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Topographic, sonographic and applied anatomy of the left side of the horse`s abdomen

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ABSTRACT

This study was conducted to define the position of various abdominal viscera with respect to concerning the abdominal wall, guided by bony and cartilaginous prominences including ribs, lumbar transverse processes, costal arch and tuber coxae to precisely identify the location where ultrasound can be used to determine the normal anatomical structure of the internal organs, as a standard to detect abnormalities and deviation accompanying the pathological conditions. Our findings showed that the stomach lies caudal to the diaphragm and liver, between the 9th and 15th intercostal spaces. Ultrasonographically, the stomach can be obtained by placing the probe between 8th and 14th intercostal spaces in the dorsal third of the abdominal wall in an oblique line extending cranioventrally from the vertebral end of the 15th rib, making an angle of 45° with the dorsal midline. The spleen is attached to the stomach by the gastrosplenic ligament. The base of the spleen can be easily probed immediately ventral to the last 3 thoracic vertebral in the last 3 intercostal spaces. The rest of the spleen can be traced from the base cranioventral till reaching the apex of the spleen at the middle of the 11th intercostal Space. The jejunum (Mobile part of the small intestine) contacts the left abdominal wall at an Area bounded dorsally by the caudal border of the spleen, ventrally by the left dorsal colon between the 13th and 16th ribs. The left ventral colon extends caudally from the sternal flexure opposite to 6th Intercostal space till the pelvic inlet. The left dorsal colon is located dorsal to the left ventral Colon. The left dorsal colon has only a single tenia and one row of sacculation, so it has a smooth appearance sonographically. The descending colon (Small Colon) contacts the left abdominal wall at an area bounded dorsally by base of spleen and Left kidney ventrally by costochondral junction of last 3 ribs, cranially by the 16th rib and caudally, occupying the left flank to the level of coxal tuber and pelvic inlet.

1. INTRODUCTION

The horse has been an essential animal throughout human history, serving roles in transportation, agriculture, sport, and therapy (Rutledge, 2021). Today, its value extends beyond work, as horses are integral to the horse industry and veterinary research.

Their use in performance and breeding programs highlights the importance of maintaining their health, particularly gastrointestinal function, which is vital for their well- being and performance (Hill, 2012).

The gastrointestinal system in horses plays a critical role due to the horse's status as a non-ruminant herbivores with a complex and sensitive digestive tract-particularly the large hindgut, is highly susceptible to gastrointestinal disorders such as colic, impactions, and displacements. These conditions can rapidly become life-threatening. (Snyder and Higgins, 2006). Understanding the structure, function, and relation of abdominal organs to the abdominal wall is therefore essential for advancing surgical techniques and improving clinical outcomes in horse practice (Budras *et al.,* 2009). The abdominal cavity houses not only the digestive organs but also other key structures like the liver, spleen, pancreas, kidneys, and portions of the reproductive tract. Their interactions contribute significantly to systemic homeostasis, including detoxification, immune modulation, and hormonal regulation (Barrelet and Ricketts, 2002). Disruption of this balance, even mildly, can lead to cascading physiological effects that impact performance, reproductive efficiency, and recovery from illness (Hillyer *et al.,* 2001). Owing to its long mesentery, the jejunal coils can be found in many parts of the abdominal cavity. Most of them (the jejunal coils) reside near the left flank, ventral to the pelvic inlet and to the left of the cecum (Budras *et al.,* 2009).

Ultrasonography was emphasized as a crucial diagnostic tool for gastrointestinal disorders in horses. Allows for the visualization of intestinal motility, wall thickness, fluid accumulation, and gas patterns-factor (Busoni *et al,*2010) that are vital in diagnosing conditions such as colic, intestinal obstruction, strangulation, and displacement (Farag. F,2018). Examination of the abdomen from the most ventral location shows jejunal intussusception and ileocecal intussusception in most horses (Reef, 2001). Advanced imaging has improved the understanding of abdominal pathology and enabled earlier detection and intervention (Tietje and Mosing, 2015). Preventive strategies-centered around diet, hydration, exercise, and stress reduction-are now widely recommended by veterinarians and equine scientists as key to maintaining digestive and abdominal health (Kaneene *et al.,* 1997).

