Advances in Flexible Endoscopy

Anant Radhakrishnan, DVM

KEYWORDS

- Flexible endoscopy
- Minimally invasive procedures
- Gastroduodenoscopy
- Minimally invasive surgery

KEY POINTS

- Although some therapeutic uses exist, flexible endoscopy is primarily used as a diagnostic tool.
- Several novel flexible endoscopic procedures have been studied recently and show promise in veterinary medicine.
- These procedures provide the clinician with increased diagnostic capability.
- As the demand for minimally invasive procedures continues to increase, flexible endoscopy is being more readily investigated for therapeutic uses.
- The utility of flexible endoscopy in small animal practice should increase in the future with development of the advanced procedures summarized herein.

INTRODUCTION

The demand for minimally invasive therapeutic measures continues to increase in human and veterinary medicine. Pet owners are increasingly aware of technology and diagnostic options and often desire the same care for their pet that they may receive if hospitalized. Certain diseases, such as neoplasia, hepatobiliary disease, pancreatic disease, and gastric dilatation–volvulus, can have significant morbidity associated with them such that aggressive, invasive measures may be deemed unacceptable. Even less severe chronic illnesses such as inflammatory bowel disease can be associated with frustration for the pet owner such that more immediate and detailed information regarding their pet’s disease may prove to be beneficial. Minimally invasive procedures that can increase diagnostic and therapeutic capability with reduced patient morbidity will be in demand and are therefore an area of active investigation.
INDICATIONS

Flexible endoscopy is a versatile tool that provides visualization of the gastrointestinal lumen. During the procedure, samples are obtained to provide greater diagnostic information. Endoscopy is commonly used for the patient with gastrointestinal signs (Box 1), because other diagnostic tests such as complete blood count, serum chemistry, radiography, and ultrasonography may not provide definitive information to diagnose the underlying condition. The typical objectives of the endoscopist include visual evaluation of the mucosal surface of the stomach, small intestine, and large intestine for lesions such as ulcers or masses, and obtaining mucosal samples for histopathology, cytology, or culture. Flexible endoscopy can be of therapeutic value in several situations, such as gastric or esophageal foreign bodies, esophageal strictures, and feeding tube placement.

EQUIPMENT

Endoscope Components

Equipment and routine flexible endoscopic procedures have been described previously and are reviewed. The typical flexible endoscope can be divided into 3 components: the handpiece, the insertion tube, and the umbilical cord (Fig. 1). The handpiece (Fig. 2) contains the main control mechanisms for the endoscope. For a fiberoptic scope, the eyepiece for visualization is on the end of the handpiece. A coupler can be attached to the eyepiece to accept a camera head for viewing on a monitor. For a flexible video endoscope, the handpiece does not contain an eyepiece. Control options include deflection of the insertion tube tip, insufflation, water infusion, and suction.

The insertion tube is the flexible portion of the endoscope that is inserted into the gastrointestinal tract for examination (Fig. 3). It contains channels for insufflation, water

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to rinse the lens, and the working channel used for suction and endoscopic instruments. The tip of the endoscope can deflect in 4 directions under control of the 2 dials on the handpiece. Typically the degree of flexion is $90^\circ$ in 3 planes and $180^\circ$ in 1 plane (Fig. 4).

The umbilical cord connects the endoscope to support items including light source with insufflator, water, and suction (Fig. 5). Air, water, and vacuum are pumped through the umbilical cord for use through the insertion tube and are controlled with the handpiece buttons. In a video endoscope, electronic signals are transmitted from the video chip in the endoscope to the external processor for image production on a monitor.

**Support Items**

A light source (xenon or halogen bulb) with insufflator, water bottle for flush, and suction are used via the umbilical cord. Additional support items include a camera, capture unit, and monitor (Fig. 6A). With a fiberoptic endoscope, a camera head can be
attached to the eyepiece and connected to an external camera for visualization on a monitor (see Fig. 6B). A video endoscope has a video microchip in the handpiece that sends electronic signals to a video processor that is included in the light source to produce an image on a monitor.

**Endoscope Sizes**

Endoscopes vary in diameter and length of the insertion tube (Fig. 7). When selecting an endoscope, the application of the scope should be considered. A longer insertion tube is necessary for giant breed dogs, whereas bronchoscopic examination in small dogs and cats will require a narrow insertion tube of 2.5 to 5 mm. Historically, it has been challenging to have 1 endoscope that adequately evaluates the gastrointestinal tract in all dogs and cats owing to the wide range of patient sizes. Bronchoscopy and

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Fig. 3. End-on view of tip of insertion tube.

Fig. 4. (A, B) Flexion of tip of insertion tube.
cystourethroscopy in the male dog place further demands on endoscope diversity. With advancement of flexible endoscopy, endoscopes with longer but narrower insertion tubes (7–9 mm diameter and 120–160 cm length) are available that also have adequate working channel size. A working channel that is large enough to pass a 2.4-mm (7-Fr) biopsy forceps or larger is recommended to obtain adequate tissue samples for histopathology.²

**Endoscopic Instruments**

Various instruments are available that pass through the working channel (Fig. 8). The most commonly used instruments for general gastrointestinal evaluation are biopsy forceps and grasping forceps for foreign body retrieval. A variety of styles are available. Additional instruments include cytology brushes and injection/aspiration needles. For advanced procedures and the experienced endoscopist, other instrumentation can be used via the working channel and are referenced in their respective sections elsewhere in this article.

