Original Research

Effect of Radiographic Positioning on the Morphometry of Cranio-Ventral Abdomen in Cows and Buffaloes

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Rec. Date:	Mar 26, 2018 10:56
Accept Date:	May 20, 2018 16:14
DOI	10.5455/ijlr.20180326105620

Abstract

The study was aimed to evaluate the effect of radiographic positioning i.e standing (right and left) and recumbent (right) lateral on the morphometry of the reticulum and diaphragm in healthy cows and buffaloes. Twenty six healthy non-gravid bovines (14 cattle and 12 buffaloes) were investigated. The ventral diaphragmatic line was clearly appreciable in 100% healthy buffaloes and in 85.71% healthy cows on the right lateral recumbent radiographs. In 71.43% (right recumbent) to 78.57% (right and left standing) cases of healthy cattle and 91.67% (right recumbent and left standing) to 100% cases (right standing) of healthy buffaloes, the cupula of the diaphragm was seen at the level of 6thsternebra. The height of the cupula was recorded to be significantly more ($p<0.05$) on recumbent compared to standing radiographic views in healthy buffaloes. The height of cupula was significantly ($p=0.038$) more in healthy buffaloes compared to healthy cows on recumbent radiographic view. The reticular wall was better defined on standing radiographic views in healthy cattle (approx. 65%) and buffaloes (approx. 90%). In conclusion, radiographic positioning and species affect the morphometry of cranio-ventral abdomen in cows and buffaloes.

Key words: Cow, Diaphragm, Positioning, Reticulography, Reticulum

How to cite: Makhdoomi, S. M., Sangwan, V., & Kumar, A. (2018). Effect of Radiographic Positioning on the Morphometry of Cranio-Ventral Abdomen in Cows and Buffaloes. International Journal of Livestock Research, 8(11), 172-181. doi: 10.5455/ijlr.20180326105620

Introduction

Cows and buffaloes though appear similar, morphologically, but are two different species and they differ in their behaviour regarding thermoregulation, eating habits, heart rate and body weight (Tajima and Chikamune, 1989). Majority of the digestive system disorders in bovine are found in and around the reticular region (Partington and Biller, 1991, Saini *et al*., 2007, Kumar *et al*., 2008). Radiography is a conventional but indispensable imaging modality for the evaluation of cranio-ventral abdominal region in bovine (Braun *et al*., 1993, Braun *et al*., 2003). Moreover, with the introduction of computerized and digital

radiography, the clarity of reticular radiographs has increased many fold and one can see a lot more than what was seen in earlier times. Various radiographic features such as clarity of the diaphragmatic line (Misk and Semieka, 2001, Saini *et al*., 2007), size of the reticulum and reticulo-diaphragmatic distance (Fubini *et al*., 1990, Partington and Biller, 1991) have implications in the diagnosis of various disorders. The radiographic morphometry may get altered in relation to species and radiographic positioning (standing or recumbent). In buffaloes, it is regular practice to take the radiograph of reticulum in recumbent position while in western countries, the reticular radiograph of cattle is taken in standing positions. As per author's knowledge, no published literature on the comparative radiographic morphometry of cranio-ventral abdomen in healthy cows and buffaloes is available. Therefore, this study was designed to evaluate the effect of radiographic positioning i.e. standing (right and left) and recumbent (right) lateral on the morphometry of the cranio-ventral abdomen in healthy cows and buffaloes.

Materials and Methods

This clinical study was duly approved by the Institutional Animal Ethics Committee. A total of 31 clinically healthy non-gravid bovines (16 cross-bred Indian cattle (*Bos tarus* and *Bos indicus*) and 15 Indian water buffaloes *(Bubalus bubalis)* were subjected to radiography of the cranio-ventral abdominal region. Out of these, 5 bovines (2 cattle and 3 buffaloes) were excluded because of the incidental detection of sharp metallic foreign body measuring 5 to 9 cm in four animals (2 cattle and 2 buffaloes) or reticulo-diaphragmatic hernia in one (buffalo). Therefore, the study included 26 healthy bovines (14 cross-bred Indian cattle and 12 Indian water buffaloes). All the bovines were subjected to reticular radiography in recumbent (right lateral) and standing (right and left lateral) positions using ceiling mounted movable Seimen's 800mA X-ray machine. The left to right lateral was denoted as "right lateral" and the right to left lateral as "left lateral" throughout in the text and figures. The radiographic exposure factors used were 90-113 kVp (kilovoltage peak), 53mAs (miliampere seconds) and 90-110 FFD (film focal distance). The radiographs were processed using Kodak computerized radiography (CR) system. The body weight (kilograms, Kgs), age (years, yrs) and body width (in centimeters, cm) was recorded in all the bovine.

