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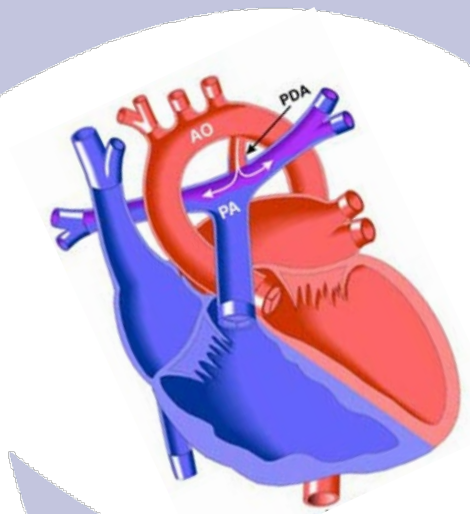

SURGICAL MANAGEMENT OF PATENT DUCTUS ARTERIOSUS IN DOGS AND CATS

Trabajo de Fin de Grado
Curso 2015-2016
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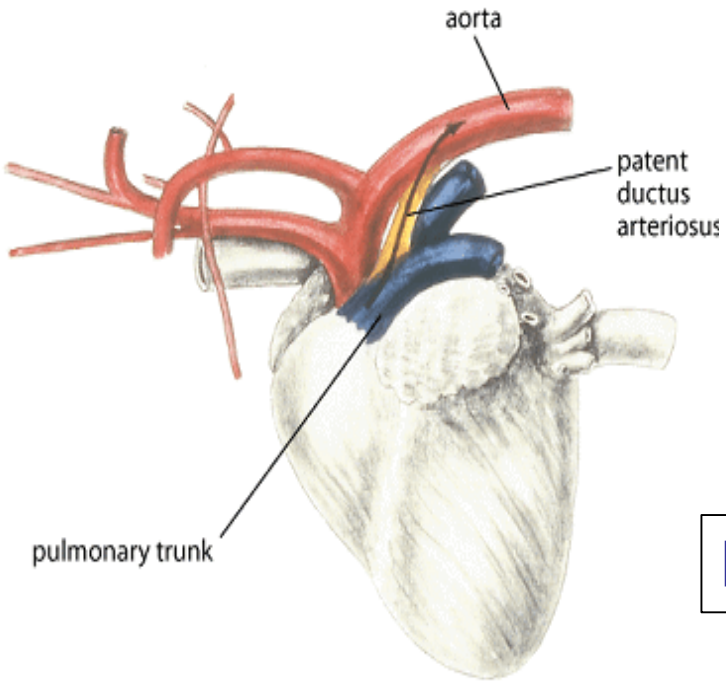
INTRODUCTION



Ductus arteriosus is a fetal vessel that connects the descending aorta and the MPA, which normally closes when animals begin to breathe. If remains open, is called

PATENT DUCTUS ARTERIOSUS

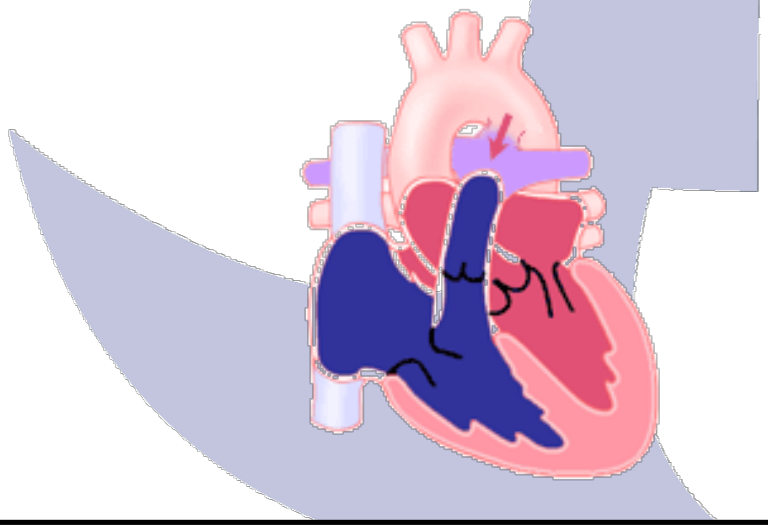
GENERAL CONSIDERATIONS AND PATHOPHYSIOLOGY

Most common congenital cardiac defect in dogs (25-30 % of congenital malformations), with female toy-breeds overrepresented. Significantly lower prevalence in cats (1-7.3 %). Any breed or sex predilections

- Left-to-right shunt
  - Volume overload of the LV
    - LV hypertrophy
      - Distension of the mitral valve annulus
        - Secondary MR
          - congestive heart failure the first 1-2 years of life

GENERAL CONSIDERATIONS AND PATHOPHYSIOLOGY

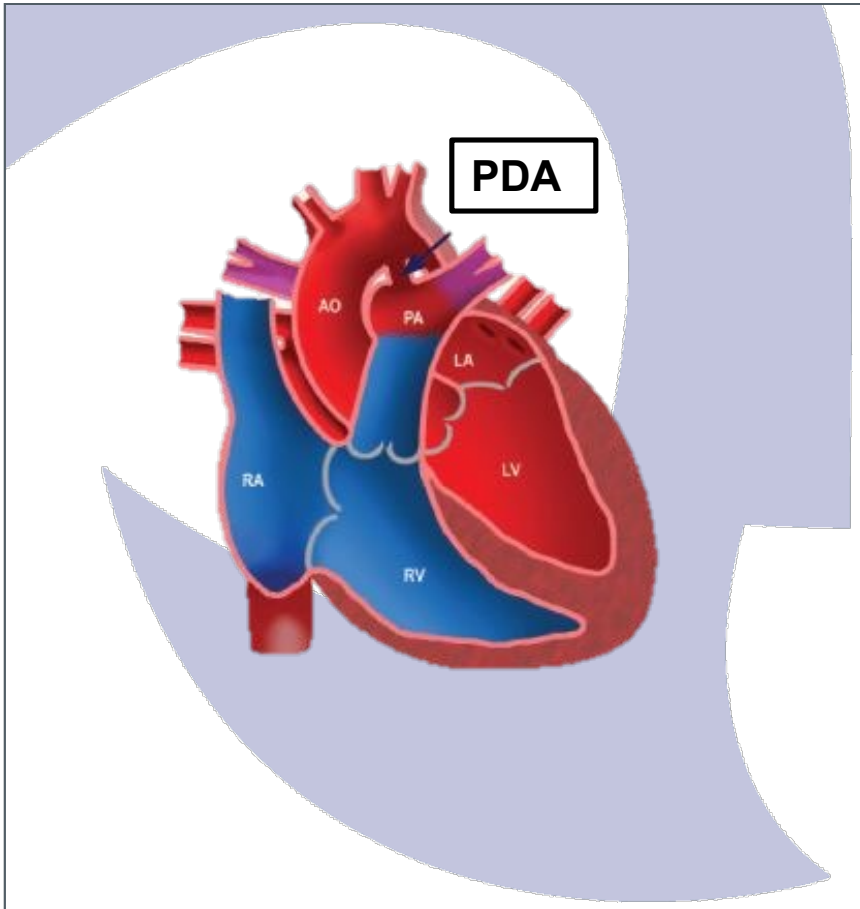
Rarely, animals with PDA develop suprasystemic pulmonary hypertension that reverses the direction of the flow (right-to-left PDA)



Late sequel (6 months) to not occluded PDA

- Cardiac volume overload
- ↓
- Pulmonary overcirculation
- ↓
- Hypertrophy and intimal proliferation
- ↓
- Gradual narrowing of pulmonary vessels
- ↓
- Pulmonary arterial hypertension

OBJECTIVE



The purpose of this study is to provide updated and detailed information about this condition in small animals, reviewing its pathophysiology, symptoms, clinical signs diagnosis and treatment options, as well as show the clinical importance of this pathological condition.

