Minimally invasive, catheter-based procedures are becoming more commonplace in veterinary medicine. Transcatheter procedures allow for treatment of several cardiac defects without the attendant morbidity and mortality associated with thoracic surgery. Interventional procedures are available for treatment of patent ductus arteriosus, pulmonic stenosis, atrioventricular valve stenoses, vascular stenoses, atrial and ventricular septal defects, heartworm disease, and certain cardiac arrhythmias. These approaches can considerably reduce morbidity and mortality. Care for these cases in the perioperative period is a bit different than some other procedures, and the catheter maybe be left in place for later removal. This session will review some of the important aspects of nursing and supportive care for Interventional Radiology cases.

Patent ductus arteriosus (PDA): one of the most common congenital heart defects in the dog. PDA causes a continuous heart murmur heard best at the left heart base, and untreated PDA leads to marked cardiac enlargement, congestive heart failure (CHF), or cardiac arrhythmias. Due to the high likelihood of progression to CHF, closure of the PDA is typically recommended. Transcatheter PDA occlusion using interventional radiology techniques, as an alternative to open surgical ligation, is (in our hands) associated with lower mortality and fewer major complications, as well as a quicker and less painful recovery. The occlusion can be accomplished with delivery of embolization coils through a catheter into the PDA or use of an Amplatz canine ductal occluder. The PDA is most commonly accessed from the ascending aorta using femoral arterial access, although a transvenous approach is also possible, especially in cats and very small dogs. Selective angiography allows delineation of the PDA size and shape. Successful occlusion is typically achieved in 85-95% of cases. Risks of coil embolization include hemorrhage, great vessel perforation, infection, hemolysis and embolization of coils to the pulmonary or systemic circulation.

Preoperative considerations include assessment of dyspnea, knowledge of body weight for calculation of contrast media dosing, knowledge of hydration and renal function to reduce the risk for contrast-induced nephropathy, and administration of medications such as diuretic, pimobendan, or antiarrhythmics if needed to control CHF or arrhythmias.

Operative concerns are for the development of bradycardia, tachyarrhythmias, hypotension, loss of a coil or device to the lung (which is usually well tolerated), los of a coil to the systemic arterial circulation (which is not well tolerated), and wound closure.

Postoperative issues include careful attention to the femoral artery incision site to watch for bleeding, a recheck PCV and total solids 2-6 hours post procedure to search for either hemolysis or dropping hematicrit, monitoring for arrhythmias, and general nursing care.

Pulmonic stenosis: is common in dogs, and the stenosis may occur at the subvalvular, valvular or supravalvular locations. Valvular stenosis, characterized by dysplastic pulmonary valve leaflets that are thickened, fused and immobile, is the most common form of the disease and is also the most amenable to balloon valvuloplasty. Dogs with pulmonic stenosis typically exhibit a loud systolic ejection murmur at the left heart base and right ventricular (RV) hypertrophy. Disease severity is gauged by the Doppler echo-derived pressure gradient across
the pulmonic valve, in combination with the degree of RV hypertrophy, right atrial enlargement, tricuspid valve regurgitation, and the presence or absence of either cardiac arrhythmias or clinical signs. Dogs with the above findings and Doppler gradients across the pulmonic valve of >100 mm Hg are likely to manifest signs of right-sided CHF, arrhythmias, syncope or sudden death. Balloon valvuloplasty is the current treatment of choice in these dogs to prevent or ameliorate clinical signs.

Pulmonic balloon valvuloplasty entails inflation of a balloon dilation catheter engaged within the pulmonary annulus at the level of stenosis. As the balloon is dilated the dysplastic leaflets tear, and this results in opening up of the narrowed pulmonary outflow tract. The best candidates for valvuloplasty are those dogs with dysplastic pulmonary valve leaflets (valvular pulmonic stenosis) and a normal pulmonary annulus size, as success is lower and complications are more frequent in dogs with subvalvular disease. English Bulldogs or Boxers with an abnormal coronary artery (R2A coronary anomaly) are at higher risk for complications. Up to 20% of dogs with pulmonic stenosis may have a concurrent atrial septal defect, which can result in hypoxemia due to increased right-to-left shunting during balloon valvuloplasty. The overall reported success rate of the procedure exceeds 90%, with sustained clinical improvement in 80% of previously symptomatic dogs.

Preoperative considerations include knowledge of PCV and total solid, evaluation for cardiac arrhythmia with an ECG, and treatment of right-sided CHF if it is present. If there is pleural effusion or ascites then these can make anesthesia more challenging, and they also make it much harder to define cardiac anatomy and determine where the catheter should pass, so centesis of the chest or abdomen is often appropriate.

Operative concerns are related to potential issues with catheter manipulation including cardiac arrhythmias and cardiac perforation, with the right ventricular outflow tract being the most ‘ticklish” area for arrhythmias. Lidocaine should be handy and/or a lidocaine infusion should be given during the procedure. When the balloon is inflated the blood pressure drops (since no blood is getting from the right heart to the left heart), and in dogs with concurrent atrial septal defect there is often a dramatic drop in SpO2 when the balloon is inflated due to worsening right-to-left shunting of blood. Perioperative antibiotics are usually given.

Postoperative issues include monitoring for and management of arrhythmias, observation of the surgical site(s) for bleeding (jugular vein or femoral vein), and routine nursing care.

