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RESEARCH ARTICLE

Trans-Endoscopic Ultrasonography of the Oesophagus and Gastrointestinal Tract in Dogs and Cats: Pathological Findings

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ABSTRACT

This study aimed to report our experience in clinical application of Trans-Endoscopic Ultrasound (TEUS) to the gastrointestinal tract. TEUS was performed on 9 dogs and 2 cats, using a 2.6 mm 12-20 MHz-mini-probe, introduced through the operative channel of a 9.7-mm-flexible endoscope. The ultrasonographic probe had 360° vision around the transducer (radial probe). TEUS examinations were well tolerated by all animals. Experience and practice reduced the time required for examination (on the average 45 min) for a complete endoscopic and TEUS examination. Out of 11 animals, two had esophageal stenosis, two showed gastric carcinoma, two had duodenitis, two exhibited rectal polyposis, one had lymphoma and ileocecal intussusception, one had rectal adenocarcinoma and one showed chronic gastritis. Thus, combination of ultrasound and endoscopy allowed intrinsic limits of both techniques to be overcome, enabling a complete diagnostic protocol and/or a minimally invasive surgical procedure. In malignant neoplasia, TEUS provided prognostic information for TNM grading.

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INTRODUCTION

Trans-Endoscopic Ultrasound (TEUS) is an imaging diagnostic technique that combines endoscopy and ultrasonography, using an echographic probe positioned on top of a flexible endoscope or introduced through the instrumental endoscopic channel (Gaschen *et al.,* 2007; Baloi *et al*., 2013). The idea to combine ultrasound and endoscopy allows intrinsic limits of both techniques to be overcome, often providing a complete diagnostic protocol and/or a minimally invasive surgical procedure (Spinella *et al.,* 2006).

In veterinary medicine, the use of TEUS is less common than in humans, because of its high instrumentation costs and longer operator-learning path. However, most human TEUS applications can be applied in animals with similar good results (Schweighauser *et al.,* 2009; Kook *et al.,* 2012).

TEUS has also been identified on the basis of its different purposes: TEUS with diagnostic aim and operative TEUS with a therapeutic aim (Hayashi *et al.,* 2012). It often provides diagnosis of lesions observable neither with endoscopy alone nor by traditional ultrasound, with their well-recognized intrinsic limits. Transabdominal ultrasound application can be limited by obesity, location and small sizes of some organs and glands, panting or other movements, and gas in the intestinal tract (Gaschen *et al.,* 2003). Otherwise, the major limitation of traditional flexible endoscopy is the impossibility of visualizing the entire visceral wall, providing a superficial image of the examined lumen. Direct contact of an ultrasonographic probe with the organ allows wall thickness to be evaluated more accurately and high definition images to be obtained (Baloi *et al.,* 2013). These aspects have made TEUS an essential imaging diagnostic technique for hepatic and pancreatic diseases (Kook *et al.,* 2012). Besides, TEUS with a diagnostic goal allows the performance of EUS-guided tissue sampling (Amin *et al.,* 2013). Finally, operative TEUS for therapeutic aims gives the flexibility to perform surgical procedures, such as drainage of cystic lesions or pancreatic abscesses, and neurolysis of celiac plexus (He *et al.,* 2013). The aim of this paper is to report our experience in clinical application of diagnostic TEUS to the oesophagus and gastrointestinal tract, describing pathological aspects of 9 dogs and 2 cats using miniprobes

introduced through the working channel of a video endoscope.

MATERIALS AND METHODS

Eleven clinical cases (9 dogs and 2 cats) were included in this study. All animals were referred to the clinic with a request for endoscopic examination consequent to clinical signs of GI diseases. History, signalment and clinical signs of animals were recorded. Hematobiochemical examinations were performed in all animals before imaging. Blood gases were monitored in all animals before, during, and after surgery. Dogs were anesthetized with propofol 3 mg/kg i.v. (Rapinovet®, Intervet, Italy) after administration of atropine sulfate 0.04 mg/kg i.m. (Atropina Solfato, FATRO-A.T.I., Ozzano, Italy) and butorfanol 0.1 mg/kg i.m. (Dolorex, Intervet s.r.l., Italy). Anaesthesia was then maintained with isofluorane (1.5-2% in 100% oxygen) using an anaesthetic system with an automatic volumetric respirator. The two cats were premedicated with medetomidine (Domitor; Pfizer, Italy) (5 µg/kg) and butorphanol (Dolorex, Intervet s.r.l., Italy) (0.2 mg/kg i.m.); anesthesia was induced via IV administration of propofol 2 mg/kg i.v. (Rapinovet®, Intervet, Italy) and maintained with a mixture of 2% isoflurane in 100% of oxygen.