Fig. 5. Umbilical cord connected to light source and insufflator.

![Fig. 5. Umbilical cord connected to light source and insufflator.](image)

Endoscopic tower, including light source insufflator, camera, capture unit, and monitor. (B) Camera attachment for a fiberoptic endoscope.

Fig. 6. (A) Endoscopic tower, including light source insufflator, camera, capture unit, and monitor. (B) Camera attachment for a fiberoptic endoscope.
GENERAL FLEXIBLE ENDOSCOPY

Patient Preparation

Patients should be fasted for 12 hours before gastroduodenoscopy and 24 to 48 hours for colonoscopy, depending on the patient’s condition and method of cleansing used. Isotonic electrolyte solutions such as GoLYTELY (Braintree Laboratories, Inc, Braintree, MA) will cause an osmotic diarrhea and typically provides adequate colon cleansing for endoscopic visualization. Failure to properly cleanse the colon impairs visibility and sample procurement.

Fig. 7. Different diameter flexible endoscope from left to right: an 11-mm gastroduodenoscope, an 8-mm gastroduodenoscope, a 5-mm bronchoscope, and a 2.5-mm urethroscope.

Fig. 8. Different foreign-body grasping devices: from left to right: basket, loop, wire basket, forceps with alligator jaws, and forceps with $1 \times 2$ teeth. (From Sum S, Ward CR. Flexible endoscopy in small animals. Vet Clin North Am Small Anim Pract 2009;39:886; with permission.)
**Patient Positioning**

For routine examination, the patient should be induced, intubated with a cuffed endotracheal tube to reduce the risk of aspiration, and maintained on inhalant anesthesia. The patient is placed in left lateral recumbency to minimize pressure on the stomach from adjacent organs and allow easier entry into the duodenum.

**Approach**

The endoscopist should be positioned in front of the head for gastroduodenoscopy and behind the tail for colonoscopy. If a monitor is used, it should be placed next to or behind the patient (Fig. 9). This positioning allows for direct visualization with coordination of the endoscope tip with the image on the screen. The placement of the monitor relative to the endoscopist is also important to minimize strain on the endoscopist, which can result in musculoskeletal discomfort such as tendinitis that can develop over time owing to compromised posture.

**Procedure**

Insufflation with air allows for distension and visualization of the lumen. The endoscope should only be advanced when the lumen is clearly visible. If visualization is not achieved or if orientation is lost, the insertion tube should be withdrawn slowly until the lumen is clearly visualized and then advanced. Contraction of the bowel may occur during the procedure, during which the endoscopist should pause until the stomach or intestinal musculature relaxes.

After visual evaluation is complete, tissue samples should be obtained from different areas for histopathology. The largest biopsy forceps that can pass through the operating channel should be used. The forceps can be advanced toward the site while trying to maintain a perpendicular approach to the mucosal wall. The forceps should be advanced firmly into tissue and, when resistance is met, the cups closed firmly. The biopsy forceps should be withdrawn with a steady tug from the mucosa. Deflating the

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**Fig. 9.** Patient positioning for routine gastroduodenoscopy. (From Sum S, Ward CR. Flexible endoscopy in small animals. Vet Clin North Am Small Anim Pract 2009;39:889, with permission; and Courtesy of UGA, Athens, GA, 2009, with permission.)
lumen with suction can improve grasping of the mucosa. A minimum of 6 samples is recommended to ensure adequate quality; however, depending on sample size and location, additional samples may be necessary. Common procedures include esophagoscopy, gastroduodenoscopy, colonoscopy, and foreign body retrieval. Foreign body retrieval is typically limited to the esophagus and stomach. Treatment of esophageal strictures by dilation with balloon catheter is also a relatively simple procedure that is commonly performed in practice. These procedures have been described elsewhere. Advanced flexible endoscopic procedures are currently being pursued more readily and show significant diagnostic and therapeutic potential.

**STENT PLACEMENT FOR BENIGN OR MALIGNANT OBSTRUCTION**

The use of stents in veterinary medicine has increased significantly. Although primarily used for tracheal and urogenital disorders such as tracheal collapse and bladder or prostate carcinoma, stents have been used in the gastrointestinal tract. Esophageal stenting in humans has been shown to be efficacious for esophageal obstruction. However, complication rates are reported to be from 26% to 52% and include tumor ingrowth in the mesh, overgrowth or granulation tissue at the stent margins, stent migration, bleeding, food impaction, esophageal injury, and chest pain. Types of stents used for esophageal stricture include biodegradable stents if short-term dilation is necessary, self-expanding plastic stents, and self-expanding metallic stents. The stents are available covered or uncovered. Nitinol stents have also been investigated and are available. 

*Procedure*

For veterinary patients, esophageal stent placement has been performed for benign and malignant esophageal obstruction. The procedure has been described in detail elsewhere. Briefly, the patient is placed in lateral or dorsal recumbency depending on the placement of tacking sutures. Endoscopy is performed for identification and evaluation of the stricture, and partial balloon dilation performed to permit passage of the endoscope through the stricture to allow visualization of the caudal aspect of the lesion. A marker catheter is passed over an angle-tipped hydrophilic guidewire into the esophagus under fluoroscopic guidance and adjacent to the endoscope for radiographic measurement of the normal esophagus as well as the stricture. Stent diameter size is selected to be 10% to 20% larger than the normal esophagus caudal to the lesion. The length of the stent is selected such that 60% of the stent is cranial to the stricture when possible and extends past the thoracic inlet if tacking sutures are to be placed.

