Interventional Radiology (IR) is defined as the use of contemporary imaging and endoscopic modalities to gain access to various anatomic structures to deliver therapeutic agents. The advantages of minimally invasive techniques are well documented in the human medical field, and the benefits of decreased hospitalization and pain and faster recovery will likely be seen in veterinary medicine with improved proficiency in these skills and thorough research is conducted. Interventional radiology and endoscopy also provide alternative treatments to traditional management or even a last option for palliation and improved quality of life with some terminal disease states.

**TRACHEAL COLLAPSE & TRACHEAL MASSES**

Medical management is the mainstay of management of tracheal collapse, and may include the use of any combination of cough suppression, anti-inflammatory medications, antibiotics, bronchodilators, and sedation. For dogs with progression of tracheal collapse, medical management may not be able to effectively control clinical signs of airway obstruction, resulting in life threatening respiratory distress.

For patients with intra-thoracic collapse, or patients with cervical collapse where there are increased risks associated with surgical prosthetic ring placement, intra-luminal tracheal stenting provides a rapid, non-invasive, permanent method to relieve tracheal collapse. Advantages of tracheal stenting include it being minimally invasive, surgical dissection is not required, anesthetic time is lessened, and it can treat disease of the intra-thoracic trachea.

The extent of tracheal collapse, including the presence of mainstem bronchi collapse is assessed with fluoroscopy and pre-operative tracheoscopy. At the time of the procedure, a thorough laryngeal examination and endotracheal wash are also performed, as tracheal infections are being more commonly recognized in dogs undergoing tracheal stenting. Stent size is selected under general anesthesia, and the stent is placed through the endotracheal tube using a bronchoscope adapter to permit continued delivery of oxygen during stent placement. Patients are generally monitored in the intensive care unit (ICU) for 24 hours after stent placement. Repeat thoracic radiographs prior to discharge are used to confirm stent positioning and evaluate for the presence of bronchopneumonia.

Lifelong continued medical management for cough control is essential for most tracheal stent patients to prevent complications associated with stents. Complications include stent migration, fracture, progressive collapse in the unstented portion of the trachea, and the development of intra-luminal inflammatory tissue cranial or caudal to the stent ends. Tracheal stents can also be used to increase tracheal lumen diameter in patients with strictures and neoplasia and have been used successfully in both cats and dogs.

**PERCUTANEOUS ANTEGRADE URETHRAL CATHETERIZATION**

When retrograde urethral catheterization is not possible, such as in small female dogs, patients with obstructive neoplasia, or patients with urethral tears secondary to trauma, antegrade urethral catheterization performed with the assistance of fluoroscopy can prevent the need for cystostomy tubes or emergency surgery.

With the patient anesthetized or heavily sedated, cystocentesis is performed with an over-the-needle catheter after aseptic preparation of the caudolateral abdomen. Urine is removed for urinalysis and
culture (if indicated), and an iodinated contrast agent is injected into the bladder under fluoroscopy to delineate the bladder and urethra. An angled hydrophilic guidewire is advanced through the catheter and into the bladder. Under fluoroscopic guidance, the wire is advanced into the trigone and out the urethra. A urinary catheter is passed retrograde over the wire, positioned appropriately within the bladder, and secured routinely.

**URETHRAL STENTING**
Intra-luminal or extra-luminal urethral obstructions and compressions can quickly become life-threatening emergencies. For many patients, surgical resection of the cause of the obstruction, particularly in the case of neoplastic obstructions, is not a viable option. Permanent cystostomy tubes are associated with complications and can negatively affect an animal’s quality of life.

The most common indications for urethral stents include transitional cell carcinoma, prostatic carcinoma, urethral strictures, and urethral compression from malignant enlargement of other abdominal organs, such as lymph nodes.

Urethral stenting provides a permanent, non-invasive, comfortable option to relieve urethral obstructions in dogs, and more recently, cats. Stent size is based on contrast retrograde cystourethrography generated measurements of normal and diseased urethral diameter and length. A repeat contrast cystourethrogram is performed after the stent is deployed to confirm patency of the urethra followed by abdominal radiographs to confirm stent positioning should future comparisons be needed.

The most significant complication associated with urethral stenting is incontinence; with approximately 25-30% of patients being affected by severe incontinence regardless of patient sex or length of urethra stented. Due to the risk of incontinence, the procedure is only performed if clients are willing to accept this possible complication. Other complications associated with urethral stenting include stent migration and stranguria.

**URETERAL STENTING AND SUBCUTANEOUS URETERAL BYPASS (SUB)**
Ureteral obstructions from ureteral calculi, strictures, and trigonal neoplasia can quickly result in life-threatening azotemia, fluid overload, and hyperkalemia. This is especially problematic in patients with pre-existing renal dysfunction, as they are less tolerant of any acute renal insult.

