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Is a transabdominal ultrasonographic examination of the equine stomach prior to gastroscopy a reliable method of predicting whether the stomach is empty?

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Summary: Up to now, there is no standard protocol to prepare a horse for gastroscopy. Therefore, the aim of the study was to evaluate whether ultrasound examination prior to gastroscopy provides reliable results regarding gastric filling. The study included two groups. Group 1 consisted of 73 horses presented to the Equine Clinic Destedt GmbH for evaluation of a gastrointestinal problem. Group 2 included ten clinically healthy horses from the Institute of Animal Nutrition, Nutrition Diseases and Dietetics of the Faculty of Veterinary Medicine at the University of Leipzig, Germany. These ten horses were examined four times each, at three-week intervals, to determine intraindividual differences after a 12-hour fasting period and possible filling states of the stomach. Transabdominal ultrasonography was performed on the left side of each horse after approximately 12 hours of fasting, directly prior to gastroscopy. Depending on the appearance of the gastric silhouette, a prognosis was made regarding the filling state of the stomach. The prognosis: "empty" was made when the gastric silhouette was wrinkled or the stomach was not visible in its typical intercostal spaces and adjacent structures as small and large intestine, omentum and spleen took its place instead. In case of liquid filling, the assessment was made depending on the amount of liquid. In case of a small amount of liquid, the stomach was considered empty, and in case of a large amount, it was considered not empty. In case of a dome-shaped stomach at sonography, the prognosis was "not emptied". The size of the stomach was determined by counting intercostal spaces where the stomach was visible at ultrasonography. Gastroscopy was used to determine whether the stomach was empty or not. The stomach was declared empty if small and large curvature, margo plicatus, pyloric antrum and pylorus could be visualised properly. In group 1, a total of 73 horses were examined and the prognosis made by ultrasound examination prior to gastroscopy was correct in 95% of the cases. In group 2, a total of 10 horses were examined four times, three weeks apart. In 39 out of 40 examinations the prediction made was correct (97.5%). In addition, the size of the stomach was determined by counting the intercostal spaces, where the stomach could be displayed in ultrasonography. The non-displayable stomach was counted with zero intercostal spaces. Although the difference between empty and non-empty stomachs does not seem great, a stomach that is more than 4 intercostal spaces in size may be an indication of a stomach that is not completely empty. In conclusion ultrasound could be an effective tool to assess the filling status of the stomach before gastroscopy and to improve the results of gastroscopy.

Keywords: stomach, equine, horses, gastroscopy, ultrasonography, stomach emptying, stomach size, stomach content

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Introduction

Disorders of the gastrointestinal tract are one of the most common health issues in horses. Among digestive tract disorders, gastric ulceration in both squamous and glandular mucosa is a frequent condition in horses (*Murray* et al. 1989, *Murray* and *Eichorn* 1996, *Sykes* and *Jokisalo* 2014). Gastroscopy is the method of choice and the gold standard for the diagnosis of gastric lesions (*Sykes* et al. 2015). Residual feed in the stomach and feed sticking to the stomach wall limits the quality of the gastroscopic examination, as even a small amount of residual feed can make it difficult to enter and visualize the pyloric antrum properly (*Sykes* and *Jokisalo* 2014). Given the particularly high prevalence of up to 58% erosions or ulcers located in the antrum or pylorus (*Murray* et al. 2001), it is evident how important a completely empty stomach is. In order to achieve a complete emptying of the stomach, the duration of feed withdrawal is of great importance, but the fasting period prior to gastroscopy varies greatly in literature with as much as six up to 23 hours of feed restriction (*Murray* et al. 2001, *Gehlen* et al. 2019, *Heller* et al. 2022). *Sykes* and *Jokisalo* (2014) suggested that the adequate duration of fasting depends on the horse's use and diet. With such a large variation in time and individual differences in gastric emptying, it is difficult to establish a standard protocol for preparing a horse for gastroscopy. Therefore, it would be of great practical use to have a reliable, non-invasive method to determine whether the stomach is sufficiently empty prior to gastroscopy.

The hypothesis of this study was that the sonographic examination of the horse's stomach immediately before gastroscopy could provide reliable information about the stomach filling. Transcutaneous ultrasound examination prior to gastroscopy was chosen as it is a non-invasive procedure that can be performed with little effort and without the need of sedating the horse.

