GASTROINTESTINAL ULTRASONOGRAPHY OF THE DOG

FERENC MANCZUR

Ph.D. Thesis

Department of Internal Medicine
University of Veterinary Science Budapest

1999

ULTRASONOGRAPHY OF THE GASTROINTESTINAL TRACT OF THE DOG

Background and objectives of the thesis

During the last decades, ultrasonography has become an essential diagnostic imaging technique both in human and veterinary medicine. For a long time, the gas containing gastrointestinal (GI) tract was considered more of a hindrance of an abdominal sonographic examination than an organ system that can be assessed by ultrasonography. Nevertheless, with the aid of technical improvement and increased operator experience, it became an accepted diagnostic technique of human GI examinations. Because ultrasonography is an easy-to-use, non-invasive technique without ionizing radiation, it became particularly important in the diagnosis of different prenatal, neonatal and pediatric diseases, however it can replace other, time consuming or invasive

diagnostic techniques even in GI diseases of adults. Besides the possibility to study the GI wall, the lumen and the adjacent organs, real time visualization also allows the operators to observe the peristaltic activity of the GI tract. By the use of different Doppler techniques, the assessment of peristalsis became easier and the examiner is also able to gain information about the vascularization of a given segment of the GI tract. Recently, the combination of endoscopy and ultrasonography in a new diagnostic technique, endosonography, enabled the operators to study both the pathological alterations and the surrounding tissues of the GI tract from the GI lumen.

The first detailed studies on the normal and pathological ultrasonographic appearance of the canine GI tract are dated from the early 90's. The normal ultrasonographic structure and the ultrasonographic alterations of some inflammatory and neoplastic conditions of the canine GI tract had been published, when in 1994, I began my PhD research on the ultrasonography of the canine GI tract. The aim of my Ph.D. study was to investigate the role of

ultrasonography in canine GI diseases. My thesis is a result of five different studies on the above mentioned topic.

1.) Intraluminal gas in the GI tract often hampers the visualization of the abdominal organs. For this reason, the first step in studying the ultrasonographic features of the different organs and thus the GI tract itself, is a waterbath study on isolated specimens. During this studies, the organs are placed into a small container, where their echostructure can be observed without any disturbing artifacts. This method is also suitable, following the surgical or pathological removal of the organs, for the detailed ultrasonographic assessment of the morphological changes caused by various pathological processes. The comparison of the GI lesions observed in vivo by the ultrasound with the in vitro sonographic appearance of these parts following surgical or pathological dissection, can be beneficial to improve the diagnostic accuracy of both the technique and the examiner. Alterations, caused by osmolarity properties of the waterbath medium or by the decaying process of the

organs, however, may prevent further histological examinations. This unwanted effects can be avoided if the organs are fixed in formaldehyde prior to the ultrasound examination. The effect of formaldehyde on the ultrasonographic structure of GI segments is not known to our knowledge. The aim of my first study was to compare the in vitro and in vivo ultrasonographic appearances and wall thickness of the GI tract of the dog and those of isolated GI segments before and after formaldehyde fixation.

2.) A possible way to avoid the disturbing effect of intraluminal gas is to administer fluids into the GI tract. The effect of fluid administration to the stomach on the ultrasonographic image has been described both in human and veterinary medicine, and fluid enema is an essential part of the ultrasonographic examination of the colon in humans. In my second study, I tried the ultrasonographic adaptation of three radiographic contrast techniques on healthy dogs using various fluids as contrast materials. The objective of this study was to assess the effect of fluid administration to the stomach for a small bowel follow through study, of the

enteroclysis technique, and of the reflux examination on the quality of ultrasonographic images of the GI tract in healthy dogs.