DIAGNOSIS - SIGNALMENT

Young purebreds female dogs.
Toy poodles, maltese, pomeranians, Yorkshire Terriers, Chihuahuas… are an increased risk for developing PDA.

Journal of Veterinary Internal Medicine
Open Access

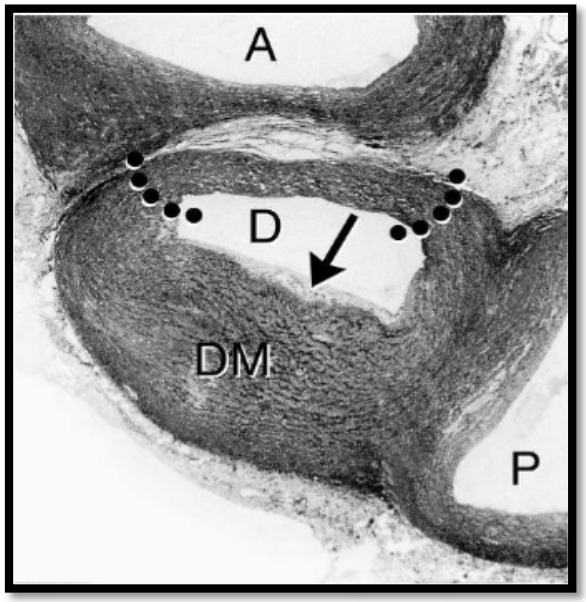
Long-term outcome in dogs with patent ductus arteriosus: 520 cases (1994-2009).
Saunders AB[1], Gordon SG, Boggess MM, Miller MW. 2014

DIAGNOSIS-SIGNALMENT

Increased prevalence in certain breeds indicated that genetic factors were involved in the pathogenesis.

- Hypoplasia and asymmetry of ductus specific smooth muscle
- Aorta-like elastic tissue in the ductus wall

Sufficient to cause patency



Journal of Veterinary Internal Medicine

Etiology of patent ductus arteriosus in dogs.
Buchanan JW[1], Patterson DF. 2003

DIAGNOSIS-CLINICAL SIGNS

Most young animals are asymptomatic or have only mild exercise intolerance or lethargy.

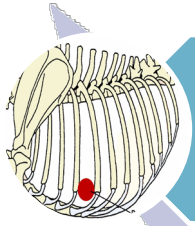
Symptomatic animals have: cough, tachypnea or both as a result of pulmonary edema.

Animals with right-to-left PDA: exercise intolerance, intermittent hindlimb weakness and seizures due to secondary polycythemia.

DIAGNOSIS-PHYSICAL EXAMINATION FINDINGS

Most cases are found when a heart murmur is detected in a perfectly healthy-looking puppy or kitten

Characteristic left base continuous (machinery) murmur.
3º left intercostal space



A palpable cardiac thrill is often present

Femoral pulses are strong or hyperkinetic ("water hammer" pulses)

SUPPLEMENTARY TESTS
ECG

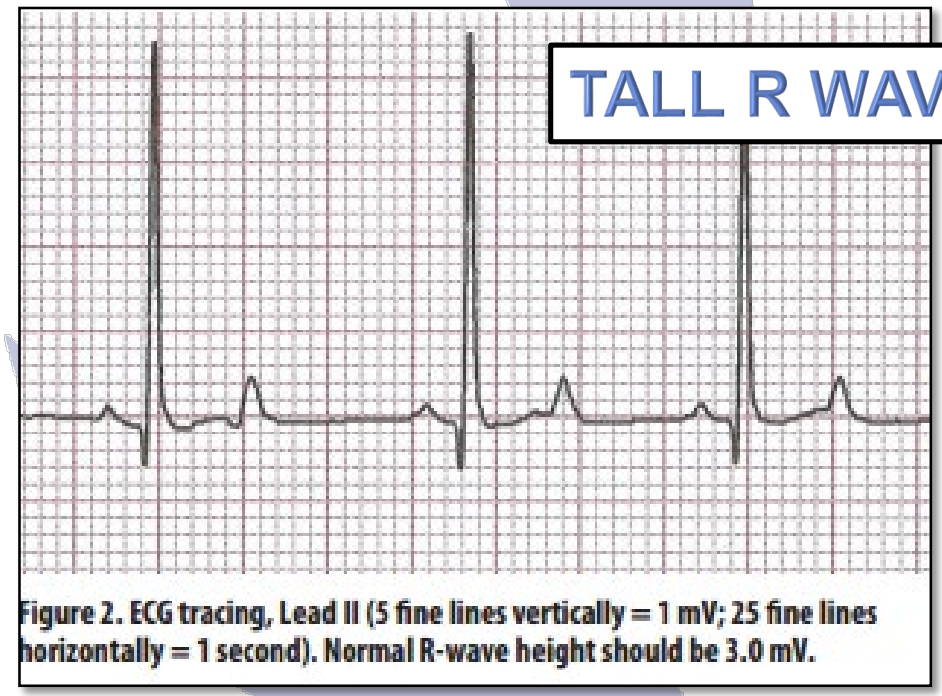


Figure 2. ECG tracing, Lead II (5 fine lines vertically = 1 mV; 25 fine lines horizontally = 1 second). Normal R-wave height should be 3.0 mV.

