COMPARATIVE STUDY OF THE STOMACH MORPHOLOGY IN RABBIT AND CHINCHILLA

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Abstract

In recent years the use of rabbits and chinchillas as experimental model both in human and veterinary medicine and as pets is gaining ground detriment to the carnivores. Moreover, major human intervention in their diet, leading to the artificiality of a major part of the food, justifies the acquisition of specific morphological knowledge to each organ. Changing the composition of nutrients increases the risk of many digestive disorders, especially digestive organs themselves. The aim of this study is achieving morphological and topographic description of the first important component of post diaphragmatic digestive tract - the stomach.

We used 10 rabbits and 10 chinchillas. The subjects were clinically healthy and of different weights and ages. Gross dissection was perform in all subjects.

In both species the stomach is simple. The transition from the esophageal mucosa to the gastric mucosa is clearly marked. The gastro esophageal sphincter is very visible, placed in the middle of the small curvature. The distal esophageal mucosa has a serrated pattern, making a strong gastro esophageal sphincter. In rabbit, the stomach shows thin walls with well individualized cardia and pilor orifices. The fornix is visible, located dorsal of the cardia orifice. Before the pyloric opening a narrow segment is visible - the pyloric antrum (Antrum pyloricum). The pylorus is mostly compressed by the duodenum and the left lobe of the liver. The gastric mucosa presents itself as a glandular type on its entire surface. At chinchillas, the stomach is oriented transversally and lies mainly caudal to the rib cage, slightly left deviated. The angular notch is sharpest and the dorsal region of the stomach is at the same level with the pylorus. The gastric folds are much more obvious in the stomach body than in the juxtapcardial region.

Both in rabbits and chinchillas, the stomach present numerous similarities regarding the topography, divisions, pattern and relationships with adjacent organs. Significant differences exist in the mucosa, and the presence of an individualized fornix and a well-developed pyloric antrum in rabbits, compared with chinchilla.

Key words: chinchilla, morphology, rabbit, stomach.

INTRODUCTION

The anatomy of digestive tract is widely studied among mammals and well represented in the scientific literature (Barrone, 1976; Brewer and Cruise, 1994; Girling, 2002). In recent years, interest in small animals of various categories has increased, not only as experimental model but also as pets. Growing number of rabbit, guinea pigs and chinchilla which needed medical care is constantly increasing. Under this condition, a good medical care required a proper knowledge of the biology of these animals. Most studies that address the digestive tract of Lagomorphs and Rodents, make a unitary description of gastrointestinal tract, without defining the particularity of each segment (Richardson, 2000; Hristov et al., 2006; Meredith et al., 2002; Davies and Davies, 2003; Brooks, 2004). Moreover, comparative studies are relatively few (Stan et al., 2013), and some aspects neither are nor fully clarified. Given the comparative anatomical investigations of the digestive tract of the two species, it can be said that the level of development of each segment is directly related to the living environment, nutritional and metabolic needs (Cheke, 1994; deBlas and Wieseman, 1997; Pinheiro et al., 2009; Kotze et al., 2010; Stan et al., 2013). Both species are true herbivores, non ruminant, which have a particular type of digestion, so-called hind gut fermentation (Shakagachi, 2003; Brooks, 2004; Quesenberry and Carpenter, 2012). The stomach, the first important post diaphragmatic digestive organ act like a reservoir from which the digestion begins. Located caudal to the visceral liver, its relations with the abdominal organs will be detailed in the following. Equally important are
the differences related to the anatomy of the digestive tract in the two species. Therefore, this research, part of an ongoing study about the anatomy of the digestive tract in the rabbit and chinchilla, wants to make a detailed anatomical description of first important post diaphragmatic segment - the stomach.

MATERIALS AND METHODS

We have used a total of 20 subjects, 10 rabbits and 10 chinchillas of different ages and weights, clinically healthy. Rabbits were brought from private households and chinchillas from a chinchilla’s fur farming. Euthanasia was performed in accordance with current requirements by IV administration of potassium chloride, 2 meq/kg/bw after prior administration of ketamine 10 mg/kg/BW. Using appropriate tools regional gross dissection was performed of each specimen. All subjects were promptly dissected fresh, without fixation. An abdominal incision along the white line was carefully performed, because the abdominal organs were visible immediately after removal of the lateral abdominal wall. Topography of abdominal organs was noted and photographed in situ, followed by removal of visceral peritoneum and ligaments of connection. Total digestive tract was removed; each component was isolated by cutting the mesenteric folds. It was perform a linear incision along the greater curvature to opening the stomach. Gastric content was removed carefully in order to visualize the content and the internal feature. The anatomical differences were noted and photographed.