The body width of the bovines was measured at the centre of radiographic exposure i.e. 18-20 cm from the xiphoid at the 6thintercostal space or 7th rib by using an L' shaped wooden frame (Fig. 1). The various objective radiographic parameters measured using inbuilt calliper in the computerized radiography system, included-

1) The height of cupula. It was measured as a perpendicular distance from the cranial most apex (cupula) of the diaphragm to the sternum (Fig. 2).
2) The position of the cupula. It was recorded based on the sternebra on which the perpendicular line (parameter 1) falls (Fig. 2). Each sternebra (S) was divided into three equal parts i.e. proximal, middle and distal.

 DOI 10.5455/ijlr.20180326105620

Fig.1: Photograph of the wooden frame used to measure the width of the bovine at the centre of X-ray beam exposure.

Fig. 2: Radiograph showing cupula height (white line) and position (yellow star) with respect to sternum.

3) The reticulo-diaphragmatic distance. It was measured at 3 points .a: cranially, b: cranio-ventrally and c: ventrally (Fig. 3).

4) The length of reticulum. It was measured from the ventral tip of the reticulum to its cranial border at the costo-chondral junction (Fig. 3).

Fig. 3: Radiograph showing the length of reticulum (white line) and the reticulo-diaphragmatic distances (a: red line, b: yellow line, c: blue line).

DOI 10.5455/ijlr.20180326105620

5) The shape of the ventral wall of reticulum. It was recorded as straight, 'V or U' (Fig. 4). Since, the reticular wall may change shape due to motility or in disease condition like adhesions or peritonitis.
6) The demarcation of the ventral diaphragmatic line. It was recorded as clear or unclear.

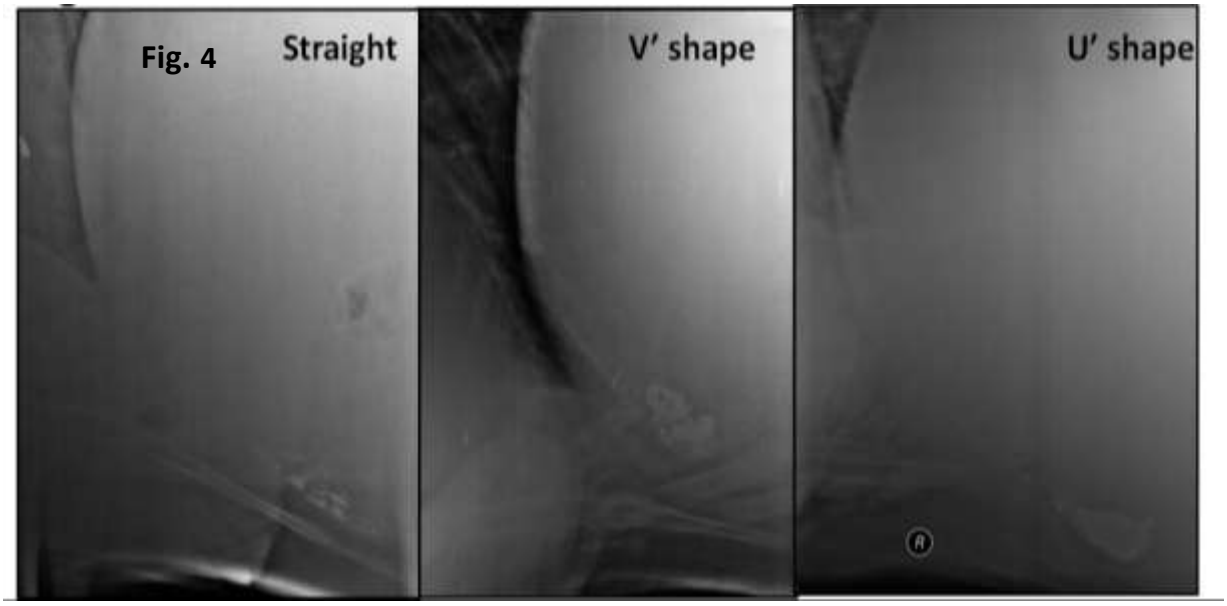

Fig. 4: Radiographs showing various shapes of reticulum.

