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Topographic, sonographic and applied anatomy of the right 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 the abdominal wall, guided by bony and cartilaginous prominences including ribs, lumbar transverse processes, costal arch and tuber coxae, as well as to precisely identify the location where ultrasound can be used to determine the normal anatomical structure of the internal organs.as astandard to detect abnormalities and deviation accompanying pathological conditions. The present work proved that, the cecum consists of abase which liesin the right flank and extends Craniad to the level 13th rib. The body of the cecum is directed craniomedially to allow the right ventral colon to make contact with costalarch while the apex ends in 11th intercostal space. Ultrasonographically the right flank occupying the base of cecum which has asacculated Appearance the right ventral colon follows the right costal arch to the diaphragm it extends between the 6th and 15th ribs. Ultrasonographically can be obtained by placing probe between the 11th and 14th intercostal space, the Right dorsol colon can be obtained by placing probe on the middle third of abdominal wall between 10th to 14th intercostal space. The right lobe of the liver extends from the 8th to the 17th rib and can be observed Ultrasongraphically by placing the probe in the dorsal third of right abdominal wall.

1. INTRODUCTION

The horse (*Equus caballus*) has long been an essential partner in various human endeavors, including transportation, agriculture, sport, military service, and therapy. Today, horses hold both economic and emotional value, contributing to a thriving equine industry that prioritizes their health and performance (Rutledge, 2021). In this context, veterinary medicine has increasingly focused on maintaining optimal organ function, especially within the gastrointestinal tract, which plays a central role in overall equine health (Hill, 2012).

As a non-ruminant herbivore, the horse possesses a monogastric stomach and a highly developed hindgut, particularly the cecum and colon, where microbial fermentation of fibrous plant material takes place. While this anatomical adaptation supports efficient digestion, it also predisposes horses to gastrointestinal disorders such as colic, impactions, displacements, and volvulus (Snyder and Higgins, 2006). Colic remains one of the most frequent and potentially life-threatening emergencies in equine practice (Clayton et al., 2005), emphasizing the need for precise anatomical knowledge and timely clinical intervention.

The abdominal cavity houses not only the digestive tract but also organs such as the liver, kidneys, spleen, and reproductive structures, all of which interact to maintain systemic homeostasis (Barrelet and Ricketts, 2002). Any disruption in their structure or positioning can result in significant health issues, including poor performance, infertility, or prolonged recovery (Hillyer et al., 2001).

In recent years, ultrasonography has become an indispensable diagnostic tool, offering real-time, non-invasive evaluation of internal organs. It enables assessment of features like wall thickness, luminal contents, motility, and abnormal gas or fluid accumulation (Busoni et al., 2010). This is especially valuable when examining right-sided abdominal organs, such as the cecum and ascending colon, which are commonly affected in conditions like cecal impaction and colonic displacement (Reef, 2001; Farag, 2018). Imaging techniques like ultrasound and CT have greatly advanced anatomical understanding and improved early diagnosis and surgical outcomes (Tietje and Mosing, 2015).

Despite these advancements, there is still a need for standardized anatomical mapping relative to consistent external landmarks—such as ribs, costal arch, lumbar transverse processes, and tuber coxae—to improve diagnostic accuracy and reproducibility between clinicians.

The aim of this study is to define the normal position of key abdominal organs in healthy horses using both anatomical dissection and ultrasonographic imaging, with special focus on the cecum, ascending colon (right ventral and dorsal parts), and liver. By correlating these findings with external reference points, this work seeks to enhance clinical ultrasonography protocols and provide a practical guide for equine practitioners.

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. BUFVTM 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

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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 at their right side using non harmful, temporary water colors to clarify the accurate position of the abdominal viscera related to the right abdominal wall inside-out.

2.4. Ultrasonographic examination

Fifteen adult native horses (8 non pregnant female and 7 males) were subjected to ultra sonography using Sonoscape e1v to descripe sonographic anatomy of the horse viscera related to right 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 right abdominal wall include the cecum, liver and ascending colon.

3.1. Cecum

The cecum in the horse is a large, comma-shaped blind sac that plays a critical role in hindgut fermentation. It is anatomically divided into a base, body, and apex. The base of the cecum occupies the right paralumbar fossa, positioned in the right flank region, and extends cranially up to the level of the 13th rib, as shown in Figures (1/3 and 2/3). This location makes it one of the most accessible parts of the gastrointestinal tract for both clinical examination and imaging.

The body of the cecum continues from the base and is directed cranio-medially, which allows it to lie adjacent to and in close contact with the costal arch. This orientation facilitates anatomical communication and interaction with other components of the large intestine, particularly the right ventral colon, as illustrated in Figures (1/4 and 2/4).

