INTERVENTIONAL RADIOLOGY AND ENDOSCOPY FOR THE FELINE PATIENTS: OUTSIDE OF THE URINARY TRACT
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Interventional Endoscopy (IE) involves the use of endoscopic equipment with other contemporary imaging modalities, such as fluoroscopy and/or ultrasound, to perform diagnostic and therapeutic procedures in virtually any part of the body accessed endoscopically (gastrointestinal, biliary, respiratory, urinary tract, etc). Interventional radiology (IR) mainly uses fluoroscopy alone (with or without ultrasound) to gain access to various regions, most commonly vascular access, but also the GI, respiratory, lymphatic and urinary tracts.

Currently, an expanding investigation of the use of some novel techniques in veterinary medicine has been undertaken. The use of fluoroscopy, with or without endoscopy, allows for one to visualize and gain access into small orifices that would otherwise require more invasive surgical techniques. A good example of this is the placement of a nasopharyngeal stent through the nares for nasopharyngeal stenosis without the need for palate surgery. Many of these interventional procedures are considered the standard-of-care in human medicine, and are currently being used in veterinary medicine. The use of these techniques are expanding in our veterinary patients as these modalities are becoming more widely available.

The invasiveness and morbidity associated with some traditional surgical techniques (i.e. ureterotomy for ureteral obstructions or strictures, biliary re-routing surgery, nasopharyngeal surgery for nasopharyngeal stenosis, etc) makes the use of minimally invasive alternatives using IR/IE appealing. The advantages of such procedures are not only their minimally invasive nature, but the lower morbidity, shorter hospital stays, and most importantly the lack of alternative options our patients have. The limitations are that these procedures are technically challenging, require specialized equipment, and extra training.

This talk is a brief overview of some of the minimally invasive interventional radiology and endoscopic procedures actively being performed in feline patients in veterinary medicine, with focus on the respiratory, gastrointestinal, vascular and lymphatic systems. The previous talks expanded upon the large use of these techniques in the urinary tract. We will also discuss some promising future applications currently under investigation.

EQUIPMENT

A C-arm fluoroscopy unit is ideal for most of the IE procedures we are currently performing. This unit has the advantage of image intensifier mobility, permitting various tangential views without moving the patient, and positioning of the patient where endoscopy is easiest (i.e. at the end of the table for rigid cystoscopy). Ultrasonography is useful for percutaneous needle access into structures (gall bladder, renal pelvis, etc) making portable ultrasound very valuable. Guidewires of various size, shape, length, and stiffness, as well as catheters and stents of various materials, shapes, and sizes are needed for each procedure (see below).

Endoscopes are used to guide the operator toward the orifice where visualization and access is needed (i.e. common bile duct, ureteral orifice, nasopharyngeal stenosis). Various flexible and rigid endoscopes are used for interventional endosurgical techniques. Flexible gastroduodenoscopes (6 mm and 8 mm), bronchoscopes, and ureteroscopes (7.5- to 8.2-French) are classically used for various body system interventions. Rigid endoscopes (1.9-7.5 mm) are also useful for cystoscopy and rhinoscopy. An adult (11 mm) or pediatric (9 mm) side-view
duodensoscope is necessary for endoscopic retrograde cholangiopancreatography (ERCP) and biliary stenting, though this is not yet commonly performed in our clinical patients. Other specialized catheters and guidewires are needed for each particular procedure which will be expanded more upon during the presentation.

**RESPIRATORY INTERVENTIONS**

*Nosopharyngeal stenosis*

Nasopharyngeal stenosis (NPS) is a pathologic narrowing within the nasopharynx caudal to the choanae resulting in a variable degree of inspiratory stertor. This can occur as a congenital anomaly or be secondary to an inflammatory condition (aspiration rhinitis), surgery, trauma, or a space-occupying lesion. Traditional therapy involves surgery or serial balloon dilatation procedures. Balloon dilatation is minimally invasive and utilizes interventional technique via fluoroscopy and endoscopy, but can result in re-stenosis in a few days to a few weeks. We have found that stenting of this nasopharyngeal region allows for a more permanent fixation and results in both dogs and cats have been extremely promising.