TEUS was performed using a 2.6 mm, 12-20 MHz mini-probe with a length of 1900 mm (Fujinon Sonoprobe SP-701, Japan). It was introduced through the 2.8 mm-operative channel of a 9.7 mm-flexible endoscope (Fujinon EVE-200 series, Japan). The ultrasonographic probe had 360° vision around the transducer (radial probe).

Each animal was subjected to the endoscopic examination before introducing the ultrasonographic probe. In order to reduce the intraluminal gaseous content, sodium chloride irrigation solution 0.9% (37°C) was introduced through the operative channel (60 ml for oesophagus and rectum, 120-150 ml for stomach). When a pathological finding was detected, an endoscopic guided biopsy was performed for a cyto-histological examination. In each animal, normal and pathological aspects, such as wall thickness, wall layers pattern and lymph nodes involvement, were recorded.

RESULTS

TEUS examination was well tolerated by all 9 dogs and 2 cats. Experience and practice reduced the time required for examination (on the average 45 min); all biopsies performed during the TEUS were diagnostic. Haematobiochemical examination and blood gases did not reveal any alteration specifically related to the diagnosed diseases.

Oesophagus and stomach

Two esophageal stenoses were detected. Typical aspects of esophageal stricture were an increase in wall thickness and the loss of different wall layer patterns (except for *tunica adventitia*) (Fig. 1 and 2). When an inflammatory situation occurred in stomach, TEUS usually showed all 5 gastric wall layers with thickness changes, especially the mucosa and sub mucosa, often supplemented by an increase in gastric folds (Fig. 3 and 4). Moreover, it was possible to examine the perigastric lymph nodes.

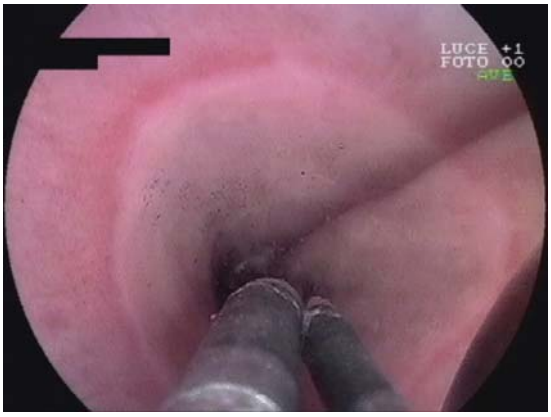

Fig. 1: Mixed breed dog, female, 6 years old; Endoscopic image of oesophagus showing a severe constriction of the esophageal lumen.

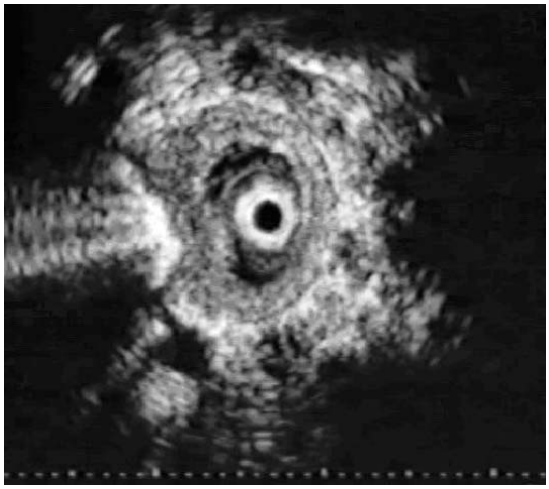

Fig. 2: Mixed breed dog, female, 6 years old; Endoscopic ultrasound image of oesophagus showing thickening of esophageal wall and anular stenosis.

Fig. 3: Dalmatian dog, female, 8 years old; Endoscopic image of gastric carcinoma showing ulcerated lesion with haemorrhagic exudates at gastric lesser curvature.

