Catheter Interventions for Palliation of Heart Disease
Janice McIntosh Bright, BSN, MS, DVM, DACVIM
Fort Collins, CO

De duobus malis, minus est simper eligendum.
(Of two evils, the lesser is always to be chosen.)

The use of cardiac catheterization as a diagnostic modality has declined dramatically in veterinary medicine because of the availability of echocardiography and Doppler echocardiography. However, the use of cardiac catheterization to treat or palliate cardiac disease has evolved as new catheters, devices, techniques, and applications for interventional cardiology have developed. "Opening" or "closing" various cardiovascular abnormalities is now achieved with catheter-delivered balloons, stents, and occlusions devices. Furthermore, use of interventional catheterization as a means of palliating heart disease continues to increase as new procedures are described and as data from interventional catheterization procedures show results similar to or better than those of comparable surgical procedures. Whereas many of the interventional procedures currently available for veterinary patients are offered as an alternative to surgery, others such as radiofrequency ablation of arrhythmias and vascular stenting do not have a "good" surgical equivalent.

Vascular access
Nearly all interventional catheterization procedures are done by percutaneous vascular access with placement of a vascular access sheath. To facilitate the intervention, vascular access sheaths have a straight cannula through which catheters and guide wires may be easily introduced and advanced and a one-way valve to prevent bleeding and air embolism. Most sheathes also have a side arm to measure pressure or to infuse medication. Percutaneous access is relatively easy, efficient, and pain free compared to traditional surgical access and can be done without sacrifice of the vessel. After completion of a catheterization procedure, the access site must be compressed until clotting has occurred. It is helpful to keep animals sedated for 6 – 8 hours after cannulation of the femoral vessels to prevent disruption of the clot as a result of excessive motion. The most frequent complications of percutaneous vascular access are hematoma formation and hemorrhage. These complications can be minimized by appropriate vessel compression after sheath removal and by use of the smallest possible sheath.

Percutaneous pulmonary balloon valvuloplasty
Numerous studies have documented percutaneous pulmonary balloon valvuloplasty as a generally safe and effective method for palliation of pulmonic stenosis in dogs.[1-4] However, the determination of whether balloon valvuloplasty is an appropriate palliative procedure in a given patient is based on echocardiographic assessment of the lesion morphology and Doppler echocardiographic determination of the severity of obstruction. Pulmonary valve stenosis in dogs is amenable to relief with percutaneous balloon valvuloplasty if the annulus and pulmonary artery are not underdeveloped and if there is absence of severe infundibular narrowing. Dogs with minimally thickened leaflets and commissural fusion typically have the

most dramatic and lasting relief from the procedure. In dogs with annular hypoplasia, a narrowed pulmonary artery, or both a right ventricular-to-pulmonary artery patch applied surgically is a more appropriate repair.[5, 6] Similarly, surgical palliation is recommended for patients with combined pulmonary valve stenosis and severe, diffuse infundibular stenosis.[5, 7] Dogs with an aberrant left coronary artery are at increased risk of fatal hemorrhage or myocardial infarction with balloon valvuloplasty.[8] Discrete subpulmonic stenosis is uncommon in dogs, but this lesion is also amenable to palliation with balloon dilation.[9] Supravalvular pulmonic stenosis can be effectively palliated with simultaneous balloon dilation and stent placement. Finally, percutaneous balloon valvuloplasty may be used in some dogs to palliate tetralogy of Fallot.

The ability to achieve sustained relief of outflow obstruction with percutaneous balloon valvuloplasty is affected by the size of the balloon relative to the size of the annulus. Studies in children and dogs have shown that optimal long-term results from the procedure are obtained when the ratio of balloon diameter to annulus diameter is 1.3 to 1.5.[1-3, 10, 11] Balloons exceeding 1.5 times the annulus have no additional advantages and may damage the right ventricular outflow tract or pulmonary artery.[11, 12] If a balloon of appropriate size is used, valvuloplasty can be performed at low risk with significant immediate and long-term relief of obstruction in most suitable cases. Clinical signs, if present before valvuloplasty, usually resolve or decrease in severity. Mortality associated with the procedure is less than mortality from surgical valvulotomy or patch-graft.[13] Furthermore, two year survival appears to be significantly improved compared to surgical repair.[13]

Aortic (and subaortic) balloon dilation

Although percutaneous balloon valvuloplasty is the treatment of choice for children with congenital aortic valvular stenosis, this procedure usually does not provide consistent and lasting relief for children or dogs with subaortic stenosis.[7, 14-18] It is likely also that balloon dilation of subaortic stenosis in dogs will not favorably affect survival.[19] Therefore, balloon dilation is reserved for palliation of clinical signs in dogs with congestive heart failure or in those with exertional syncope due to fixed, high resistance to outflow.

