Inflow Venous Occlusion for Intracardiac Resection of an Occluding Right Ventricular Tumor

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ABSTRACT

Use of normothermic venous inflow occlusion enabled removal of an intracardiac tumor in a 4 yr old, 27 kg, spayed female Airedale terrier with a history of appendicular osteosarcoma and recent exertional syncope. Inflow venous occlusion via a median sternotomy thoracotomy without hypothermia was used to access the mineralized mass within the right ventricular outflow tract. Duration of circulatory arrest was 70 s for this beating heart surgery. A circumscribed intracardiac chondrosarcoma tumor was marginally resected in this dog, successfully alleviating exertional syncope and restoring a normal echogenic appearance of the right heart. Asymptomatic intracardiac chondrosarcoma recurrence and pulmonary metastasis was detected at 309 days and cardiopulmonary arrest occurred 372 days following intracardiac surgery. Use of inflow occlusion is a viable technique for select intracardiac tumors in dogs with preoperative planning. (J Am Anim Hosp Assoc 2016; 52:259–264. DOI 10.5326/JAAHA-MS-6318)

Introduction

The prevalence of intracardiac neoplasia is well established in veterinary medicine.1–3,10–18 The most common types of cardiac neoplasia include hemangiosarcoma, chemodectoma, ectopic thyroid carcinoma, and lymphoma.3,12,16,17 The location of the mass within the heart, size of the mass, and invasiveness determines the symptoms and the potential options for treatment. Clinical signs associated with right ventricular outflow tract obstructions are variable, but they can include exertional syncope, congestive heart failure, and anasarca.1,18 The removal of intracardiac masses has frequently been described using techniques of cardiopulmonary bypass and systemic hypothermia.6 Cardiopulmonary bypass surgery uses an extracorporeal system to provide oxygenated blood to the lungs and tissues with the aid of hypothermia induced bradycardia or cardiac arrest.19 The benefits of this technique are that it allows for extended time periods of open-heart surgery and that it provides a motionless and clean operative field.19 The drawbacks of this procedure include hemodilution, initiation of a systemic inflammatory response, coagulatory derangement from thrombocytopenia, acquired platelet dysfunction, dilutional coagulopathy, and hemorrhage. In addition, it requires the availability and use of specialized and expensive equipment, advanced monitoring, and an extensive surgical team.5 Deep hypothermia involves inducing an ambient body temperature between 21° and 38°C.3 The problems associated with this procedure are related to the detrimental effects on the cardiac myofibers, which are subjected to low temperatures and include ischemic necrosis and hypoxic damage.19 The use of inflow occlusion in removing intracardiac masses poses a feasible alternative to such techniques without the need for extracorporeal systems and systemic hypothermia. The principle advantages are the simplicity; the lack of need for specialized equipment; and the minimal cardiopulmonary, metabolic, and hematologic derangements after surgery.2,9 Limitations of this procedure are related to the brief period of access to the intracardiac structures while performing surgery on a beating heart; a total duration of 4 to 8 min has previously been described for total venous

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inflow occlusion in dogs. In addition, there is the possibility of significant hemorrhage if the entry incision is not closed swiftly or if there is inadequate occlusion of the azygous or caudal vena cava vessels. Use of inflow occlusion for removal of right ventricular cardiac tumors has been reported, but those prior cases were aided with the use of hypothermia techniques and cardioplegic solution. We report the use of inflow occlusion for removal of an obstructing right ventricular tumor without the use of intentional hypothermia or of cardioplegic solution.

Case Report
A 4 yr old intact female Airedale terrier presented for acute weakness, fatigue, trembling, and collapse. An evaluation through a referral center revealed a grade IV/VI systolic murmur and a large intracardiac mass in the right ventricular outflow tract identified with echocardiography. The dog was started on clopidogrel and sildenafil with marked improvement of clinical signs. One week following onset of clinical signs the dog was presented to the authors’ institution. Ten mo ago, the dog was treated for a chondroblastic osteosarcoma in the right distal femur, at the same institution, with hindlimb coxofemoral disarticulation amputation and adjuvant chemotherapy of carboplatin, gemcitabine, and doxorubicin.