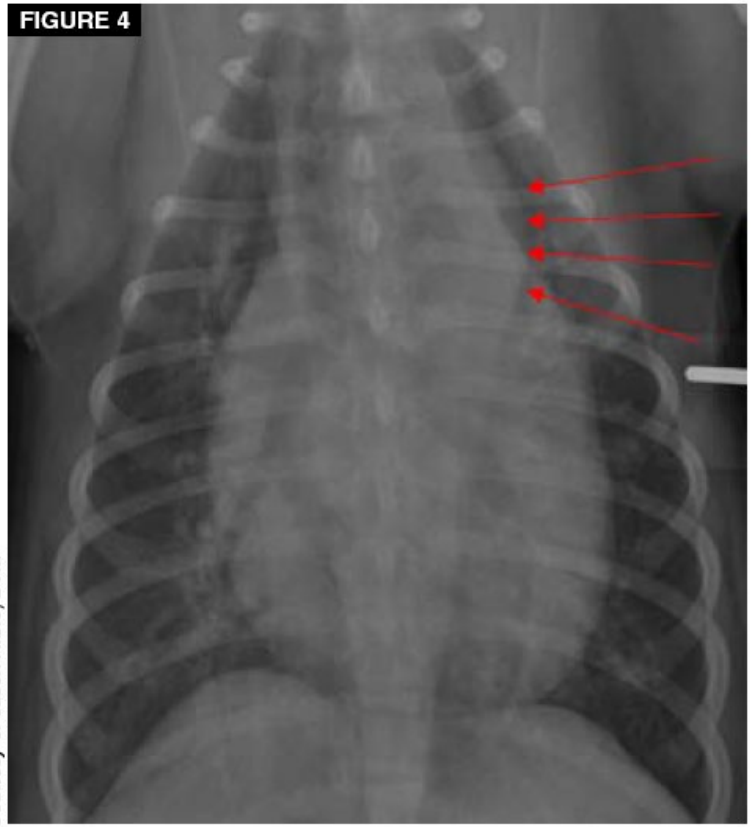
TALL R WAVES

WIDE P WAVES

Atrial fibrillation or ventricular ectopy may occur in advanced cases

SUPPLEMENTARY TESTS
RADIOGRAPHY

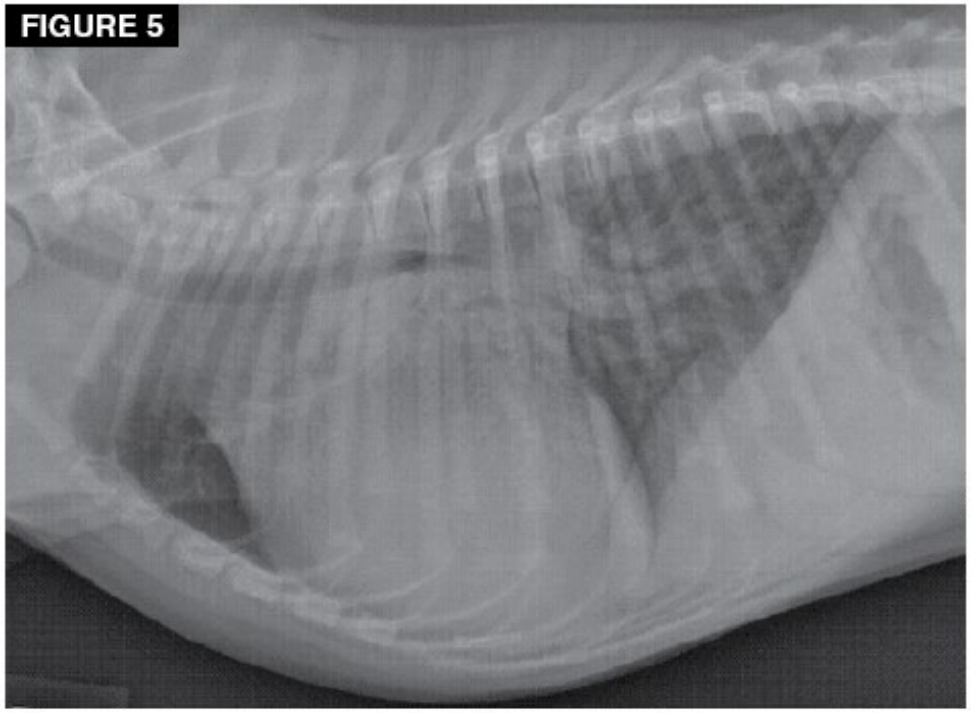
FIGURE 4



Courtesy of Jason Arble, DVM

Dorsoventral view of the thorax in a patient with PDA. The cardiac silhouette is elongated due to left-sided heart enlargement. Note the ductal aneurysm (*arrows*).

FIGURE 5



Courtesy of Dr. Arble

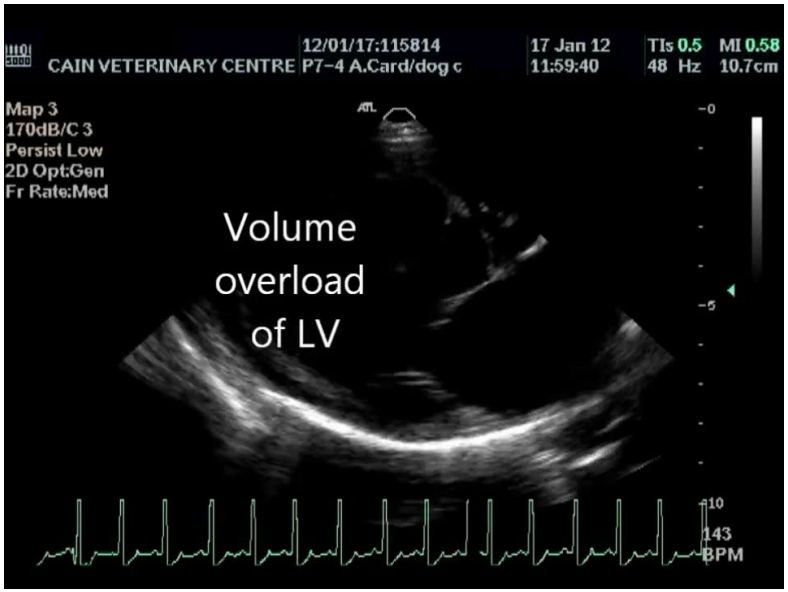
Lateral view of a patient with a PDA. Note the increased height and width of the cardiac silhouette, increased sternal contact, and dorsal elevation of the trachea. The pulmonary vasculature is overperfused, and there is evidence of early pulmonary edema.

Compendium
CONTINUING EDUCATION FOR VETERINARIANS

Patent ductus arteriosus in dogs.
Broaddus K[1], Tillson M. 2010

SUPPLEMENTARY TESTS
ECHOCARDIOGRAPHY

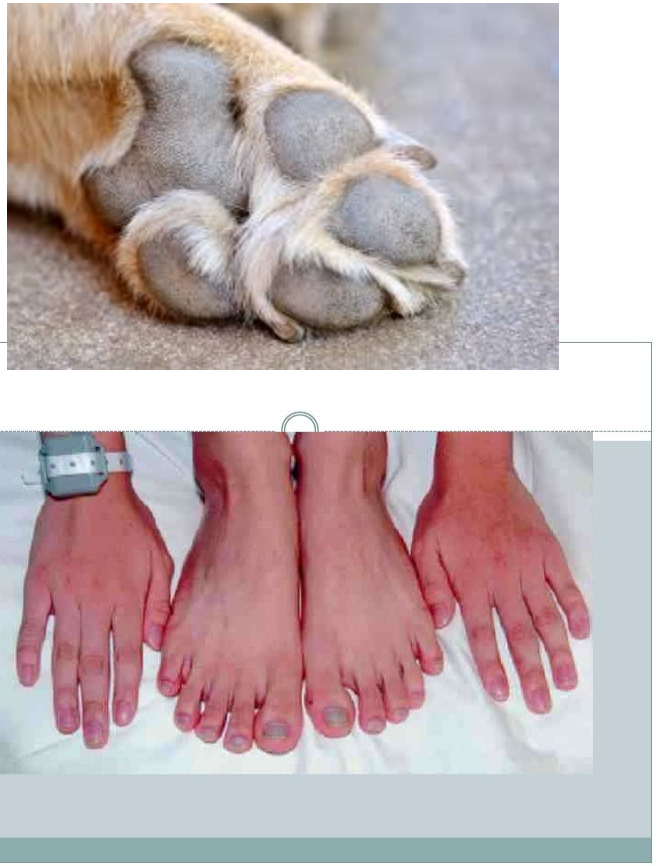
- LV and LA dilation
- PA dilation
- Characteristic reverse turbulent doppler flow pattern in MPA



Test of choice for PDA

REVERSE PDA – PHYSICAL EXAMINATION FINDINGS

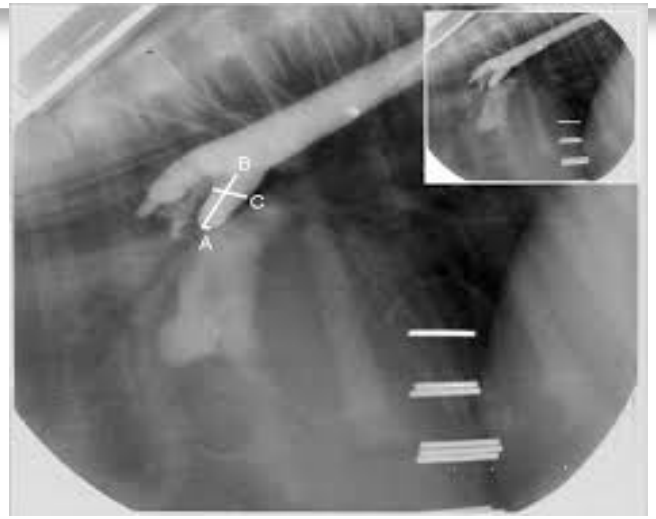
- Differential cyanosis is a characteristic examination finding:
  - ✓ Pink mucous membranes cranially
  - ✓ Cyanotic mucous membranes caudally
- Femoral pulses are normal
- A faint systolic cardiac murmur is often present