Materials and methods

Animals

The study population consisted of two groups of horses. Group 1 comprised a total number of 73 horses (37 geldings and 36 mares) of different breeds (62 Warmblood horses, 1 Haflinger, 2 Icelandic horses, 1 Frisian horse, 1 Pura Raza Española, 3 Quarter horses, 1 Rhenish German Coldblood, 1 German Riding Pony and 1 donkey) that were referred to the Equine Clinic Destedt GmbH for further investigation of gastrointestinal problems. The average age was twelve years (range 5–25 years). 53 of those horses starved overnight in the clinic for 12 hours with a muzzle and water was not withheld. 20 horses were either ambulant patients in the clinic or gastroscopy was performed at their stable. Therefore, these horses starved at home and the fasting time was set to 12 hours but could not be monitored by the authors.

Group 2 consisted of 10 Warmblood geldings, aged 8 to 24 years, belonging to the Institute of Animal Nutrition, Nutrition Diseases and Dietetics of the Faculty of Veterinary Medicine at the University of Leipzig, Germany. These horses were each examined four times at intervals of three weeks to detect intraindividual differences and repeatability of the examination. Each horse in this group starved in an empty box and water was withheld in the last two hours before the gastroscopic examination. All experimental procedures were approved by the Leipzig District Government (No. TVV 45/18).

Study design

This is a prospective study including patients presented to the clinic (group 1, n = 73, horses with gastrointestinal problems) and experimental horses engaged in a feeding trial (group 2, n = 10, control group). Each horse was examined by transabdominal sonography immediately before gastroscopy (first examination). Gastroscopy was performed to investigate the gastrointestinal disorders of the patients (group 1) or to investigate the status of the stomach mucosa in the feeding trial horses (group 2). The stomach was characterized as empty when there were no feed residuals and all structures, including the pylorus and antrum, could be visualized and evaluated properly.

In addition, the horses whose stomachs were not empty in the first examination were examined again after further fasting for four hours, followed by another sonographic examination and gastroscopy. This resulted in two and in some cases in three repeated examinations.

Ultrasound technique

An Esaote® MyLabTM Delta with a 3.5-MHz convex probe was used for the transabdominal ultrasound examination of the equine stomach in the starved state just before gastroscopy. To ensure adequate contact of the transducer, the left thoracic wall of the horse was prepared with 90% isopropyl alcohol using a spray bottle. Although the quality of the image suffered in adipose horses and horses with very thick and long hair, the hair was not clipped as using alcohol provided sufficient image quality. The viewing depth was set to 20–25 cm. Beginning in the 17th intercostal space and continuing cranially, each intercostal space on the left thoracic wall was scanned from dorsal to ventral. To follow the intercostal spaces the transducer was orientated slightly obliquely and transversely to the horse's trunk, and the dorsal part of the body was on the left side on the screen. The stomach wall was identified as a curvilinear hypoechogenic to echogenic line with a hyperechogenic gas echo caused by areas of different acoustic densities, which arises at the interface between mucosa and gastric lumen (*Barton* and *Henry Barton* 2011, *Glatzel* and *Berg* 2011, *Reef* 2012) adjacent to the spleen. The appearance of the hypoechogenic line and possible filling of the stomach were used to predict if the stomach was empty or not. In case of stomach filling, the type of chyme was described based on the ultrasound image as liquid or feed. If the stomach was empty, adjacent structures such as small and large intestine, omentum and spleen were identified in the intercostal spaces, where stomach is usually seen. In addition, the dimension of the stomach was determined by counting the intercostal spaces where the hypoechogenic line of the stomach was visible.

Gastroscopy

Immediately before the gastroscopic examination, the horses were sedated with butorphanol (Torbugesic® 10 mg/ml, Zoetis; 0.025 mg/kg bodyweight (bw) i.v.) and with detomidine (Detogesic® 10 mg/ml, Zoetis; 0.01 to 0.02 mg/kg bw i.v.) or with xylazine (Xylavet® 20 mg/ml, CP-Pharma; 0.6 to 1 mg/kg bw i.v.). After applying a nose twitch to the upper lip of the horse, a nasogastric tube of 1 m length was inserted into the proximal oesophagus to prevent the gastroscope from potential damage. The stomach was examined with a 3 m flexible video endoscope 60130 PKS/NKS (Karl Storz GmbH & Co. KG, Tuttlingen). Air was insufflated until the folds in the mucosal lining of the stomach disappeared.

Data analysis

Data were analyzed using descriptive methods. Data such as stomach size were reported as medians with 1st and 3rd percentile (25th and 75th percentiles) using Microsoft® office Excel.

