Ultrasoundographic examination of the stomach, duodenum and jejunum of normal adult spiti horses and Himalayan hill mules of India

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ABSTRACT

The study was conducted on equids of high altitude to develop baseline topographical data of landmarks, sonographic caliper measurements and dynamic parameters of abdominal organs. Ultrasonography was performed on healthy adult spiti horses and Himalayan mules of either sex. The wall thickness, contractility, character and echo-architecture of these organs were recorded for standardization. The stomach was found between 8th-15th and 8th-14th Inter-Costal Space (ICS) with wall thickness of 4.92 ± 0.23 and 4.24 ± 0.06 mm in horses and mules, respectively. Ascending duodenum was found between 11th-13th and 10th-13th ICS with a wall thickness of 2.0 ± 0.00 and 1.96 ± 0.04 mm in horses and mules, respectively. Descending duodenum was found from 16th and 15th ICS to just caudal to the last rib in horses and mules, respectively. Jejunum was found from 12th (±1) to 17th ICS with wall thickness of 2.04 ± 0.04 and 2.02 ± 0.02 mm in horses and mules, respectively. Detailed ultrasonographic examination of these organs helped to compile baseline data, which will be useful in future in management of the affections of stomach, duodenum and jejunum.

Key words: Duodenum, Horse, Jejunum, Mule, Stomach, Ultrasonography.

INTRODUCTION

The diagnostic abdominal ultrasonography is increasingly used in veterinary practice and has an important role in decision making in equines with abdominal disorders. Furthermore, ultrasonography has the potential for wide spread use in diagnosis of disorders of several body systems in horses, (Scharner et al., 2002).

Ultrasonography has a number of advantages over other imaging techniques. It can distinguish between soft tissues of different echogenicity. It enables different regions of the gastrointestinal tract to be identified by their location, size, anatomical features (such as sacculations), luminal contents and motility. Fluid and soft tissue can be differentiated using ultrasonography. The small intestine wall can therefore be distinguished from its fluid contents and parameters such as wall thickness and nature of intestinal contents can be evaluated. The ultrasound image is constantly updated, producing a real-time moving image. Consequently, position and movement of the structures relative to each other can be assessed. Frequency, amplitude and velocity of peristaltic contractions can also be evaluated by B- mode, M- mode and Doppler ultrasonography (Freeman, 2002). In addition, it is easy to perform and allows immediate interpretation, which is essential in colic patients. Other methods of imaging gastrointestinal tract, such as radiography and endoscopy are of limited value in the adult horses due to large size of the abdomen. Sonographic assessment of abdominal organs in different equine breeds has already been described (Reef, 1998; Freeman, 2002; Epstein et. al., 2008; Barton, 2011) but no such study has been conducted on native breeds of India. Thus the objective of this study was to perform detailed ultrasonographic examination of stomach, duodenum and jejunum and to compile baseline data of spiti horses and Himalayan hill mules, which will be useful in future to delineate the normal and abnormal conditions and will provide an important diagnostic lead in management of the affections of stomach, duodenum and jejunum.

MATERIALS AND METHODS

Standardization was carried out on 50 clinically healthy adult native animals of either sex (25 Spiti horses and 25 Himalayan hill mules). The horses were between 8-17 years of age and weighed between 120-165 kg, whereas mules were between 8-15 years of age and weighed between 90-110 kg. The normal equine abdomen was subjected to ultrasonographic examination for standardizing the technique and machine settings. Trans-abdominal ultrasonography was performed to scan and document images of stomach, duodenum and jejunum, to delineate their topographical anatomy in different planes, to define their echotexture and to determine their thickness and site for placement of the transducer at various locations. Ultrasonography was carried out using Siemens Acuson X300 ultrasound system, premium edition, a grey scale B + M-mode and 4D scanners. The standing animals were restrained in a crate without any

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sedation and were kept for 15 minutes so that their heart rate becomes normal. All animals were fasted for 12 hours prior to ultrasonography and in some animals fasting was extended to 24 hours to determine decrease in contraction rate at different time intervals but drinking water was kept available all the time. The topographic regions of all animals were shaved and cleaned with tap water. Contact gel was applied and animals were examined using two different transducers: i) 5.3-10 MHz linear transducer with a maximum depth of field of 13 cm and ii) 2-5 MHz volumetric (4D) transducer with a maximum depth of field of 30 cm. Care was taken to record the ultrasonograms at the peak of inspirations. The organ echotexture, motility pattern, wall thickness, size, optimal topographical locations as well as associated structures were studied with photographic recordings.