7) The visibility of a gas shadow caudal to reticulum. It was recorded as corresponding to part of abomasum (Fig. 5).

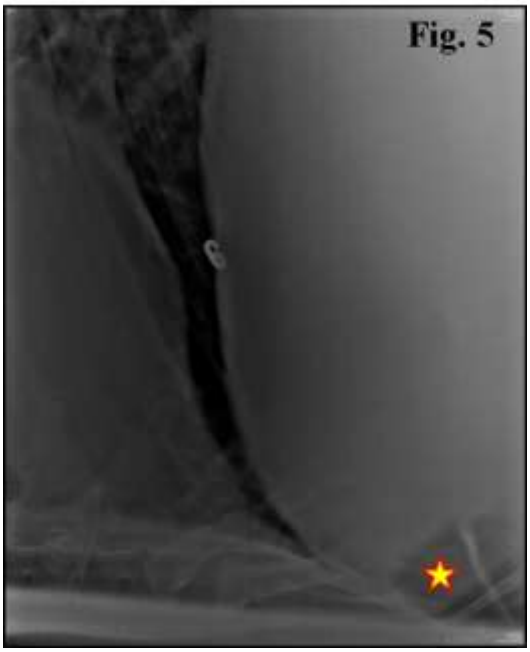

Fig. 5 Radiograph showing abomasum gas (red star) in right recumbent position in buffalo.

DOI 10.5455/ijlr.20180326105620

The data generated was subjected to statistical analysis using Microsoft Excel. The mean and the standard deviation of all the numerical parameters were calculated in all the bovine. The student t-test was applied to test the significance of differences in the radiographic parameters in various groups in cows and buffaloes (between various radiographic views and between same radiographic view) at 1% and 5% level of significance.

Results and Discussion

A total of 26 healthy non-gravid bovines (14 cows and 12 buffaloes) were included in the study. The mean ± Sd of body weight, age and body width in cows and buffaloes were 425.28 ± 53.75 kg (range 325-512 kg), 5.36 ± 1.28 year (range 4-8 year), 33.14 ± 4.31cm (range 27-40 cm) and 401 ± 78.09 kg (range 296-500 kg), 4.5 ± 0.8 year (range 3-5 year), 36.08 ± 3.09 cm (range 31-40 cm), respectively. The buffaloes had significantly (p=0.05) higher body width (at the centre of radiographic exposure) as compared to cattle. The centre of radiographic exposure was done at 18-20 cm from the xiphoid at the 6th ICS or 7th rib (Partington and Biller, 1991) but Braun *et al.*, 2003, made the centre of the radiographic beam at 8th rib in cattle. Higher body width in buffaloes compared to cattle (even though the mean body weight in buffaloes was less than that of the cattle) might be the reason for less clear radiograph of buffaloes in standing position. The detailed radiographic findings of both the species in all three radiographic views are depicted in Table 1. The ventral diaphragmatic line was clearly appreciable on the right lateral recumbent radiographs of all the healthy buffaloes (n=12) (Fig. 6b) and in 85.71% cows (12 out of 14 cases) (Fig. 6a).