3.) The second most common cause why dog owners bring their animals to a veterinarian is GI disease. These animals often vomit and/or have diarrhea. These signs are generally caused by some self limiting, milder disease of the GI tract, but many potentially lethal diseases also cause the same clinical signs. One of the most frequent severe disorder of the GI tract is GI obstruction. Ileus, dilation of the intestines and ceasing of intestinal passage, can be caused by mechanical and functional problems. The correct diagnosis is essential for the successful treatment, because mechanical obstruction generally require surgical intervention, while functional or paralytic ileus can be generally treated without surgery. The differentiation between the two condition is not easy and provides a challenge for even the most experienced veterinarians. The diagnosis is traditionally based on the physical findings and proven by plain film radiography. If the physical and radiographic findings are equivocal, repeated films are taken, following the

administration of a radiographic contrast material. Radiographic contrast techniques are time consuming methods and do not always provide a definitive diagnosis. In this latter case, diagnostic laparotomy remains as the only possibility to achieve the final diagnosis, which often unnecessarily increases the costs and risks of the treatment. The aim of my third study was to investigate, whether ultrasonography is suitable for the diagnosis of intestinal obstruction of the dog. In this study, I tried to establish new ultrasonographic criteria to diagnose this disorder in the dog.

4.) In my fourth study, I continued the assessment of the newly established ultrasonographic criteria for diagnosing intestinal obstruction of the dog. I also intended to investigate how ultrasonography can be integrated into the diagnostic process of canine intestinal obstruction. Human clinical studies found ultrasonography to be a useful diagnostic technique in the differential diagnosis of different forms of ileus. A prospective study regarded ultrasonography to be as sensitive and more specific than plain film radiography in the diagnosis of bowel obstruction of humans. Others

reported the sensitivity of ultrasonography higher than conventional radiography in diagnosing small bowel obstruction and strangulation. Similar comparative studies have not been reported in veterinary medicine. The objective of my fourth study was to compare the diagnostic value of ultrasonography with that of plain film radiography in canine intestinal obstruction.

5.) Changes in the thickness and/or structure of the GI wall, in the diameter and content of the lumen, and in the peristalsis are consistent ultrasonographic features of gastrointestinal disorders. The observed ultrasonographic changes have been reported in certain gastrointestinal disorders of the dog. These observed ultrasonographic alterations, however, have not been assessed on a large number of clinical cases. The objectives of my fifth study were to observe the ultrasonographic changes on a large number of clinical cases, and to try to determine the diagnostic value of these sonographic alterations. My final goal was to combine my findings with those of other authors in order to determine the role of ultrasonography in the diagnosis of canine gastroenterological diseases.

Materials and methods

Experimental studies

The first two studies were performed on healthy dogs or on dogs that had no GI disease.

In the first study, abdominal ultrasonography was done on 8 dogs prior to euthanasia due to untreatable disorders not related to the GI tract at the University of Veterinary Science Budapest. The appearance of their GI tract were observed and the wall thickness of the descending duodenum and some jejunal loops were measured. After the dogs had been euthanized, segments of the descending duodenum, the jejunum and the descending colon were cut out. The isolated intestinal segments were cleaned with flushing, using tap water or physiologic saline solution. The intestinal parts were cut in half in seven dogs. One half of the segments were used for an immediate ultrasound examination in waterbath, using the same bathing fluid in each case that was also used during the earlier cleaning process. The intestinal segments were immersed in the bathing fluid and the transducer was placed on the fluid surface, about 4-6 cm

distance from them. The other parts of the intestinal segments were fixed in 10% neutral formaldehyde solution for at least a week before the ultrasound examination. Tap water was used as waterbath medium during the ultrasound examination of the formaldehyde fixed intestines. Wall thickness measurements at three different points were made in saggital and transverse section of both the formaldehyde fixed and unfixed duodenum, jejunum and colon segments. Full thickness samples were obtained for histological examination from the formaldehyde fixed intestines.

In the second study, ultrasonographic examinations of the GI tract were performed on 9 clinically healthy beagles. Before any fluid was administered to the GI tract, an initial ultrasonographic examination of the abdomen was performed in every dog. Then, seven dogs were examined following administration of fluid to the stomach through a gastric tube. In 3 of these 7 dogs, a reflux examination was performed following the administration of fluid to the colon, and another 3 of these 7 and 2 other dogs were examined following selective filling of the small

intestines with fluid, following intubation of the duodenum. When dogs were examined twice, there were at least 2 weeks in between examinations. All ultrasonographic examinations were focused on the GI tract. GI wall recognition, the nature of luminal content (fluid, mucus, or gas pattern) and the presence of peristalsis were the main criteria for the assessment of the quality of the sonographic images. The stomach and the proximal duodenum, the small intestines and the large intestines were separately assessed and graded in each dog. This study was performed in Utrecht, at the Department of Radiology, Faculty of Veterinary Medicine by the aid of Tempus SJEP program.