The constrained stent is passed over the guidewire alongside the endoscope under fluoroscopic guidance. It is passed through the stricture into the caudal esophagus. The stent is deployed such that 60% of the stent is cranial to the stricture. Esophageal patency and stent position are confirmed with endoscopy and fluoroscopy (Fig. 10). For tacking suture placement, the patient must be in dorsal recumbency and a 4- to 5-cm midline approach is performed before introduction of the stent, but with the endoscope in the esophagus. Blunt dissection to the cervical esophagus is performed until the endoscope can be palpated. When the appropriate area of the cervical esophagus is identified where the cranial aspect of the stent is expected, stent deployment can proceed. Two to 3 synthetic monofilament polypropylene sutures are placed to secure the stent to the cervical esophagus and the incision closed in standard fashion (Fig. 11).
Complications

- Ptyalism
- Regurgitation
- Gagging
- Nausea
- Megaesophagus
- Stent migration

Fig. 10. (A) A constrained stent (white arrows) is passed across an intrathoracic esophageal stricture. (B) Endoscopic image obtained of the constrained stent (white arrows) before deployment. (C) Lateral fluoroscopic image after stent placement (black arrows) with the stent extending across the thoracic inlet for suture tacking if necessary. (D) Endoscopic image immediately after stent placement demonstrating good esophageal wall apposition. (From Lam N, Weisse C, Berent A, et al. Esophageal stenting for treatment of refractory benign esophageal strictures in dogs. J Vet Intern Med 2013;27:1066; with permission.)

Fig. 11. (A) Lateral fluoroscopic image of a partially deployed (white arrows) and partial constrained (black arrows) esophageal stent. The Gelpi retractors are apparent at the caudal cervical surgical approach (white dotted line) where the suture tacking will take place. The stent is narrowed at the level of the stricture (white block arrow). (B) Endoscopic view showing a luminated area (white dotted line) where the operative approach has been made and the suture needle (white arrows) passing through the esophageal wall and engaging the stent. (C) Endoscopic view after 2 polypropylene sutures (black arrows) have been placed to tack the stent to the esophageal wall. (From Lam N, Weisse C, Berent A, et al. Esophageal stenting for treatment of refractory benign esophageal strictures in dogs. J Vet Intern Med 2013;27:1066; with permission.)
• Stent shortening
• Recurrence of esophageal stricture
• Hyperplastic ingrowth of tissue
• Tracheal–esophageal fistula

Postoperative Care

• H2 receptor antagonist or proton pump inhibitor
• Metoclopramide
• Antiemetics (maropitant citrate or ondansetron)
• Antibiotics if indicated
• Feed high-calorie gruel or canned food with gradual increase in consistency of diet

Outcomes

In the veterinary literature, several case reports describe the successful stent placement for management of esophageal stricture and neoplasia. However, a retrospective study of 9 dogs with refractory benign esophageal stricture suggests a high risk of complications and poor long-term outcome with esophageal stenting in dogs. Of the 9 dogs, 7 experienced complications resulting in additional procedures and only 3 of the 9 dogs received palliation of clinical signs beyond 6 months. Stricture recurrence or stent-related complications resulted in euthanasia in 4 dogs. Complications are listed in the previous section. Biodegradable stents tend to have a greater incidence of stricture recurrence and uncovered stents greater hyperplastic tissue ingrowth. A covered stent with tacking sutures is the current recommendation if an esophageal stent is considered.

Limitations and Future Considerations

Stent placement for esophageal stricture is a relatively new procedure with limited information. The current literature has small patient numbers and variability in management among cases. There was also variation in stent type, location, or in additional security such as tacking sutures. In some patients, stent placement was a salvage procedure thereby creating selection bias. Although difficult, future evaluation ideally will control management and technique such that patient factors can be evaluated to determine ideal candidates and identify risk factors.

Colonic Stents

Colonic stent placement has been described in humans for treatment of benign and malignant obstructions. Technical and clinical success rates are reported to be high. Complications reported include stent migration, colonic perforation, recurrent obstruction owing to tumor ingrowth, fistula formation, and tenesmus. Colonic stent placement has been reported in 1 dog and 2 cats with successful resolution of constipation. All 3 patients were euthanized owing to disease-related complications, with 1 cat being euthanized 19 days after stent placement. Another cat and a dog survived for 274 and 238 days, respectively, after stent placement. The procedure described is similar to that for esophageal strictures (Figs. 12 and 13).

ENDOSCOPIC ULTRASONOGRAPHY AND ENDOSCOPIC ULTRASOUND-GUIDED FINE NEEDLE ASPIRATION OF THE PANCREAS

Endoscopic Ultrasonography

Endoscopic ultrasonography was introduced approximately 30 years ago in humans and has proven to be a reliable technique for assessing the abdominal cavity.
An ultrasound probe is mounted to a flexible endoscope such that the endoscopist is able to evaluate both the lumen of hollow organs and the structures deep to the mucosa and adjacent organs (Fig. 14). The ultrasound probe has a closer proximity to deeper abdominal structures that permits the use of higher frequencies and minimizes compromise of the image owing to intestinal gas or fat.\(^{19,21,22}\) The result is higher resolution images and improved identification of abdominal structures.