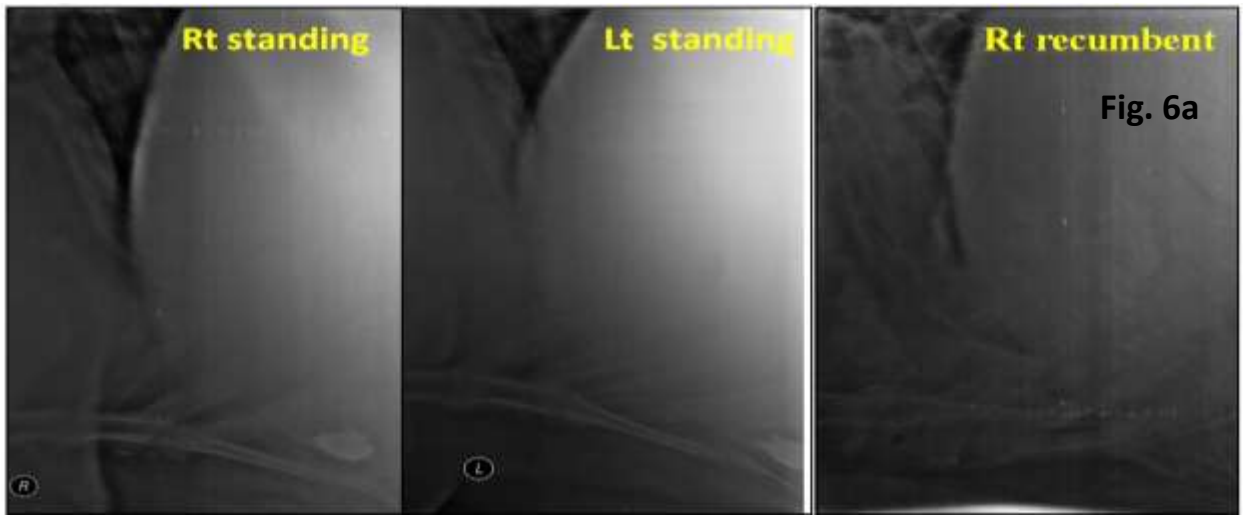

Fig. 6a: Radiographs showing clarity of diaphragm line in various views in a cow.

DOI 10.5455/ijlr.20180326105620

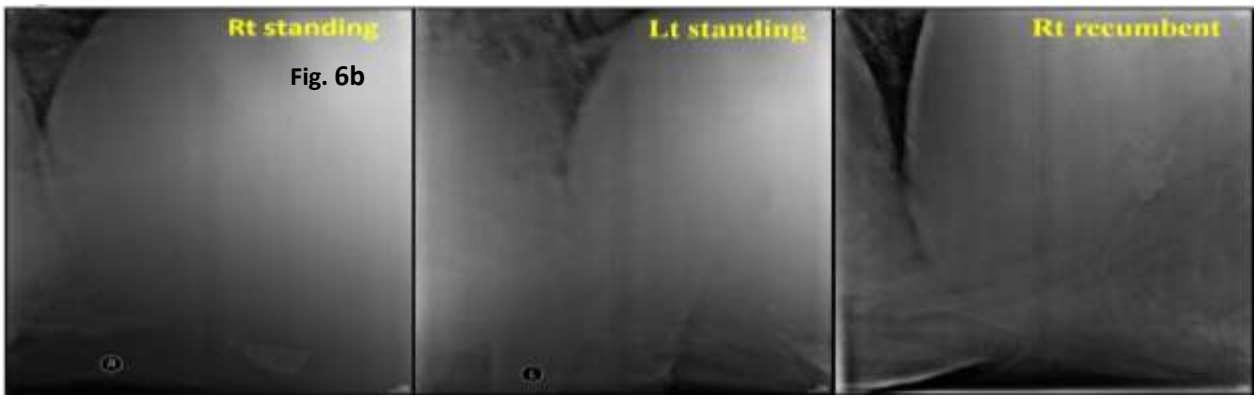

Fig. 6b: Radiographs showing clarity of diaphragm line in various views in a buffalo.

However, in standing position the diaphragmatic line was clearer in more percent of cows (71.43% in right standing and 78.57% in left standing) as compared to buffaloes (50% in right standing, 41.67 % in left standing) (Table 1). There was no marked difference in the cranial most extent of cupula in cows and buffaloes (Table 1).

Table 1: Mean ± SD of radiographic features of reticulum in various views in healthy cattle and buffaloes