Under both fluoroscopic and rhinoscopic guidance a hydrophilic guidewire is advanced caudally from the nares through the ventral nasal meatus, through the stenotic opening, and down the esophagus. This is viewed inside the nasopharynx with retroflex rhinoscopy, and from the outside with fluoroscopy. Once the stenotic lesion is identified, a percutaneous transluminal angioplasty (PTA) balloon, preloaded with a metallic stent (balloon expanded metallic stent—BEMS) is advanced over the guidewire and centered over the stenotic lesion. Using both fluoroscopic and endoscopic viewing the balloon is inflated (with a 50:50 mixture of contrast and saline) and the waist of the stenosis is subsequently broken with the balloon. As the balloon expands, the stent deploys. Once the stenosis is open, the balloon is deflated and removed over the wire, and the stent is left to remain in place. More recently the authors are infusing 2-5 ml of topical Mitomycin C (0.1%) onto the stenotic lesion after the stent is deployed to prevent aggressive fibrosis. The stent will re-epithelialize in a few days-weeks (approximately 2-6 weeks). The size (length and width) of the stent and balloon are typically chosen based on Computed Tomography (CT), which is done prior to the procedure. The patients usually go home the same day as the procedure with anti-fibrinolytic doses of glucocorticoids (prednisone 0.5 mg/kg BID) tapered over 6-8 weeks, 2 weeks of antibiotics, and tramadol as needed for any discomfort. The author recommends feeding moist food for the first 2 months as well.

*Tracheal Tumor/Polyp Polypectomy or Laser ablation*

Tracheal tumors can be treated in various different ways depending on the location, type and extent. Many tumors are found in the intrathoracic trachea and surgical removal via resection and anastomosis are associated with a significant morbidity, particularly when a diagnosis is not yet made, or there is evidence of concurrent metastasis. With the use of electrosurgical snares, polypoid mass (tracheal polyp, extramedullary plasmacytoma or leiomyoma/leiomyosarcoma) can be effectively resected during the biopsy procedure, providing both a diagnosis and treatment concurrently. If the mass is broad based and not amenable to polypectomy then either a laser (diode or CO2) or stent can be used to open the airway. In feline patients, tracheobronchoscopy can be more risky and fast and safe palliative options for both benign and malignant obstructions involve the use of tracheal stenting.
Tracheal aspirate or biopsy for obstructive lesions

Tracheal masses are often difficult to biopsy in cats using endoscopy due to the small airway. Since lymphosarcoma is common, aggressive surgery may be unnecessary and tissue sampling is imperative to have a reasonable therapeutic plan. Using a brush or sterile endoscopic biopsy instrument, using fluoroscopic guidance through the endotracheal tube a sample can be easily and safely obtained without losing access to the airway while gaining diagnostic information.

Tracheal Stricture balloon dilatation

For tracheal strictures, balloon dilatation prior to considering stent placement is often ideal. In order to avoid tearing the trachea, a hot-knife can be used to pre-determine where the stricture should tear, preventing a longitudinal tear in the normal tracheal tissue.

GASTROINTESTINAL INTERVENTIONS

Esophageal balloon dilation and esophageal stenting

Esophageal strictures are frustrating to treat for both veterinarians and physicians. Patients classically present with signs of regurgitation. Strictures in the esophagus can be secondary to reflex esophagitis (commonly post-anesthesia), caustic substance ingestion, medications sitting on the esophageal mucosa for lengths of time (i.e. doxycycline tablets), from esophageal foreign bodies, etc. Many alternative therapies have been tried because recurrence is very common. Balloon dilation or bougienage procedures using endoscopic guidance is currently the treatment of choice in veterinary medicine. Regardless of the intervention chosen, many of these strictures recur and present as a monetary and clinical dilemma for our feline patients. In human medicine, fluoroscopy, in conjunction with endoscopy, is used for dilation of esophageal strictures, allowing better visualization that the waist of the stricture is not just stretched, but completely broken. The biggest concern about stenting an esophagus is that this area is very motile (vs the nasopharynx) and food will need to pass through the area. The risk of the stent migrating into the stomach, or proliferative tissue growth around the ends of the stent material, makes permanent stenting for benign disease less than ideal. In order to circumvent these concerns pliable stents with a shape that would ideally hold up again peristalsis (dumb-bell and self expanding) have been tried. Knowing that the stenotic tissue will heal over 14 or more days, having a stent that can be removed or resorbed (polyactic acid or PDS stents) in a few months are being investigated. This has been studied in humans for some time and in a small handful of clinical veterinary cases. The technique holds a more clear indication for non-resectable esophageal malignancies, and this has been performed with success.