The apex of the cecum tapers and curves ventrally and slightly medially, ending approximately at the level of the 11th intercostal space. This position varies slightly depending on the fullness of the cecum and the overall condition of the gastrointestinal tract.

From a diagnostic imaging perspective, ultrasonographic visualization of the cecum is most reliably achieved by placing the ultrasound probe on the right paralumbar area, specifically at the level of the 13th rib. In sonographic images, the cecal wall typically appears hypoechoic (dark gray) due to its muscular structure. The gas content within the cecal lumen causes acoustic shadowing, which prevents the transmission of ultrasound waves and creates dark zones beneath gas-filled areas. Furthermore, the cecal wall often appears sacculated, reflecting its segmented external surface and the internal arrangement of haustra, as demonstrated in Figure (3/1).

3.2. Ascending colon

The ascending colon of the horse is a complex and spacious portion of the large intestine that is subdivided into multiple distinct parts, two of which—the right ventral colon and the right dorsal colon—are located on the right side of the abdominal cavity.

The right ventral colon begins in close continuity with the cecum and runs cranioventrally, following the curvature of the right costal arch toward the diaphragm. It extends longitudinally from approximately the 6th to the 15th ribs, occupying a substantial portion of the right ventrolateral abdominal wall. Anatomically, it is connected to the lateral band of the cecum via the cecocolic ligament, a fibrous structure that provides both mechanical support and positional stability to these adjacent intestinal segments (see Figures 1/7, 2/7, and 8).

From an ultrasonographic perspective, the right ventral colon can be effectively imaged by placing the ultrasound probe between the 11th and 14th intercostal spaces on the right side. In this location, the large diameter and gas content within the colon may lead to acoustic shadowing, especially when the colon is filled with gas or ingesta. The wall of the right ventral colon often shows a sacculated appearance, although it may be less prominent than in the cecum.

The right dorsal colon, in contrast, lies dorsally to the right ventral colon, occupying a position closer to the middle third of the right abdominal wall. It can be visualized sonographically by placing the probe between the 10th and 14th intercostal spaces. Unlike the ventral colon, the right dorsal colon appears more homogenous and hypoechoic (dark) on ultrasound. Its wall typically lacks sacculations and appears smooth, which is a useful distinguishing feature during imaging (see Figure 3/3). The presence of gas within its lumen may also result in acoustic shadowing, limiting deeper visualization.

Together, these findings provide essential landmarks for clinical assessment of large intestinal health, particularly in cases of suspected colonic displacement, impaction, or tympany.

3.3. Liver

The liver in the horse is a vital organ with important metabolic and detoxification functions. It is predominantly located on the right side of the abdominal cavity, with the right lobe being the most prominent and accessible portion for ultrasonographic examination.

Anatomically, the right lobe of the liver extends from the 8th to the 17th rib, occupying the dorsocranial quadrant of the right abdomen (see Figures ½ and 2/1). It lies cranial and medial to the cecum and colon, and ventral to the diaphragm. Because of this positioning, only the right lobe is reliably visualized during routine ultrasound examination, as the left lobe is mostly shielded by the lungs and stomach.

Ultrasonographic examination of the liver is best performed by placing the ultrasound probe in the dorsal third of the right abdominal wall, particularly between the 10th and 15th intercostal spaces. In this region, the liver can be observed beneath the diaphragm, just cranial to the right dorsal colon. The hepatic tissue appears with homogeneous echotexture and is typically moderately echogenic, which means it reflects ultrasound waves to produce a medium-gray appearance on the screen (see Figure 3/2). The echogenicity may vary slightly depending on the machine settings and the condition of the liver.

Although the liver usually has a smooth surface and uniform texture, abnormalities such as hepatic lipidosis, abscesses, or fibrosis can alter its appearance and echogenicity. It is important to note that the lung field partially overlaps the liver cranially, so respiratory movements may interfere with image stability during scanning. Identifying clear liver margins and distinguishing it from the adjacent diaphragm and lung interface are essential skills in equine ultrasonography.