Three-view thoracic radiographs revealed a focal area of stippled mineralization superimposed over the right ventricle and just to the left of midline superimposed over the cardiac silhouette at the level of the fourth intercostal space (Figure 1). The pulmonary vasculature, mediastinal structures, and pleural space appeared normal with no evidence of visible metastasis. Echocardiogram revealed a mineralized right ventricular mass causing obstruction to the outflow tract with associated left ventricular pseudohypertrophy and ventricular ectopy (Figure 2). The mass appeared to extend from the tricuspid valve and invade the interventricular septum. Thoracic and abdominal computed tomography with arterial, venous, and delayed contrast imaging revealed an ovoid, well-demarcated, mixed attenuating mass with internal granular osseous attenuating regions within the right ventricular outflow tract (Figure 3). The mass measured approximately 6.0 cm x 3.0 cm and was well visualized as a filling defect on
arterial and venous phases. There was also a soft tissue attenuating, multifocal, interstitial-to-mild alveolar pattern within the mid-to-ventral aspect of the right cranial lung lobes, ventral aspect of the cranial subsegment of the left cranial lung lobe, ventral aspect of the right middle lung lobe, and ventral aspect of the caudal subsegment of the left cranial lung lobe. As there was no evidence of pulmonary metastasis or abdominal organ abnormalities and taking into consideration the nature and location of the mass, the decision was made to pursue surgical resection of the intracardiac mass. Without attempt to relieve the physical obstruction within the heart, the short-term prognosis was grave for this symptomatic dog.

During the procedure, a median sternotomy approach was made to access the heart. After blunt dissection, the azygous, cranial, and caudal vena cava were isolated using preplaced loosely encircling 1 silk suture and 12 Fr red rubber Rommel tourniquets (Figure 4). The pericardium was incised longitudinally and retracted from the apex of the heart to the heart base. The pericardium was sutured to the surrounding pectoralis muscles using 2-0 coated braided polyester as stay sutures. The heart and right ventricular mass were palpated for preparation of incision and four stay sutures of 2-0 coated braided polyester were placed along the proposed incision line (Supplementary Video 1). The Rommel tourniquets were secured. A linear incision was made along the right ventricle with a 10-blade scalpel. Once the right ventricular outflow tract was incised, a large, approximately 1.5 × 3 cm, calcified, irregular mass at the right ventricular free wall below the pulmonic valve annulus was briskly exteriorized and freed from a narrow base using tangential vascular clamps and bone cutting forceps (Figure 5). Once the mass was marginally excised, the incision in the ventricle was loosely apposed with tangential vascular forceps and flow to the heart was restored by removing the red rubber catheters and silk sutures around the great veins. Air was removed from the heart by administering a large breath, loosening the tangential vascular forceps, and maintaining positive the pressure in the lungs while the heart continued to beat, just long enough to permit displacement of intracardiac air and to minimize blood loss. The tangential vascular forceps were replaced on the right ventricle, allowing internal flow and simultaneous hemostasis. Total time of inflow occlusion was 70 s. The heart was closed with medium sized pledgets on double-armed 4-0 polypropylene with simple interrupted horizontal mattress sutures (Figure 6). The incision was oversewn with a simple continuous pattern of 2-0 coated braided polyester (Figure 7; Supplementary Video 1). The stay sutures were removed from the pericardium and it was loosely apposed using 2-0 coated braided polyester to allow for drainage while avoiding any herniation or tamponade. There was a small area of the right cranial lung that experienced mild iatrogenic air leakage, which was effectively repaired with a thoracoabdominal stapler using vascular staples for a subtotal lobectomy. A 20-fr chest tube was placed exiting the right lateral thorax at the eighth intercostal space. The mediastinum, sternum, and soft tissues were closed routinely. The dog recovered from the procedure with no postoperative complications and was discharged 2 days postoperatively. Following surgery, adjuvant radiation therapy was recommended, but it was not pursued since tumor
Resection was incomplete. Histopathology of the extirpated mass revealed a grade 2 chondrosarcoma with neoplastic cells extending into the natural tissue margins. This tumor was determined to be histopathologically distinct from the chondroblastic osteosarcoma diagnosed in the right distal femur. Recheck echocardiogram completed 2 wk postoperatively revealed normal cardiac structures and no evidence of any mass or outflow tract obstruction (Figure 8). Physical examination and thoracic radiographs were unremarkable (Figure 9). A complete return to normal activity level was noted by the owners, despite recommendation for longer rehabilitation. Thoracic radiographs, echocardiograms, and physical examinations were recommended to occur every 2–3 mo for disease monitoring. As the dog continued to be asymptomatic, the owners delayed reevaluation until 309 days postoperatively, at which point a recurrent mineralized mass, measuring 2.4 cm × 2.2 cm with echocardiography, was detected in the right ventricular outflow tract as well as a solitary pulmonary metastasis on thoracic radiographs. Two mo later the dog exhibited progressive exertional fatigue and collapse. The dog presented to the institution with pronounced exertional fatigue and collapse and experienced fatal cardiovascular arrest prior to any second thoracotomy attempt 372 days after cardiac surgery. Necropsy findings supported a cause of...
death due to recurrent chondrosarcoma at the right ventricle with metastasis to kidney and lungs (Figure 10).