Results

Dimension of the stomach in horses after 12 hours of fasting

The size of all horses' stomachs was noted after 12 hours of fasting by counting the number of intercostal spaces in which

the hypoechogenic line of the stomach wall was visualized at ultrasound examination immediately before gastroscopy. When the stomach wall could not be visualized at ultrasonography the dimension was set to zero.

Group 1

In group 1 including 73 horses, the median expansion of the stomach was one intercostal space (25th percentile = 0; 75th percentile = 3) (Figure 1). The median size of the stomachs that were validated as empty at gastroscopy (n = 57) was one intercostal space (25th percentile = 0; 75th percentile = 2) (Figure 1). The biggest dimension in a stomach that was empty was four intercostal spaces. Compared to that, the median size of the 16 stomachs that were not empty at gastroscopy, was three intercostal spaces (25th percentile = 2; 75th percentile = 6.25). Eight intercostal spaces were the dimension of the largest stomach that was not emptied (Figure 1). As shown above, 16 empty and one not emptied stomachs could not be visualized at ultrasound examination and were counted with zero intercostal spaces.

In the horses of group 1 with an empty stomach, the most cranial intercostal space, where the stomach could be displayed, was the 7th intercostal space and the most caudal intercostal space was the 12th. The most cranial intercostal space in horses of group 1 with a "not emptied stomach" was the 7th intercostal space and the most caudal one was the 17th.

Group 2

In 10 horses that were examined four times (group 2), the median of ten stomachs in four examinations measured by intercostal spaces was zero intercostal spaces (25th percentile = 0; 75th percentile = 2). Four intercostal spaces were the largest dimension of an empty stomach in group 1. One out of 40 stomachs was not empty at ultrasonography and was visible in two intercostal spaces (Figure 2).

Sonographic evaluation of gastric filling in group 1

In group 1, a total of 73 horses were examined. In 57 (78.1%) of 73 horses, the stomach was expected to be empty by ultrasound examination and gastroscopy confirmed the expectation. Four (5.5%) out of 73 stomachs were declared empty after ultrasound examination, but gastroscopy revealed that the stomachs could not be examined completely. 12 (16.4%) out of 73 stomachs were expected not emptied and the result not emptied was verified by gastroscopy.

In total, the prediction made with ultrasound was correct in 69 out of 73 (95%) cases and false in four out of 73 (5%) cases. That resulted in a validity of 95% for predicting the filling of the stomach of 73 patients (group 1) by ultrasound examination.

11 of the 16 horses, whose stomachs were not empty at gastroscopy at the first examination, were examined a second time after another four hours of feed deprivation. Seven (64%) out of 11 stomachs were expected to be empty by ultrasound examination. This was confirmed by gastroscopy in all seven cases (100%). Four (36%) were expected not to be emptied and this was confirmed by gastroscopy in all four cases (100%). As four horses still did not have an empty stomach, three out of four horses were examined a third time. One horse was expected and confirmed empty, and two horses were expected and confirmed not emptied.

In total, 11 horses were examined 14 times which led to a 100% accuracy of prediction in the second and third examination.

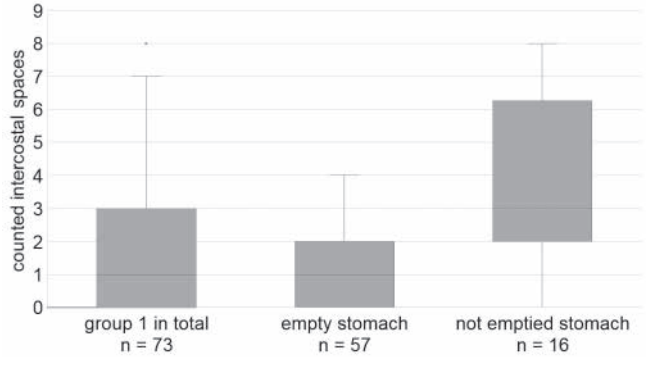

Fig. 1 Size of the stomachs in group 1 (n=73) after 12 hours of fasting measured by counting the intercostal spaces, where the stomach was visualized at sonography; the line in the boxplot represents the median, the limits of the boxplots represent the 25th and 75th percentile, min and max are included as the end of the line above or below the boxplot, dots represent statistical outliers. | *Magengröße in Gruppe 1 (n=73) nach 12-stündiger Fastendauer, die Anhand des Zählens der Interkostalräume, in welchen der Magen ultrasonografisch darstellbar war, festgestellt wurde. Die Linie in der Kastengrafik repräsentiert den Median, die Begrenzungen stellen das 25. und 75. Perzentil dar. Minimum und Maximum sind als Linie über beziehungsweise unter der Kastengrafik dargestellt, Punkte repräsentieren statistische Ausreißer.*