RESULTS AND DISCUSSION

Stomach: The stomach was found between 8th to 13th ICS, while in fed horses up to 15th ICS (Fig-1.1[a, b]). In mules, it was found between 8th to 14th ICS, caudal to the liver, cranial to the spleen and dorsal to the right dorsal colon at the level of shoulder. At this location only visible part of the stomach was wall of greater curvature, which was identified as semicircular, curvilinear hyperechoic line with proximity to the adjacent spleen at the level of splenic vein. In fasted horses, the stomach was not found at its usual position, instead it was found ventral to the costochondral junction (Fig-1.2[a, b]). It was observed that the lumen generally contained gas, casting strong acoustic shadowing and often contents of the stomach were not visible (Fig-1.3[a, b]), but when the stomach contained fluid a distinct gas fluid interface was observed and in addition to this, specks of feed were seen floating within the fluid of the stomach (Fig-1.1[a, b]). In horses, the stomach wall thickness varied from 4 to 5.2 mm (Mean ± SE=4.92 ± 0.23 mm) and in mules, varied from 4.1 to 4.4 mm (Mean ± SE= 4.24 ± 0.06 mm). It was observed that stomach has the thickest wall of the gastrointestinal tract and all the muscle layers of the stomach wall (serosa, muscularis, sub-mucosa, mucosa and mucosal gas interface) were distinctly appreciable (Fig-1.4[a,b]). The findings of the present study

Fig 1.1(a, b): Ultrasonogram of Stomach (Horse) at 15th ICS. The image was obtained with linear transducer at 5.3 MHz at a depth of 5 cm. MGI: mucosal gas interface, ICM: intercostal muscle, D: dorsal, V: ventral, M: medial.

Fig 1.2(a, b): Ultrasonogram of Stomach (Horse) at 8th ICS. The image was obtained with linear transducer at 10.0 MHz at a depth of 6.5 cm. LDC: left dorsal colon, D: dorsal, V: ventral, M: medial.
Fig 1.3(a, b): Ultrasonogram of Stomach (Mule) at 12th ICS. The image was obtained with linear transducer at 10.0 MHz at a depth of 6.5 cm. MGI: mucosal gas interface, ICM: intercostal muscle, D: dorsal, V: ventral, M: medial.

Fig 1.4(a, b): Ultrasonogram of Stomach (Mule) at 12th ICS. The image was obtained with linear transducer at 10.0 MHz at a depth of 6.5 cm (zoom view). MGI: mucosal gas interface, ICM: intercostal muscle, D: dorsal, V: ventral, M: medial.

were similar to previous reports (Canon et al., 1995; Reef, 1998; Freeman, 2003; Colin et al., 2005 and Barton, 2011).

However, the wall thickness variations obtained in the current study were lower that of previous study (Freeman, 2003), where it was reported that wall thickness varies with the degree of gastric distention but is usually less than 0.75 cm. Barton (2011) also reported that stomach has the thickest wall measuring roughly 7 mm and if the stomach is empty, wall may be up to 1 cm thick. The difference regarding the ultrasonographic imaging of wall thickness in local horses may be possibly attributed to the variations in the body weight/size or breed type. But in mules, the present findings revealed the stomach wall thickness was in agreement with Epstein et al., (2008) who reported the stomach wall thickness in ponies to be 0.431 ± 0.06 cm.

**Duodenum:** The duodenum was found at two locations in slightly oblique transverse plane in the right hemi abdomen of equines i.e. i) ascending duodenum from 11th to 13th ICS in horses and 10th to 13th ICS in mules, at the level of shoulder located between the liver and the right dorsal colon or medial to the liver where it was imaged transversely in short axis and ii) at the level of the ventral right kidney or around the caudal pole of the right kidney and dorsal to the caecum between 16th to 17th ICS and in some cases from 16th ICS to just caudal to the last rib at paralumbar fossa as descending duodenum in horses. Whereas in mules, it was relocated from 15th ICS to just caudal to the last rib at paralumbar fossa.

The duodenum appeared as a small circular loop with a hypoechoic to echogenic wall during peristaltic propulsion of ingesta giving it an oval to round shape, otherwise it appeared flattened (Figure-2.1[a, b]). A completely round duodenum with a centralized star shape was imaged during circular contraction phases and sonographic appearance was created by mucosal invaginations of the duodenum (Figure-2.2[a, b]). This centralized star shape was also previously reported by (Kirkberger et al., 1995). The contents of the duodenum varied from a hyperechoic gas echo to hypoechoic or hyperechoic fluid, mucus or ingesta and sometimes a fluid pattern containing multiple echogenic specks. The frequency of contractions of the duodenum was recorded as 5-6 contractions/minute in fed animals, 2-3 contractions/minute when fasted for 12 hrs without holding drinking water and
The duodenal wall thickness was recorded as 2.0 in horses (Figure-2.3[a, b]), however, in mules it varied from 1.8 to 2.0. whereas Barton, (2011) reported that wall thickness of the duodenum was less than 4mm. Our findings were almost similar to previous reports (Kirkberger et al. 1995; Reef, 1998 and Freeman, 2002). However, these variations regarding ultrasonographic imaging of wall thickness in local horses and mules may be possibly attributed to body weight/size, breed type, and/or hybrid (interspecies variation) nature of mules. Our findings regarding the wall thickness of duodenum of mules were in agreement with the study of Epstein et al. (2008) in which the duodenal wall thickness in ponies was found to be 0.188 ± 0.033 cm.

