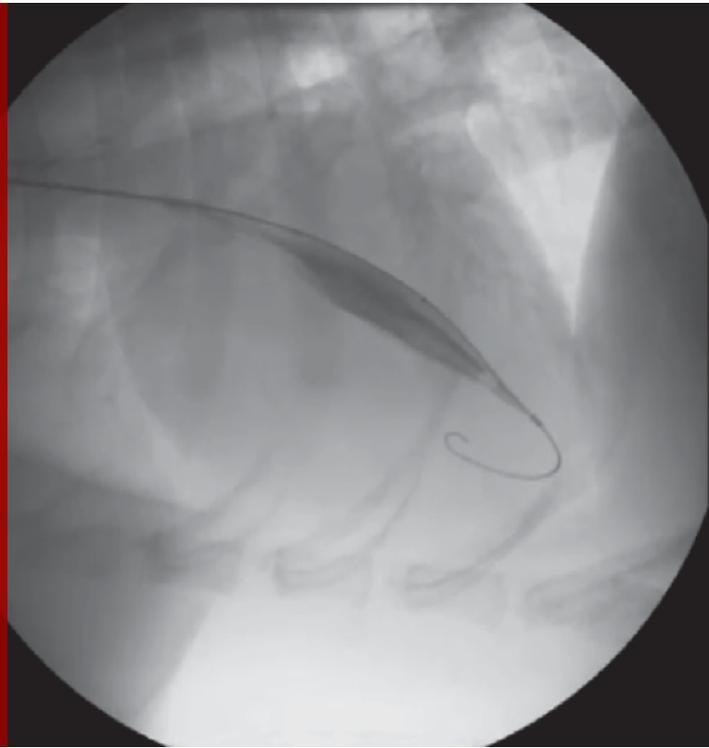


Cardiac Interventional Therapy

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Cardiac interventional therapy is the treatment of cardiac disease using minimally invasive percutaneous techniques. Cardiac catheterization has historically been considered the gold standard for diagnosis of congenital and acquired heart disease.

With the evolution of noninvasive imaging modalities (eg, echocardiography), the need for diagnostic catheterization has decreased substantially. The focus of cardiac catheterization has shifted to the development of interventional treatment strategies. Advance-

ments in technique and equipment have allowed interventionalists to provide a less invasive approach to the definitive treatment of many types of heart disease while complementing the surgical treatment of others.

Indications and Advantages

As the field of cardiac interventional therapy continues to evolve, more of its applications will likely be used in veterinary medicine. Many diseases once thought untreatable may soon have more palliative or corrective treatment options available. The use of interventional techniques in veterinary patients offers a number of advantages compared with more traditional therapies. These procedures

are minimally invasive and may lead to reduced perioperative morbidity and mortality, shorter anesthesia times, and shorter hospital stays. Some less equipment-intensive procedures can result in reduced costs as well. In addition, some techniques offer alternative treatment options for patients with conditions that may not be amenable to standard therapies such as congestive heart failure that is not clinically responsive to medical management, medically refractory arrhythmias, or an owner who cannot afford such therapies.

Over the past decade, tremendous improvement has been made in techniques now considered common in veterinary cardiology, such as transvenous pacemaker therapy for

bradyarrhythmias,¹⁻¹⁰ balloon valvuloplasty for pulmonic stenosis,¹¹⁻¹⁴ and canine-specific occlusive devices for patent ductus arteriosus.¹⁵⁻¹⁸

Growth has likewise developed in catheter-based procedures for the more uncommon interventions such as: use of cutting balloons for subaortic stenosis¹⁹ and cor triatriatum dexter²⁰ and sinister²¹; high-pressure balloons for pulmonic^{11,22-24} and subaortic¹⁹ stenosis; atrial or ventricular septal defect closure devices²⁵⁻²⁷; percutaneous valve repair and replacement techniques²⁸⁻³³; stenting of dysplastic valves³⁴ and other occlusive intracardiac and peripheral arterial lesions^{35,36}; targeted cardiac stem cell³⁷ or gene therapy³⁸; as well as more advanced electrophysiological applications of intracardiac defibrillation devices³⁹ and ablation techniques.⁴⁰⁻⁴²

Potential advantages of interventional therapies include reduced morbidity and mortality owing to the minimally invasive nature of the procedures. These therapies also offer alternative treatments for conditions in which standard treatments do not exist (eg, subaortic stenosis, extremely dysplastic pulmonary valves) or involve unacceptable risks (eg, open heart surgical repair necessitating cardiopulmonary bypass in small patients) or when palliation is the goal (eg, stenting peripheral pulmonary arteries compressed by heart base masses). Although some of these therapies have been performed in veterinary patients with success, there is even greater potential to expand their

application in veterinary medicine.