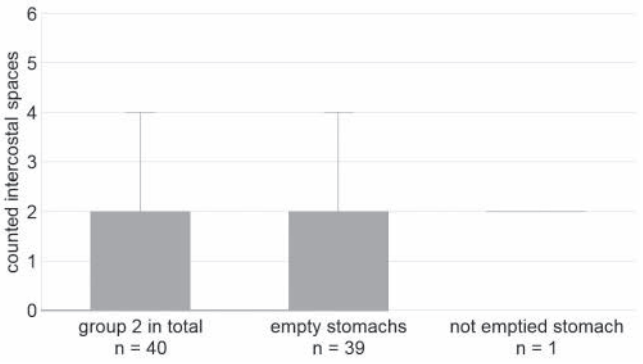

Fig. 2 Size of the stomachs in group 2 (10 horses, four repetitions: n=40) after 12 hours of fasting, measured by counting the intercostal spaces where the stomach was visualized at ultrasonography; the line in the boxplot represents the median, the limits of the boxplots represent the 25th and 75th percentile, min and max are included as the end of the line above or below the boxplot, dots represent statistical outliers. | *Magengröße in Gruppe 2 (10 Pferde, vier Wiederholungen: n=40) nach 12-stündiger Fastendauer, die anhand des Zählens der Interkostalräume, in welchen der Magen ultrasonografisch darstellbar war, festgestellt wurde. Die Linie in der Kastengrafik repräsentiert den Median, die Begrenzungen stellen das 25. und 75. Perzentil dar. Minimum und Maximum sind als Linie über beziehungsweise unter der Kastengrafik dargestellt, Punkte repräsentieren statistische Ausreißer.*

Sonographic evaluation of gastric filling in group 2

In group 2, a total of 10 horses were examined four times three weeks apart. In all 40 examinations the stomachs were expected to be empty after sonography. In 39 out of 40 cases the follow-up gastroscopy confirmed an empty stomach. In 1 case, the gastroscopy revealed a stomach that could not be examined in total, due to fecal ingestion. In total, the prediction made with ultrasound was correct in 39 (97.5%) and wrong in 1 out of 40 (2.5%) cases. That results in a validity of 97.5% for predicting the filling of the stomachs in group 2 by ultrasound examination.

Stomach silhouette in ultrasound after 12 hours of feed deprivation (group 1)

Depending on the appearance of the gastric silhouette in the ultrasound examination, the stomach was considered empty or not. The gastric contour was differentiated by ultrasound examination in 4 different conformations: (1) wrinkels, (2) domeshaped, (3) fluid-filled or (4) not visible.

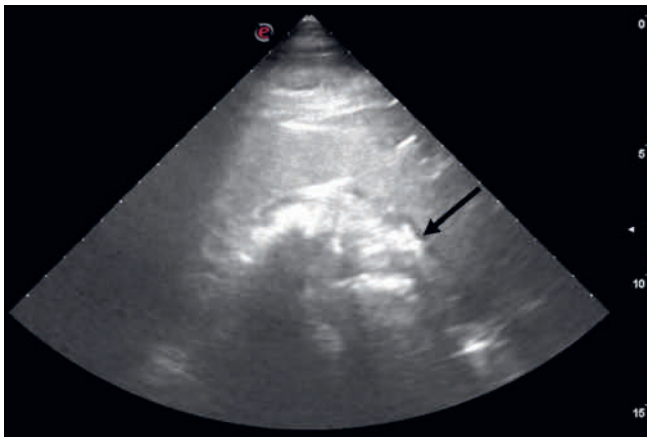

Fig. 3 Ultrasound image of a wrinkled stomach wall (the arrow points to the hypoechogenic line of the stomach wall). | *Ultraschallbild einer in Falten liegenden Magenwand (der Pfeil zeigt auf die hypoechogene Linie der Magenwand).*