**Procedure**

Materials and methods for endoscopic ultrasound have been described elsewhere.\(^{19–22}\) An ultrasound videogastroscope is supported by an ultrasound unit. The ultrasound endoscope contains a curved linear array transducer with a frequency range of 5 to 10 MHz. A nonsterile balloon that can be filled with water is placed over the insertion tube tip. The patient is prepared for routine gastroduodenoscopy or colonoscopy and placed in left lateral recumbency. Examination is similar to routine flexible endoscopy and several readily identifiable landmarks guide the examination. However, in human medicine 150 procedures are recommended for clinicians to learn the method and 250 to 500 to achieve clinical competency.\(^{20}\) Readily identified structures include the portal vein and caudal vena cava, spleen, cranial duodenal flexure, left kidney, and aorta as the 5 primary landmarks. From the stomach, the liver,
gallbladder, bile ducts, kidneys, adrenal glands, body, and left limb of the pancreas can be visualized. Advancing the ultrasound endoscope into the duodenum allows for scanning of the right limb of the pancreas.\textsuperscript{22}

Complications

- Difficulty passing endoscope ultrasound through the pylorus into the duodenum owing to the size and shape of the transducer with endoscope tip.
- Reduced flexibility of the tip of the endoscope owing to the ultrasound transducer.
- Limited visualization of abdominal structures owing to anatomic proximity to the stomach and duodenum.

Endoscopic Ultrasound-Guided Fine Needle Aspiration of the Pancreas

Procedure

Endoscopic ultrasound-guided fine needle aspiration of the pancreas is considered a safe procedure in humans. A recent experimental study in Beagles found it to be safe...
and feasible, although the entire pancreas can be difficult to visualize (Fig. 15). The procedure for endoscopic-ultrasound guided fine needle aspiration is described. A 19-guage endoscopic ultrasound needle is used to aspirate the right limb of the pancreas with power Doppler imaging to avoid vasculature. A spiral metal sheath

Fig. 14. The tip of the radial ultrasonographic gastroscope used to perform endoscopic ultrasonography examinations in 14 anesthetized healthy Beagles in a study conducted to characterize the ultrasonographic appearance of the canine esophagus. Notice the red radial probe tip (A), the water-filled balloon that served as a standoff (B), and the optical device and working channel of the gastroscope (C). The water-filled balloon provided a distance of approximately 2 mm between the probe tip and the esophageal wall. (From Baloi PA, Kircher PR, Kook PH. Endoscopic ultrasonographic evaluation of the esophagus in healthy dogs. Am J Vet Res 2013;74:1006; with permission.)

Fig. 15. The endoscope is positioned into the duodenum from where it is directed medially to visualize the pancreas, outlined with small white arrows. The pancreas is less homogeneous but delineated. It is landmarked by the vena pancreatic duodenale. (From Kook PH, Baloi P, Ruetten M, et al. Feasibility and safety of endoscopic ultrasound-guided fine needle aspiration of the pancreas in dogs. J Vet Intern Med 2012;26:515; with permission.)
connected to a biopsy handle supports the needle, and the apparatus is inserted into the biopsy channel and secured by a Luer-lock onto the biopsy channel. The needle and attached stylet is advanced under endoscopic and ultrasound guidance. The distance from the end of the needle sheath and the target is measured while the handle and adjustable needle stopper prevents the needle from advancing beyond the target. The stylet is retracted and the needle advanced forward by the thrust of the handle. When the tip of the needle is in the target, the stylet is removed and a 10-mL syringe is attached to apply negative pressure while the needle is moved within the target under ultrasound-guided control. Negative pressure is then released and the needle retracted into the sheath and locked. The needle assembly is removed and the cytologic samples made.

**Complications**
- Potential iatrogenic acute pancreatitis.
- Potential iatrogenic infection.
- Constraints on visualization. Sections of the pancreas that are not adjacent to the stomach or duodenum are not easily imaged.
- Technical strain with the ultrasound endoscope and complete needle device (sheath, biopsy needle, stylet, and handle) can be experienced. This strain affects maintenance of image of aspiration target.
- Immediate, on-site cytologic evaluation is ideal to minimize the risk of inadequate cellularity of the samples before recovery from anesthesia.
- The risks in the report were low with no complications; however, further evaluation in dogs with pancreatic disease is necessary.

**Postoperative care**
- Postoperative analgesia if indicated
- Monitoring for iatrogenic infection and pancreatitis
- Treatment as indicated for underlying disorder

**Follow-up and clinical implications**
Endoscopic ultrasonography can improve visibility of deeper abdominal structures and aid in the identification of lesions. Ultrasound-guided fine needle aspiration via endoscopy can improve diagnostic capability thereby providing better prognostic information and development of treatment plans.

**Outcomes**
The patients in this study experienced no adverse effects clinically and exhibited no laboratory abnormalities after the procedure.\(^\text{22}\)

**Limitations and future considerations**
The pancreas can still be difficult to visualize with endoscopic ultrasonography. The skill and experience of the operator is a key factor in identifying abdominal structures and obtaining diagnostic samples. Further evaluation in patients with pancreatic disease is necessary.