RESULTS AND DISCUSSIONS

In rabbit, the stomach has a transversal arrangement, continuing the last rib cage, slightly left deviated (Figure 1). Caudally, its projection was made until near the second lumbar vertebra. The stomach was covered by the liver in almost all its anterior region. We note the stomach enclosure by a complete serous coat (the visceral peritoneum), similar in appearance to the membrane covering the body wall, and the extension of this coat into a mesentery for the attachment of the stomach to the dorsal body wall.

Figure 1. Topographical anatomy showing the abdominal organs in situ in rabbit

Displacing the posterolateral portion of the liver forward, we exposed the ventral surface of the stomach, making in this way a better exposure of its contour and divisions. It has a pouch-like shape, with thin walls. Greater curvature (curvatura ventriculi major), located posterior (caudally) have a convex appearance, while the small curvature (curvatura ventricoli minor) was anterior situated (cranial), concave arrangement and slightly contracted (Figure 2).

Figure 2. External configuration of rabbit stomach

The esophagus enters into the stomach via the middle of the small curvature. The cardial orifice is covered by the lesser omentum which makes an attachment fold with the caudal lobe of the liver - hepatogastric ligament, closer by hepatoduodenal ligament. Both of these ligaments are parts of lesser omentum, with their gastric insertion located on the small curvature. Dorsal and to the left of the esophageal entrance, we visualized the presence of a diverticular expansion of background region of the stomach - the fornix.
The body of the stomach was located mostly in the left median plane. We identified the pyloric region, located on the right, with slightly contracted walls making the pyloric antrum well defined. It is compressed by the duodenum and the right hepatic lobe. Raising and turning forward the posterior portion of the stomach, we note on the dorsal surface of the greater curvature, at the left side, a flat elongated body - the spleen. Also, we observed a broad fold of the peritoneum, which makes the link between the dorsal abdominal wall and the diaphragm, with the greater curvature on its dorsal surface. This fold was separated by spleen, and the ventral part of it connects the spleen with the greater curvature - the gastrosplenic ligament. On the greater curvature, the peritoneum duplicates as a free fold, making the greater omentum, which covered the intestines. Ventral of the greater curvature, between the duodenal loop and ileum (Figure 3), we remarked a small report of stomach with the left lobe of the pancreas. We observed that the left kidney was displaced further back than the right, by the posterior expansion of the greater curvature, until the third lumbar vertebra.

![Figure 3. Rabbit postdiaphragmatic digestive tract](image)

At the exit of the stomach, duodenum describes a sharp angle with the visceral face of the liver, being easily compressed by it. Opening the body on the greater curvature we have viewed the internal conformation, especially the longitudinal arrangement of mucosal folds, crossed by small transverse folds that appear connecting the longitudinal ones in some areas. Passing from the esophageal mucosa to the stomach is suddenly done and clearly differentiated. Cardial and pyloric openings were well individualized. Proximal to the cardia, we viewed a rosette (serrated) arrangement of the mucosa. Gastric mucosa color was gray in the fundus of the stomach and pale pink at the pylorus. Rabbit stomach contents fibrous residues and soft, compressible cecotropes. In chinchillas, the stomach was oriented transversely, slightly deviated to the left of the median plane (Figure 4).