ANGIOGRAPHY

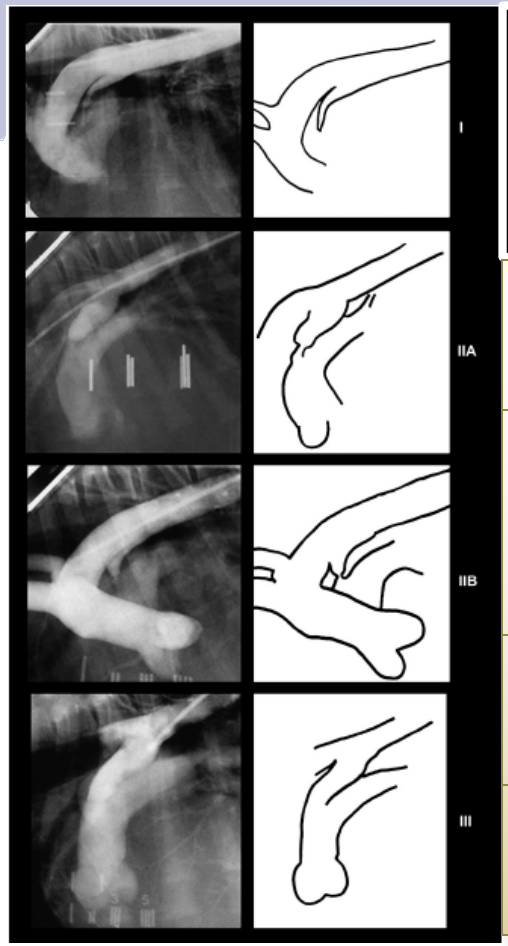
Determine:

- Ductal morphology and size
- MDD



Access to the femoral artery percutaneosly or via cut down. In both cases, an introducer is placed within the femoral artery, and a catheter is advanced through the descending aorta. The radiopaque contrast agent is injected (1 ml/kg nonionic contrast media)

ANGIOGRAPHY



The most important aspect of PDA morphology is related to the presence of adequate tapering as it enters the MPA

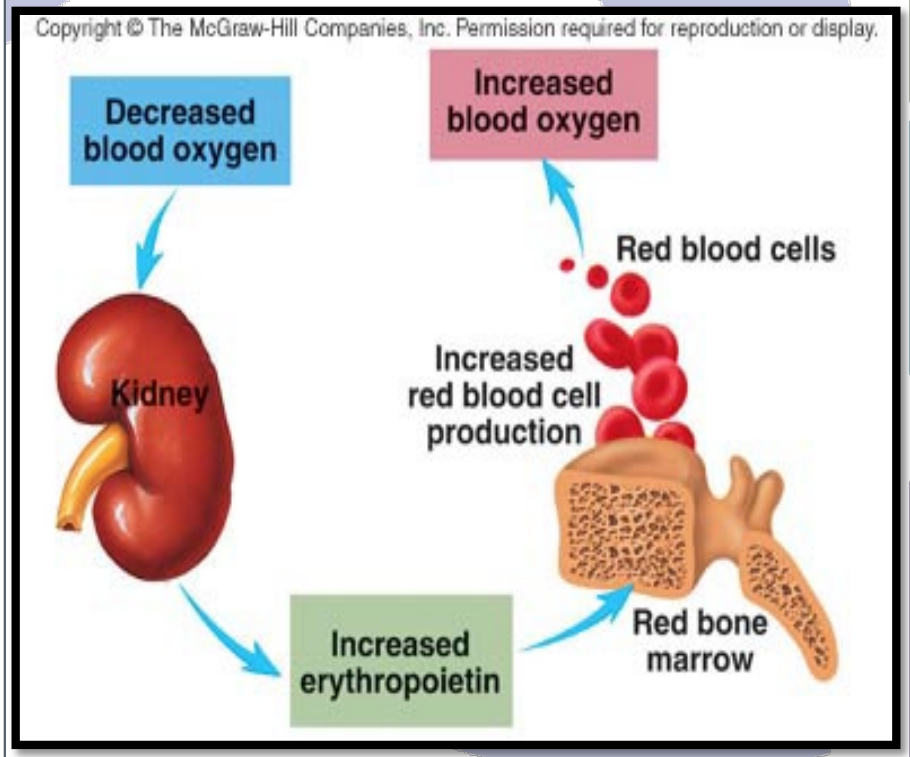
Type I	Diameter of the ductus gradually decreases in size from the aorta to the pulmonary artery.
Type IIA	Most common. Walls of the ductus parallel each other with abrupt decrease in diameter of the ductus at the pulmonary ostium.
Type IIB	Diameter of the ductus markedly decreases in size from the aorta to the pulmonary artery.
Type III	Ductus is tubular with little or no change in diameter throughout its length.

Journal of Veterinary Cardiology ESVC

Angiographic classification of patent ductus arteriosus morphology in the dog.

Miller MW[1], Gordon SG, Saunders AB, Arsenault WG, Meurs KM, Lehmkuhl LB, Bonagura JD, Fox PR.

LABORATORY FINDINGS



Uncommon in animals with left-to-right shunting PDA

Animals with right-to-left PDA are commonly polycythemic

Perfusion of the kidneys with deoxygenated blood causes excessive release of erythropoietin

DIFFERENTIAL DIAGNOSIS

The characteristic physical examination findings make diagnosis of PDA straightforward in most cases.

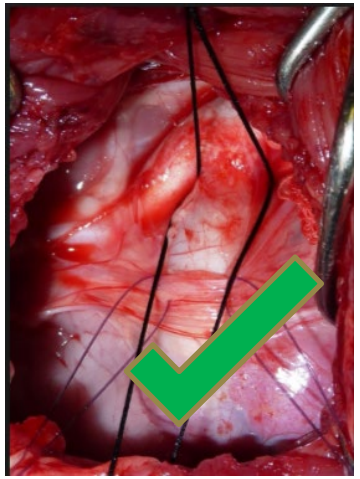
Other differentials would include:

- Subaortic stenosis
- Pulmonic stenosis
- ASD and VSD
- Tetralogy of Fallot
- Right-to-left shunting
- Other rare complex forms of cyanotic heart disease

MEDICAL MANAGEMENT

In human pediatric medicine: Prostaglandin synthase inhibitors (indomethacin, ibuprofen) to stimulate natural closure

Does not appear to be effective when there is hypoplasia of the PDA smooth muscle



Mechanical occlusion of PDA remains the mainstay of treatment in animals

MEDICAL MANAGEMENT

Right-to-left PDA is managed medically.

Long-term management has been described in only a small number of dogs using phlebotomy or hydroxiurea to decrease polycythemia.