This work aims to determine the position of various abdominal viscera concerning the abdominal wall, guided by bony cartilaginous prominences, including ribs, lumbar transverse processes, costal arch, and tuber coxae, to precisely identify the location where ultrasound can be used to determine the normal anatomical structure of the internal organs.

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2. MATERIAL AND METHODS

2.1. Ethical approval

All procedures were conducted following the Guide for the Care and Use of Laboratory Animals. Ethical approval was granted by the Scientific Research Committee, Faculty of Veterinary Medicine, Benha University, Egypt (Approval No. BUFVT M 31-09-25).

2.2. Sample collection

Twenty-seven adult, apparently healthy native horses of weight ranging from 350 - 400 Kg were used in this work. For gross anatomical investigation, 10 adult horses (6 males and 4 females) were anesthetized by chloroform inhalation, then bled to death by 2cm longitudinal incision in the right or left common carotid artery. After that 10% formalin solution was injected, the specimens were left for a week for fixation, then the abdomen was thoroughly dissected, and the position of the abdominal viscera related to the left abdominal wall was accurately determined.

2.3. Anatomical examination

Two adult native living horses (1 male and 1 female) were painted on their left side using non-harmful, temporary watercolors to clarify the accurate position of the abdominal viscera related to the left abdominal wall inside-out.

2.4. Ultrasonographic examination

Fifteen adult native horses (8 non-pregnant females and 7 males) were subjected to ultrasonography using Sonoscape E1V to describe the sonographic anatomy of the horse viscera related to the left abdominal wall. **Sonoscope E1V:** Portable ultrasound diagnostic system is a new generation of black and white product from sonoscope, packed with professional veterinary work.

3. RESULTS

The abdominal viscera related to the left abdominal wall include the stomach (fundus and body), spleen (parietal surface), liver (left lateral lobe), left kidney, jejunum, ascending colon (left ventral and left dorsal parts), and descending (small) colon.

3.1. Stomach

The stomach is the most dilated part of the alimentary tract present between the esophagus and duodenum. The stomach presents two surfaces: Parietal and visceral, two openings: cardia and pylorus, two curvatures: greater and lesser, and three parts: fundus, body, and pyloric part.

The parietal and visceral surfaces are convex. The parietal surface is directed craniodorsally and to the left. The visceral surface is directed caudo-ventrally and to the right. The cardia is located to the left of the median plane, while the pylorus lies to the right of the median plane. Both the cardia and pylorus have a sphincter; the pyloric sphincter is marked externally by the pyloric constriction. The lesser curvature is the concave dorsal border. It extends from the cardia to the pylorus. It presents in its middle a depression (incisura angularis), which is the deepest point of the lesser curvature. The greater curvature is the ventral convex border. It extends from the cardia, extends dorsally forming with the abdominal part of the esophagus a deep cardiac notch, then the greater curvature overlies the extensive fundus (sacus cecus ventriculi), Fig. (2\10). Then crosses the median plane from left to right, then ascends to the end of the pylorus. The fundus of the horse's stomach is an extensive blind sac. It is the part above and to the left of the cardia. The body of the horse's stomach is the part of the stomach from the level of the cardia to the level of the angular notch. The pyloric part of the horse's stomach is the part to the right of the median plane. It consists of a wide proximal part (pyloric antrum) and a distal narrow part (pyloric canal).

The stomach of the horse is J-shaped. It is fixed in position by several ligaments:

gastro-splenic to the spleen Fig. (2\3)., gastro-phrenic to the diaphragm, gastro-pancreatic to the pancreas, lesser omentum to the porto hepatis of the liver and greater omentum to the transverse colon. It lies caudal to the diaphragm and liver between 9th To 15th intercostal spaces. Fig. (1\2, 3\2). Ultrasonographically, the stomach can be obtained by placing the probe between 9th and 15th intercostal spaces in the dorsal third of the abdominal wall in an oblique line extending cranioventrally from the vertebral end of the 15th rib, making an angle of 45 ° with the dorsal midline, which appears hyperechoic curve linear appearance Fig. (4/2).