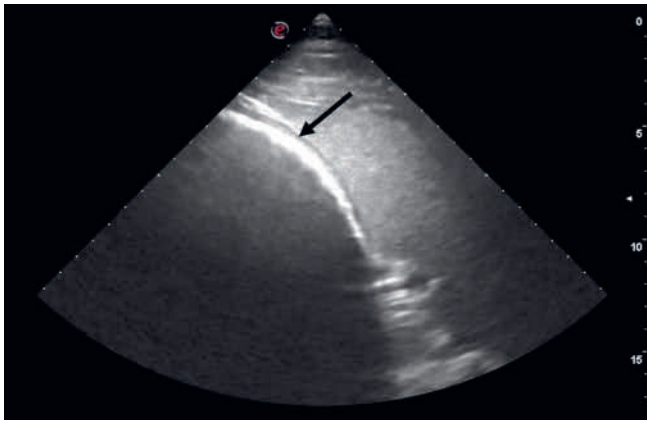

Fig. 5 Ultrasound image of a dome-shaped stomach wall (arrow: hypoechogenic line of the stomach wall, adjacent stomach content is hyperechoic and prevents further penetration of the ultrasound beam). | *Ultraschallbild einer kuppelförmigen Magenwand (Pfeil: hypoechogene Linie der Magenwand, der Mageninhalt ist hyperechogen, was zur Schallauslöschung führt).*

In group 1, a total of 73 horses were examined. In 38 horses (52%), the gastric silhouette lay in wrinkles which led to the expectation of an empty stomach. In 10 horses (14%), the gastric silhouette was dome-shaped, in that case the expectation was "not emptied". 8 horses (11%) had a stomach with liquid content. In this case, the prediction depended on the amount of fluid seen in ultrasound examination. The stomach was expected to be empty in another 17 cases (23%) when the stomach silhouette could not be displayed.

Wrinkled gastric silhouette

In 38 horses out of 73 horses in group 1, the stomach wall lay in wrinkles (Figure 3) at ultrasound examination leading to the expectation of an empty stomach. In 35 out of those 38 horses (92%), the gastroscopy confirmed that the stomach was empty. The stomach of 3 horses (8%) was not completely emptied and could therefore not be examined completely by gastroscopy. Two horses that were considered to have an empty stomach at sonographic examination had feed residues in the fundus of the stomach, which prevented visualization of the pylorus and py-

Fig. 4 Gastroscopic image of a stomach with food adherent to the mucosa (sonographically wrinkled). | *Gastroskopisches Bild eines Magens, an dessen Schleimhaut Futterreste kleben. Das Ultraschallbild zeigt eine in Falten liegende Magenwand.*

Fig. 6 Gastroscopic image of a stomach filled with ball shaped food, that presents as dome-shaped in ultrasound. | *Gastroskopisches Bild eines Magens gefüllt mit kugelförmigem Futter, der sich im Ultraschall kuppelförmig zeigt.*

loric antrum at gastroscopy. Feed particles sticking to the stomach wall of the glandular region of the greater curvature in one horse (Figure 4) prevented complete gastroscopic examination.

Dome-shaped gastric silhouette

A dome-shaped hypoechogenic line (Figure 5) was detected at transabdominal ultrasound examination before gastroscopy in 10 out of the 73 horses in group 1. Gastroscopy confirmed in all 10 cases (100%) that the stomach was not empty. In two horses, the fundus was filled with feed residues obscuring the pylorus and antrum and in eight horses gastroscopy revealed a solid ball shaped filling of the stomach (Figure 6).

Stomach with liquid content

In eight horses ultrasound examination revealed a stomach with different amount of liquid content (Figure 7). The decision, whether the stomach was empty or not, was made considering the amount of fluid that was visible at sonography and especially the ultrasonographic appearance of the stomach silhouette. When the gastric wall lay in wrinkles and a small amount of liquid was visualized, the stomach was considered empty. In case of a dome-shaped stomach wall filled with liquids, the stomach was considered as not emptied.

In six out of eight cases, the stomach was declared empty as only a small amount of fluid was visible at ultrasonography. The other two of these eight cases were declared as not empty at sonography due to a higher amount of liquid. Gastroscopy confirmed the expectation in all eight cases (100%) to be correct. It revealed that in those two horses' stomach liquid prevented complete examination of the pylorus and antrum pyloricum (Figure 8).

No stomach silhouette detectable at sonography

The stomachs of 17 horses were declared empty because the hypoechogenic line of the stomach wall and the hyperechogenic line shadowing gas echo originating from the gastric mucosa could not be visualized at ultrasonography. In 16 out of 17 cases, the gastroscopy confirmed an empty stomach, in one case the gastroscopy revealed a solid ball shaped filling as in Figure 6. Overall, this led to a correct prediction based on sonographic findings in 95% (69 out of 73 horses) (table 1).

