Interventional cardiology: Resolution of congenital heart diseases in small animals

Ángel Cañete Pizarro
February 2017, Bachelor's thesis

Universitat Autònoma de Barcelona

FACULTAT DE VETERINÀRIA

Introduction

Interventional cardiology is a subspecialty of veterinary cardiology, whose main aim is to treat heart diseases by introducing a catheter into the heart chambers trough the blood vessels. All these procedures are image-guided and have many advantages that the rest of thoracic surgical interventions have not: lower risk, as they do not require thoracotomy; and faster recovery after surgery with less pain suffered.

Main goals

- To present interventional cardiology as an option to bear in mind, to solve or diminish the severity of congenital heart diseases in small animals, whose prevalence is about 0.13% in mixed-breed dogs, 0.89% in purebred dogs and 0.14% in mixed-breed cats.
- To know which imaging techniques are being used, and the methods and materials for vascular access.
- To detail the most frequently used procedures in small animal clinics, including: characteristics of every intervention, material or devices to choose in each case, the vascular access more appropriate to each procedure, and concerning all associated risks.

Due to most of the interventions are being used in dogs, this revision is always refers to canine patients unless there are any differences with respect to cats.

Occlusion of patent ductus arteriosus (PDA)

Patent ductus arteriosus (PDA) is one of the most common congenital cardiac defects in dogs (but uncommon in cats), consisting in the remanence after birth of a shunt between the aorta and the pulmonary trunk called ductus arteriosus. The blood flow of the ductus goes from the aorta to the pulmonary artery (left to right), but if pulmonary artery pressure increases over the aorta's, the direction of the blood flow is reversed (right to left) and surgical treatment becomes contraindicated.

Nowadays, invasive surgical techniques (PDA ligation, that requires a left-sided thoracotomy) are not the only choice. The occlusion of PDA by means of certain devices is being introduced, with lower periprocedural risks and a high success rate.

The choice of the device depends on:

- PDA size: measurements of the ductal ampulla (wider diameter) and minimal ductal diameter (MDD).
- PDA morphology: 4 different PDA phenotypes have been identified (Fig. 1). The most common type is IIA, being type III the least common.

Trombogenic devices: coils	Self-expanding devices: Amplatz ® Canine Duct Occluder (ACDO)
– Spiral-shaped device composed by synthetic fibres (Dacron®) with trombogenic function. – Device selection: coil loop diameter at least twice the MDD, or closest to ampulla width. – Indication: < 10 kg and < 4mm MDD (or < 3mm, with less associated risks). – Contraindication: PDA type III. – Left-heart catheterization is preferred. – The coil is deployed within the ductal ampulla and delivered when placement appears to be stable. The occlusion function is noticeable to be seen few weeks after surgery. – Higher risk of residual flow and device embolization.	– Self-expanding nitinol mesh device composed of a short waist that separates a flat distal disc from a cupped proximal disc (Fig. 2). – Device selection: waist diameter must be 1.5 to 2 times the MDD's. – Indication: > 10 kg and > 4mm of MDD. – Contraindication: PDA type III. – Left-heart catheterization is preferred. – Once in the pulmonary artery, the device must start to be deployed: firstly, the flat distal disc, and secondly, the cupped one— when in the ductal ampulla. The device is delivered once the placement appears to be stable (Fig. 3). – Lower associated risks.

Prognosis after PDA closure is usually excellent if any complications are not seen.

Figure 1. Classification of the four PDA phenotypes according to Miller *et al.* (2006). *Figure modified of* Miller *et al.* (2006).

Figure 2. Amplatz ® Canine Duct Occluder (Infiniti Medical 2016).

Figure 3. Occlusion of PDA with ACDO (Pradelli 2013).

Pulmonary valvuloplasty

Pulmonic stenosis (PS) is also a common congenital cardiac defect in dogs (uncommon in cats), that produces an obstruction in the right-ventricle outflow tract. It can be subvalvular, supravalvular and valvular. The last one is the most common presentation and it is divided in: type A (fused valve) and type B (dysplastic valve). In some breeds such as English bulldog and boxer it can be caused by an abnormal right coronary artery type R2A.

The severity of stenosis is measured by the transvalvular pressure gradient: mild (< 50 mmHg), moderate (50-80 mmHg) and severe (> 80 mmHg). β-blocker therapy is indicated in moderate and severe cases showing symptoms.

Balloon valvuloplasty of pulmonic stenosis (PS)

- Stenosis dilation by using a balloon catheter.
- Balloon diameter must be 1.2-1.5 times the pulmonary valve annulus diameter.
- Double-balloon valvuloplasty is recommended in small size puppies or kittens.
- Indication: in severe and moderate cases of valvular stenosis both type A and B.
- Contraindication: pulmonic stenosis caused by an abnormal right coronary artery type R2A.
- Right-heart catheterization.
- A guide wire is introduced going through the stenosis until pulmonary trunk. The same procedure is repeated with the balloon catheter.
- Once there, the balloon catheter is inflated with diluted contrast for 5 seconds, and the process is repeated twice or three times, with an interval of 3 and 5 minutes (Fig. 4).
- Complications seldom appear: ventricular arrhythmias and tricuspid insufficiency.

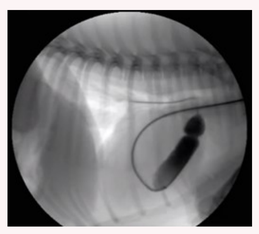

Figure 4. Balloon valvuloplasty of pulmonic stenosis. Narrowest part of the balloon shows the stenosis. (Canada West Veterinary Specialists 2016).

The prognosis is good if transvalvular pressure gradient diminish under 50 mmHg. β-blocker therapy is commonly recommended in order to control associated dynamic stenosis until next recheck.