Journal of Veterinary Internal Medicine — Open Access

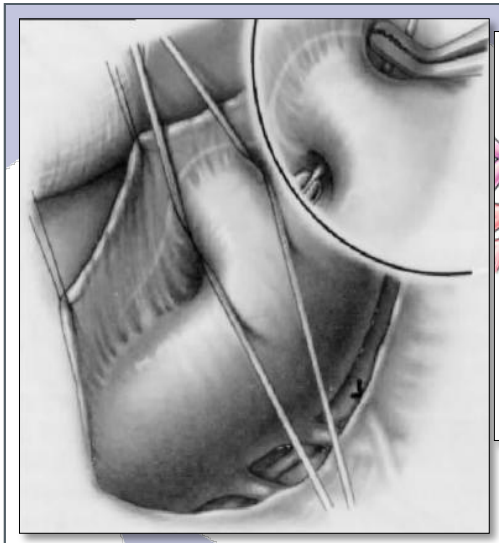
Long-term clinical management of right-to-left ("reversed") patent ductus arteriosus in 3 dogs.
Côté E[1], Ettinger SJ. 2001

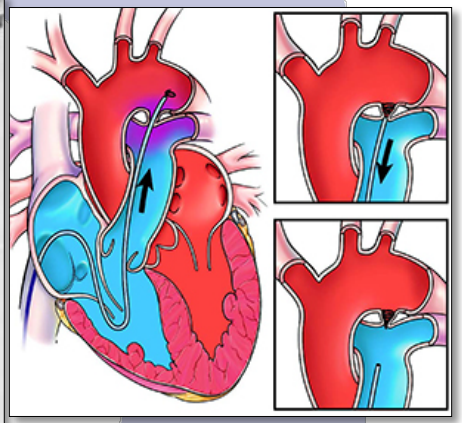
Pentoxifylline as adjunct therapy to routine phlebotomies was described in a 10-years-old Chihuahua

Pentoxifylline as adjunct therapy to long-term clinical management of a right-to-left patent ductus arteriosus.
Turner E[1]. 2016

The Canadian Veterinary Journal
La Revue vétérinaire canadienne

SURGICAL TREATMENT





Left-to-right PDA must be managed with occlusion using either open surgical ligation or minimally invasive techniques.

No surgical treatment for reverse PDA

- Increase in pulmonary hypertension
- Right heart failure
- Death

Medical management only

PREOPERATIVE MANAGEMENT

- Preoxygenation
- Opioid premedication
- Anesthesia
- Etomidate for patients with CHF
- Pretreatment with Inodilators, vasodilators and diuretics should be initiated as needed
- Blood should be available

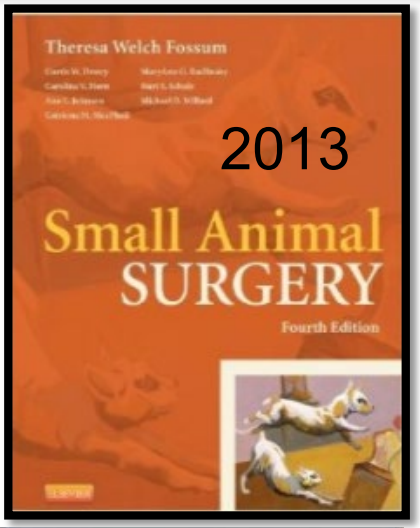
SURGICAL LIGATION

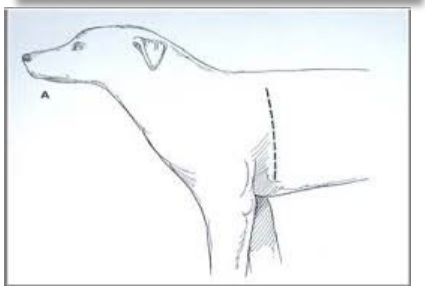
The current surgical technique is described by TW Fossum

Right lateral recumbency. The left thorax is prepared for aseptic surgery

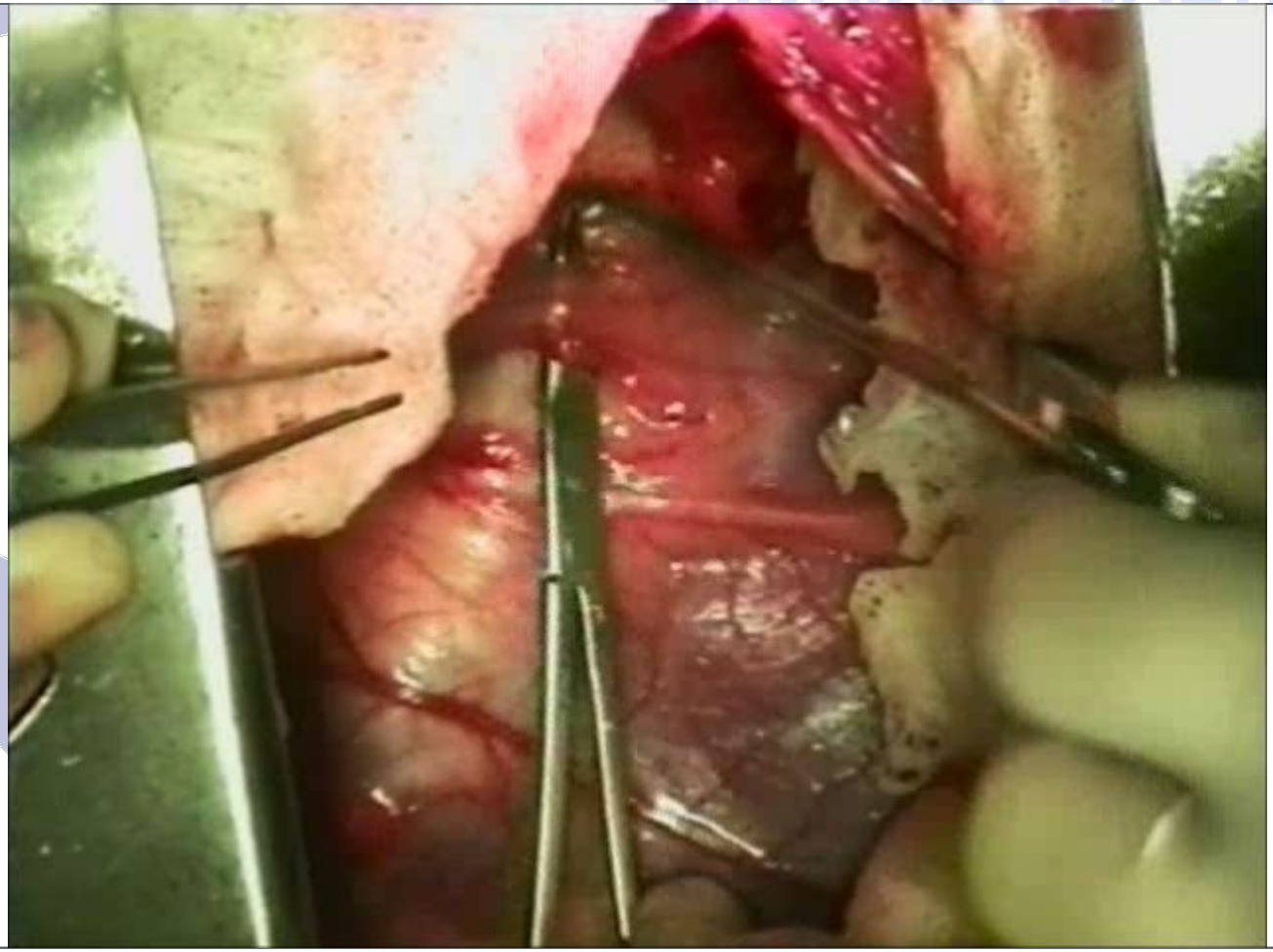
A small rolled towel is placed under the cranial thorax to maximize exposure by arching the chest and spreading the ribs on the left side.

The standard approach remains a left fourth space intercostal thoracotomy





SURGICAL LIGATION



MINIMALLY INVASIVE TECHNIQUES TRANSARTERIAL COIL EMBOLIZATION

Coils: surgical stainless steel and prothrombotic poly-Dacron fibers to hasten coagulation

Straight and loaded in a thin metallic cylinder to facilitate introduction into a catheter for embolization

It can be approached from the aorta via a peripheral artery (most common) or from the MPA via a peripheral vein

Selected coils are generally greater than twice the minimal ductal diameter.