**ENDOSCOPIC RETROGRADE PANCREATOGRAPHY AND CHOLANGIOPANCREATOGRAPHY**
Endoscopic retrograde pancreatography (ERP) and cholangiopancreatography (ERCP) use endoscopy and fluoroscopy to evaluate and image the biliary and pancreatic duct systems.\(^\text{23}\) ERCP is used in humans for diagnosis of extrahepatic biliary
problems and for the preoperative and postoperative management of patients undergoing gallbladder surgery. It is also used for cholelithiasis, stenting, or drainage of biliary and pancreatic ducts, and treatment of papillary stenosis with sphincterotomy or papillectomy via endoscopy. In humans, the common bile duct and pancreatic duct terminate together in the major papilla, making selective duct cannulation difficult.

ERP and ERCP have been shown to be technically feasible in dogs. In contrast with humans, the common bile duct opens into the duodenum at the major papilla and the accessory pancreatic duct terminates in the minor papilla (Fig. 16). Therefore, selective cannulation is possible to allow for endoscopic retrograde cholangiography or pancreateography as well as cholangiopancreatography.

**Procedure**

In contrast with standard gastroduodenoscopy, ERCP is performed in dorsal recumbency. A side view flexible endoscope is required for ease of identification of the major and minor papillae as well as cannulation of the biliary and pancreatic ducts. A standard catheter used for ERCP is prefilled with iodinated contrast medium and passed through the working channel of the endoscope to insert into the papilla. There were 10 to 40 mL of contrast medium administered through the major papilla for cholangiography and 1.0 to 2.0 mL of contrast medium administered through the minor papilla for pancreateography. Contrast medium is injected under fluoroscopic guidance until the target area is filled (Fig. 17).

**Complications**

- Transient increase in serum pancreatic enzymes
- Difficulty cannulating pancreatic or biliary duct
- Potential for pancreatitis (reported in humans)
- Potential for hemorrhage (reported in humans)

![Fig. 16. Endoscopic view of the major and minor papillae (black arrows) and the accessory papilla (white arrow). (From Spillman T, Schnell-Kretschmer H, Dick M, et al. Endoscopic retrograde cholangio-pancreatography in healthy beagles. Vet Radiol Ultrasound 2005;46:99; with permission.)](image)
Potential for infection (reported in humans)
Potential for perforation (reported in humans)

Postoperative Care
- As indicated for findings and clinical signs
- Ursodeoxycholic acid

Follow-up and Clinical Implications
Patients found to have filling defects may undergo medical therapy or surgical exploration. The nature of the filling defect can guide the clinician toward the appropriate therapeutic plan. Patients may be able to undergo minimally invasive treatment for biliary or pancreatic duct obstructions.

Outcomes
In 1 study of dogs with chronic gastrointestinal disease undergoing ERCP, 5 of 20 dogs had abnormal bile duct shape. Two dogs had dilated bile ducts, 2 dogs had filling defects in the common bile duct, and 1 dog had a deviated position of the common bile duct suspicious for bile duct deformation. In the 2 patients with dilated bile duct and the 1 patient with suspected deformation, no further investigation was performed. In the remaining 2 patients, 1 was treated with oral ursodeoxycholic acid with successful resolution of clinical signs (Fig. 18). The other patient had minimal excretion of contrast medium after administration of ceruletide. ERC was repeated 5 days after the initial procedure with the same findings and papillary stenosis was diagnosed (Fig. 19). Clinical signs resolved after sphincterotomy was performed through the side view endoscope. A guidewire was placed via the ERCP catheter and the catheter removed. A sphincterotome was placed over the guidewire and pushed into the papilla. The papilla was cut electrosurgically.
ERP is the diagnostic tool of choice in humans to differentiate between inflammation and neoplasia.\(^{22-25}\) Stages of pancreatitis can also be better assessed by this method. The utility of ERP in veterinary medicine could allow for better differentiation of the severity of pancreatic disease. Two patients in the study were diagnosed with end-stage pancreatic acinar atrophy and had alterations in the course of their left and right accessory pancreatic ducts compared with normal anatomy.\(^{24}\) No clinical side effects were noted in dogs, although an increase in serum pancreatic enzyme levels (amylase or lipase) can be seen transiently in some dogs.

Cats are notoriously challenging for diagnosing and treating diseases of the gallbladder and pancreas. ERCP was evaluated recently in 4 healthy cats and found to be feasible, although technically challenging.\(^{26}\) Identification of the major duodenal papilla was best accomplished using chromoendoscopy with 1 to 3 drops of undiluted 1% methylene blue through an ERCP catheter onto the duodenal mucosa. The presence of bile exiting the papilla was clearly visible with chromoendoscopy (Fig. 20). However, white light endoscopy failed to identify the major duodenal papilla in all cats. Cannulation of the duodenal papilla with an ERCP catheter was only possible in dorsal, and not in ventral, recumbency, similar to dogs and in contrast with humans. Complete ERCP was possible in 2 cats and ERP or ERC was achieved in the other 2. Because the pancreatic duct and common bile duct terminate in the major papilla and the feline papilla is smaller in size, an unselected filling with contrast occurs of the 2 duct systems based on placement of the ERCP catheter into the common junction of the 2 ducts versus inserting the catheter into the duct of 1 system (Fig. 21).
Fig. 19. Endoscopic retrograde cholangiography (dorsal recumbency) of a Great Munsterland (12 years old, male, 29 kg), with recurrent vomiting, diarrhea, and abdominal pain for about 9 months; marked structures are dilated common bile duct (white arrows, maximum diameter 4.5 mm) and stenotic papilla major during excretion of contrast medium into duodenum after stimulation of gallbladder contraction with ceruletide (black arrow). (From Spillman T, Schnell-Kretschmer H, Dick M, et al. Endoscopic retrograde cholangio-pancreatography in dogs with chronic gastrointestinal problems. Vet Radiol Ultrasound 2005;46:293-99; with permission.)