S. No.	Parameters	Cattle (mean ±Sd and range) (N=14)			Buffalo (mean ±Sd and range) (N=12)		
		Rt lateral recumbent	Rt lateral standing	Lt lateral standing	Rt lateral recumbent	Rt lateral standing	Lt lateral standing
1	Diaphragm line clear %	12/14=85.71%	10/14=71.43%	11/14=78.57%	12/12=100%	6/12=50%	7/12=58.33%
2	Cranial most extent of cupula	S 5-6	S 5-6	S 5-6	S 5-6	S 5-6	S 5-6
3	Cranial most extent of cupula (%)	4/14=28.57%	3/14= 21.43%	3/14=21.43%	2/12=16.67%	2/12=16.67%	1/12=8.33%
4	Caudal most extent of cupula	At mid S7	At proximal S7	At proximal S7	Proximal S7	S 6-7	Proximal S7
5	Caudal most extent of cupula (%)	1/14=7.14%	3/14=21.43%	3/14=21.43%	1/12+8.33%	4/12=33.33%	1/12=8.33%
6	Cupula position in and around S6 (%)	10/14=71.43%	11/14=78.57%	11/14=78.57%	11/12=91.67%	12/12=100%	11/12=91.67%
7	Cupula height in cm	16.48 ± 3.46*	15.55 ± 3.06	15.87 ± 4.64	19.43 ± 3.24*$	17.04 ± 1.54$	16.29 ± 2.9$
8	Reticulum length in cm	18.15 ± 6.24	21.08 ± 6.78	21.43 ± 5.6	18.2 ± 6.78	22.50 ± 5.76	20.4 ± 5.5
		(11.3-26.08)	(9.9-32.51)	(15-30.10)	(13.4-22.9)	(9.6-30.85)	(10.2-23.0)
9	Reticulo-diaphragmatic interface						
	a	1.21 ± 0.66	1.84 ± 0.76	1.37 ± 1.37	1.71 ± 0.53	1.68 ± 0.55	1.7 ± 0.34
	b	2.04 ± 1.24	2.79 ± 1.12	2.69 ± 1.0	2.08 ± 0.28	2.26 ± 0.64	2.61 ± 0.62
	c	2.07 ± 1.57	1.8 ± 2.12	1.88 ± 0.85	2.58 ± 1.63	1.18 ± 0.59	1.59 ± 1.09
10	U or V shaped reticulum %	4/14=28.57%	3/14=21.43%	1/14=7.14%	3/12=25%	1/12=8.33%	None
11	Reticular wall defined %	7/14= 50%	10/14= 71.43%	9/14=64.28%	5/12=41.67%	11/12=91.67%	11/12=91.67%
12	% of Abomasum seen	3/14=21.43%	None	None	5/12=41.67%	None	None
13	Cystic lesions in chest (incidental finding)	2/14=14.28%	2/14=14.28%	1/14=7.14%	None	None	None

DOI 10.5455/ijlr.20180326105620

However, the caudal most extent of cupula was seen upto mid S7 in cows and at proximal S7 in buffaloes. In 71.43% to 78.57 % cases of cows and 91.67% to 100% of buffalo the cupula was seen in and around 6thsternebra. In healthy cattle, the cranial most apex of diaphragm is reported to be visible at the level of, or caudal to, seventh rib (Braun *et al*., 1993). If the apex was not visible clearly or if it's most cranial aspect is present at the level of or cranial to the sixth rib, such findings were considered to be pathological (Braun *et al*., 1993). In the present study, the position of cupula was recorded relative to the position of sternebra as these are better visualised in the radiographs compared to the ribs probably due to dense material in the rumen. Since the ribs are present caudal to the respective sternebra, the cupula position was maximum seen at the level of 6thsternebra, while in literature it is reported to be at 7th rib (Braun *et al*., 1993).

The height of the cupula in buffaloes was recorded to be significantly more in recumbent compared to standing radiographic views ($p<0.05$). Also, the height of the cupula was significantly ($p<0.05$) more in buffaloes compared to cows in recumbent radiographic views (Table 1, Fig. 7a and 7b). In the present study the height of the cupula was recorded significantly more in buffaloes compared to cattle in recumbent radiographic views, which might be the reason that the diaphragm of cattle on the lateral reticular radiograph appears more dome shaped compared to buffalo, which relatively appears straight.