Clinical Techniques in Small Animal Practice

Transarterial coil embolization for canine patent ductus arteriosus occlusion.
Gordon SG[1], Miller MW. 2005

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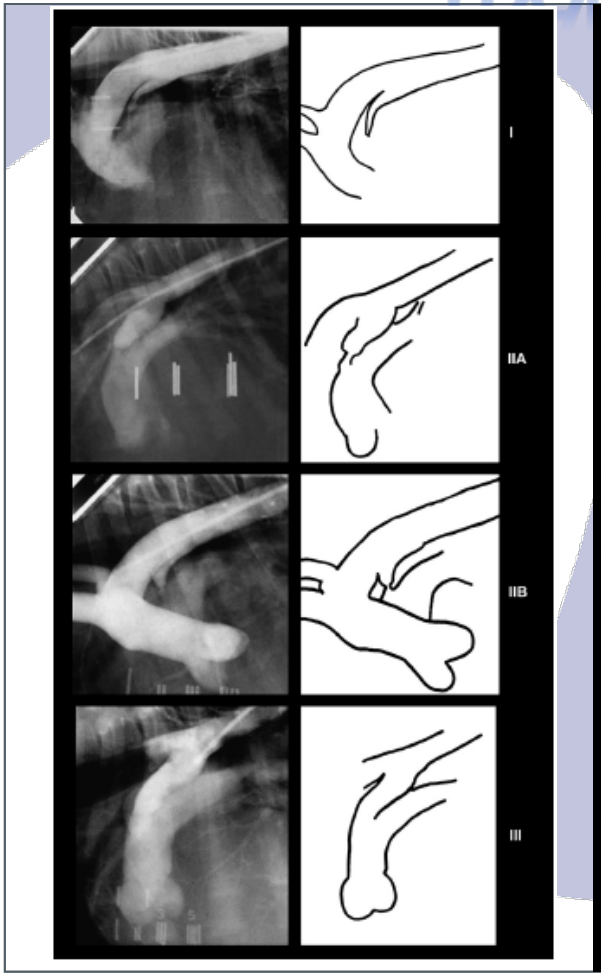
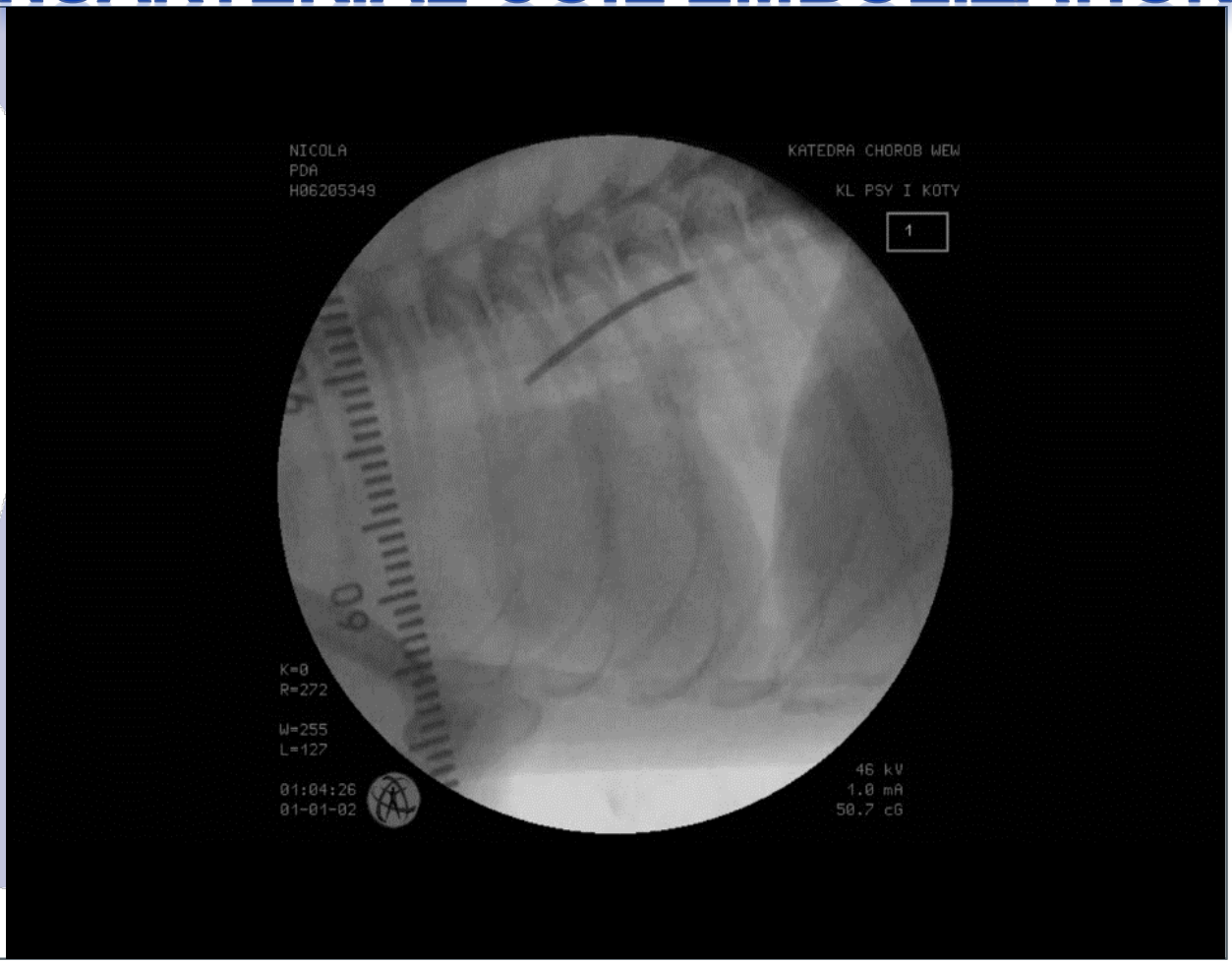
MINIMALLY INVASIVE TECHNIQUES
TRANSARTERIAL COIL EMBOLIZATION