Colon and rectum: Polyps appeared connected by their bases to the mucosa and sub-mucosa layers, while other deeper layers appeared normal. Malignant tumours,

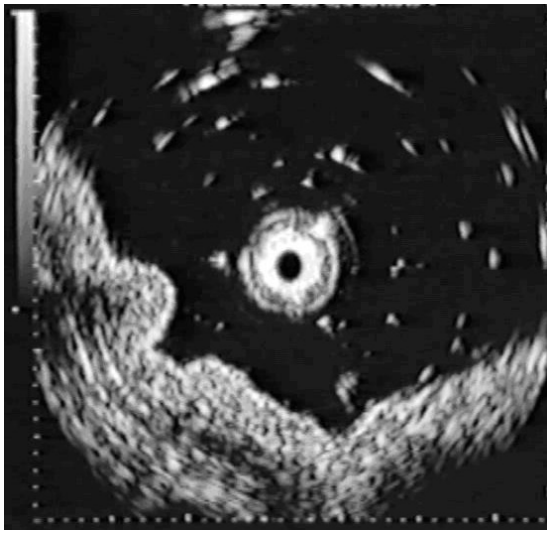

Fig. 4: Dalmatian dog, female, 8 years old; Endoscopic ultrasound image of gastric carcinoma showing severe thickening of mucosal and submucosal layers.

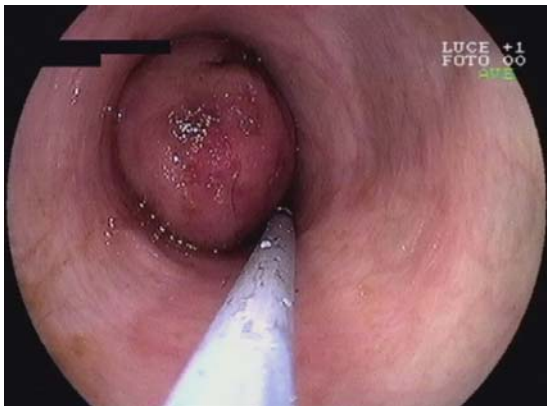

Fig. 5: European cat, female, 8 years old; Endoscopic image of colon showing cecum intussusception occupying colic lumen.

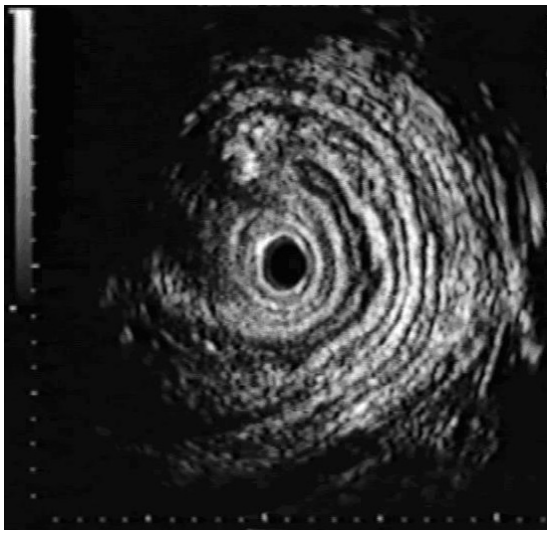

Fig. 6: European cat, female, 8 years old; Endoscopic ultrasound image of colon showing ultrasonographic aspect of cecum intussusceptum occupying the colic lumen.

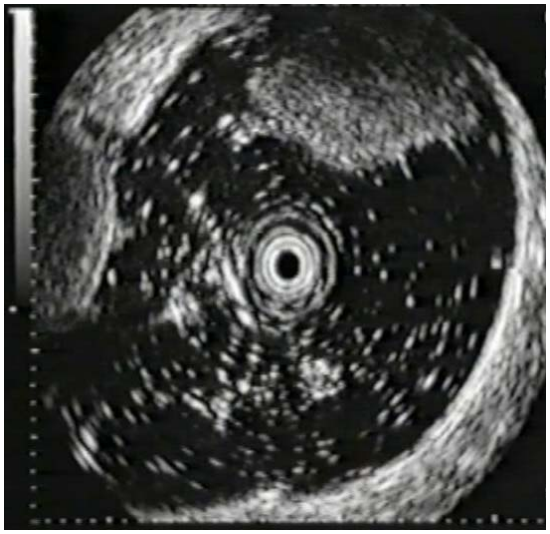

Fig. 7: European cat, female, 8 years old; Endoscopic ultrasound image of colon polypoid, cranially to the mass, a target sign lesion was visualized for an intestinal invagination.

especially carcinomas, were characterized by an early infiltration of the visceral wall with a complete subversion of all intestinal layers, with a possible exclusion of serosa. In one of two cats, TEUS allowed us to cross the focal lesion of the descending colon (alimentary lymphoma) to detect a cecocolic intussusception, probably due to the lymphoma (Fig. 5, 6 and 7). Signalments, clinical signs, endoscopic and TEUS results and diagnosis of all animals have been summarized in Table1.