Fig. 20. Chromoendoscopic image of the feline duodenal papilla after administration of 2 to 3 drops of methylene blue. Note the yellow color that represents bile. The papilla (arrow) is the small slit in the mucosa. This image shows how difficult it could be to find the papilla if it was not highlighted by the dye. (From Spillman T, Willard MD, Ruhnke I, et al. Feasibility of endoscopic retrograde cholangiopancreatography in healthy cats. Vet Radiol Ultrasound 2014;55:87; with permission.)
No clinical side effects were observed with ERCP in the 4 cats in this study. Two cats had marked but temporary increases in feline pancreatic lipase immunoreactivity concentrations. Pancreatic biopsies were not obtained; therefore, a subclinical pancreatitis could not be ruled out. Similarly, ERCP causes transient increases in serum pancreatic enzyme levels. Potential complications with ERCP include pancreatitis, hemorrhage, perforation, and infection. Overfilling of the gallbladder or pancreatic ducts resulting in contrast filling of the pancreatic parenchyma has been used to experimentally induce pancreatitis in dogs. Additional limitations were encountered in performing ERCP. Dogs weighing less than 10 kg were unable to undergo ERCP because the diameter of the duodenum was too small for the side view endoscope. In addition, partial or total failure of performing ERCP occurred in 30% of dogs, usually owing to food remains or mucus obscuring the view of the papillae, difficulty in cannulation of the papillae, changes to the duodenal mucosa, and difficulty entering the pylorus of the stomach.

**Limitations and Future Considerations**

ERCP can be challenging technically in small dogs and cats. However, the procedure can be performed safely and successfully. Further evaluation of ERCP in patients with biliary tract and pancreatic disorders is warranted.

**NATURAL ORIFICE TRANSLUMINAL ENDOSCOPIC SURGERY**

Natural orifice transluminal endoscopic surgery (NOTES) is an endoscopic procedure that allows access to the abdominal cavity without cutaneous incisions. NOTES is a relatively new procedure still under investigation in human medicine. Surgical access to the abdomen is achieved via the stomach, colon, or vagina. Because of the
method of access, it is hypothesized that the patient will experience less pain and
disability with a quicker return to function. However, there is risk of bacterial contam-
ination into the peritoneum. Instrument limitations exist, resulting in limited visibility of
the operative field and occasionally impractical approaches to tissue manipulation for
certain procedures.

Procedure

Recently, a veterinary feasibility study was conducted for oophorectomy in dogs. Ten
dogs underwent bilateral ovariectomy. The necessary equipment and procedure
were described in detail. Patients are placed in dorsal recumbency and the abdomen
clipped and prepared for aseptic surgery. The stomach is lavaged and then instilled
with cefazolin (1 g/200 mL sterile 0.9% NaCl). A dual-channel endoscope is passed
down to the stomach and transilluminates the ideal gastrotomy site. A guidewire is
passed percutaneously into the stomach via an 18-guage catheter and pulled into
the endoscope. A needle–knife is passed down to the stomach to create the
gastrotomy.

An endoscopic balloon dilator is passed over the guidewire to dilate the gastrotomy.
The endoscope is positioned behind the balloon and the 2 are passed together
through the gastrotomy into the peritoneal cavity. Insufflation is achieved through
the endoscope with room air. Alternatively, insufflation can be achieved percutane-
ously with a CO₂ laparoscopic insufflator. Once access to the peritoneal cavity is
achieved, the endoscope is removed over the guidewire, leaving the wire in place
for access to the abdominal cavity from the mouth. The endoscope is reintroduced
into the abdominal cavity beside the guidewire.

The patient is tilted head down and to the right to improve visibility of the left ovary.
An endoscopic electrocautery snare is passed through 1 working channel of the endo-
scope and endoscopic grasping forceps passed through the other channel. The for-
ceps are passed through the loop of the snare to then grasp and elevate the ovary.
The loop is positioned around the elevated ovary and when in position, the snare is
activated to resect the ovary. The ovary is held with the grasping forceps or snare
and removed with the endoscope. The right ovary is removed in a similar fashion
(Fig. 22).

The gastrotomy site is closed with T-fasteners positioned at 12, 3, 6, and 9 o’clock
positions (Fig. 23). A beveled cap is placed on the end of the insertion tube of the
endoscope. The T-fastener has 2–0 nylon suture swaged to the center of a 1-cm hol-
low needle. The needle is loaded onto a delivery device to be passed through the
working channel of the endoscope. Suction is applied to aspirate the gastric mucosa
into the cap on the insertion tube. The needle is advanced into the tissue and the
T-fastener deployed. Once the 4 T-fasteners are placed in their respective positions,
the fasteners located across the incision from each other are secured with a closure
element (12 o’clock and 6 o’clock; 3 o’clock and 9 o’clock). The stomach is deflated
via the endoscope and the abdomen deflated via percutaneous catheter.