MINIMALLY INVASIVE TECHNIQUES
INTRAVASCULAR OCCLUDING DEVICES

Amplatz Vascular Plug

Amplatz Canine Duct Occluder

Short waist that separates a flat distal disc from a cupped proximal disc

Designed to conform to the morphology of canine PDA

These devices use nitinol mesh that expands within the lumen

The multiple layers result in progressive thrombosis of the vessel

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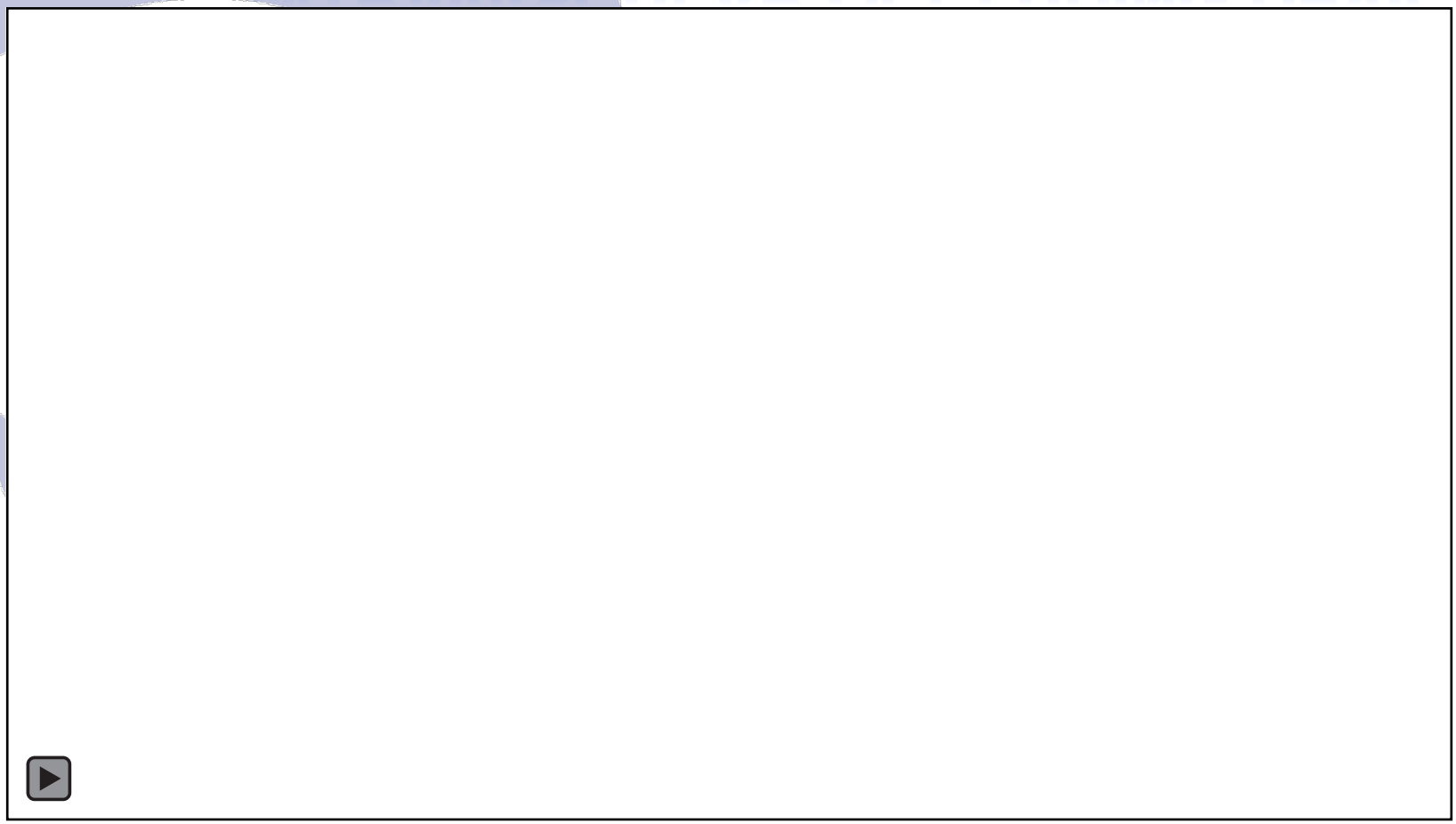
MINIMALLY INVASIVE TECHNIQUES INTRAVASCULAR OCCLUDING DEVICES



SURGICAL COMPLICATIONS

SURGICAL LIGATION

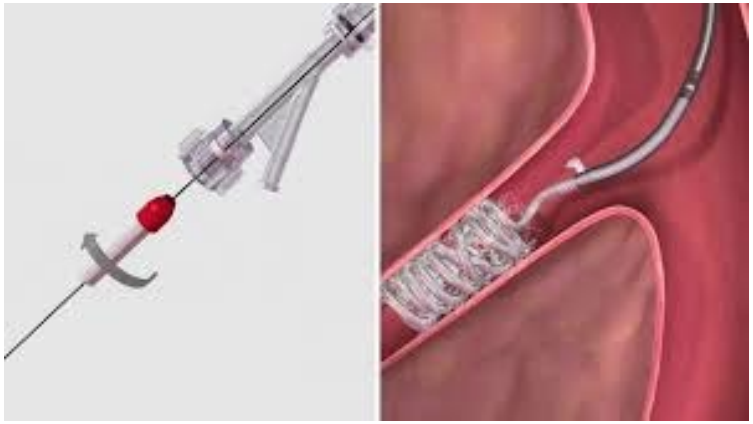
- Most serious: rupture
- Sodium nitroprusside to lower the systemic mean arterial pressure
- If bleeding is severe, vascular clamps to occlude the aorta while the ductus is ligated
- Bleeding controlled: continue/stop in favor of repair later
→2º surgeries are more difficult owing to adhesions at the surgical site

SURGICAL COMPLICATIONS

MINIMALLY INVASIVE TECHNIQUES

Moderate to severe haematoma is one of the most commonly reported complication after catheter based procedures

- Coil dislodgment
- Inaccurate coil deployment
- Lameness after arterial cut-down
- Significant residual flow
- Severe hemorrhage
- MPA embolization
- Partial aortic deployment
- Hemolysis
- Implant infections



POSTOPERATIVE CARE AND ASSESSMENT

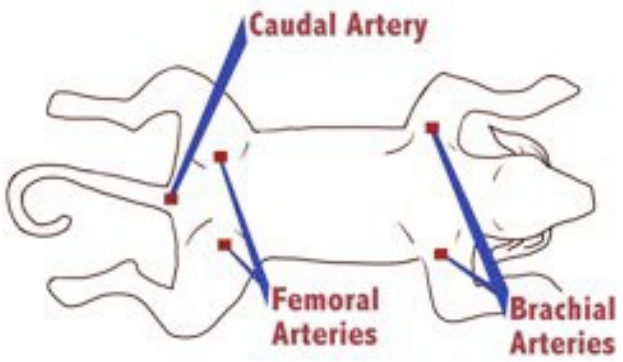
SURGICAL LIGATION

- Bupivacaine intercostally or intrapleurally
- When animales are recovered, they should be fed
- Thoracostomy tubes/smaller catheter before thoracic closure → removed 4-24 hours after surgery
- Light wrap over the thoracic incision
- Patients are discharged 48 hours after PDA ligation

POSTOPERATIVE CARE AND ASSESSMENT

TRANSCATHETER PROCEDURES

Direct pressure is applied for a mínimum of 30 min or chitosan acetate dressing may be applied and held in place for 10 min



Patients usually go home the following day

Antibiotics for 7 days

Monitor patients with post-release angiography, follow-up radiography, auscultation and echocardiography

PROGNOSIS

Closure →excelent long-term prognosis

70 % of dogs with untreated PDA die before 1 year of age

Older animals and those with right atrial dilation on preoperative RX are less likely to survive

Clinical signs at presentation, concurrent CHD and severe MR within 24 hours of closure, negatively affect survival

DISCUSSION

DISCUSSION

Patent ductus arteriosus closure

- Confers important survival benefits
- Results in long-term reverse cardiovascular remodeling

Negatively affect survival

- Clinical signs at presentation
- Concurrent congenital heart disease
- Severe MR

Long-term outcome in dogs with patent ductus arteriosus: 520 cases (1994-2009).
Saunders AB[1], Gordon SG, Boggess MM, Miller MW. 2014

DISCUSSION

Contraindications to occlusion or ligation

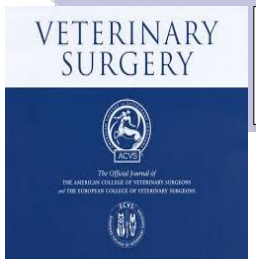
- Right-to-left shunting
- Bidirectional shunting
- Concurrent cardiac conditions that rely on the PDA for survival (e.g TF)

Compendium
CONTINUING EDUCATION FOR VETERINARIANS®

Patent ductus arteriosus in dogs.
Broaddus K[1], Tillson M. 2010

Ideal patient for SL

- 8-16 weeks of age
- Not concurrent cardiac disease
- Minimal secondary heart changes



