LECTURE TITLE: Advanced Surgical Management of Patent Ductus Arteriosus and Vascular Ring Anomalies in Dogs and Cats

Subtitle: A Practical Approach to PDA and PRAA: Diagnosis, Technique, and Outcomes in Small Animal Patients

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INTRODUCTION

Patent ductus arteriosus (PDA) and persistent right aortic arch (PRAA) are two congenital vascular anomalies that necessitate thoracic surgical intervention. These conditions are often referred to specialized centers, yet general veterinary practitioners with a solid understanding of thoracic surgery principles may be able to manage them, especially where referral options are limited. Early diagnosis and timely surgical intervention dramatically improve patient outcomes. This lecture aims to detail the pathophysiology, clinical presentation, diagnostic strategies, surgical and interventional treatment options, and postoperative management for PDA and PRAA, while integrating current literature and imaging innovations.

EPIDEMIOLOGY

PDA is among the most prevalent congenital cardiac defects in dogs, accounting for approximately 25–30% of all such anomalies. It is commonly found in females and certain breeds such as Poodles, Maltese, Pomeranians, Shetland Sheepdogs, and German Shepherds. Though less common, PDA also occurs in cats. PRAA represents about 95% of vascular ring anomalies in dogs, with large breed dogs—particularly German Shepherds and Irish Setters—showing a genetic predisposition. Clinical signs often emerge at weaning when puppies begin consuming solid food.

ANATOMY

The ductus arteriosus is a fetal vessel that connects the pulmonary artery to the descending aorta, bypassing the non-functioning fetal lungs. Physiological closure occurs within a few days after birth due to increased oxygen tension and reduced prostaglandin E2. In PDA, this closure fails, allowing persistent blood flow from the aorta to the pulmonary artery and resulting in a left-to-right shunt. In PRAA, the right fourth aortic arch persists instead of the left, which normally forms the functional arch. This anomaly, combined with a left ligamentum arteriosum, creates a vascular ring around the esophagus and trachea, leading to constriction.

Less common vascular ring anomalies include PRAA with an aberrant left subclavian artery, double aortic arch, left aortic arch with a right ligamentum arteriosum, and aberrant right subclavian artery. A classification system using CT angiography, such as the one by Schorn et al. (2021), facilitates precise anatomical identification and surgical planning.

PATHOPHYSIOLOGY AND CLINICAL SIGNS

In PDA, left-to-right shunting increases pulmonary circulation and venous return, causing volume overload of the left atrium and ventricle. If untreated, this can lead to congestive heart failure. Clinical signs include a continuous "machinery" murmur, tachypnea, cough, exercise intolerance, syncope, and bounding pulses. In severe or reversed PDA (right-to-left), signs like differential cyanosis, polycythemia, and collapse may be observed.

In PRAA, esophageal and occasionally tracheal compression occurs due to the vascular ring, resulting in regurgitation upon solid food intake, poor weight gain, failure to thrive, and recurrent aspiration pneumonia. Megaesophagus is often noted, which can persist postoperatively and affect long-term prognosis.

DIAGNOSTICS

In PDA, auscultation of a continuous murmur over the left heart base is diagnostic. Radiographs may show left-sided cardiomegaly and pulmonary overcirculation. ECG may indicate left atrial or ventricular enlargement. Echocardiography confirms abnormal flow between the aorta and pulmonary artery. Advanced imaging, including CT angiography, is useful in atypical or complex cases.

For PRAA, radiographs show a dilated esophagus cranial to the heart base. A barium swallow study can help determine the level and severity of obstruction. CT angiography remains the gold standard for

vascular anomaly diagnosis and surgical planning. Endoscopy can assess esophageal integrity and rule out other causes of regurgitation.

SURGICAL TECHNIQUE

Surgical correction of PDA via left fourth intercostal thoracotomy involves careful dissection and ligation of the ductus arteriosus while preserving nearby structures like the vagus nerve. Double ligation with non-absorbable suture is standard. Some surgeons reinforce the closure with vascular clips or staples. Alternatively, transcatheter techniques using Amplatz® occluders or embolization coils offer a minimally invasive approach with reduced recovery time and complication rates. Thoracoscopic PDA ligation is an emerging technique that allows improved visualization and reduced postoperative pain, although it requires specialized skills and equipment.

Surgical correction of PRAA typically involves left fourth intercostal thoracotomy, ligation, and transection of the ligamentum arteriosum, and release of fibrous constrictions. Esophageal and tracheal decompression are confirmed intraoperatively. In double aortic arch or complex anomalies, preoperative CT determines the dominant arch and optimal surgical approach. Aberrant subclavian arteries may require ligation or transposition. Thoracoscopic approaches, though technically demanding, are gaining traction for suitable cases due to reduced postoperative discomfort.

POSTOPERATIVE CARE

Postoperative management includes analgesia with opioids and NSAIDs, monitoring for hemorrhage, and respiratory support if needed. Echocardiography verifies PDA closure. PRAA patients require nutritional support, upright feeding, and monitoring for aspiration pneumonia. Long-term esophageal dysfunction may necessitate lifelong dietary changes.

COMMON COMPLICATIONS

In PDA surgery, major risks include intraoperative hemorrhage, nerve injury, and incomplete closure resulting in residual shunting.

In PRAA, complications include persistent regurgitation, aspiration pneumonia, and rare issues such as chylothorax or pneumothorax. Thoracoscopic procedures may fail in cases of complex anatomy, requiring conversion to open thoracotomy.

PROGNOSIS

PDA has an excellent prognosis if treated early, with over 90% of dogs leading normal lives post-ligation or device occlusion. Early surgical intervention minimizes the risk of irreversible cardiac remodeling and congestive heart failure. However, in cases where residual shunting persists after surgery or interventional closure, the long-term outcome can be more guarded. Ongoing left-to-right shunting may result in continued volume overload, left heart dilation, and progressive heart failure, necessitating medical management and potential re-intervention. Right-to-left shunting (Eisenmenger's physiology) carries a significantly worse prognosis, as these cases are typically inoperable and require lifelong palliative care.

For PRAA, prognosis is generally favorable if surgery is performed before significant esophageal dilation becomes irreversible. Many dogs show substantial improvement in regurgitation and weight gain following surgery. However, prognosis is highly dependent on the duration and severity of preoperative esophageal compression. Megaesophagus may persist despite anatomical correction, especially in older patients or those with prolonged symptoms, potentially necessitating lifelong upright feeding and dietary modification. Recurrence of aspiration pneumonia or persistent regurgitation can negatively impact quality of life and long-term outcome.

ABSTRACT

Patent ductus arteriosus (PDA) and persistent right aortic arch (PRAA) are congenital vascular anomalies requiring surgical correction. PDA results in left heart overload and heart failure, while PRAA causes esophageal compression and regurgitation. Diagnosis includes physical exam, imaging, and CT angiography. Treatment ranges from open thoracotomy to minimally invasive techniques. Postoperative care includes pain management, nutritional support, and monitoring for complications. Prognosis is favorable with early intervention.

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