.17[a]	14.78±0.86[b]	27.03±1.44[b]	43.57±2.06[a]	16.75±1.08[a]	19.46±1.18[a]

Value with different alphabets superscripts differ significantly ($P<0.05$) from corresponding value in column.

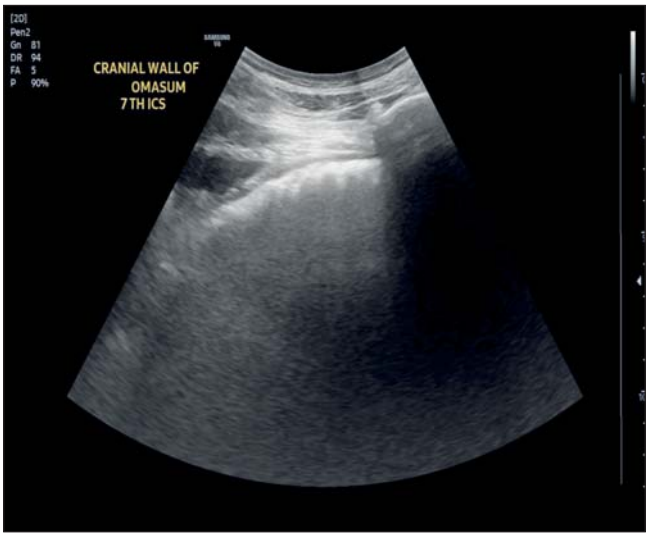

Figure 4 - Ultrasonogram showing the cranial wall of omasum at 7th ICS.

Figure 6 - Ultrasonogram showing the ventral wall of omasum at 9th ICS.

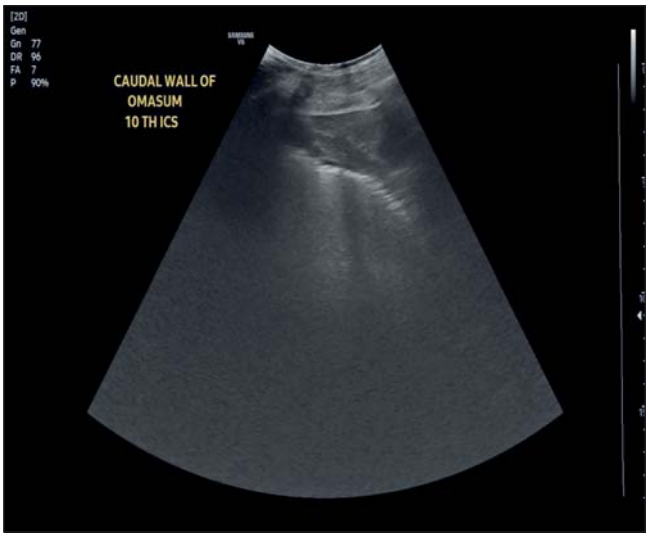

Figure 5 - Ultrasonogram showing the Caudal wall of omasum at 10th ICS.

of the omasum was seen closest to the last rib in apparently healthy bovines (Group I, 20.66±3.12 cm), followed by bovines suffering from foreign body syndrome (Group II, 22.27±1.63 cm) and was seen farthest distance from the last rib in bovines suffering from diaphragmatic hernia (Group III, 27.03±1.44 cm) (Table 1). Caudal wall of omasum was found to be significantly ($P<0.05$) farthest from last rib in bovines suffering from diaphragmatic hernia as compared to apparently healthy bovines and those suffering from foreign body syndrome. In contrast, the caudal wall of omasum was found to be closer to last rib in animals affected by diaphragmatic hernia as compared to those affected with foreign body syndrome [19].

The ventral wall of the omasum (Fig. 6) appeared as the lower half of a circle running from cranial to caudal direction. The ventral wall of omasum was seen closest to ventral midline in apparently healthy bovines (Group I, 37.16±4.45 cm), followed by bovines suffering from foreign body syndrome (Group II, 37.86±2.32 cm) and was seen farthest from the ventral midline in bovines suffering from diaphragmatic hernia (Group III, 43.57±2.06cm) (Table 1). There was no statistically significant variation was observed in the distance from the ventral wall of the omasum to the ventral midline among the three groups. The omasum wall reached upto the ventral midline in 2 bovines and dorsally, it was visible up to the middle part of the rib cage in 4 animals [11]. The ventral wall of omasum was difficult to distinguish because of its close proximity of the abomasum [21].