![Figure 4. The topography of abdominal organs in chinchilla](image)

The thin, almost transparent gastric walls have not showed a distinct visible transition between the background and the body portion of the stomach. Externally, the stomach was simple (unilocular) and with no divisions. In all studied subjects the fornix was not well-defined, while the background region had an rounded aspect. Also, we have not noticed a clear delimitation of the pyloric antrum. Instead, the angular notch was sharper compared to the rabbits. The attachment elements presented mostly similar to the ones in rabbit. The gastrosplenic ligament passes from the great curvature of the stomach to the spleen hilus. We noticed that the spleen was facing the dorsal part of the stomach, having a large base heading towards the median plane of the greater gastric curvature, and a rounded peek in the left of the great curvature. From the great curvature, the great omentum attaches itself to the transverse colon through the mezoduodenum, thus achieving an indirect link between the stomach and the transverse colon. The gastro-hepatic ligament attaches the small curvature of the stomach to the visceral part of the liver, precisely the right hepatic lobe. The
pylorus orifice was situated at the same level with the dorsal extremity of the stomach (Figure 5).

![Figure 5. Stomach configuration in chinchilla](image)

The left kidney was slightly caudal dislocated by the great curvature, similarly to rabbits. After opening the stomach along the great curvature, we visualized the internal pattern (Figure 6). In the cardia and gastric body region there was a mucosa with well defined longitudinal folds. In the fundus, the gastric wall presented itself thin and lacking of longitudinal folds. Preceding the pyloric sphincter, the walls and the gastric mucosa showed no condensed look as in rabbits. The duodenum leaves the stomach by an small dilatation - ampula duodenalis. The stomach content was represented by fibrous residue and small soft cecotropes covered by a layer of mucus.

![Figure 6. The internal feature of the chinchilla’s stomach](image)

Whereas previously only a few veterinary texts were published about Rodents and Lagomorphs, now there are many books, journals and scientific articles related to these species. However, the majority of these treat the systems together, without describing each component. The gastrointestinal tract is often described starting from oral cavity to the distal colon. Moreover, comparative anatomical studies are relatively scarce (Stan et al., 2013). Both rabbits and chinchillas are truly herbivores, non ruminant, and presenting so-called physiologic particularity - hind gut fermentation (Richardson, 2000; Yildiz et al., 2001; Sagakachi, 2003). The gastrointestinal system is long, relative to body weight (Davies et al., 2003). The largest sizes are of the stomach and cecum, whose content is on average 10% of body weight. The stomach occupied 15% of the gastrointestinal tract as reported by many authors (Brewer et al., 1997; Richardson, 2000). More accurate reporting, using imaging methods, on live rabbits, were performed by Girling, 2002; Daian and Besoluk, 2011, which stated that 11% of the gastrointestinal tract area is occupied by the stomach and 17% of the volume is attributed to the stomach. The stomach's topography, situated transversely, slightly oriented to the left, covered by the visceral side of the liver, is common to both rabbits and chinchillas and similar to other studies (Popesco, 2002; Broks, 2004). In this regard, topographic studies on rabbit abdominal organs reported by Hristov et al., 2006 showed that the gastric body region is disposed between the visceral side of the liver and gallbladder, without being in contact with the abdominal wall. In our study, we have also described the attachment elements between the liver and the stomach by stating the presence of the gastro-hepatic ligament.

Using morphological and morphometric methods to study the abdominal organs in rabbit, Yildiz et al., 2001, have showed that the caudal part of the stomach comes in relation with the transverse colon. We have encountered this aspect much more clearly in chinchillas than in rabbits. By modelling a 3D reconstruction of the rabbit's stomach using computer tomography, Daian and Besoluk, 2011, have showed that the stomach is in contact with the caecum. We can't fully support these claims because we couldn't clearly show this aspect. Indeed, both in rabbits and chinchillas, due to the fact that the caecum is quite voluminous, it seems to be in contact with the stomach at the opening of the abdominal
cavity, but we couldn't observe any direct anatomical connection between these two organs. Differences in topography result here from the methodology used, computer tomography being achieved on live rabbits, while anatomical descriptions are made after dissection.

Stomach morphology is various and differs substantially among rodents, as described by many authors (Girling, 2002; Hristov, 2006; Quesenberry and Carpenter, 2012). The presence of a unilocular glandular stomach, not compartmentalized in rabbits, chinchillas and guinea pigs and the presence of a compartmentalized bilocular or even discoglandular (Carleton, 1973) stomach of other rodents, like New World Cricetine it was reported. The same author has shown that there is a direct link between notch depth and angular orientation and type of stomach examined. The presence of erased angular incisures belongs to a unilocular glandular stomach. In contrast, a sharp angular notch is specific to a bilocular or compartmentalized stomach. Our results are not fully similar to the ones specified above because the sharp angular incisure of the chinchilla's stomach hasn't been correlated with the bilocular stomach. In chinchillas, the stomach was clearly unilocular.