Clinical studies

Patients

The remaining 3 studies were performed on clinical patients of the Department and Clinic of Internal Medicine at the University of Veterinary Science Budapest. Data of the dogs with possible signs of GI disorder that were examined ultrasonographically by the same author (myself) between May 1 1996 and April 30

1998 were analyzed. 44 canine patients with the signs of intestinal obstruction (vomiting, abdominal pain, abnormal abdominal palpatory findings, changes in defecation) during a one-year time period were entered into the third study. 45 dogs with the clinical signs of ileus that underwent both plain film abdominal radiography and abdominal ultrasonography within 24 hours during a two-year time period were selected for the fourth study. In the fifth study, data of the ultrasonographic examination of 265 dogs were analyzed. The indications for ultrasonography in the fifth study were vomiting, chronic diarrhea, abdominal pain, rectal bleeding, palpable mass in the abdomen and chronic weight loss.

Ultrasonographic examinations

All ultrasonographic examinations were performed using ultrasound scanners (Brüel and Kjaer 1840 and Brüel and Kjaer, Panther 2002, Naerum, Denmark) and 3.5-5 MHz convex array and a 7 MHz mechanical sector transducer except the second study, where a high definition ultrasound system (HDI 3000,

Advanced Technology Laboratories, Woerden, The Netherlands) equipped with a 5-3 and a 7-4 MHz broadband phased array, and a 10-5 MHz broadband linear array transducer was used. The actual choice for a transducer depended on both the size of the dog and on the depth of the area of interest. No particular preparations of the dogs were performed prior to the ultrasound examinations, but for the second study, they were fasted for 24 hours and fluid was administered through a gastric, duodenal or rectal tube. The abdominal skin of the animals was always prepared as for a routine abdominal ultrasound examination (clipping of the hair, wetting with ultrasound gel.) Ultrasonographic examinations were performed on the dogs in dorsal and right lateral recumbency. When the pylorus and the proximal part of the duodenum could not be identified using this approach, the dogs were positioned oblique between dorsal and right lateral recumbency. When gas containing parts of the GI tract interfered with the transmission of ultrasound, scanning from the dependent side of abdomen was tried. Often a slight increase of pressure with the transducer was used to displace

superficial, gas containing intestinal loops. Sedation was not necessary during the examinations, except during the enteroclysis and reflux examinations in the second study.

Results and conclusions

First study

Comparison of in vivo and in vitro ultrasonographic appearances and wall thickness measurements of the canine intestinal tract

The formaldehyde fixation did not change the appearance of the intestinal segments, thus in vitro ultrasonographic examination of different pathological processes of the intestines is possible following formaldehyde fixation. Considerable differences between in vivo and in vitro GI wall thickness measurements were stated, which was explained by post mortal changes of the segments, the waterbath media and the transducer position. This latter is of special importance when measuring GI wall thickness in living animals. To minimize erroneous ultrasonographic measurement of the

gastrointestinal tract, the transducer should be always kept perpendicular to a gastrointestinal segment and measurements should be done when the largest luminal diameter, hence the thinnest wall thickness is observed in saggital section. On the contrary, measurements in transverse view should be done when the smallest and most circular luminal area is observed.

Second study

Fluid aided ultrasonography of the GI tract in healthy beagles

The reflux examination proved to be the most promising sonographic contrast technique for the visualization of the small and large intestines. Disadvantages of the reflux examination are that the animals have to be sedated and prepared by previous enemas for an optimal examination, which limits the clinical use of the technique. Because this technique causes paralysis of the intestines, the peristaltic activity should be assessed prior to this examination. No considerable difference was found among the different fluids used as contrast media during this study. It was not

possible to systematically follow the whole intestinal tract from pylorus to rectum or vice versa, even when it was completely filled with fluid. Thus, a systematic scanning of the entire abdomen is required during ultrasonography of the gastrointestinal tract. If gas containing gastrointestinal segments are encountered, their negative effect can be avoided by positional changes and compression, similarly to non-contrast sonographic techniques. Fluid administration through a gastric tube helped to visualize the stomach and duodenum but failed to produce marked improvement of the ultrasonographic quality in other parts of the GI tract. Gas removal and application of smooth muscle relaxant drugs may improve the effectiveness of this technique.