3.2. Spleen

The spleen is triangular in shape, and it is fixed to the stomach by the gastrosplenic ligament. It has 2 surfaces: parietal and visceral, 2 borders: cranial and caudal, a base, and an apex. The base of the spleen lies dorsally opposite to the last three intercostal spaces. The apex lies ventrally opposite to the middle of 11th rib. So the spleen was identified as a triangular organ that extends from its dorsally-located base at the uppermost of the last three intercostal spaces to its ventrally-situated apex at the level of the middle of the 11th rib. It was characterized by a homogenous and echogenic appearance. Figs. (1/3, 2/4 and 3/3). The visceral surface is related to the greater curvature of the stomach to which is connected by the gastro-splenic ligament Fig. (2/4). The spleen can be easily probed immediately ventral to the last 3 thoracic vertebral in the last 3 intercostal spaces. The rest of the spleen can be traced from the base cranioventrad till reaching the apex of the spleen at the middle of the 11th intercostal space. It appears most homogenous and echogenic of abdominal organs with a hyperechoic capsule Figs. (4/3 and 5/3).

3.3. Duodenum

The duodenum is the first part of the small intestine. It extends from the pylorus to the duodeno-jejunal flexure. The duodenum of the horse consists of the cranial part, the descending duodenum, and the ascending duodenum. The cranial part of the duodenum presents an ampulla duodeni, which describes a slight S-shaped curve on the visceral surface of the liver, which forms a duodenal impression on the latter organ. The cranial part of the duodenum is connected to the porta hepatis of the liver by the hepato-duodenal ligament (a part of the lesser omentum). The descending duodenum continues from the cranial duodenal flexure caudally towards the right kidney, where it inclines medially, forming the caudal duodenal flexure. The latter crosses the median plane from right to left to be continued by the ascending duodenum. The ascending duodenum passes cranially to the left of the median plane. It`s connected to the descending colon by the duodeno-colic ligament. Sudden elongation of the very short mesoduodenum allows the formation of the duodeno-jejunal flexure and the onset of the jejunum.

3.4. The Jejunum

The jejunum is very long. It forms several jejunal coils. It has long mesojejunum hence it is known as the mobile part of small intestine, due to its long mesentery, the position of jejunum is variable, but mostly near left flank and pelvic inlet, it contacts the left abdominal wall at an area bounded

dorsally by caudal border of spleen ventrally by left dorsal colon between the 13th and 16th ribs Fig. (1/6, 3/4), The jejunum usually found empty of food, hence it is named jejunum. It has a thinner wall, wider lumen than the ileum, and a longer mesentery than the duodenum, which ultrasonographically appear as small tubular structures with hypoechoic walls and heterogeneous echogenic fluid Fig. (1/5).

3.5. Left ventral colon

The left ventral part of the ascending colon Fig (1/5 and 2/6) begins just after the ventral diaphragmatic (sternal) flexure opposite to the 6th Intercostal space. It proceeds caudally on the abdominal floor towards the pelvic inlet, where it turns dorsally, forming the pelvic flexure, to be continued by the left dorsal part of the ascending colon. It has four bands of taeniae and four rows of sacculation. It is connected to the left dorsal part by the intercolic ligament.

Ultrasonographically, the left ventral colon is obtained from the 13th to 17th Intercostal space and the ventral part of the left flank Fig. (5/2).

3.6. Left dorsal colon

The left dorsal colon (1/4 and 2/5) is located dorsal to the left ventral colon. It begins at the pelvic flexure opposite to the pelvic inlet and extends cranially to the diaphragmatic flexure opposite to the 6th intercostal space. It is related dorsally to the body of the stomach, jejunum, and visceral surface and caudal border of the spleen. Its caudal 1/3 is related laterally to the descending colon.

The left dorsal colon has only one tenia and one row of sacculation, so it gives a smooth appearance. Ultrasonographically, the left dorsal colon is obtained from the 13th to 16th intercostal Spaces.

3.7. transverse colon

The transverse colon is short. It extends from the right colic flexure to the left colic flexure. It crosses the median plane transversely from right to left in front of the root of the mesentery and cranial mesenteric artery. It lies at the level of the last thoracic vertebra.