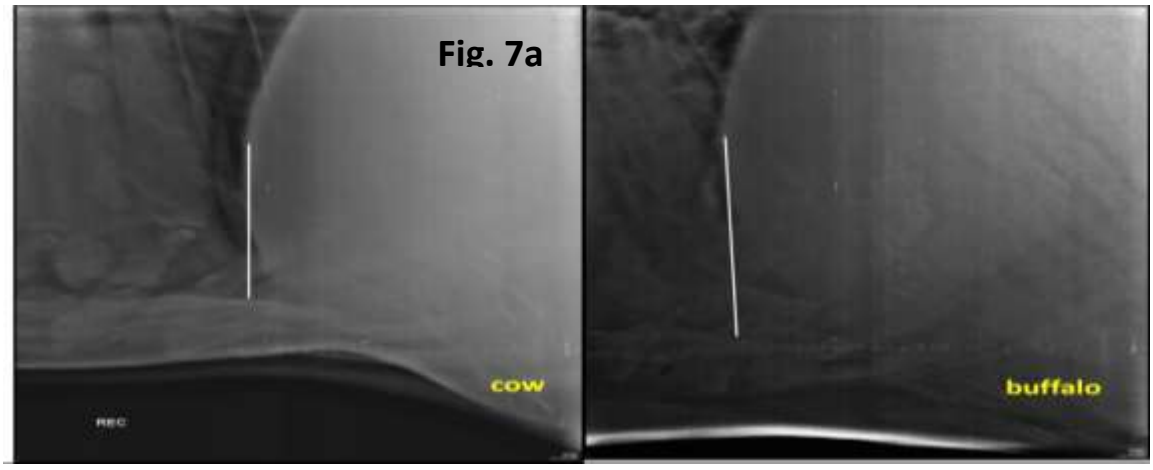

Fig. 7a: Radiographs showing comparative height of cupula (white line) in cow and buffalo in right recumbent position.

The length of the ventral reticular wall ranged from 9.90 to 32.51cm and 9.60 to 30.85 cm in cows and buffaloes, respectively. The mean length of the reticulum was non-significantly shorter in recumbent position compared to the standing radiographic views, irrespective of the species. In general, the shape of the reticulum was elongated along the sternum in all the three views and maximum number of bovines. The 13 cows and 12 buffaloes had elongated reticulum in left standing lateral radiograph, while it was U' or V' shaped on radiographs in recumbent position (n=7; 4 cows and 3 buffaloes).

DOI 10.5455/ijlr.20180326105620

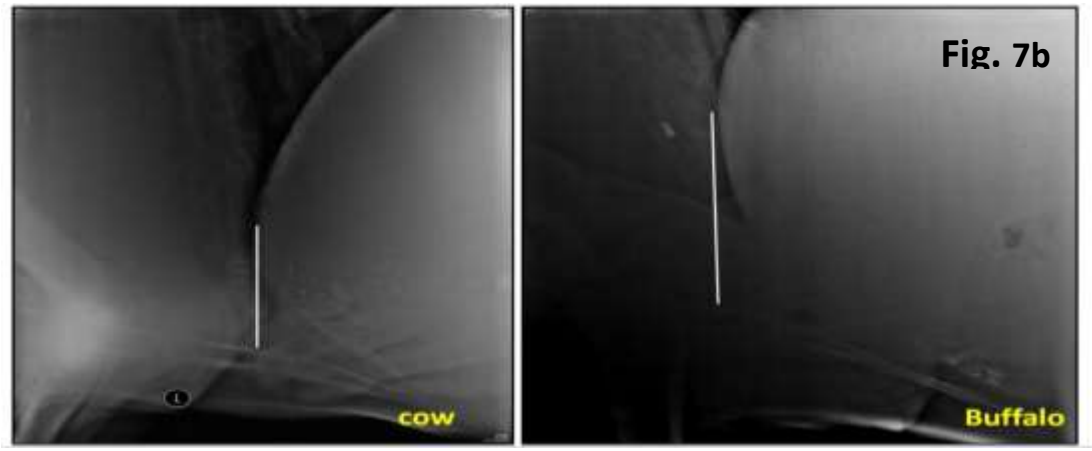

Fig. 7b: Radiographs showing comparative height of cupula (white line) in cow and buffalo in standing position.