DISCUSSION

The application of endoscopic ultrasound technique in gastroenterology has been widely reported in the human medical literature (Amin *et al.*, 2013; Nishida *et al.*, 2013). Similarly, this technique has been well recognized in veterinary literature in normal dogs (Gaschen *et al.*, 2003; Baloi *et al.*, 2013) but less frequently for canine gastrointestinal diseases, and even less in cats (Schweighauser *et al.*, 2009; Hayashi *et al.*, 2012). Our experience with TEUS application in dogs and cats has provided better clinical evaluation of referred animals, providing a good diagnostic and therapeutic approach, including a more accurate prognosis not achievable with traditional endoscopy or transabdominal ultrasonography. Moreover, the small size of the miniprobe offered the advantage of performing the examination using an endoscope with a smaller diameter, feasible in small dog breeds and cats.

TEUS application in esophageal lesions allowed us to evaluate ultrasonographically this organ that is hard to detect with conventional ultrasound, especially in the thoracic tract (Baloi *et al.*, 2013). In our experience, the most common application of TEUS has been in esophageal strictures. The small diameter of the TEUS probe permitted crossing the luminal constriction and enabled ultrasonographic evaluation of esophageal wall thickness close to the lesion. Usually, during esophageal and intestinal stenosis, use of traditional endoscopy has

Table 1: Signalments, signs, endoscopic and endoscopic ultrasound (EUS) findings, and diagnosis of examined cases (M = Male; F = Female; y = years old).

Signalment	Signs	Endoscopic exam	EUS exam	Diagnosis
German Shepherd dog, F,5y	Regurgitation and weight loss	Six previous examinations for esophageal stenosis, treated with a dilatation with Eder-Puestow dilatators	Severe esophageal stenosis 35 cm from incisor teeth due to scar tissue for a previous endoscopic treatment.	Esophageal stenosis
Mixed breed dog, F,6y	Dysphagia and right submandibular lymphadenomegaly	22 cm from incisor teeth severe esophageal stenosis	22 cm from incisor teeth, the esophageal wall stratigraphy was partially preserved with a high thickness increase. Few millimeters more distally, only the *tunica adventitia* was observed.	Esophageal stenosis
Dalmatian dog, F, 8y	In the last year occasional vomiting	Gastric ulcerate lesion close to cardial orifice	Thickening of hypoechoic gastric mucosa and submucosa.	Gastric carcinoma
Chow Chow Dog, F,11y	Daily vomiting in the last month	Gastric mucosa diffusely hyperemic with petechiae and a 5mm ulcer close to lesser gastric curvature	Upset of gastric stratigraphy well observed in the lesser gastric curvature. Perigastric lymph node hypoechoic and increased in size.	Gastric carcinoma
Rottweiler Dog, M,3y	Occasional diarrhea and vomiting	Thickening and hyperemic duodenal mucosa	Duodenal thickening and hypoechoic mucosa and submucosa. No alteration of muscular and serosa layer was observed.	Chronic duodenitis
Cocker dog, F, 11y	Halitosis and recurrent gastric dilatation, diarrhea and melena	Gastric and duodenal mucosa diffusely edematous with damaged villi	Hypertrophy of gastric plicae with hyperechoic mucosa and submucosa. Thickening of duodenal mucosa and submucosa.	Chronic gastro-duodenitis
Dogue de Bordeaux, M, 2y	Rectal bleeding after defecation	1 cm polyp in rectal tract with a wide basis of implantation. Several very small polyps were also detected.	In the deeper tract of rectum (close to 1 cm mass) the absence of the normal stratigraphy was visualized with the presence of the only serosa.	Rectal polyposis
Mixed breed dog, M, 11y	Occasional hemorrhagic diarrhea and vomiting	Hyperemic rectal and colic mucosa with petechiae. 3 mm mass in the rectum, polypid like with hyperemic mucosa	Colon: thickening and hypoechoic mucosa and submucosa, with normal muscular and serosal layers Rectum: Normal stratigraphy with a 3 mm polyp adhered to the mucosa and submucosa.	Rectal polyposis
Fox Terrier dog, M, 11y	Occasional and periodic hemorrhagic diarrhea in last year	Rectal mucosa hyperemic, feeble and ulcerate mass	Complete upset of rectal wall stratigraphy with several ectasic vessels.	Rectal adenocarcinoma
European cat, F, 8y	Tenesm and diarrhea 10 days before endoscopy. In the last 3 days a reddish polypoid mass occasionally appeared in the anus after defecation	Polypoid mass in the colon with hyperemic mucosa, that hindered the endoscope transit	The hypoechoic polyp was attached to the colon wall with an intact stratigraphy. Cranially to the polyp, a target sign lesion was visualized for an intestinal invagination. Mild increased size of meseraic lymph node	Lymphoma and ileocecal intussusception
European cat, M, 9y	Occasional vomiting and weight loss	Gastric mucosa diffusely hyperemic	Gastric mucosa and submucosa thickening. Normal aspect of more external layers.	Chronic gastritis