Using both fluoroscopic and endoscopic guidance, the stent is placed over a guidewire and centered over the esophageal stenosis or tumor inside its delivery system. Once deployed the stent is expanded across the stenosis. For benign lesions it is recommended that the stent be tacked with a suture (either endoscopically or manually placed suture) to prevent stent migration into the stomach. The preliminary results thus far have been variable. In the future, this may be a consideration at the time of 2nd or 3rd balloon dilation to avoid serial anesthetic procedures and high costs, but the ideal stent needs to be investigated before this is routinely recommended.
Esophageal-jejunal feeding tubes

Enteral methods of feeding are preferred over parenteral nutrition in humans due to the benefits on gut mucosal integrity, barrier function, and lower complication rates. Jejunal feeding in small animal patients is controversial. In animals that are intolerant of gastric feedings, have intractable vomiting, have pancreatitis where pancreatic exocrine duct by-pass is desired, or are unconscious and regurgitation or reflux is a concern (ventilated animals), feeding directly into the jejunum is often considered. Classically, this has been done via surgical or laparoscopic techniques with a high complication and orad dislodgement rates. More recently there has been investigation of PEG-Jejunal feeding tube placement using endoscopy, and this has been met with success.

Due to the ease of placing a nasal feeding tube or an esophagostomy feeding tube, tubes have been able to be placed into the jejunum from the nares (NJ) or esophagus (EJ) with fluoroscopy +/- endoscopy, eliminating the complications associated with enterotomy or gastrotomy (septic peritonitis or unnecessary gastric or jejunal orifices). NJ and EJ tube placement is aided with fluoroscopy visualizing the guidewire and catheter placement into the duodenum and into the jejunum. If an upper GI endoscopic procedure is being performed at the same time than wire placement across the pylorus can be done through the endoscope. This technique is fast, effective and fairly inexpensive when compared to surgical placement and parenteral access with intensive care monitoring of TPN. These tubes have been left in place in clinical patients for over 2 weeks, and once the J-feedings are unnecessary an E-tube remains for convenience.

Colonic stenting

Colonic obstructions are rare in cats but when present can be frustrating. They can be due to neoplastic lesions, strictures, or granulomatous lesions. In humans, colonic stents have been available for over a decade and are most commonly placed for people with neoplasia who are a prohibitive surgical risk or resection holds little chance of surgical cure. They have been used as a mechanism to help de-obstipate for bowel preparation prior to resection and anastomosis. In humans, colonic stents can either be placed through the endoscope for direct visualization while they are deployed, or they can be placed over a guidewire under fluoroscopy alone. They are preferred to be placed through the scope for precise stricture localization, for proximal tumor locations and to guide the stent across acute angulations in the colon. In humans, clinical success is seen in up to 95% of patients. In our practice, 4 colonic stents have been placed in cats; 3 for tumors and 1 for a stricture. In all cases, colonoscopy was done to visualize the lesion and help localize the lesion fluoroscopically. A guidewire was then advanced through the stenotic lesion. Under fluoroscopic guidance a self-expanding metallic stent (SEMS) was placed across the stenotic lesion or tumor and the stent was deployed in that position. Patency was re-established immediately in all cases and subsequent de-obstipation was achieved. All cats were fecally continent, and no stent migrations were seen. The stent was visualized to be incorporated into the colonic mucosa within 4 days in one cat that was re-scoped.