**Jejunum:** The jejunum was found from 12th(±1) to 17th ICS caudal to the spleen (Figure-3.1[a, b]), dorsal to left dorsal colon, ventral to descending colon, in the mid flank and left inguinal area in both horses as well as mules. In some animals, it was found that interposed gas filled large colon made it hard to visualize jejunum unless a peristaltic wave generates transient expansion of the lumen from the movement of fluid contents but in most of the animals, the jejunum was found in left mid flank ventral to the descending colon. Similar finding was reported by Barton, (2011) who reported that it is difficult to visualize the small intestine in normal horses unless a peristaltic wave causes moderate expansion of the lumen. Jejunum was more visible in fasted horses but with decreased activity. This increase in visibility may have occurred due to emptying of colon. Similar findings were reported by Colin et al., (2005). On ultrasonography, jejunum appeared as small circular to triangular loops with no sacculations and contents were predominantly fluidy, which varied in echogenicity depending upon the amount of fluid, ingesta and gas (Figure-4.1[a, b]). Similar findings were reported by Desrocher, (2005) who reported that small intestine appears as small tubular or circular loops, which lack sacculations, having frequent contractions and wall thickness measures less than 0.3 cm. In the present study, fluid was seen as hypoechoic, ingesta as echogenic producing a heterogeneous pattern with mixed fluid and particulate.
**Fig 2.3(a, b):** Ultrasonogram of descending duodenum (Mule) at 16\(^{th}\) ICS. The image was obtained with linear transducer at 5.3 MHz at a depth of 6.5 cm (zoom view). D: dorsal, V: ventral, M: medial.

**Fig 3.1(a, b):** Ultrasonogram of jejunal loops (Horse) at 12\(^{th}\) ICS. The image was obtained with linear transducer at 10.0 MHz at a depth of 6.5 cm. ICM: intercostal muscles, D: dorsal, V: ventral, M: medial.

**Fig 4.1(a, b):** Ultrasonogram of jejunal loops (Horse) at 14\(^{th}\) ICS. The image was obtained with linear transducer at 10.0 MHz at a depth of 6.5 cm. ICM: intercostal muscles, D: dorsal, V: ventral, M: medial.
matter often visible without acoustic shadowing (Fig-4.2[a, b]) and gas as hyperechoic with acoustic shadowing.

It has been (Freeman, 2002) reported that intestinal wall comprises of five layers, serosa, muscularis, submucosa, mucosa and mucosal gas interface and this five layered ultrasonographic appearance is present throughout small and large intestines of horse, except for ileum which has seven layered appearance due to additional muscle layer, but these findings are evident only during in vitro (water bath) studies and concluded that in vivo these features are difficult to identify. In present study, this five layered ultrasonographic appearance was appreciated in vivo, however it was difficult to differentiate between submucosa and mucosa but rest of the layers were appreciable (Fig-4.3[a, b]).

Fig 4.2(a, b): Ultrasoundogram of jejunal loops (Mule) at left inguinal region. The image was obtained with linear transducer at 7.3 MHz at a depth of 6.5 cm. Cr: cranial, Cd: caudal, M: medial.

Fig 4.3(a, b): Ultrasoundogram of jejunal loop (Mule) at left mid flank region showing the various muscle layers of wall of jejunum. The image was obtained with linear transducer at 7.3 MHz at a depth of 6.5 cm.

Fig 4.4(a, b): Ultrasoundogram of jejunal loop (Horse) at 9th ICS showing the wall thickness. The image was obtained with linear transducer at 10.0 MHz at a depth of 10 cm. LDC: left dorsal colon, D: dorsal, V: ventral, M: medial.
It was also observed that jejunum had the most visible motility than any other part of the gastrointestinal tract, with peristaltic waves producing rhythmic contractions of about 5-15 contractions/minute and fasting adversely decreases the motility of the intestine up to 4 contractions/minute. The fluid content of lumen enabled distinction of wall thickness and visualization of distal wall in either its long or short axis. Wall thickness of the jejunum varied from 2-2.2 mm, whereas, in mules it varied from 2-2.1 mm (Fig-4.4[a, b]). Epstein et. al., (2008) reported the mean wall thickness of jejunum in ponies as 0.195 ± 0.03 cm. Our findings with regards to jejunum were in agreement with the other studies (Reef, 1998; Freeman, 2002 and Barton, 2011) except for the wall thickness which varied from the normal published values (Freeman, 2002, Barton, 2011). However, Freeman, (2002) reported that due to variation in size of horses the wall thickness of the intestine could potentially vary accordingly. So this could be the reason for the variation in the wall thickness of jejunum.

CONCLUSION

Based on the sonographic evaluation of the abdomen of equids, the surgeon/clinician can be able to differentiate the true and false colic, which will help in accurate diagnosis and formulation of a precise and efficient therapeutic plan.

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