3.8. descending colon

The descending colon extends from the left colic flexure, where it is preceded by the transverse colon, to the pelvic inlet, where it is succeeded by the rectum. The descending colon (Small Colon) has 2 tenia and 2 rows of sacculation. It has a smaller diameter than the ascending colon, hence usually named the small colon. It contacts the left abdominal wall at an area bounded dorsally by the base of the spleen and left kidney, ventrally by the costochondral junction of the last 3 ribs, cranially by the 16th rib, and caudally, occupying the left flank to the level of the coxal tuber and pelvic inlet Fig. (1/7, 2/7).

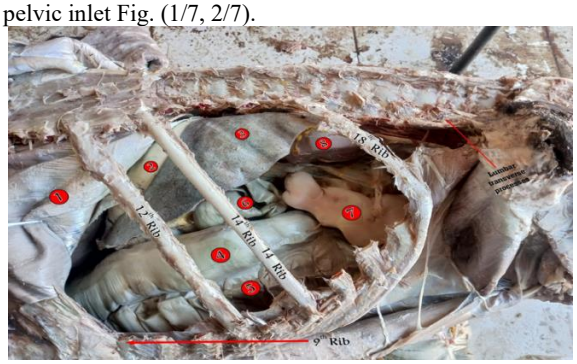

Fig. (1). A photograph of left side horse's abdomen showing the abdominal viscera. 1.Diaphragm (Reflected), 2.Stomach, 3.Spleen, 4.Left dorsal colon, 5.Left ventral colon, 6.Small intestine, 7.Descending colon, 8.Left Kidney.

Fig. (2). A photograph of left side horse's abdomen showing the intrathoracic abdominal viscera. 1.Diaphragm (Reflected), 2. Body of Stomach (Corpus ventriculi), 3.Gastro Splenic Ligament, 4.Spleen (Parietal surface),5.Left Dorsal Colon, 6.Left Ventral Colon, 7.Descending Colon, 8.Liver (Left Lateral Lobe), 9.Left Kidney, 10.Sacus Cecus Ventriruli (Extended Fundus).

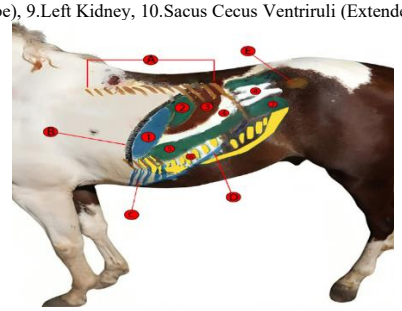

Fig. (3). A photograph of a colored horse showing the surface anatomy of the left side of the horse abdomen. Ribs (from 6th to 18th Inclusive) (A), Most cranial extension of diaphragm (B), Costal cartilage of sternal ribs (C), Costal arch (D), Coxal tuber (E). 1.Liver, 2. Stomach, 3. Spleen, 4. Jejunum, 5. Left dorsal part of ascending colon, 6. Left ventral part of ascending colon, 7.Pelvic Flexure.

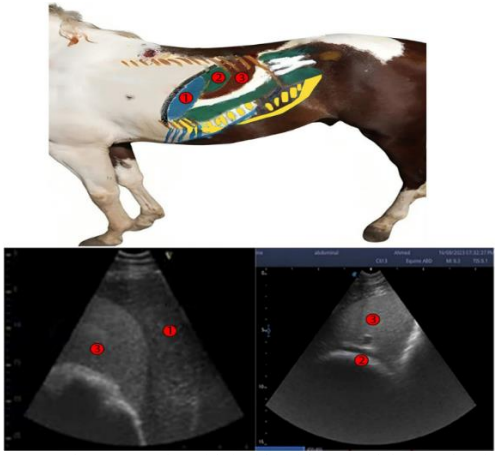

Fig. (4). An ultrasonography of left side of horse's abdomen showing the position of probe and the echogenicity of some left side viscera.1.Liver, 2. Stomach, 3. Spleen.