been limited in its diagnostic prosecution (Gouda and Gupta, 2012).

In the stomach, TEUS application has been proven to be a good approach for stadiation of gastric neoplasia in human medicine (Tschmelitsch *et al.*, 2000; Seo *et al.*, 2013); a similar use could also be hypothesized in veterinary medicine. The increasing popularity of this technique is due to greater sensibility of TEUS compared to abdominal TC reported in some clinical studies (Amin *et al.*, 2013). Indeed, TEUS allows more correct evaluation of neoplasia in adjacent tissues, assigning a T1, T2 or T3 staging according to TNM (Tumor-Nodes-Metastasis) grading (De Angelis *et al.*, 2013). In our clinical cases of gastric carcinoma, TEUS provided useful information on infiltration tumour grading in the gastric wall, excluding neoplastic infiltration in adjacent organs.

In TNM grading, traditional endoscopy has limitations because of its superficial evaluation, proving a sample collection without any assessment of possible neoplasia infiltration (Hayashi *et al.*, 2012). TEUS also has other major diagnostic advantages, such as the visualization of perigastric lymph-nodes. Perigastric lymph-nodes are potentially involved in malignant neoplastic lesions of the stomach and are difficult to visualize with trans-abdominal echography, above all during the incipient step; whereas TEUS, with its close opposition to the pathological structure through the gastric wall, provides higher definition visualization with an early diagnosis of lymph-node involvement (Seo *et al.*, 2013).

In our findings of duodenal tract inspection, TEUS has been used in duodenitis to give information about the normal stratigraphy of this intestinal tract, providing information about wall thickness and, above all, the mucosa and sub-mucosa. For the colon and rectal intestinal tract, the major application of TEUS has been related to diagnosis of neoplastic lesions, with high definition imaging of the colon wall to evaluate tumour infiltration. As previously described, this is important prognostic information for the surgeon, who has to decide between endoscopic ablation or exeresis in open surgery laparatomy in order to provide safer clean margins (Gouda and Gupta, 2012). When polyps have been observed, they often have a confined base of adhesion to the colon-rectum mucosa and partially to the submucosa, while deeper wall layers appear normal. This aspect is suggestive of a benign lesion and an endoscopic ablation could be performed. Whereas malignant neoformations, such as carcinomas, have a more penetrating feature with an upset of all the intestinal wall. For these lesions an open surgery is advisable (Hayashi *et al.*, 2012).

In conclusion, TEUS application in gastric diseases has allowed correct classification of the flogistic process, also when superficial mucosa appears normal. Conversely, when wall stratigraphy was subverted, a probable neoplastic disease was suspected. In the latter case, TEUS can provide a TNM grading, with a primitive lesion

stadiation, visualizing, more or less, the involvement of perigastric lymph nodes (Gouda and Gupta, 2012).

In the colorectal tract, TEUS found its main application in evaluating the penetrating feature of neoplastic lesions, with good differential diagnosis between benign and malignant processes, orienteering the surgeon's choice regarding ablation technique (endoscopic or open surgery) (Nishida *et al.*, 2013). However, the size of the miniprobe, even though it represents an advantage for its application in small dogs and cats, may still be a limitation because of the inability to perform an ultrasound-guided biopsy.

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