BILIARY INTERVENTIONS

Extrahepatic biliary obstructions present a great dilemma, as they induce life-threatening metabolic derangements, causing excessive morbidity and mortality. Surgical treatment is often indicated, but the outcome with biliary re-routing surgery holds such a high risk, with the mortality rate ranging from 25-70% in dogs and over 75% in cats. If the metabolic derangements can be relieved by a fast and effective decompressive procedure than future surgical
interventions for a more definitive fixation may be safer for the patient. We will discuss two options that can be performed in veterinary patients 1) endoscopic drainage through the common bile duct (ERCP) and 2) laparoscopic assisted biliary drainage by cholecystostomy tube placement.

Laparoscopic cholecystostomy tubes

Laparoscopic cholecystotomy tubes have been reported in a small number of clinical veterinary patients. They can be accomplished with very short anesthesia times. An 8 or 10 french locking-loop pigtail catheter can be advanced through a right paracostal approach being visualized with laparoscopy. With transhepatic penetration of the catheter, the gallbladder is accessed. Once the trocar is into the lumen of the gallbladder, as visualized via laparoscopy, the trocar and stylette are slowly removed and the locking loop mechanism is set in place. The catheter can drain the gallbladder and can be sutured securely to the body wall. This can remain in place until the patient is a better anesthetic candidate for surgery, or for 4—6 weeks while a seal is achieved and a more benign lesion resolves (pancreatitis), bypassing the need for surgical intervention. In the clinical reports, most patients needed to have the rent in the gallbladder closed surgically once stabilized, as a seal did not form very quickly.

Endoscopic retrograde cholangiopancreatography (ERCP) and biliary stent placement

Endoscopic retrograde cholangiopancreatography (ERCP) is an IE technique used for the diagnosis, and potential treatment, of biliary tract disease, pancreatitis, or pancreatic obstructive lesions. To date endoscopic biliary stents have been successfully placed in a small handful of normal purpose-bred dogs, but has not been attempted in a cat. Stents have been placed surgically in cats to unobstruct the biliary tract avoiding the need for biliary re-routing surgery, which has been associated with excessive morbidity and mortality.

VASCULAR INTERVENTIONS

The use of IR techniques to gain access into various organs of the body through the arterial (carotid or femoral arteries) or venous (jugular or femoral veins) blood supply can provide the ability to open budd-chiari like obstructions (caval strictures, tumors, etc) with stents, balloon open vascular membranes like cor-triatriatum dexter, perform thrombectomy or catheter directed thrombolysis for aortic thromboembolism, embolize open portosystemic shunting vessels with either coils (IHPSS or EHPSS) or with glue embolization for arteriovenous malformations. In addition, the delivery of chemotherapy with or without associated embolization to the arterial supply of tumors allows for dramatically higher local concentrations of chemotherapy into the tumors without excessive toxicity. This has been performed in cats for head and neck tumors, the liver for hepatocellular carcinoma, and the periphery for various other sarcomas.

Feline intra-arterial stem cell delivery for chronic kidney disease

Currently under investigation is the use of autologous mesenchymal stem cells (MSC) for the treatment of feline chronic kidney disease. We are currently have a fully funded, randomized placebo controlled study investigating the use of stems cells in feline patients with IRIS stage 3 chronic kidney disease and compare the delivery of these cells intravenously and intra-arterially to a placebo. This study is following the patients out over 3 years assessing systemic signs, blood pressure, GFR, biochemical parameters, ultrasonographic and radiographic parameters. Preliminary data and a review of the current literature will be discussed.
LYMPHATIC INTERVENTIONS

Idiopathic chylothorax is a frustrating disease in our feline patients. When thoracic duct ligation and pericardectomy fail, other options include cisterna chyli ablation and thoracic duct glue embolization through the cisterna chyli. This has only been performed in a small number of cats to date, but will be discussed.

In conclusion, IR/IE provides new alternatives to the treatment of various conditions in feline patients that are traditionally very difficult to manage, or when minimally invasive palliation is desired.