The maximum distance from dorsal to ventral wall of omasum was seen in bovines affected with foreign body syndrome (Group II, 19.59±1.21cm), followed by apparently healthy bovines (Group I,17.83±2.33 cm), while minimum was seen in bovines affected with diaphragmatic hernia (Group III, 16.75±1.08cm) (Table 1). No significant differences was seen in the distance from dorsal to ventral wall of omasum among apparently healthy bovines and those suffering from foreign body syndrome and diaphragmatic hernia. The size of omasum was not a criteria for diagnosis of omasal impaction [15].

The maximum distance from cranial to caudal wall of omasum was seen in bovines suffering from foreign body syndrome (22.770±1.33 cm), followed by apparently healthy bovines (22.5±2.55cm) and was seen minimum in bovines suffering from diaphragmatic hernia (19.46±1.82 cm) (Table 1). There was no statistical significance difference of distance from cranial to caudal wall of omasum was seen among the three groups. The vertical and horizontal diameter were smaller in animals suffering from diaphragmatic hernia as compared to healthy animals [21].

The tunica serosa of the omasal wall appeared as thin echogenic line which was followed by a thin non echogenic tunica muscularis, and a thick echogenic line tunica mucosa and submucosa [20]. Accurate measurement of the wall thickness was not always possible, as the mucosal border was not clearly demarcated due to the presence of omasal lamina and gas [19]. Approximate measurements were taken by extending up to the origin of the omasal lamina (Fig. 7). The maximum omasum wall thickness was seen in diaphragmatic hernia (Group III, 0.87±0.06 cm), followed by foreign body syndrome and was seen minimum in apparently healthy bovines (Group I, 0.74±0.12 cm). No significant difference of thickness of omasal wall was seen among the three groups. In another study,

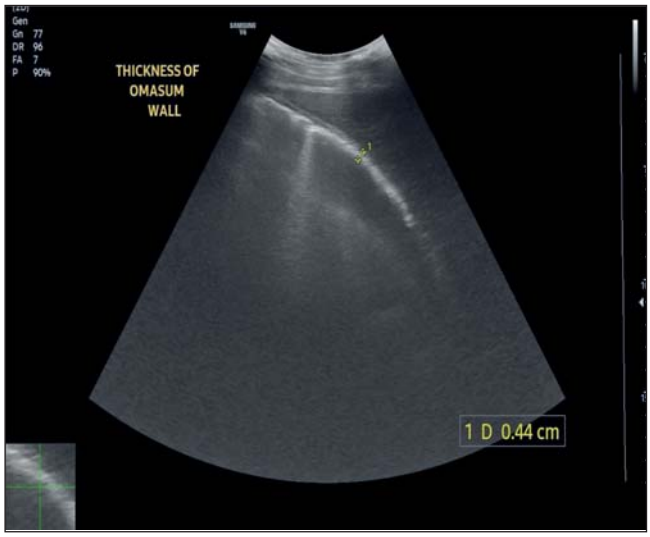

Figure 7 - Ultrasonographic measurement of the thickness of omasal wall.

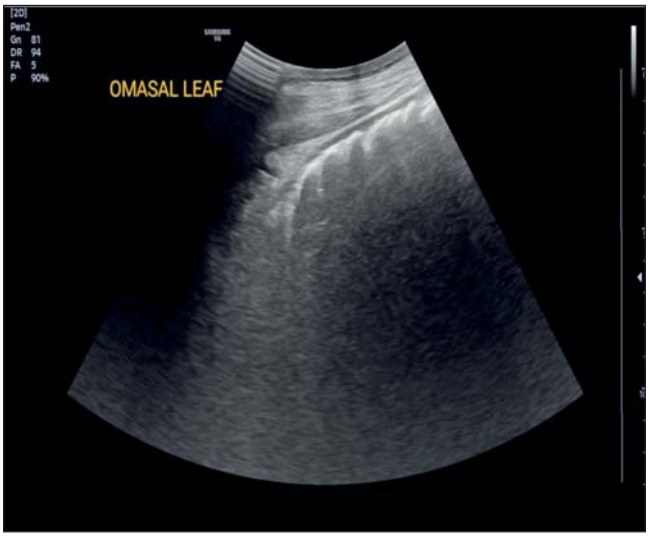

Figure 8 - Ultrasonogram showing the omasal leaves as short projections lying nearly parallel to the mucosal surface of the wall.

the omasum was appeared as a crescent shaped structure with an echogenic wall of 9-10.2 mm in healthy cows and 5-7mm in healthy buffaloes. Similarly, the mean wall thickness of the omasum was recorded as 0.62 ± 0.45 cm in animals suffering from foreign body syndrome and 0.63 ± 0.11 cm in animals suffering from diaphragmatic hernia [19].