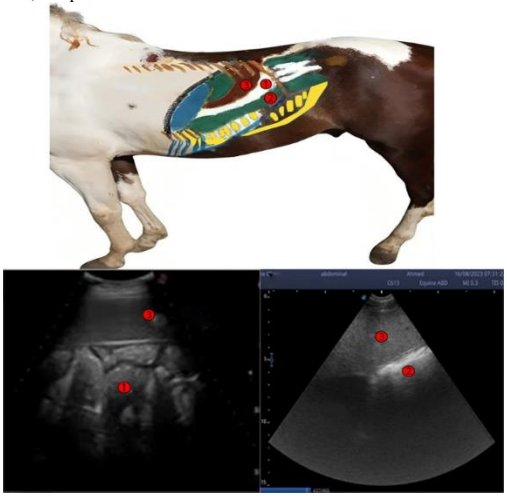

Fig. (5). An ultrasonography of left side of horse's abdomen showing the position of probe and the echogenicity of some left side viscera.1.Small intestine, 2. Left dorsal colon, 3. Spleen.

4. DISCUSSION

The present study provides detailed anatomical and ultrasonographic observations of the Horse's abdominal viscera with particular emphasis on the positioning of the stomach, spleen, small intestine, left ventral colon, left dorsal colon, and descending colon, which came in agreement with Ashdown and done (2011). The anatomical relationships observed in this study were consistent with previous descriptions, but ultrasonographic imaging offered a valuable, non-invasive approach for confirming the organ positions and evaluating their normal appearance, which agreed with Dingboom (2002).

The stomach was located caudal to the diaphragm, extending between the 9th and 15th intercostal spaces. This observation is consistent with the findings of Rantanen and McKinnon (1998), and confirmed by Reef ((2001), who emphasized the visibility of the stomach between the 8th and 13th intercostal spaces during ultrasonography. The latter author added that the stomach appeared sonographically as a curved hyperechoic line, aiding in its identification.

Our findings showed that the spleen was identified as a triangular organ that extends from its dorsally-located base at the uppermost of the last three intercostal spaces to its ventrally-situated apex at the level of the middle of the 11^{th} rib, and it was characterized by a homogenous and echogenic appearance, consistent with (Barton,2011). This topographic and imaging clarity makes the spleen an ideal reference point for identifying surrounding structures, which was similar to that of Smith et al. (1999).

The jejunum, a mobile part of the small intestine, was located between the 13^{th} and 16^{th} ribs. It was bordered dorsally by the caudal margin of the spleen and ventrally by the left dorsal colon, which agreed with Green (2006). our results showed that the jejunal coils lie near to the left flank and close to the pelvic inlet, a finding which agrees with (Budras et al., 2009). In the same respect, Konig and Liebich (2004) who mentioned that most of the jejunum is found within the left dorsal part of the abdomen. On ultrasound, it appeared as a tubular structure with hypoechoic walls and heterogeneous fluid content.

The left ventral colon extended caudally from the sternal flexure to the pelvic inlet, while the left dorsal colon lay dorsal to it, which agreed with Dyce et al. (2010). The dorsal colon had a single tenia and smooth surface, in contrast to the sacculated left ventral colon, which was similar to that of Clayton et al. (2005). These features could be differentiated sonographically, especially from the 13^{th} to 17^{th} intercostal spaces. Consistent with (Farag, F. 2018).

The descending (Small) colon extended from the transverse colon to the rectum, visible in the left flank, caudal to the 16^{th} rib. These findings align with those of Alsafy *et al*. (2013). Overall, the ultrasonographic appearance and anatomical location of left-sided organs were consistent with existing literature. This precise mapping of the left abdomen provides a critical reference for diagnosing gastrointestinal conditions like displacements, impactions, and inflammatory lesions. The integration of sonography with anatomical landmarks proves essential in guiding clinical evaluation and therapeutic intervention.

5. CONCLUSIONS

The study of the left side of the horse's abdomen revealed a more complex arrangement of soft tissue structures, including the stomach, spleen, jejunum, left colon segments, and descending colon. Each organ demonstrated consistent anatomical positioning and clear ultrasonographic features, making this side particularly accessible for non-invasive diagnostic evaluation.

In conclusion, the left side of the abdomen offers a favorable window for evaluating gastrointestinal segments critical in colic diagnostics. The clear visualization of multiple organs supports the value of sonography as a frontline diagnostic tool in horse practice.

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