Challenges and Disadvantages

Because most of these procedures are minimally invasive (performed through catheters or small holes in the skin), traditional sterile operating rooms are recommended but not required. Most of these procedures are performed in clean angiography suites. The entry sites receive a traditional sterile scrub, and operators wear full lead gowns, lead thyroid shields, caps, gowns, masks, and gloves. The radiation exposure during conventional or C-arm fluoroscopy can be substantial. The operator should review radiation safety guidelines, minimize exposure time and beam size, and maximize shielding and distance from the beam.

Vascular access is arguably the most important part of any cardiac or vascular interventional procedure. Several access sites are commonly used in veterinary medicine. For venous

with a blind needle stick; for the latter, the vessel is bluntly dissected and entered with a needle using direct visualization. With either approach, a series of over-the-wire exchanges are then made to place an introducer with a hemostasis valve into the vessel through which various catheters can be passed without concern of blood loss. For many of the more commonly performed procedures, a traditional fluoroscopy unit is sufficient. A C-arm fluoroscopy unit has the advantage of mobility of the image intensifier, permitting multiple tangential views without moving the patient.

The primary challenges or disadvantages of interventional therapy include the required technical expertise, specialized equipment (fluoroscopy with or without digital subtraction capabilities), and the requisite large initial capital investment to amass a suitable inventory of catheters, guidewires, balloons, stents, and coils.

Potential advantages of interventional therapies include reduced morbidity and mortality owing to the minimally invasive nature of the procedures.

access, the jugular, femoral, or saphenous vein is typically used. For arterial access, the femoral, carotid, or brachial artery is typically used. These vessels can be accessed using either a percutaneous approach or a small cutdown incision. For the former, the vessel is initially entered

Clinical Impact

Interventional catheterization, better termed *therapeutic catheterization*, is commonly used in adult, pediatric, and veterinary cardiology. Techniques are constantly improving thanks to smaller introducers and sheaths, low-profile balloons, novel

devices, and innovative uses of equipment. These advancements have allowed cardiologists to provide a less invasive approach to the definitive treatment of many types

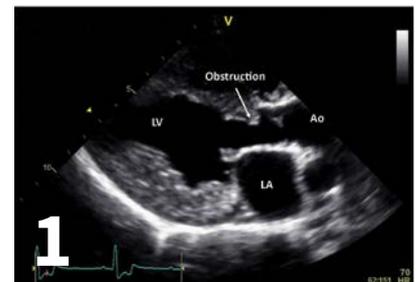
of heart disease while complementing the surgical treatment of others. Hybrid approaches, in which interventional cardiologists and surgeons work together to allow delivery of

devices or access to locations in the heart in very small patients, are continuously being developed.²⁵

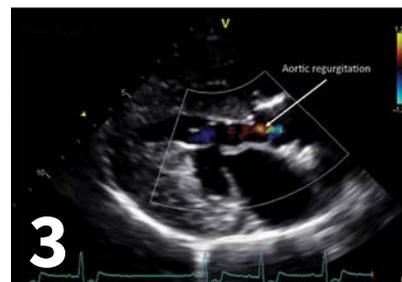
For videos that illustrate the following figures, visit cliniciansbrief.com/interventional-cardiology

SUBVALVULAR AORTIC STENOSIS

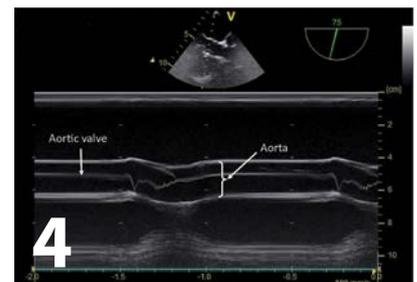
▶ Right-sided 5-chamber long-axis view showing the left ventricular (LV) outflow tract. The LV is hypertrophied, and there is an obstructive ridge in the LV tract below the valve. (Ao = aorta; LA = left atrium)