Omasal leaves were not visualised in majority (66.7%) of apparently healthy bovines. In bovines suffering from foreign body syndrome, omasal leaves were not visualised in 72.7% of bovines and were visualised in 27.3%. Similarly, In bovines suffering from diaphragmatic hernia, omasal leaves were not visualised in 67.9% of bovines, while they were visualised in the remaining 32.1% (Fig. 8). The omasal leaves may be visualised occasionally in healthy cow [11]. The omasal leaves appeared as a small projection parallel to the mucosal surface of the omasal wall in healthy cattle and buffaloes [21].

Omasum motility was not seen in all the three groups (Fig. 9). In another study, the motility of the omasum was not reported in any cow even after positioning the transducer at same position for 5 minute [15].The omasum consistently remained in contact with the transducer, confirming the lack or minimal contractility of the omasum in cattle and buffaloes [11]. Mild motility was detected in healthy cattle and buffaloes during scanning of omasum [21].

In all the bovines that were diagnosed for foreign body syndrome (Group II, n=22), rumenotomy was performed. The reticulum was examined and if any foreign body was present, they were retrieved. The size and consistency of omasum were recorded intra-operatively. Intra-operatively the size of omasum was found to be similar as viewed upon ultrasonographically. In 14 bovines, non-penetrating foreign bodies were found lying free in the reticulum and were retrieved upon rumenotomy with no adhesion of reticulum wall was observed. In the remaining 8 bovines, foreign bodies were penetrating reticu-