It is important to mention here that the reticulum length could not be measured in 8 buffaloes and 7 cattle in recumbent position as it was not clearly defined in recumbent position, while it was better defined in standing position for measurement. In cattle, the reticular wall was defined in 64.23% in left standing and 71.43% in right standing while in only 50% in recumbent lateral radiograph. Similarly, in buffaloes it was defined in 91.67% in left and right standing and only 41.67 % in recumbent lateral radiograph. The reticular wall is defined on a radiograph due to presence of radio-dense opacities present at the ventral reticular floor entangled in the honey comb cells (Partington and Biller, 1991; Braun *et al*., 1993). In standing position these radio-dense opacities (iron dust) may get well settled on the ventral floor making the reticular wall more defined whereas, in recumbent position, the contents and the iron dust of the reticulum may spread and are no more visible on the ventral reticular floor. Also that the buffaloes might have had more iron dust in the reticulum compared to cattle, thus they had better defined reticular walls (90%) compared to cows (65%) in standing radiographic positions in the present study. The recumbent lateral view may also have implications in the diagnosis of reticulo-diaphragmatic hernia whereas, the standing lateral views in the diagnosis of foreign bodies in the reticulum in bovine. In healthy cattle, and in standing radiographic position, the ventral tip of the reticulum is reported to lay caudo-ventral to xiphoid when relaxed and dorsal to xiphoid during contraction resulting in change in shape of reticulum and hence is not considered to be pathological (Partington and Biller, 1991). In the present study also the U' or V' shape of the reticulum was observed in few healthy bovines in the recumbent radiographic position, though; it was elongated in the standing radiographic views. The hypothesis behind the shorter length and dorsal lifting of reticulum in recumbent position might be that due to casting, a few bovines' may contract the reticulum or hold the breath, thus resulting in contracted or altered shape of the reticulum.

The reticulo-diaphragmatic distance showed significant variations at various locations. The distance 'b' in cranio-ventral direction was found to be non-significantly more than that of 'a' and c' in all the views in

 DOI 10.5455/ijlr.20180326105620

cows and buffaloes; and, it was statistically significant in the right lateral standing position in cows (p=0.047 for a' and b' and p= 0.0049 for b' and c') and left lateral standing position in buffaloes (p=0.00062 between a' and b' and p=0.021 between b' and c') and right lateral standing in buffaloes (between b' and c'; p=0.00043). The reticulo-diaphragmatic distance measured at the level of the costo-chondral junction and the sternum is reported to be of no statistical significant relationship with any reticular disease process (Partington and Biller, 1991). But, the authors (Partington and Biller, 1991) did not measure the cranio-ventral (b) distance, which was found to be significantly more than the cranial (a) and ventral (c) distances in various standing positions in healthy bovine of this study. The reason for it could not be ascertained.

The 21.43% cows (n=3) and 41.67% buffaloes (n=5), recorded a gas opacity in the region caudal to reticulum in right lateral recumbent radiographs. This opacity was not seen in any of the other radiograph taken in standing position (Table 1). The gas opacity was considered corresponding to the abomasum. Since, anatomically, the position of abomasum is caudal to reticulum in the post xiphoid region, so, in the right recumbent position the gas cap was visualized. However, this gas in pylorus is reported to be seen in left lateral recumbency in dog (Kealy *et al.,* 2011). But, since, no left recumbent radiographs of bovine were taken in this study, the finding could not be confirmed. It is important to mention that this gas shadow seen caudal to reticular region was not an abcess or abnormality, as confirmed on ultrasound scanning. The visibility of the abomasum in the same cassette may also depend on the visibility of reticulum on radiograph as the abomasum is anatomically placed caudal to the reticulum.

Conclusion

From the present radiographic study the following conclusions were drawn-

1. Diaphragmatic line is more clearly defined in recumbent radiographic view; however, the reticular wall is more defined in standing views.
2. The buffaloes have more height of diaphragmatic cupula compared to cattle.
3. Reticulo-diaphragmatic separation varies at various locations and it is highest at the cranio-ventral aspect, irrespective of the species and the radiographic views.
4. A gas density caudal to reticulum in right recumbent radiograph may be normal in bovine and is part of abomasum.

Acknowledgement

The authors duly acknowledge Indian Council of Agricultural research (ICAR), for the financial aid provided under the "All India network program on diagnostic imaging and management of surgical conditions in animals" for the completion of this study. The authors also acknowledge Mr. Harmesh Lal, Senior Radiographer and Mr. Jagdish Chander Bhardwaj , Radiographer, for the technical help rendered in the positioning and exposure of the reticular region in bovine.

DOI 10.5455/ijlr.20180326105620

Conflict of Interest

The authors have no conflict of interest.

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DOI 10.5455/ijlr.20180326105620