Third study

Sonographic diagnosis of intestinal obstruction of the dog

Sonographic criteria for small bowel obstruction were 1.) the presence of pendulous movement of the ingesta inside the dilated bowel, or 2.) observation of invaginated intestines or an ingested intraluminal foreign body, or 3.)

observation of non-uniform peristaltic activity of the dilated intestines, or 4.) observation of akinetic intestinal loops together with abdominal fluid accumulation. By using these criteria, intestinal obstruction was correctly diagnosed by ultrasonography in 11 of the 13 dogs with mechanical ileus, and obstruction was correctly excluded in 29 of the 31 non-obstructive cases. Thus, the above mentioned sonographic criteria had 85 % sensitivity and positive predictive value, and 94 % specificity and negative predictive value. Based on these findings, I suggests that ultrasonography is a valuable tool to diagnose small intestinal obstruction in the dog.

Fourth study

Comparison of ultrasonography and survey radiography in intestinal obstruction of the dog.

By using the above described criteria, intestinal obstruction was correctly diagnosed by ultrasonography in 8 of the 11 dogs with mechanical ileus, while the possibility of intestinal obstruction was correctly excluded in 32 of the 34 dogs without intestinal

obstruction. Intestinal obstruction was correctly diagnosed by radiography in 10 of the 11 cases, while mechanical ileus was correctly excluded in 25 of the 34 cases. The sensitivity, specificity, positive and negative predictive values of ultrasonography in the diagnosis of small bowel obstruction were 73 %, 91 %, 73 % and 91 % respectively, whereas those for plain film radiography were 91 %, 74 %, 53 % and 96 %, respectively. When the largest small intestinal diameter per fifth lumbar vertebral body height ratio of 1.6 was used as threshold level for diagnosing small intestinal obstruction on the radiographs, the diagnostic value of radiography was increased. It is concluded that ultrasonography is a less sensitive and more specific technique than survey radiography in diagnosing small intestinal obstruction of the dog. The combination of the two imaging methods highly improved the diagnostic capability and resulted in very accurate decisions about the need of surgical interventions of dogs with signs of ileus. The diagnostic value of radiography was increased by using more objective criteria. A similar approach in ultrasonography using measurements of the bowel lumen and Doppler

signs may have similar effect on the diagnostic value of ultrasonography.

Fifth study

Gastrointestinal ultrasonography of the dog: A review of 265 cases (1996-1998)

The ultrasonographic alterations of the GI tract were classified in three main categories: thickening of the gastrointestinal wall, changes in peristalsis and dilation of the lumen. Changes in the gastrointestinal wall structure, peristalsis, luminal diameter and content and the morphological alterations of the pancreas and adjacent organs were readily detected by this imaging modality. Localized thickening of the GI wall with disrupted structure was caused by both neoplastic disease and by inflammatory disorders. Diffuse thickening with retained wall structure however, generally was associated with inflammatory disease. Prominent middle echogenic layer of small intestines with normal overall wall thickness was seen in some dogs with gastroenteritis. Diagnostic criteria set in the third study for diagnosing

intestinal obstruction were successfully applied on a large number of GI disorders. Localized paralysis of the intestines, although suggested in the fourth study proved to be an unreliable ultrasonographic sign of intestinal obstruction. Pancreatitis was most often associated with hyperechoic mesentery and hypoechoic mass in the pancreas region, but similar alterations were also encountered in some cases of gastric or duodenal ulceration. The ultrasonographic appearances of muscular hypertrophy of the small intestines and gastric glandular hyperplasia were described in my study first time in veterinary medicine. Even though the observed changes (except invagination and mechanical obstruction) were not specific enough for a definitive diagnosis, ultrasonography was of value to decide further diagnostic processes or treatment of gastrointestinal diseases of the dog.