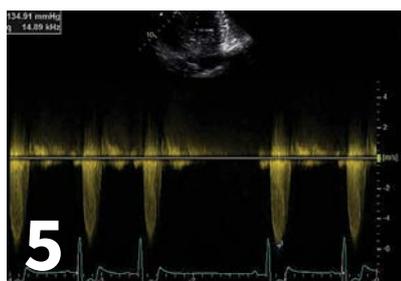
▶ Right-sided 5-chamber long-axis view showing the left ventricular (LV) outflow tract during systole. The left ventricle is hypertrophied, and color flow shows turbulent high-velocity flow starting at the subvalvular area. (LA = left atrium)



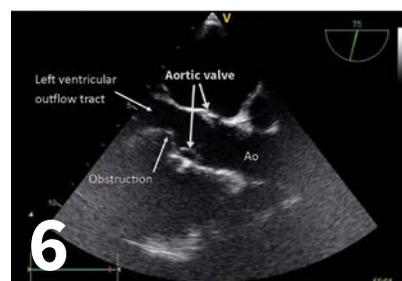
▶ Right-sided 5-chamber long-axis view showing the left ventricular outflow tract during diastole. The left ventricle is hypertrophied, and color flow shows a small jet of aortic regurgitation extending from the aortic valve.



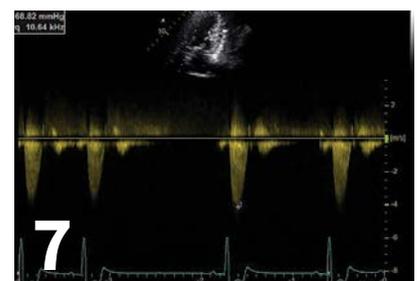
▶ Transesophageal M mode image across the aortic valve showing the abnormal valve movement. While the valve appears to open normally, it partially closes in early systole.



▶ Left-sided apical view looking at the left ventricular outflow tract before dilation. Peak velocity is 5.81 m/s, which equates to 134.1 mm Hg using the modified Bernoulli equation.

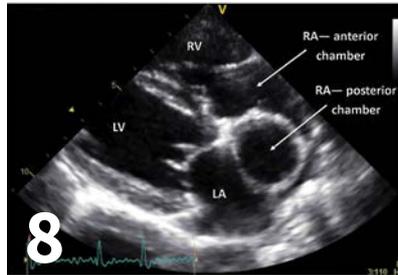


▶ Transesophageal echocardiogram optimized for the left ventricular outflow tract. The muscular obstruction can be seen beneath the valve. (Ao = aorta)

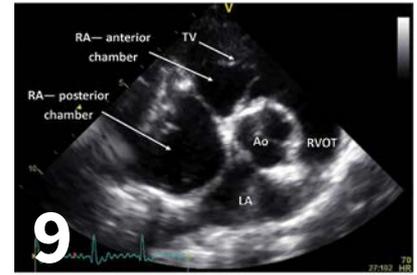


▶ Left-sided apical view looking at the left ventricular outflow tract after dilation. Peak velocity is 4.15 m/s, which equates to 68.8 mm Hg using the modified Bernoulli equation after dilation.

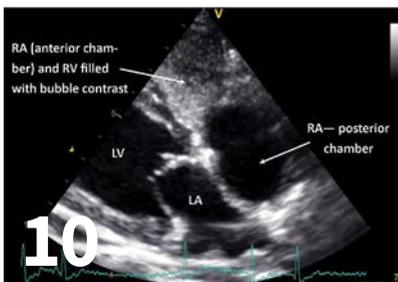
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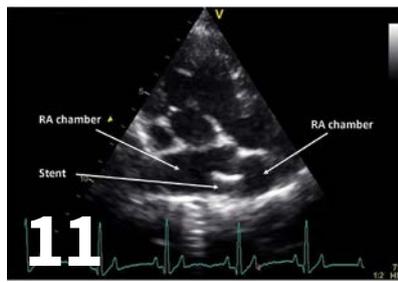
▲ Right-sided long-axis view showing the 2 chambers of the right atrium (RA) with the left and right ventricles. (Ao = aorta; LA = left atrium)