Complications

- Dropping an ovary into the abdominal cavity
- Incomplete excision of ovaries
- Ovarian bursa was mistaken for the ovary and the ovaries were not removed in 1
  patient in heat
- Subcutaneous emphysema
- Potential for peritonitis
- Potential for infection
Potential for hemorrhage.

Postoperative Care

- Analgesic (hydromorphone)
- Monitoring for pain and infection
- As indicated for procedure and clinical examination

Follow-up and Clinical Implications

Patients in the reported study were euthanatized at 10 to 14 days postoperatively.

Outcomes

Ten patients underwent oophorectomy. In the first 5 patients, 2 of the 5 patients had complete excision of both ovaries. Four of the 5 patients had complete excision of both ovaries in the second group. Two ovaries were dropped during the procedure for dogs in the first group.

Limitations and Future Considerations

Various limitations exist with NOTES. Currently, there is not an endoscopic instrument available that can cut and coagulate tissue. An electrocautery snare can be used; however, it is difficult to position with precision and it creates a wide zone of coagulation. The canine anatomy also provides the clinician with challenges because of the presence of the suspensory ligament, ovarian pedicle, and round ligament of
the ovary. Adipose tissue is also typically present around the ovarian structures. Restrictions to access and visibility can lead to complications such as incomplete resection or failure to identify target structures.

NOTES was performed safely and somewhat effectively. Prospective evaluation in long-term surviving patients is necessary. NOTES is currently being investigated further in human medicine and may be used for other thoracic or abdominal procedures in veterinary medicine.

ENDOMICROSCOPY

Flexible endoscopy allows clinicians to assess in a minimally invasive manner a patient with gastrointestinal symptoms. Limitations with flexible endoscopy include the absolute number of samples to be obtained and delay in histopathology reporting. Confocal endomicroscopy uses flexible endoscopy in conjunction with microscopic imaging to provide immediate, histologically comparable imaging of the gastric and small intestinal mucosa. A miniature confocal microscope is integrated into a flexible endoscope to provide histologic detail of the mucosa. Alternatively, confocal miniprobeS can be passed through the biopsy channel of a video endoscope. Fluorophores are administered to provide contrast for cellular detail in confocal images.30,31

Procedure

After routine white light endoscopy, exogenous fluorophores are administered. Fluorescein 10% aqueous solution is administered intravenously at 15 mg/kg intravenous bolus and/or acriflavine is applied topically to the mucosal surface via an endoscopic washing catheter. Confocal endomicroscopy is performed by placing the tip of the endoscope containing the microscope in a forward facing direction and in direct contact with the mucosal surface. Gentle suction stabilizes the image. Five sections, at a

Fig. 23. Closure of gastric incisions with use of a T-fastener system. (From Freeman L, Rahmani EY, Sherman S, et al. Oophorectomy by natural orifice transluminal endoscopic surgery: feasibility study in dogs. Gastrointest Endosc 2009;69:1325; with permission.)
minimum, are evaluated per fluorophore. Intravenous administration of fluorescein provides 30 minutes of imaging and cellular cytoplasmic detail. With acriflavine, repeated application for visualization owing to elapsed time or to evaluate a new area may be necessary. Acriflavine provides subcellular, including nuclear, detail and therefore identification of individual cells (Fig. 24). It also allows for identification of Helicobacter and Helicobacter-like organisms.

**Complications**
- Visibility impaired owing to food and debris
- Image artifact owing to movement
- Reduced endoscope flexibility of endoscope insertion tube tip

**Postoperative Care**
- As indicated for disease

**Follow-up, Clinical Implications, and Outcomes**
The studies regarding endomicroscopy were in research colony animals and therefore follow-up and clinical implications were not evaluated in these reports. Because endomicroscopy is comparable with present-day gastroduodenoscopy, follow-up and clinical implications are similar owing to indications for pursuing gastroduodenoscopic

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Fig. 24. (A) Pyloric antrum. Confocal endomicroscopy (CEM) image of the mucosal surface of the lower pyloric antrum. Only cellular cytoplasmic features are highlighted. Superficial imaging of the mucosal surface demonstrates the regular mosaic pattern of the epithelial cells. Image collected after intravenous administration of fluorescein. (B) Pyloric antrum. Topical administration of acriflavine results in preferential staining of nuclear contents providing superior visualization of individual cells and enhancing the superficial mosaic pattern. Histologic images of the pyloric antrum, including standard orientations (C) and orientations comparative with those obtained by using CEM (D) are also shown. (From Sharman MJ, Bacci B, Whitem T, et al. In vivo histologically equivalent evaluation of gastric mucosal topologic morphology in dogs by using confocal endomicroscopy. J Vet Intern Med 2014;28:801; with permission.)
evaluation. Diagnosis of conditions such as inflammatory bowel disease, *Helicobacter* gastritis, or neoplasia may be enhanced with confocal endomicroscopy.

**Limitations and Future Considerations**

Limitations with endomicroscopy are primarily related to the fact that imaging is a crucial part of the procedure. Food and debris obscure the image and therefore adequate fasting and patient preparation are necessary. Image artifact can also occur owing to motion or poor mucosal contact. Suction stabilizes contact of the endoscope to the mucosal surface. The flexibility of the endoscope is limited by the presence of the microscope in the tip of the insertion tube. Interpretation of confocal endomicroscopic images requires training and experience. Training that includes comparison of confocal endomicroscopic images to histopathology improves the investigator’s ability to detect disease in vivo. There also seems to be a limitation to assessing deep mucosal and submucosal tissues. However, this has not been assessed in veterinary patients with gastrointestinal disease at this time. Adaptation of available technology may enable evaluation of deeper tissue structures.