Stomach silhouette in ultrasound after 12 hours of feed deprivation (group 2)

Group 2 included a total of 10 horses that were examined four times in three week intervals.

Wrinkled stomach silhouette

In 17 out of 40 examinations (42.5%), the stomach wall lay in wrinkles and was expected to be empty. The follow up gastroscopy confirmed in 16 out of 17 cases that the stomach was empty. In one case at gastroscopy the gastric wall was covered in ingested feces that stuck to the mucosa and could not be rinsed away with water. In consequence, the gastric mucosa could not be evaluated in total and this stomach was flushed by nasogastric tube with six liters of water. Feed and water were deprived for another 1.5 hours with a muzzle. Afterwards, the stomach was empty in ultrasound and confirmed empty by gastroscopy.

No stomach silhouette detectable at sonography

In 23 out of 40 examinations (57.5%), the stomach could not be visualized at sonography and was therefore declared empty. Gastroscopy confirmed this in all 23 cases (100%).

Discussion

Transcutaneous ultrasound examination in horses is a safe, noninvasive diagnostic method and leads to reliable results rapidly with relatively low material effort (*Desrochers* 2005, *Lores* et al. 2007). Nevertheless, the knowledge of an expe-

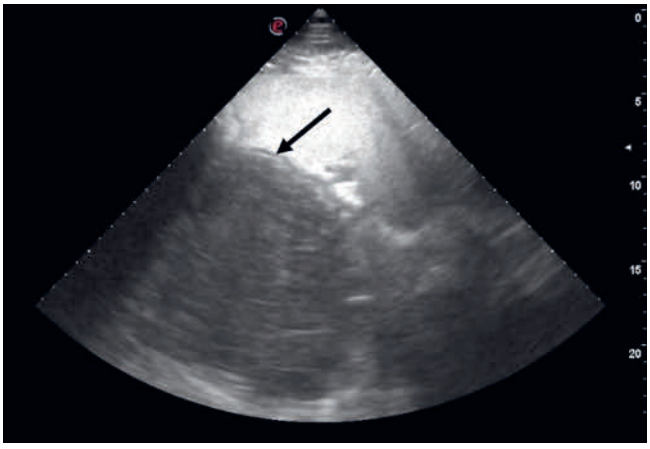

Fig. 7 Ultrasound image of a stomach with fluid content, considered as not emptied, (arrow: hypoechogenic line of the stomach wall). | *Ultraschallbild eines mit Flüssigkeit gefüllten Magens, der als nicht entleert eingestuft wurde (Pfeil: hypoechogene Linie der Magenwand).*

Fig. 8 Gastroscopic image of the small curvature of Figure 7. Despite of air insufflation pylorus and antrum were not visible. | *Gastroskopisches Bild der kleinen Kurvatur aus Abbildung 7, trotz Aufpumpen des Magens mit Luft, sind Pylorus und Antrum pyloricum nicht sichtbar.*

rienced examiner is required for a proper interpretation of the results. In sonography on the left side of the body of the fed horse, the stomach is usually visualized between the 9th and the 12th (*Mitchell* et al. 2005) or 13th intercostal space at approximately at the level of the shoulder (*Barton* and *Henry Barton* 2011). Evaluation of the stomach in a fed state is usually limited to the greater curvature (*Barton* and *Henry Barton* 2011, *Le Jeune* and *Whitcomb* 2014). In the current study, horses were examined with sonography after approximately twelve hours of feed deprivation immediately before gastroscopy. These findings indicate that these horses were scanned in expectation of an empty stomach. To predict the filling state of the stomach prior to gastroscopy, it is helpful to count the intercostal spaces in which the stomach is visible to define the dimension of the stomach. Although the difference might be small, it must be considered that the non-visible stomach in group 1 is counted with zero intercostal spaces. Nevertheless, a stomach exceeding four intercostal spaces in ultrasound examination prior to gastroscopy, is suspected of not being empty. In comparison to the fed condition, where even very large stomachs were completely emptied in some cases after 12 hours of fasting (*Heller* et al. 2022), the size of the stomach in the fasted condition is indeed a finding that allows conclusions to be drawn about the filling condition.

With 92 % of correct prediction of an empty stomach in group 1 and 94 % in group 2, a stomach wall lying in wrinkles was a reliable interpretation of an empty stomach.