Our study is consistent, with the statements of Langer, 2002, who showed that the species which shows a great diversity of hastra, semilunar valve, great caecum, long colon have a low degree of differentiation of stomach morphology. Also, Boeluner and Crosby, 2009, studying dentition in rabbits, guinea pigs and chinchillas have concluded that the dentition plays an important role in morphological adaptation of the stomach. Elodont, aradicular dentition in rabbit and chinchilla is also an important factor that contributes to the morphological simplicity of the stomach in the two species. These issues are directly related to the particular type of nutrition of rabbits and chinchillas. In a study on a total of 19 species belonging to the order Rodenta, Perrin and Curtis concluded that there is no conclusive evidence of digestive tract morphology correlation with the type of nutrition. Contrary to them, Sakaguchi et al., 2003, showed that the species with hindgut fermentation have developed a digestive tube adapted to this process. Moreover, the author has shown that the coprophagy, present both in rabbits and chinchillas are a rich source of vitamins, amino acids and other nutrients. By studying the content of the stomach, we noticed the presence of cecotropes at all subjects. Another study on the effect of levels of high dietary fiber and low fiber on the performances and health status of growing rabbits, digestibility and caecal fermentation, concluded that the reduction of dietary fibre level increased food digestibility but worsens rabbit grow performances (Pinheiro et al., 2009).

Clear delineation between the esophagus and the stomach mucosa was present in both species. Moreover, the serrated aspect of the gastric mucosa was clearly revealed in the juxtacardial area. This feature, together with the lack of striated muscle in the distal esophagus and the presence of the crural sling-like a cuff surrounding the lower esophagus proximal to the cardia, is specific to rodents and researched by many authors (Brewer, 1994; deBlas et al., 1997; Richardson, 2000; Davies, 2003). All these elements are part of the so-called gastroesophageal barrier which opposes to the act of emesis. In addition, Porter and Balaban, 1997 showed that in rabbits, cats and rodents there are no neural connections between the brain stem nuclei and neither between them and the visceras involved in the act of emesis. Another anatomical feature involved in the impossibility of performing emesis is related to the presence of that fold-margo plicatus (Limiting ridge). It extends circumferentially from the esophagus and lesser curvature level, to the great curvature and back. This fold separates the stomach in two portions: glandular and nonglandular in mice, rats and hamsters (Kotze et al., 2010; Quesenberry and Carpenter, 2012). There are authors (Brewer and Cruise, 1994, Davies et al., 2003), who claim that in rabbits there is a non-glandular region of the stomach in the cardia region.

We did not reveal this pattern in any of the species studied in this research. However, we noticed a slight difference regarding the stomach mucosa in chinchillas. This difference consists in the presence of a well individualized mucosa with well defined longitudinal folds in the body of stomach, and less observable one in
the cardial region. Supporting this hypothesis requires extensive histological studies. Stomach topography in chinchilla and rabbit offers anatomical explanations to the main digestive disorders. In chinchillas, the gastric tympanum is relatively rare compared to rabbits and rodents and is related to gastroenteritis and dysbacteriosis (deBlas, 1997; Quesensbery and Carpenter, 2012). The explanation is related to the absence of diverticular region with possible gas content on the one hand and on the other hand that the pyloric antrum is not so well represented as in rabbits. Moreover the emphasis of a small duodenal ampulla, makes that the liver doesn't compress the pyloric region so hard. In rabbits, the presence of the pyloric antrum and the compression exerted by the right hepatic lobe, correlated with an angled exit of the duodenum from the stomach, and the lack of duodenal ampulla, makes that the gastric distension is more often reported for this species (Cheke, 1994; Brooks, 2004).

In conclusion, by performing a detailed and concise description of the first postdiaphragmatic segment of the digestive tract, in rabbit and chinchilla we provided a substantial support both to researchers and practitioners. The results obtained in this study are further contribution to anatomical science.

REFERENCES