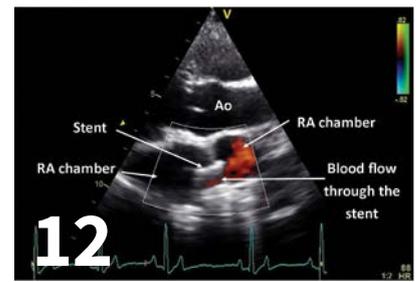
▲ Right-sided short-axis view at the level of the aortic valve showing the anterior and posterior chambers of the right atrium (RA) and their relationship to the tricuspid valve (TV). (Ao = aorta; LA = left atrium; RVOT = right ventricular outflow tract)



▲ Right-sided 4-chambered long-axis view showing the left side with no contrast. The posterior chamber of the right atrium (RA) does not contain any contrast, but the anterior chamber of the RA and the right ventricle (RV) are filled with bubble contrast. Contrast is created by injecting sterile agitated saline and a small amount of the patient's blood into a peripheral catheter. Echocardiogram is performed simultaneously with injection. (LA = left atrium; LV = left ventricle)

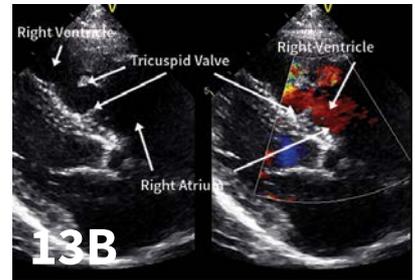
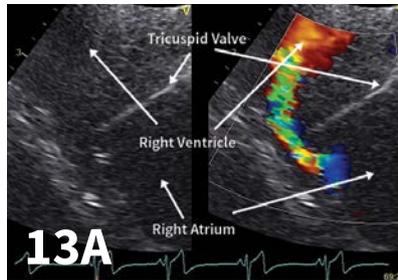


▲ Left-sided parasternal short-axis view of the aortic valve. Distally, the 2 right atrium (RA) chambers can be seen with the stent in place across the membrane.

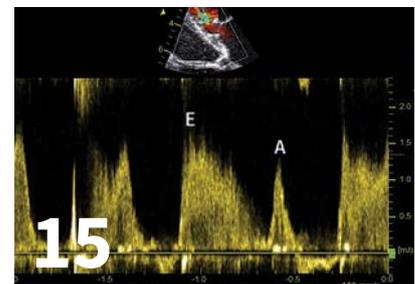
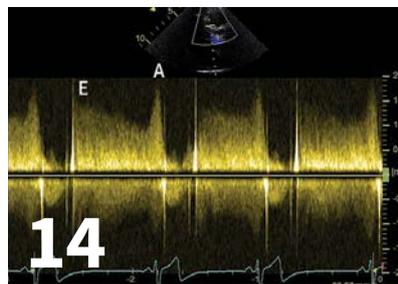


▲ Left-sided parasternal long-axis view of the aortic valve and ascending aorta (Ao). Distally, the 2 right atrium (RA) chambers can be seen with the stent in place across the membrane. Color flow Doppler shows blood flow through the stent.

TRICUSPID STENOSIS



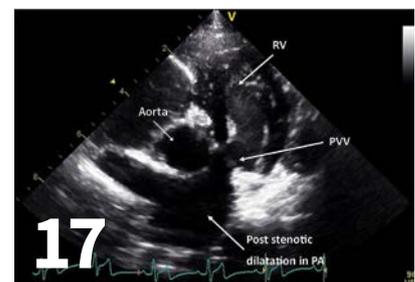
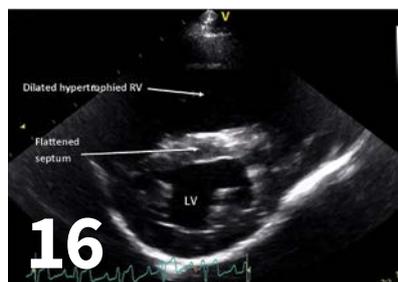
▲ Left-sided apical view optimized for the right ventricle and right atrium showing the high-speed diastolic flow from the right atrium into the right ventricle (A). Right-sided view of the right atrium and right ventricle. The tricuspid valve does not open completely. However, after ballooning the diastolic inflow from the right atrium to right ventricle, it is more laminar and not as turbulent as it was before ballooning (B).