In four out of 55 (7 %) stomachs with wrinkled mucosa in sonography, gastroscopy could not be performed properly. In two cases, despite of a wrinkled stomach wall in sonography, residual feed particles that were attached to the glandular mucosa and could not be rinsed away with water limited the value of the ultrasound as gastroscopy could not be performed completely. Since, according to our definition, the stomach was declared empty only when all stomach regions, including the pylorus and antrum, could be assessed, these above mentioned stomachs did not meet the specified requirements of an empty stomach. It was hypothesized that the cause of this condition could be either ingestion of shavings or feces through the muzzle or an insufficient mucus production or mucus of insufficient quality, which interferes with a complete gastric emptying. To prevent horses from feces or shavings intake, horses need to be continuously monitored during their fasting period. In this study horses in group 1 fasted under different conditions than horses in group 2. This should be critically evaluated. For example, part of group 1 fasted in the home stall (20 out of 73 horses), which made veterinary monitoring impossible. In addition, the horses in group 1 were stabled in boxes with their usual bedding material with a muzzle and had free access to water during the entire fasting period. The 10 horses in group 2, on the other hand, were kept in empty stalls during the fasting period and were deprived of water during the last two hours before gastroscopy. This might explain why there was no horse in group 2 that had fluid in the stomach at the time of the examination. Oral ingestion of bedding material is also prevented by keeping the horses in empty stalls prior to gastroscopy, only feces can be ingested under these circumstances. In case of attempts of ingestion of feces or shavings, a fasting period in an empty box with a muzzle should be considered.

The remaining two horses had feed residuals in their stomachs. In one horse, gastroscopy revealed a solid ball shaped filling in the stomach and in the other horse, the fundus was filled with feed. A possible explanation could be that the filling was not big enough to straighten the folds of the mucosa and the gastric wall lying next to the transducer was lying in wrinkles.

Nevertheless, a wrinkled stomach wall in ultrasound is a good reference for predicting whether the stomach is empty or not and was correct in 93 % in total.

In case of a dome-shaped gastric wall, findings can be misleading to predict whether the stomach is filled with gas, liquid or solid content (Figure 5, Figure 9) as the extinction does not

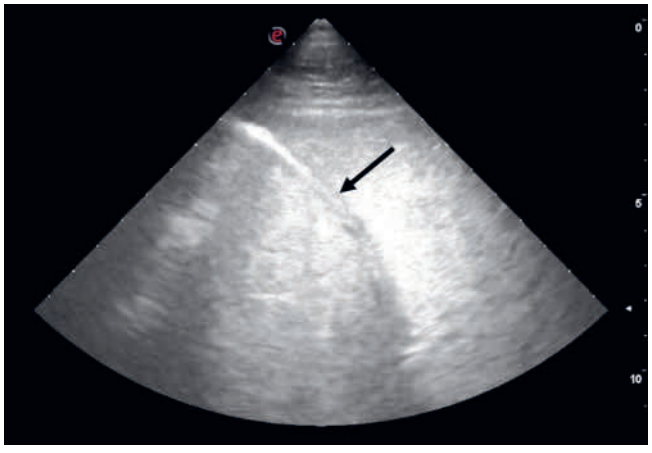

Fig. 9 Dome-shaped line of the gastric wall in ultrasound with an hyperechogenic outer layer (arrow) and an hypoechogenic inner layer. The stomach is filled with gas represented as hypoechogenic air artefacts. | *Ultraschallbild einer kuppelförmigen Magenwand, mit der zweischichtigen Darstellung: äußere Linie ist hyperechogen (Pfeil) und die innere Schicht hypoechogen. Der Magen ist Gas gefüllt, was durch die nach unten strahlende hyperechogene Luftartefakte dargestellt wird.*

Table 1 Conformation of the stomach wall and the prediction whether it would be empty or not and the gastroscopic confirmation (group 1). | *Dargestellte Form der Magenwand und die Vorhersage, ob der Magen leer oder nicht leer sein würde und die gastroskopische Auswertung (Gruppe 1).*

	gastroscopy: empty	gastroscopy: not emptied	total
ultrasound: wrinkled expectation: empty	35	3	38
ultrasound: dome shaped expectation: not emptied	0	10	10
ultrasound: liquid content, small amount expectation: empty	6	0	6
ultrasound: liquid content, high amount expectation: not emptied	0	2	2
ultrasound: not visible expectation: empty	16	1	17
total	57	16	73

always allow a conclusion to be made regarding the contents of the stomach. Nonetheless, in this study, all horses that had a dome-shaped gastric wall were correctly predicted as not empty. In those cases, further gastroscopic examination could be avoided because it would not provide adequate results due to the residual filling of the stomach. Nevertheless, the cause of the incomplete emptying of the stomach should of course be investigated. As gastric impaction or distention might be a reason for insufficient gastric emptying depending on the clinical history of the horse (*Kidd* et al. 2014, *Bäuerlein* et al. 2019). Gastroscopic examination may be performed after further feed deprivation in those horses. Another indicator for the residual gastric filling can be provided by the adjacent structures. As small intestine, spleen, small colon and the left dorsal part of the large colon are pushed caudally in case of a stomach that is distended with feed material, gas or fluid (*Wyse* 1999).