Ureteral stenting provides intra-luminal bypass of obstructions by inducing passive ureteral dilation and urine flow through the stent, though this effect is lost as the stent becomes filled with cellular debris over time. Most ureteral stents are made of multi-fenestrated polyurethane and have a double pig-tail construction such that a coil is in place in the renal pelvis and one is in place in the bladder to prevent migration.

Ureteral stents can be placed cystoscopically, percutaneously via access into the renal pelvis, or surgically depending on patient size, sex, and the nature of the obstruction. Due to variations in patient size, ureteral stent sizes have been developed exclusively for veterinary patients.

Subcutaneous ureteral bypass (SUB) devices are an alternative technique for relief of ureteral obstructions. The device is placed via laparotomy; minimally invasive placement is not possible. A locking loop catheter is placed in renal pelvis via access from the caudal pole of the kidney and secured with a dacron cuff and cyanoacrylate glue. A second straight catheter is placed in the apex of the bladder and secured with sutures and cyanoacrylate glue. The catheters are connected to a port placed on the external body wall, which allows future percutaneous access for sample collection and device flushing.

Many azotemic patients experience significant post-obstructive diuresis upon relief of the obstruction and often require multiple days of intensive care and fluid management. Careful management of fluid balance and hydration is essential in these patients to prevent both fluid overload and intravascular volume depletion that can result when there are excessive urinary losses. Due to
concerns about infections in patients with urinary implants, urinary catheters are avoided if at all possible in this patient population to avoid ascending infections which have the potential to create a biofilm on the ureteral stent or SUB device.

**ARTERIAL AND VENOUS OBSTRUCTIONS**

Arterial and venous obstructions from clots or invasion of perivascular neoplasms can have catastrophic effect on regional blood supply, such as in aortic thromboembolism, and venous and lymphatic drainage, as with invasive adrenal masses and cranial mediastinal neoplasia. Surgical excision is often not possible in these diseases given the critical nature of the patient and extent of local disease.

Interventional techniques for intravascular delivery of thrombolytic compounds to break down clots, such as tissue plasminogen activator (TPA) and mechanical thrombectomy have been performed in dogs and cats with aortic thromboembolism. Surgical cut-down to the carotid artery is performed, followed by placement of a vascular sheath, and wire and catheter advancement to the location of the clot under fluoroscopic guidance. TPA infusion cranial to and within the clot is performed or mechanical removal via rheolytic thrombectomy is performed to restore flow. Endovascular stenting can be used in combination with these techniques to maintain vessel lumen patency. With arterial obstructions, intensive monitoring for electrolyte imbalances that occur secondary to return of perfusion to a previously ischemic region is essential.

Endovascular stents for venous obstructions secondary to vascular sarcomas and adrenal gland tumors can be placed under fluoroscopic guidance to relieve peripheral edema and ascites, and improve venous return to the heart.

**TRANSARTERIAL EMBOLIZATION FOR HEMORRHAGE AND NEOPLASIA**

When traditional medical and surgical techniques fail to alleviate hemorrhage, life threatening hypovolemic shock, anemia, thrombocytopenia, and coagulopathies can develop. Physiologic derangements, particularly in electrolytes, can result from massive transfusion. There are substantial financial implications for clients of patients requiring large amounts of blood products, and the strain placed on a veterinary practice’s blood product supply can impact future patients in need.

Selective, transarterial catheterization can be performed via access through the femoral or carotid artery with the aid of fluoroscopic guidance. Hemostasis can be achieved through placement of thrombogenic coils, gelfoam, or polyvinyl alcohol particles. This technique has been used for intractable epistaxis, hemorrhage from gastric ulceration, and traumatic laceration of the genicular artery in a dog with a femoral condylar fracture.

In patients with non-resectable neoplasms, particularly hepatocellular carcinomas, intra-arterial delivery of chemotherapy with or without embolic polyvinyl alcohol particles is an emerging interventional option for tumor management. This technique has also been used for soft tissue sarcomas, tumors of the head and neck, and urinary tract neoplasias. Using arterial access (femoral or carotid), selective catheterization into the arterial blood supply of a given tumor is achieved with angiography and fluoroscopy. Depending on the nature of the mass, collateral blood supply, and other structures being supplied by the artery in question, chemotherapy with or without embolic particles are delivered under fluoroscopic guidance. Often, a systemic dose of chemotherapy is given locally to increase drug levels within the tumor. Embolic particles are added to achieve stasis of blood flow to the tumor.

Experience with intra-arterial chemotherapy and chemoembolization is still in its infancy in veterinary medicine, though preliminary experiences are promising and clinical trials are being conducted at several institutions to determine safety and efficacy.
REFERENCES


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