Based on the results of this PhD thesis and those of previous reports, it can be concluded that ultrasonography is a useful diagnostic imaging method in GI abnormalities of the dog. Changes in the GI wall

structure, peristalsis, luminal diameter and content, as well as the morphological alterations of the adjacent organs can be readily detected by this imaging modality, however the observed changes are rarely (except invagination and mechanical obstruction) specific enough in themselves for a definitive diagnosis. Nevertheless, ultrasonography is of value to decide further diagnostic processes or treatment of the animal.

During this PhD study I firstly investigated and described:

1. The effect of formaldehyde on the ultrasonographic image of isolated GI segment.
2. The effect of fluid administration to the stomach for a small bowel follow through study, of the enteroclysis technique, and of the reflux examination on the quality of ultrasonographic images of the GI tract in healthy dogs.
3. Ultrasonographic criteria for diagnosing small bowel obstruction in the dog.
4. The comparison of radiography and ultrasonography in the diagnosis of intestinal obstruction of the dog.
5. The ultrasonographic signs of GI disorders of 265 dogs.

NEW STATEMENTS CONCLUDED BY THE RESULTS OF THE PRESENT Ph.D. STUDY:

1. The formaldehyde fixation does not change the appearance of the intestinal segments, thus in vitro ultrasonographic examination of different pathological processes of the intestines is possible following formaldehyde fixation.

2. In vitro ultrasonographic measurements are affected by various factors, that should be considered when comparing them with in vivo ultrasonographic measurements. To minimize erroneous ultrasonographic measurement of the gastrointestinal tract, the transducer should be always kept perpendicular to a gastrointestinal segment and measurement should be done when the largest luminal diameter, hence the thinnest wall thickness is observed in saggital section. On the contrary, measurements in transverse view should be done when the smallest and most circular luminal area is observed.

3. The reflux examination is the most promising sonographic contrast technique for the visualization of the small and large intestines. Because this technique causes paralysis of the intestines, the peristaltic activity should be assessed prior to this examination.

4. It is not possible to systematically follow the whole intestinal tract from pylorus to rectum or vice versa, even when it is completely filled with fluid thus, a systematic scanning of the entire abdomen is required during ultrasonography of the gastrointestinal tract. If gas containing gastrointestinal segments are encountered, their negative effect can be avoided by positional changes and compression, similarly to non-contrast sonographic techniques.

5. The administration of fluid to the stomach has little effect on the image quality of the intestinal tract. Nevertheless, it is a useful technique for the examination of the stomach and proximal duodenum. Gas removal and application of smooth muscle

relaxant drugs may improve the effectiveness of this technique.

6. The observation any of the following ultrasonographic criteria can be used to diagnose intestinal obstruction in the dog:

    - the presence of one or more fluid filled small intestinal loop(s) with unsuccessful peristaltic activity, observed as a pendulous, i.e. "to-and fro" movement of the intestinal ingesta, or
    - the presence of invaginated intestinal loops or a foreign body which transmits the ultrasound beam in the distended bowel, or
    - distended small intestinal loops with non-uniform peristaltic activity (both increased and decreased), or
    - the presence of akinetic intestinal loops together with free abdominal fluid accumulation in the abdomen.

Ultrasonography is a valuable diagnostic technique in the diagnosis of canine intestinal obstruction by using the listed criteria.

7. Ultrasonography is less sensitive and more specific than plain film radiography in diagnosing intestinal obstruction of the dog. The combination of plain film radiography and ultrasonography results in very accurate decisions about the need of surgical interventions of dogs with signs of ileus.

8. Localized thickening of the GI wall with disrupted structure can be caused by both neoplastic disease and by inflammatory disorders. Diffuse thickening with retained wall structure however, generally is associated with inflammatory disease.

9. Localized paralysis of the intestines is an unreliable ultrasonographic sign of intestinal obstruction.

10. Pancreatitis is most often associated with hyperechoic mesentery and hypoechoic mass in the pancreas region, but similar alterations can be also encountered in some cases of gastric or duodenal ulceration.

11. The ultrasonographic appearances of idiopathic muscular hypertrophy of the small intestines and gastric glandular hyperplasia have been described in this study as first time in veterinary medicine.

12. The ultrasonographic alterations of the GI tract (except invagination and mechanical obstruction) are not specific enough for a definitive diagnosis. Nevertheless, ultrasonography is of value to decide further diagnostic processes or treatment of gastrointestinal diseases of the dog.