Retrospective comparison of surgical ligation and transarterial catheter occlusion for treatment of patent ductus arteriosus in two hundred and four dogs (1993-2003).
Goodrich KR[1], Kyles AE, Kass PH, Campbell F. 2007

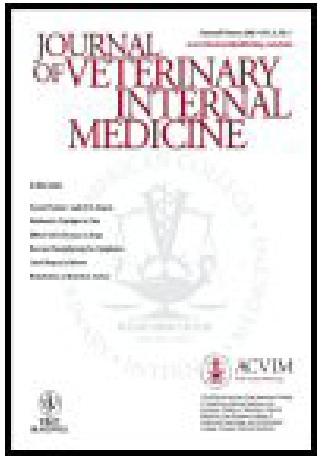
Increased risk for death: patients>24 months or weighing >23 kg

DISCUSSION

Long-term outcome in dogs with patent ductus arteriosus: 520 cases (1994-2009).
Saunders AB[1], Gordon SG, Boggess MM, Miller MW. 2014

Minimally invasive techniques have less risk for complications than surgical ligation via thoracotomy

However, mortality rates are comparable between SL and TCO

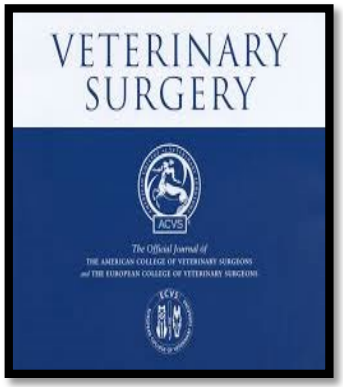


Immediate and Late Outcomes of Transarterial Coil Occlusion of Patent Ductus Arteriosus in Dogs 2006
F.E. Campbell, W.P. Thomas, S.J. Miller, D. Berger, and M.D. Kittleson

Transarterial coil embolization is not possible in dogs with large PDA, large shunt volume and CHF, so surgical ligation is required

An aberrant coil migration occurs in 22 % of cases

DISCUSSION



Retrospective comparison of surgical ligation and transarterial catheter occlusion for treatment of patent ductus arteriosus in two hundred and four dogs (1993-2003).

Goodrich KR[1], Kyles AE, Kass PH, Campbell F. 2007

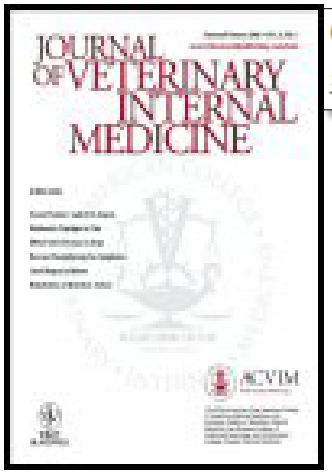
Initial sucess rate (complete dissapearance of the murmur) was higher for SL
Mortality rates are comparable
Incidence of minor complications were more common with TCO

[Patent ductus arteriosus in the dog: a retrospective study of clinical presentation, diagnostics and comparison of interventional techniques in 102 dogs (2003-2011)].

[Article in Dutch]
Meijer M[1], Beijerink NJ. 2012

There was no difference in initial sucess rate and survival time between SL and TCO

DISCUSSION



Occlusion devices and approaches in canine patent ductus arteriosus: comparison of outcomes.
Singh MK[1], Kittleson MD, Kass PH, Griffiths LG. 2012

ACDO: device of choice for the majority of PDA occlusions although is a too large device for transarterial delivery in small dogs (<2.5kg)

Limited in small animals, very expensive and cost prohibitive method

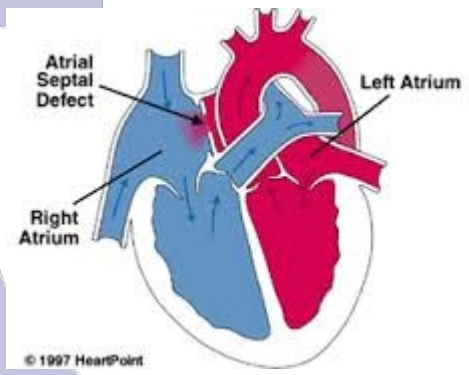
A new prototype PDA occlusion device (NFC) is being investigated

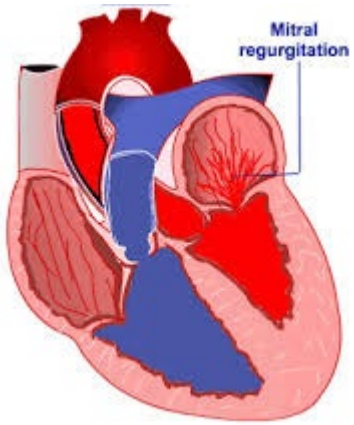
Mechanical and in vitro evaluation of an experimental canine patent ductus arteriosus occlusion device.
Wierzbicki MA[1], Bryant J[1], Miller MW[2], Keller B[1], Maitland DJ[3]. 2016

CONCLUSIONS AND CLINICAL IMPORTANCE

CONCLUSIONS AND CLINICAL IMPORTANCE

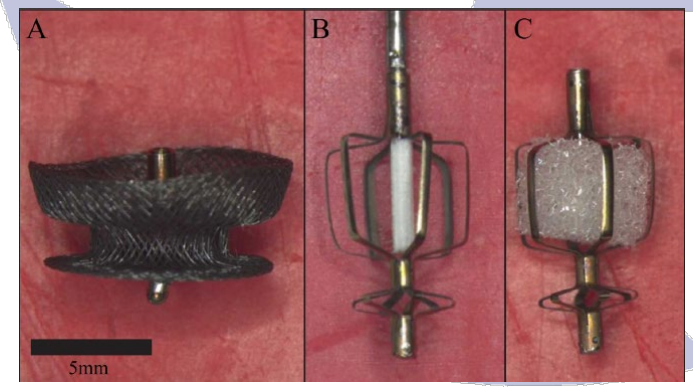
1- PDA closure confers important survival benefits and results in long-term reverse cardiovascular remodeling in most cases where clinical signs at presentation, concurrent CHD and severe MR negatively affect survival





CONCLUSIONS AND CLINICAL IMPORTANCE

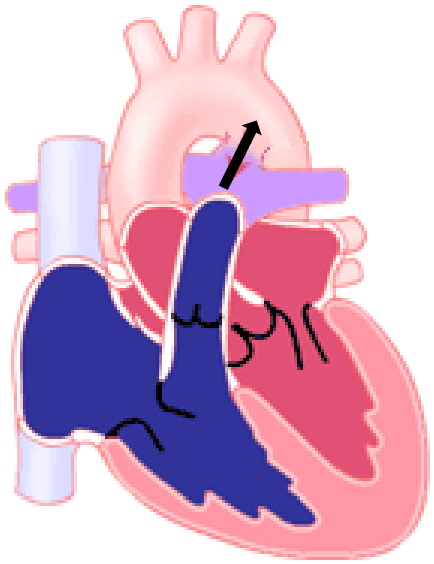
2- Both SL and TCO are suitable techniques for PDA closure. SL is a highly successful method that may be broadly available for most owners due to its reduced cost. TCO is a minimally invasive treatment option only performed by experienced surgeons in veterinary referral centers.



Further investigations are being undertaken in order to develop an effective device with lower cost and improve the assemble for all patients sizes

CONCLUSIONS AND CLINICAL IMPORTANCE

3- Finally, in animals with a reverse PDA occlusion is contraindicated. PH should be managed by medical treatment and close control of patients, and long-term prognosis is poor.



THANK YOU