Discussion

The use of cardiopulmonary bypass is well described in veterinary medicine and, although there are many indications for the procedure, the potential complications warrant investigation of alternative techniques in certain circumstances.5 This case exemplifies the novel application of non-bypass inflow occlusion as an acceptable technique for the removal of a right ventricular outflow tract obstruction. The reported decrease in postoperative complication rates and recovery times, as well as lower surgical costs, makes inflow occlusion an appealing alternative to cardiopulmonary bypass. There were minimal intraoperative and postoperative complications associated with this procedure and it resulted in the successful removal of the mass with durable palliation postoperatively. Potential risks that could have been encountered in this procedure include: (1) a cardiac mass that may not have been resectable; (2) brain hypoxemia and/or cardiac arrest if inflow occlusion exceeded an estimated 4 min or a heart that did not respond following occlusion; (3) intracardiac visualization revealing the mass to actually involve cordae tendineae, the tricuspid valve, intraventricular septum, or aortic wall; (4) iatrogenic bundle branch block if the bundle of His were incised; (5) an intracardiac hole if too deep of a resection was made for tumor removal; (6) air embolism; or (7) massive intraoperative blood loss. Other previously described techniques utilized to remove masses within the right ventricle without the need for cardiopulmonary bypass include the use of cardioplegia solution, aortic cross clamping, and systemic hypothermia.4 In addition to the absence of cardioplegia, intentional hypothermia, and aortic cross clamping, the surgical approach through the ventricle is a unique attribute of this technique with previously described approaches involving the pulmonary artery and right atrium.1,8,11 The necessity for cardiac arrest in other procedures increases the risk of surgical complications, such as reperfusion injury, hypoxemia, hemorrhage, thrombosis formation, and failure to successfully restart the heart. In comparison, recent studies completed have reported decreased rates of hemodynamic, metabolic, and neurologic complications in dogs undergoing total venous occlusion.7,9,19 Similar comparisons between cardiopulmonary bypass procedures and inflow occlusion in human medicine have concluded less patient morbidity related to inflow occlusion and a decrease in the use of blood transfusion with this procedure.9 In addition to these potential patient benefits, the required materials for inflow occlusion are more readily accessible when compared to cardiopulmonary bypass, making its application more realistic for more surgeons.

The histopathologic finding of chondrosarcoma and location of the mass within the right ventricle are of clinical significance as it indicates two distinct primary malignant neoplasms occurring in a middle-aged dog. Primary cardiac chondrosarcoma is rare in veterinary medicine and canine chondrosarcoma normally occurs in locations on the appendicular skeleton, but the presence in several other sites has been reported with an incidence of 1–13%.20 This tumor likely arises from the cartilaginous tissues that compose the cardiac skeleton, such as the valves or chordae tendineae, but it may also arise from primitive mesenchymal cell differentiation of several tissue types.20,21

Cardiac surgery requires a therapeutic approach tailored to an individual patient. Proper presurgical planning and case selection are critical when considering the use of total venous inflow occlusion to intracardiac mass removal. Advanced imaging, such as computed tomography, magnetic resonance, and echocardiography, are valuable modalities for determining resectability of masses in such procedures.5,18 The combination of echocardiography and computed tomography provided vital information in identifying the precise location of this mass within the right ventricular outflow tract and aided in surgical planning.

Conclusion

This case report offers another option for removal of right ventricular outflow tract masses with minimal resulting complication. The decreased morbidity and simplicity of inflow occlusion make this technique an appealing alternative to conventional cardiopulmonary bypass for intracardiac mass removal in select patients.

VIDEO 1 Intraoperative video of right ventricular outflow tract being prepared for incision, removal of the intracardiac chondrosarcoma, de-airing of the heart, and ventricular wall closure. Patient orientation is cranial to the top and caudal to the bottom of the image.
REFERENCES