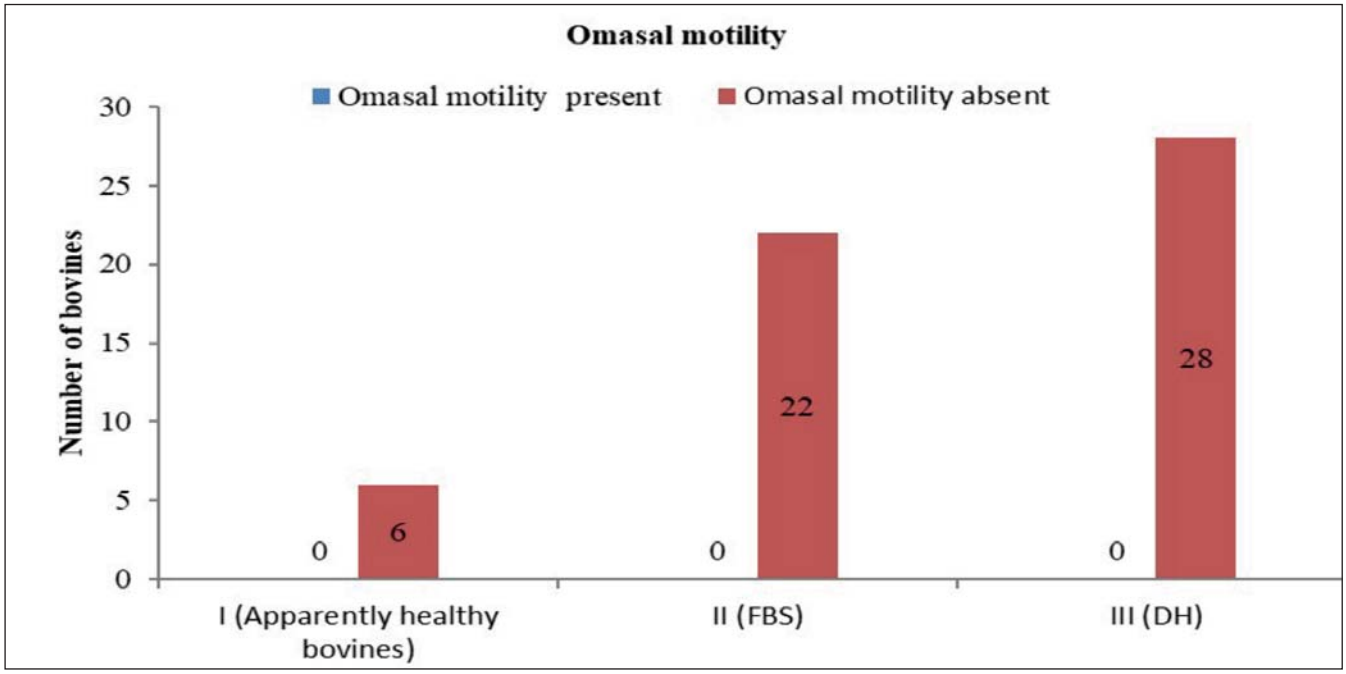

Figure 9 - Graphical presentation of omasal motility (Present or Absent).

lar wall and adhesion was observed. Omasum was observed doughy on palpation in 12 bovines, while 3 bovines it was watery. In remaining 7 bovines omasum was hard. In these bovines (n=7) the omasal contents were evacuated by kneading and retrograde flushing was done with soft pipe having small diameter. Subsequently, 400 ml liquid paraffin was inserted into the omasum.

In all the bovines that were diagnosed for diaphragmatic hernia (Group III, n=28)) rumenotomy was performed and diaphragmatic hernia was confirmed. The reticulum was examined and foreign bodies penetrating the reticular wall were retrieved from the reticulum in 5 bovines. Intra-operatively size of omasum was found to be similar as viewed upon ultrasonographically. Omasum was observed doughy on palpation in 21 bovines, watery in 4 bovines and hard in remaining 3 bovines.

CONCLUSIONS

Ultrasonographic assessment of omasum in relation to anatomical landmarks was useful to evaluating the size and position of omasum in bovines suffering from foreign body syndrome and diaphragmatic hernia. The size of omasum in apparently healthy bovines and those suffering from foreign body syndrome and diaphragmatic hernia was found to be similar. However, location of the omasum is seen significantly cranially in bovines suffering from diaphragmatic hernia as compared to apparently healthy bovines and those suffering from foreign body syndrome.

Ethical Approval Statement

The experimental procedures conducted in this study were approved by the Institutional Animal Ethics Committee (IAEC) of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Approval No: GADVASU/2023/IAEC/71/20, Year: 2024).

Acknowledgement

The authors are thankful to Dr. Amandeep Singh, Department of Veterinary and Animal Husbandry Extension Education, College of Veterinary Science, Rampura Phull for his help and Indian Council of Agriculture Research under All Indian Network Program on Diagnostic Imaging and Management of Surgical Affections in Animals and DST under the project Funds for Infrastructure in Science and Technology for funding this study.Top of Form

Author Contributions

Manjeet Kumar: Conceptualization, data collection, ultrasonographic examinations and manuscript writing.
Harmanpreet Singh Sodhi: Study supervision, methodology refinement, manuscript review and editing.
NU Devi: Clinical diagnosis, rumenotomy and post-operative management.
Kritima Kapoor: Anatomical interpretations
Mandeep Singh Bal: Data analysis, literature review, manuscript editing.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