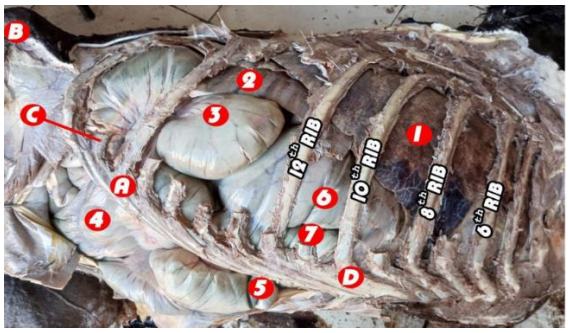

Fig. (1). A photograph of right side horse's abdomen showing the abdominal viscera. A.Costal Arch, B.Tuber Coxae, C.Last Rib, D.Costal Cartilage of 10th rib, 1.Lung (Right Lobe), 2.Liver (Right Lobe), 3.Base of Cecum, 4.Body of Cecum, 5.Apex of Cecum, 6.Right Dorsal Colon, 7. Right Ventral colon.

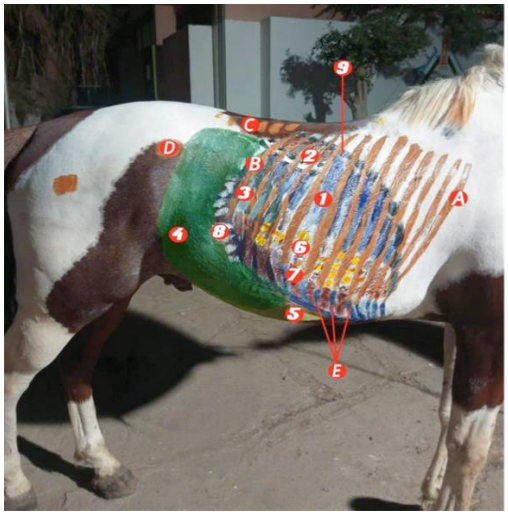

Fig. (2). A photograph of colored horse showing the surface anatomy of the right side of the horse's abdomen.A.6th Rib, B.18th Rib, C.Lumbar Transverse process, D.Tuber Coxae, E.Costal Cartilages, 1.Liver, 2.Right Kidney, 3.Base of Cecum, 4.Body of Cecum, 5.Apex of Cecum, 6.Right Dorsal Colon, 7.Right Ventral Colon, 8.Cecocolic Ligament.

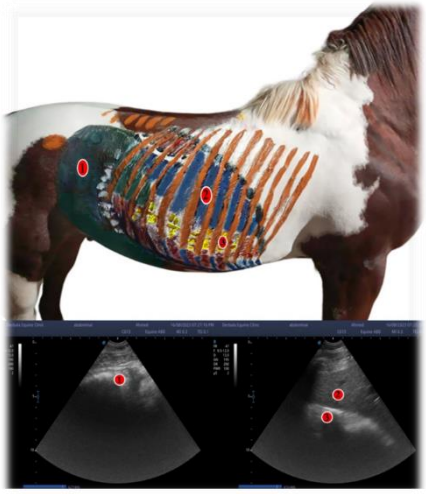

Fig. (3). ultrasonography of right side of horse`s abdomen showing the position of probe and the echogenisty of some right side viscera.1.Cecum, 2.Liver, 3.Right Dorsal Colon.

4. DISCUSSION

The findings of the present study provide a significant contribution to equine abdominal imaging by integrating detailed anatomical dissection with ultrasonographic evaluation of key right-sided abdominal organs specifically the cecum, right ventral and dorsal colon, and liver. This dual approach not only enhances the understanding of organ positioning and echogenic characteristics in clinically normal horses but also affirms the reliability of ultrasonography as a practical diagnostic tool in equine practice which agreement with (Ashdown and done , 2011)

The anatomical positioning of the cecum, as extending from the 13th to the 18th rib within the right paralumbar fossa, is in agreement with classic anatomical texts (Dyce et al., 2010). Ultrasonographically, its hypoechoic, sacculated appearance and acoustic shadowing are consistent with previous descriptions (Reef, B, 2001), underscoring the consistent imaging patterns that can be used to confirm its location and assess its health. This is particularly relevant for conditions such as cecal tympany or impaction, where early recognition of structural or functional changes can significantly influence prognosis and treatment outcomes.

The right ventral colon ,observed between the 6th and 15th intercostal spaces, followed the curvature of the costal arch and displayed sacculations and a relatively thin wall which agrees with (Budras et al ,2009). In the same respect (Konig and Liebich, 2004) .These features correspond to those described by (Barton ,2011) reinforcing the reproducibility of its ultrasonographic characteristics. The ability to visualize these features non-invasively contributes to a more accurate evaluation of gastrointestinal motility and structural integrity in live animals, reducing the reliance on more invasive diagnostic methods.