Transcatheter occlusion of patent ductus arteriosus

Transcatheter occlusion of patent ductus arteriosus can be done with a variety of closure devices and a variety of techniques. Because of the high success rate (97% to 100%) and low frequency of complications, transcatheter closure is preferred to traditional surgical ligation in children with isolated PDA.[20, 21] Studies of canine patients indicate that transcatheter closure is also safe and effective in dogs.[22-28] The major advantages of transcatheter closure over surgical ligation are significantly reduced morbidity and reduced risk of ductal (or great vessel) rupture. A disadvantage of transcatheter occlusion is a lower success rate in dogs with a large-diameter or nontapering ductus.[20, 27] This disadvantage is likely to become less significant as experience is gained and as availability of a wider variety of occlusion devices increases. Whereas embolization would seem a potential disadvantage of catheter-deployed occlusion devices,

there have been no adverse effects of pulmonary embolization in dogs.[26] Also, the incidence of embolization has decreased with larger occlusion coils and with controlled-release delivery systems.[20, 25, 27]

The most commonly used occlusion device used for transcatheter PDA closure in dogs and cats is a Gianturco vascular occlusion coil. These coils are made of surgical stainless steel enclosed in a mesh of Dacron strands. The strands promote formation of occlusive thrombus. The coils may be placed transarterially or transvenously into the ductus. Patient size does not significantly affect ductal coil occlusion because coils are available in a variety of sizes and can be deployed through a 4 French delivery sheath. Successful deployment of an occlusion coil is affected by ductal size and ductal shape. It is difficult for the coil to retain its coiled configuration and, hence, remain in the desired position with high ductal flow. It is also difficult for the coil to become anchored in a ductus that does not taper. Heavier gauge coils (0.052") and controlled delivery systems have facilitated coil closure even in patients with less ideal ductal size and anatomy.

In addition to coils, several self-expanding devices are available have been used for transcatheter ductal closure in dogs. Of these, the Amplatzer ductal occluding device is most commonly used.[26]

Percutaneous balloon pericardiotomy

Pericardial tamponade due to neoplastic effusion is common in dogs. Surgical pericardiectomy and creation of a pericardial window with thoracoscopy are palliative procedures for prevention of recurrent tamponade. Percutaneous balloon pericardiotomy is a relatively simple and safe alternative for creating a pericardial window.[28,29] However, exploration or biopsy cannot be done with percutaneous pericardiotomy.

Transvenous heartworm extraction

Transvenous removal of heartworms from the caudal vena cava and right atrium is recommended for treatment of dogs with caudal vena cava syndrome.[30] Transvenous extraction of heartworms from the pulmonary arteries may also be done as an alternative to adulticide administration in both dogs and cats.[31, 32] Tranvenous heartworm extraction is done by advancing a grasping or entangling instrument through the jugular vein into the atrium, caudal vena cava, or pulmonary artery. Fluoroscopic guidance is helpful for removal of worms from the caudal vena cava and right atrium and essential for extraction of worms from the pulmonary artery or right atrium. Basket catheters are suitable for transvenous retrieval from the pulmonary arteries, right-sided cardiac chambers, and venae cavae in both dogs and cats. Basket catheters are also less likely than alligator or other grasping forceps to cause intravascular severing of parasites with resultant anaphylaxis or pulmonary embolism. Although it is possible to access the jugular vein percutaneously for heartworm extraction, there is less risk of severing parasites if worms are removed directly through a venotomy incision rather than pulled through an access sheath.

Transvenous balloon angioplasty of cor triatriatum dexter
Percutaneous palliation of cor triatriatum has been reported in both humans and dogs.[33, 34] Data from human studies and veterinary reports show this procedure to be safe, effective, and lasting when it is used for right-sided lesions.

Radiofrequency catheter ablation of arrhythmias
Multipolar catheters can be passed transvenously into the heart for determining the mechanism of arrhythmias and for delivering radiofrequency energy for arrhythmia treatment. In people, radiofrequency catheter ablation has replaced pharmacologic therapy for a variety of cardiac arrhythmias.[35] Radiofrequency catheter ablation is the recommended treatment of paroxysmal supraventricular tachycardia caused by atrioventricular nodal reentry or by accessory pathway reciprocating tachycardia.[35] With these arrhythmias, an essential reentry circuit can generally be safely and permanently interrupted. Electrophysiologic mapping and radiofrequency ablation have also been safely used in dogs to create complete atrioventricular block to achieve permanent rate control by ventricular pacing in dogs with sustained atrial fibrillation.

Unlike pharmacologic treatment with antiarrhythmic agents, radiofrequency ablation provides a method of cure or permanent rate control in patients with tachycardia. The cost of the electrophysiologic testing and ablation, although considerable, is potentially less than the expense of long-term medication and monitoring.

Other interventional catheterization procedures
Several other interventional catheterization procedures are routinely done in human patients and may conceivably be used in dogs as well. Transcatheter closure of atrial septal defects is now an acceptable alternative to surgical closure in children, adults, and dogs.[21, 36, 37] The basic design of the atrial septal defect closure device is a self-expandable occluder with two discs positioned on opposite sides of the defect. Similar transcatheter occluding devices have been used with varying success to close ventricular septal defects in humans.[20, 38] Muscular and perimembranous defects with a significant septal rim between the defect and the aortic valve are amenable to catheter closure.

Finally, transvenous balloon dilation atrial septostomy is now done to palliate severe people with severe pulmonary hypertension. This procedure improves functional status, hemodynamic status, and survival in patients refractory to vasodilator therapy.[39]

Future directions
Percutaneous mitral annuloplasty and percutaneous mitral prolapse repair are currently being studied in animal models of dilated cardiomyopathy and in preliminary human clinical trials. Transcatheter annuloplasty is done by placing a stent in the coronary sinus and subsequently shortening the stent through the delivery catheter to reduce mitral annular circumference. The result is reduced mitral regurgitation due to left ventricular dilation. Valvular repair using transcatheter devices that join the free edges of the mitral leaflets is being attempted to reduce

mitral regurgitation caused by mitral prolapse. These procedures have the potential of revolutionizing care of dogs with chronic mitral valvular disease.

References

(Available upon request)