▲ Doppler study across the tricuspid valve showing the E and A waves. The velocities are high, and the E wave deceleration is prolonged.

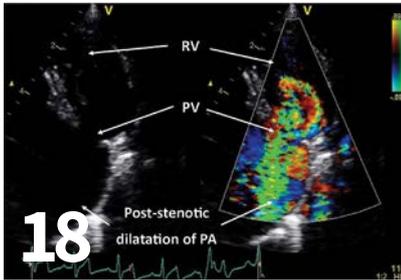
▲ Doppler study across the tricuspid valve showing the E and A waves after ballooning of the valve. The velocities are high, and the E wave deceleration is prolonged but much shorter than before.

PULMONIC STENOSIS STENT

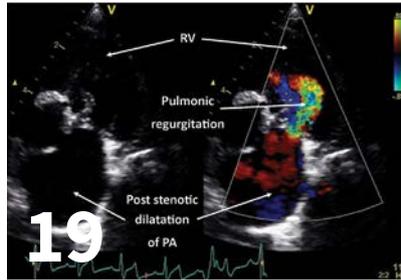


▲ Right-sided short-axis view at the level of the papillary muscles. The interventricular septum is flattened, suggesting elevated right ventricular pressures, which may exceed systemic pressures.

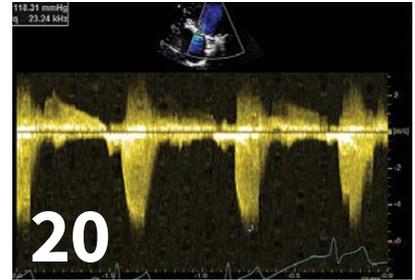
▲ A right-sided short-axis view optimized for the right ventricular outflow tract during diastole. The aorta is seen in the middle. The valvular stenosis (PVV) can be visualized with post-stenotic dilatation in PA (PA = pulmonary artery; RV = right ventricle)



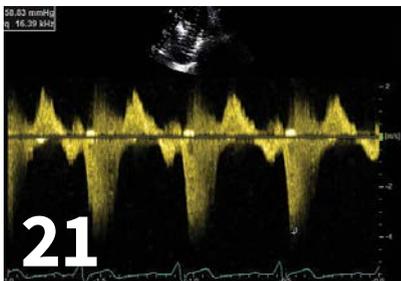
▲ Simultaneous images of a right-sided short-axis view optimized for the right ventricular outflow tract with and without color during systole. The valvular narrowing can be visualized (PV) with poststenotic dilatation. The green systolic jet of turbulent flow in the pulmonary artery (PA) can be seen starting in the right ventricular outflow tract. (PV = pulmonary valve; RV = right ventricle)



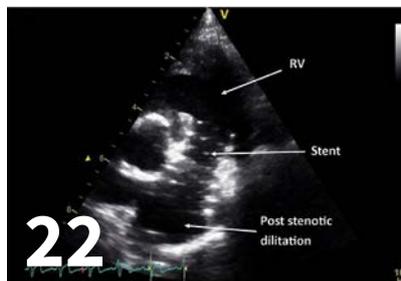
▲ Simultaneous images of a right-sided short-axis view optimized for the right ventricular outflow tract with and without color during diastole. The valvular narrowing can be visualized with poststenotic dilatation. The green diastolic jet of pulmonic regurgitation can be seen in the right ventricular outflow tract. (PA = pulmonary artery; RV = right ventricle)



▲ Right-sided short-axis view used to assess pulmonary artery flow. The peak velocity is 5.54 m/s, which equates to 118.3 mm Hg using the modified Bernoulli equation prestenosing. Diastolic pulmonic regurgitation can be seen with positive flow above the baseline.



▲ Right-sided short-axis view used to assess pulmonary artery flow. The stent can be seen in position. The peak velocity is 3.84 m/s, which equates to 58.8 mm Hg using the modified Bernoulli equation poststenting.



▲ Right-sided short-axis view showing the right ventricular outflow tract with the stent in place. The poststenotic dilatation can be visualized. (RV = right ventricle)

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