The two horses that had liquid content in their stomachs, that prevented complete gastroscopic examination, might have drunken prior to ultrasonographic examination. Their stomachs were empty after additional two hours of fasting with withdrawal of water.

In horses with acute colic, a stomach distended with fluid can be an indication for reflux (*Klohnen* 2012). Consequently, it is of great importance to recognize liquid in the stomach and to be able to estimate the amount. Therefore, *Bankert* et al. (2019) assessed gastric fluid content in horses with secondary gastric distention sonographically by evaluating the number of intercostal spaces with detectable fluid levels as well as the maximum height of gastric fluid. In the present study, the prediction was made by an experienced examiner (MV) and someone with less experience might need an objective system for prediction. In case of doubt prior to gastroscopy, it would be recommendable to prolong the fasting period with an additional withdrawal of water to avoid unsatisfactory results of gastroscopy.

A non-visible stomach in ultrasound examination was interpreted as an empty stomach. In those cases, adjacent structures as small and large intestine, omentum and spleen were identified in the intercostal spaces where stomach is usually seen. The prediction was right in 94% in group 1 and in 100% in group 2. In one case in group 1, including 73 horses in total and 17 with a non-detectable gastric silhouette, the gastroscopy revealed a solid ball shaped filling of the stomach. This could be due to acoustic shadowing from gas and ingesta within the small and large intestine that prevented visualization of the stomach. These factors represent a limitation of equine gastrointestinal ultrasonography (*Freeman* 2002, *Epstein* et al. 2008). The large intestine is located along most of the lateral and ventral abdominal wall and can move between the transducer and the stomach wall, which is responsible for a non-visible stomach in sonography. In case of an empty stomach, the intestine has more room and can move easily between thoracic wall and the small or empty stomach.

In contrast to the ultrasonographic examination that can be performed without sedation in most horses, sedation is necessary for gastroscopic examination. Even though the procedure is not painful, it is needed to avoid defensive movements, distress of the animal and to guarantee the safety of the examining veterinarian and of the technical devices. No pharmacological intervention is without potential adverse effects, and for sedatives bradycardia and ataxia are major side effects (*Taylor* et al. 1988). It is also well known that sedatives affect the gastrointestinal motor activity. Although xylazine as an alpha 2 agonist is reported to have a mild effect on gastrointestinal tract motility, the rate of gastric emptying decreased significantly (*Doherty* et al. 1999). Butorphanol delays the time of gastric emptying (*Doherty* et al. 1999) and the combination of detomidine and butorphanol delays the gastric emptying rate significantly (*Sutton* et al. 2002), which is in our case an undesired side effect for gastrointestinal examination.

The equine patient undergoing gastroscopic examination usually has an intestinal disorder that makes gastroscopy necessary. *Spanton* et al. (2020) investigated post-gastroscopy colics and reported an infrequent occurrence (2.9%). But nevertheless, insufflation of the stomach can lead to abdominal pain in horses especially in horses with gastric impactions (*Spanton* et al. 2020). To avoid further interventions with intestinal motility, sedation should be reduced to an essential minimum.
In comparison to gastroscopy that requires sedation, ultrasound examination is a non-invasive procedure that, depending on the horses' behavior, can usually be performed without sedation. In addition, the stress of the animal can be reduced, as portable ultrasound devices can also be used in the familiar environment of the animal. With a validity of 95%, a decision according to the ultrasound results can be made whether gastroscopy can be performed or not. As ultrasound examination takes little time and may prevent the horse from an invasive examination that is not conclusive and the examiner from an unsatisfactory result, it should be considered if ultrasound can be included in the clinical routine prior to gastroscopy.

Certainly, in some cases, ultrasound cannot be used to make a definite statement about the state of filling of the horse's stomach, nevertheless the transabdominal ultrasound examination is a reliable technique for predicting if the stomach is empty or not prior to gastroscopy.

Conflict of interest

The authors declare that there are no conflicts of interest.

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