References

1. Abu-Seida, A. M., and Al-Abbadi, O. S. (2016). Recent Advances in the Management of Foreign Body Syndrome in Cattle and Buffaloes: A Review. *Pakistan veterinary journal*, *36*(4).
2. Chanie, M., & Tesfaye, D. (2012). Clinico-pathological findings of metallic and non-metallic foreign bodies in dairy cattle: A review. *Academic Journal of Animal Diseases*, *1*(3), 13-20.
3. Radostits, O. M., Blood, C. C., Hinchclif, K. W., and Constable, P. D. (2007). Veterinary medicine a text book of disease of cattle, horse, sleep, pig and goat. England, London. *Saunders Elsevier*, 112-522.
4. Silva, T. V., Cajueiro, J. F. P., Silva, N. A., De Souza, M. I., Costa, N. A., Mendonça, C. L., Afonso, J. a. B., & Neto, E. G. M. (2021). Ultrasound diagnosis of reticular diaphragmatic hernia in bovines. Pesquisa Veterinária Brasileira, 41. https://doi.org/10.1590/1678-5150-pvb-6801.
5. Aref, N. E. M., & Abdel-Hakiem, M. A. (2013). Clinical and diagnostic methods for evaluation of sharp foreign body syndrome in buffaloes. *Veterinary World*, *6*(9), 586.
6. Saini, N. S., Kumar, A., Mahajan, S. K., & Sood, A. C. (2007). The use of ultrasonography, radiography, and surgery in the successful recovery from diaphragmatic hernia in a cow. *The Canadian Veterinary Journal*, *48*(7), 757.
7. Athar, H., Mohindroo, J., Singh, K., Kumar, A., & Raghunath, M. (2010). Comparison of radiography and ultrasonography for diagnosis of diaphragmatic hernia in bovines. *Veterinary Medicine International, 2010*, 939870. https://doi.org/10.4061/2010/939870.
8. Ghosh, R. K. (2020). *Primary veterinary anatomy: Systemic and regional* (8th ed., pp. 220-221). Current Books International.
9. Leek, B. F. (1993). Digestion in the ruminant stomach. In M. J. Swenson & W. O. Reece (Eds.), *Dukes' physiology of domestic animals* (11th ed., pp. 408–409). Cornell University Press.
10. Constable, P. D., Hinchcliff, K. W., Done, S. H., & Grünberg, W. (2016). Veterinary medicine: a textbook of the diseases of cattle, horses, sheep, pigs and goats, 11th Edn. pp. 499-500 Elsevier Health Sciences.
11. Mohindroo, J., Kumar, A., Sangwan, V., Udehiya, R., & Singh, S. S. (2008). Ultrasonographic evaluation of the omasum in cows and buffaloes. *Veterinary Radiology & Ultrasound*, *49*(3), 295-299.
12. Braun, U., Blessing, S., Lejeune, B., & Hassig, M. (2007). Ultrasonography of the omasum in cows with various gastrointestinal diseases. *Veterinary Record*, *160*(25), 865-869.
13. Hussain, S. A., Uppal, S. K., Randhawa, C., Sood, N. K., & Mahajan, S. K. (2013). Clinical characteristics, hematology, and biochemical analytes of primary omasal impaction in bovines. *Turkish Journal of Veterinary & Animal Sciences*, *37*(3), 329-336.
14. Athar, H., Mohindroo, J., Singh, K., Kumar, A., & Singh, T. (2009). Ultrasonographic features of omasal impaction in bovines. *Indian Journal of Veterinary Surgery*, *30*(2), 115-116.
15. Imran, S., Tyagi, S. P., Kumar, A., & Sharma, S. (2011). Ultrasonographic imaging of normal and impacted omasum in Indian crossbred cows. *Veterinary Medicine International*, *2011*(1), 485031.
16. Hussain, S. A., Uppal, S. K., & Sood, N. K. (2021). Prevalence and etiology of omasal and abomasal impaction in buffaloes and cattle: a necropsy study. *Buffalo Bulletin*, *40*(2), 259-265.
17. Toor, A. S., & Saini, N. S. (2008). Diagnostic and prognostic indicators of omasal impaction in buffaloes (Bubalus bubalis). *Veterinary Record*, *162*(9), 275-277.
18. Bicalho, R. C., Mayers, H. M., Cheong, S. H., Rosa, B. V., & Guard, C. L. (2009). Omasal dilation and displacement in 4 Holstein dairy cows. *The Canadian Veterinary Journal*, *50*(4), 393.
19. Sodhi, H. S., Mohindroo, J., Mahajan, S. K., Verma, P., & Singh, O. (2019). Comparison of ultrasonographic features of omasum in cattle and buffaloes suffering from various gastrointestinal tract disorders. *Indian Journal of Veterinary Surgery*, *40*(1), 20-25.
20. Braun, U., & Blessing, S. (2006). Ultrasonographic examination of the omasum in 30 healthy cows. *Veterinary Record*, *159*(24), 812-815.
21. Diniz, N. G., Kumar, A., Mukhopadhyay, C. S., & Uppal, V. (2016). Ultrasonographic morphometry and topography of the reticulum and omasum in pregnant bovine. *Indian Journal of Veterinary Surgery*, *37*(1), 14-18.
22. Hussain, S. A., Uppal, S. K., & Singh, T. (2021). Ultrasonographic assessment of change in omasal position during the last month of gestation and first month of lactation in buffaloes. *Schweizer Archiv fur Tierheilkunde*, *163*(6), 411-418.