Subaortic Stenosis: Aortic stenosis, typically a result of subvalvular obstruction secondary to a ridge of fibrous tissue, is common in the dog. Typical clinical findings include a loud systolic ejection-quality murmur heard well at the left and right heart base and weak arterial pulses in a large breed dog. Stenosis results in concentric LV hypertrophy and can lead to focal fibrosis of the papillary muscles and subendocardium, a consequence of tissue hypoxia and ischemia. This substrate can lead to ventricular arrhythmias and sudden death in severely affected dogs (transvalvular aortic gradient > 80 to 100 mm Hg). Balloon valvuloplasty is less successful in the treatment of aortic stenosis compared to pulmonic stenosis, although an immediate reduction in the aortic outflow gradient can be seen in many dogs. Many cardiologists routinely administer atenolol to affected dogs. Balloon dilation of the aortic valve is associated with greater risk and more serious arrhythmia than that encountered during pulmonic balloon valvuloplasty.
Preoperative considerations include the knowledge of whether current arrhythmias exit, and whether medications are currently being given — if the dog is on atenolol then this drug should be given the day of the procedure.

Operative concerns are usually related to ECG monitoring for arrhythmia and preparedness for cardiovascular collapse or serious arrhythmia at the time of balloon inflation. Hypotension usually develops transiently during balloon inflation, as with pulmonic stenosis, but on occasion it can take longer (more than 30 seconds) to return to normal. Lidocaine is often used to treat or pre-empt arrhythmias. If possible, catecholamines are avoided as these may trigger ventricular arrhythmias. Some cardiologists use heparin whenever catheterizations are done on the left side of the heart, so bleeding complications may develop. Perioperative antibiotics are usually given.

Postoperative issues include monitoring the incisions for bleeding, ECG monitoring, ongoing perioperative arrhythmias, and general nursing care.

**Congenital and Acquired Caval Stenosis:** Vena caval stenosis or stricture formation may occur as a congenital defect or may be acquired secondary to endothelial injury from cardiovascular devices or from cardiac masses. The consequences of caval stenosis depend on the location and severity of the stenosis (cranial cava or caudal cava), and percutaneous treatment of symptomatic stenoses may be achieved with balloon angioplasty or intravascular stenting.

Stenosis of the caudal vena cava (Budd-Chiari-like syndrome) causes hepatomegaly, hepatic venous congestion, and often intractable ascites. Narrowing of the cranial cava results in cranial vena caval syndrome, manifest as jugular distension without pulsation, head and neck edema, sometimes pleural effusion, and depressed mentation. Successful balloon venoplasty and/or stent placement can eliminate clinical signs, sometimes for long periods of time, even in dogs with large obstructive masses.

Preoperative considerations include removal of excess ascites or pleural effusion as this may limit the fluoroscopic imaging, knowledge of weight for calculation of contrast, and knowledge of hydration status and renal function.

Operative concerns are often related to measurement of the size of the cava for determination of the correct size for the balloon or stent. Perioperative antibiotics may be given.

Postoperative issues include careful monitoring to watch for complications. ECG monitoring may be appropriate if a stent crosses into the right atrium.

**Bradyarrhythmias and Cardiac Pacing:** High degree second-degree and third-degree atrioventricular (AV) block are associated with signs of exercise intolerance, syncope, cardiac enlargement, and a high incidence of sudden cardiac death. Pacemaker therapy is the only treatment effective in alleviating clinical signs and prolonging survival in affected dogs, and pacemaker implantation is the current standard of care for patients with high grade AV block, atrial standstill, and sick sinus syndrome. Permanent transvenous cardiac pacing can be achieved using a wide variety of pacing modalities, but the single-chamber permanent transvenous pacing method is used most frequently in the dog and is achieved by passing the leadwire through the jugular vein and advancing the lead through the right atrium and into the right ventricle. The pulse generator is implanted beneath the skin, and the pacing mode and rate, amplitude and pulse width of the pacing stimulus, and a variety of other features can be subsequently adjusted via an external computer programmer. Complication rates are fairly low (10-20%) and can include lead
fracture or dislodgement, infection, battery failure or development of congestive signs in patients with associated structural cardiac disease. The majority of dogs do well and never have recurrence of clinical signs related to the cardiac bradyarrhythmia, with typical survival in excess of 2 years.

Preoperative considerations include monitoring for collapse, knowledge of BUN, creatinine, lactate, PCV and total solids, ECG monitoring, and routine preparation for anesthesia.

Operative concerns are often encountered right at the induction of anesthesia, as the escape rhythm sometimes fails to fire and serious bradycardia or ventricular arrhythmias can develop. The availability and familiarity with use of either an external transthoracic pacing system (part of some defibrillators) or a temporary transvenous pacing system is almost essential to perform the procedure safely. Arrhythmias sometimes develop during transvenous catheter manipulations and lead placement. Perioperative antibiotics are usually administered.

Postoperative issues include ECG monitoring and routine nursing care. We usually wrap the neck with a bandage to keep it clean and to reduce the chance for nosocomial infection. We continue antibiotics for 12 hours (or longer). Analgesics are more likely to be needed after pacemaker implantation than for other catheter procedures.

Additional Interventional Procedures: other minimally invasive approaches are currently used for the treatment of acquired cardiovascular disease in small animals. These include transjugular heartworm removal for patients with advanced heartworm disease, catheter placement for local thrombolytic therapy, thrombectomy, endomyocardial biopsy, and pulmonary artery catheterization for measurement of cardiac output and pulmonary capillary wedge pressures. Portosystemic shunt correction with a stent and coil procedure is also becoming more common – these dogs often need careful postoperative monitoring for the development of signs of portal hypertension. Dogs with certain procedures may have a large catheter placed percutaneously in the neck, and if this is left in place after the procedure then a solid 20 minutes of firm pressure, plus a bandage, is needed to limit the change for significant bleeding after catheter removal. Interventional radiology is developing rapidly and newer minimally invasive approaches will undoubtedly increase the applications in the future.