In contrast, the right dorsal colon ,situated dorsally between the 10th and 14th intercostal spaces, lacked sacculations and had a thicker wall with more homogeneous echogenicity which agreement with (Green, 2006). These findings support previous anatomical frameworks and align with (Siwinska et al. 2017), who recommended beginning right dorsal colon imaging at the 9th intercostal space. The difference in ultrasonographic appearance between the right ventral colon and right dorsal colon is a critical diagnostic feature, aiding in the differentiation of these adjacent structures, especially during suspected colonic displacements or impactions. Given the common incidence of large colon volvulus and right dorsal colitis in horses, such clear anatomical and ultrasonographic distinctions are highly clinically relevant.

The liver, primarily its right lobe, was visualized between the 8th and 17th ribs, occupying the dorsal third of the right abdominal wall. This positioning, while generally consistent with earlier anatomical texts, shows some discrepancy with authors who reported the liver between the 6th and 12th intercostal spaces (Dyce et al. 2010), a variance possibly due to individual differences or the influence of gastric distension, as noted by some authors. Despite this, the liver's dorsal location and homogenous echotexture made it a reliable sonographic landmark, particularly when evaluating the spatial relationships between hepatic and gastrointestinal structures.

This variability in liver positioning emphasizes the need for individualized imaging protocols and highlights the value of integrating sonographic findings with clinical examination and case history. Furthermore, the distinct echogenic signature of the liver aids in differentiating it from adjacent viscera and pathological structures such as abscesses or neoplastic masses.

From a clinical perspective, the ability to accurately identify these organs and their relative positions using ultrasonography is indispensable in emergency and routine veterinary settings. Conditions such as cecal impaction, colonic displacement, and hepatic disease can often present

with overlapping clinical signs; thus, precise imaging becomes crucial for differential diagnosis and monitoring therapeutic responses. The findings also reinforce the importance of a systematic ultrasonographic scanning technique, beginning from known anatomical landmarks and progressing through the intercostal spaces, to maximize diagnostic yield and minimize operator error. which agreement with (Farag, 2018)

Importantly, the integration of anatomical and ultrasonographic data serves as a foundation for future studies involving pathological cases. This is particularly relevant in the development of diagnostic protocols for acute abdominal syndromes, which continue to pose diagnostic and therapeutic challenges in equine medicine. The characterization of normal sonographic anatomy in this study establishes a reference standard against which abnormal findings can be compared, thereby improving diagnostic confidence and clinical outcomes. Which agreement with (Hillyer et al. , 2001)

Furthermore, the educational implications of this work should not be understated. For veterinary students and equine practitioners alike, understanding the interplay between anatomical knowledge and imaging interpretation enhances the accuracy and speed of diagnosis. The correlation between physical structures and their sonographic appearance not only deepens anatomical understanding but also fosters more effective clinical decision this observison is consistent with the finding of (Rantanen and McKinnon, 1998)

In conclusion, the present study validates the utility of ultrasonography as a reliable and non-invasive modality for evaluating the cecum, right colon, and liver in horses. The close agreement between anatomical and sonographic observations confirms the method's accuracy in depicting organ topography and morphology These findings align with (Alsafy *et al*. , 2013). These findings enhance our ability to diagnose right-sided abdominal disorders and serve as a valuable reference for both clinical and educational applications. Future research should build upon this foundation by including pathological cases and exploring dynamic changes over time, which would further refine ultrasonographic diagnostics and potentially lead to improved prognostic tools in equine gastrointestinal medicine.

5. CONCLUSIONS

This study highlighted the topographic and ultrasonographic features of the right equine abdomen, with emphasis on the cecum, ascending colon, and liver.

The cecum, consistently located in the right paralumbar fossa, extended cranially to the 11th intercostal space. Its sacculated wall and strong gas shadowing provided a reliable landmark for ultrasonography, particularly in the evaluation of cecal impaction or tympany.

The ascending colon was divided into: The right ventral colon, following the costal arch, characterized by sacculations and a thin wall. The right dorsal colon, extending from the 10th to 14th ribs, with a smooth, thicker wall and uniform echogenicity. This distinction is clinically relevant for diagnosing large colon displacement or torsion.

The liver, extending from the 8th to 17th ribs in the dorsal third of the abdominal wall, was consistently identified despite rib coverage, serving as a key reference in the ultrasonographic evaluation of hepatic disorders.

Recommended scanning sequence involves:

Starting at the paralumbar fossa to identify the cecum then, tracing the ventral and dorsal colonic segments along the costal arch and rib spaces.Completing the exam dorsally over the 8th–17th intercostal spaces to evaluate the liver.

Overall, the use of external landmarks (ribs, costal arch, tuber coxae, lumbar transverse processes) ensures a systematic and reproducible ultrasonographic approach, enhancing diagnostic accuracy in equine abdominal disorders.

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