Confocal endomicroscopy provides the advantage of better identification of superficial lesions and thereby focus endoscopic biopsies strategically to areas that may provide greater information. Other advantages of confocal endomicroscopy include the ability to evaluate a greater region and increased number of sites compared with histopathology samples because of the limitation in obtaining a number of biopsies.

In humans, confocal endomicroscopy has been used to identify a variety of gastrointestinal conditions, including dysplastic, neoplastic, inflammatory, and autoimmune diseases.\(^{30,31}\) Identifiable microscopic changes are demonstrated in diseases including, but not limited to, atrophic gastritis, chronic inflammatory gastritis, intestinal metaplasia, and neoplastic diseases, such as tubular adenocarcinoma. Lesion identification during endomicroscopy helps to guide endoscopic biopsy and improves diagnostic yield. Future prospective evaluation of endomicroscopy in patients with clinical symptoms is warranted.

**ENDOSCOPIC GASTROPEXY**

Prophylactic gastropexy is often recommended in breeds that are recognized as predisposed to developing gastric dilatation volvulus (GDV). For various reasons, owners may elect to postpone or decline prophylactic gastropexy. A quicker, less invasive, and less expensive gastropexy procedure could increase client compliance and reduce the risk of GDV.

**Procedure**

An endoscopic gastropexy method was recently evaluated.\(^{32}\) Patients were prepped for surgery in routine fashion after induction. Dogs were positioned in left oblique recumbency approximately 30° to the plane perpendicular to the operating table (Fig. 25). The gastroscopy was passed orally to the stomach and the stomach inflated until rugal folds were minimally visible. Identification of the gastropexy site was accomplished with external palpation across the body wall while visualizing the pyloric antrum. A stay suture was placed using size 0 or size 2 polypropylene suture on a cutting needle. The needle was passed through the right lateral aspect of the body wall immediately caudal to the 13th rib. The needle and suture were visualized in the pyloric antrum endoscopically as they entered and exited; the needle exited the body wall and the suture was pulled tight and secured with mosquito hemostats. An additional length of suture was passed 4 to 5 cm Aborad to the first suture position for a second stay
suture (Fig. 26). An incision was made between the 2 stay sutures parallel to the 13th rib through the layers of abdominal musculature until the stomach was visible. Gelpi retractors are used to improve visibility. A 3- to 4-cm longitudinal incision was made through the serosal and muscular layers of the pyloric antrum. The seromuscular layer was sutured to the transversus abdominus muscle in 2 individual continuous patterns. The obliquus externus abdominal muscles were apposed and sutured in a simple interrupted pattern followed by routine closure of the subcutaneous tissue and skin. The stay sutures were removed and the stomach decompressed with endoscopic visualization.

Complications

- Needle bending
- Needle breakage
- Hemorrhage
- Potential difficulty in approaching pyloric antrum for gastropexy owing to caudal ribs (not encountered)
- Potential for entrapment of loop of small intestine (not encountered)

Postoperative Care

The patients used in the study were euthanatized after the procedure for reasons unrelated to the study.
Follow-up, Clinical Implications, and Outcomes

Owing to the nature of the study, follow-up and outcome information is not available. However, no major complications were identified. The procedure was short and suspected to be relatively inexpensive. At necropsy, all gastropexy sites were determined to be sound with no damage to other abdominal organs nor entrapment of viscera.

Limitations and Future Considerations

Long-term results are not available for this procedure because all patients in the 1 study evaluating endoscopic gastropexy were euthanatized upon completion of the procedure. However, during the procedure, complications that occurred were limited to needle bending (5 instances in 2 dogs) and needle breakage (2 instances in 1 dog). The needle could not be retrieved in the second instance. Changing from size 0 polypropylene suture to size 2 polypropylene suture resolved the problem. Minor hemorrhage occurred with body wall incision and gastropexy procedure. Minimal blood was detected endoscopically with placement of the stay sutures. Post mortem physical inspection of the gastropexy site revealed proper position of the pexy and no complications.

Successful prophylactic gastropexy requires the formation of a permanent, strong adhesion without complications. Mesothelium between the serosal surface of the stomach and the body wall prevents the formation of an adhesion; therefore, the seromuscular layer of the stomach must be sutured to the transversus abdominus muscle. Correct anatomic position to prevent volvulus without interfering with normal gastric function is important to any gastropexy technique. Additionally, the procedure should have little to no complications and require minimal postoperative management of the patient. Endoscopic gastropexy may prove to be a reliable, inexpensive, and minimally invasive procedure to prevent GDV. Prospective long-term evaluation in animals at risk for GDV is warranted.

SUMMARY

As flexible endoscopy continues to gain popularity in veterinary medicine, its versatility should expand. Several novel minimally invasive diagnostic and therapeutic
procedures are under investigation. Shorter recovery time and reduced morbidity are 2 major benefits of minimally invasive procedures. However, some of the techniques described herein should improve care for patients at risk for debilitating and life-threatening diseases and could have significant impact in small animal practice.

REFERENCES

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