Vascular access and imaging techniques

Vascular access can be arterial (via common carotid artery or femoral artery) or venous (via external jugular vein or femoral vein). The choice depends on:

- Type of catheterization: left-heart catheterization (arterial) or right-heart catheterization (venous).
- Size of patient: large calibre vessels are preferred in smaller cats and dogs.

There are two different methods to perform the vascular access: cut-down (surgical access) or percutaneous access, being the first one more used in veterinary cardiology. The cut-down access can be performed by the modified Seldinger Technique (a single-wall puncture technique) or via arterotomy or phlebotomy.

The use of imaging techniques is needed, such as fluoroscopy, transthoracic echocardiography (TTE) or transoesophageal echocardiography (TEE), and angiography (contrast administration).

Aortic valvuloplasty

Aortic stenosis is another usual congenital cardiac defect in dogs, but less common in cats. It can be subvalvular, valvular and supravalvular. Subvalvular aortic stenosis –or subaortic stenosis (SAS)– is the most common form, and it involves the appearance of fibrotic bands under the aortic valve. The severity of this abnormality depends on fibrotic band size (more severe if it is a fibrotic ring), and the transvalvular pressure gradient (> 80 mmHg in severe cases).

Treatment is not required in mild cases. However, β-blocker therapy is indicated in cases with clinical signs. The second option would be an aortic valvuloplasty by dilation with balloon, and the last one is open-heart surgery. It is important to bear in mind that any of these therapies have clear advantages of survival on each other.

Balloon valvuloplasty of subaortic stenosis (SAS)

- A high-pressure balloon is needed to perform a successful dilation because of the high resistance of the fibrotic bands.
- High-pressure balloon valvuloplasty might be combined with a cutting balloon in order to improve the outcomes (but only in SAS).
- Balloon diameter must be 0.9 to 1 times that of the aortic annulus.
- Indication: severe aortic stenosis and SAS. Younger patients have better results on account of the lower resistance of their fibrotic bands.
- Left-heart catheterization- c. carotid artery.
- Inflating procedure is the same as with pulmonic valvuloplasty.
- During initial inflation, gentle advancement is applied to the cutting balloon catheter in order to prevent the balloon from being expelled into the aortic arch. Make sure that cutting balloon is totally deflated before removal.
- Complications are more common than pulmonic valvuloplasty: periprocedural ventricular arrhythmias and aortic regurgitation.

SAS presents a poor long-term prognosis due to both medical and surgical treatments are limited, as well as its success rate. Furthermore, it is common to find ventricular arrhythmias 24 h after surgery.

Less usual interventions

Occlusion of septal defects

- Septal defects are a common congenital cardiac defect in cats, but unusual in dogs.
- Device selection depends on defect size, morphology and location.
  - Atrial septal defect (ASD): atrial septal tissue around a minimum of 75% of the ASD circumference is needed for secure deployment of the self-expanding device.
  - Ventricular septal defect (VSD): VSD surrounded by muscular septum are more indicated than perimembranous defects, which require specific devices in order to not interfere with tricuspid and aortic valve function.
- Indication: Left-to-right blood flow is required.
- Currently, this intervention is not available for cats due to device incompatibility.
- Right-heart catheterization.
- Complications are more common than in other interventions: embolization, thrombosis, and arrhythmias. Aortic insufficiency and endocarditis have been seen in occlusion of VSD.

Balloon valvuloplasty of mitral and tricuspid stenosis

- Mitral and tricuspid stenosis are uncommon in companion animals.
- Balloon diameter in humans is recommended to be between 70 and 110% that of the valve annulus diameter. The effective balloon diameter in double-balloon technique is about 80%.
- Atrial trans-septal puncture with a Brockenbrough needle is necessary for left-heart approach.
- Right-heart catheterization.
- Monitoring intracardiac pressures during the procedure.
- Complications are extrapolated from human medicine: chordae/valvular rupture that resulting in severe valvular insufficiency.

Conclusions

- Interventional cardiology is increasingly being considered as the first option of treatment for the most common congenital heart diseases in dogs– PDA, PS, and SAS.
- Arterial or venous access is required in order to perform a cardiac catheterization, and the choice of the access depends on defect location and indications of the procedure. As for the blood vessel, it is chosen according to the size of the patient– vessel diameter.
- Success of the intervention depends mainly on the correct measurement of the defects by using TTE, TEE and angiography.
- These interventions present many advantages with respect to medical and invasive surgery, but balloon valvuloplasty of SAS has not clear advantages of survival. In addition, interventional cardiology is not always the first option because of some limitations: type III of PDA, the presence of abnormal coronary artery of type R2A, and surrounded septal defect tissue.
- The most common congenital cardiac defect in cats has no treatment option by cardiac catheterization.

References

- Cunningham S, Rush J. 2008. Interventional Cardiovascular Procedures. Vet Focus 18:16–24.
- Infiniti Medical [Internet]. 2016. Menlo Park (CA): Infiniti Medical. [cited 2016 Nov 8]. Available from: http://infinitimedical.com/products/canine-ductal-occluder/
- Manubens J, García L. [Internet]. 2014. Diagnóstico y tratamiento del conducto arterioso persistente. Zaragoza (Spain): argos.portalveterinaria.com; [cited 2015 Nov 23]. Available from: http://argos.portalveterinaria.com/noticia/9359/articulos-archivo/diagnostico-y-tratamiento-del-conducto-arterioso-persistente.html
- Miller MW, Gordon SG, Saunders AB, Arsenault WG, Meurs KM, Lehmkuhl LB, Bonagura JD, Fox PR. 2006. Angiographic classification of patent ductus arteriosus morphology in the dog. J Vet Cardiol. 8:109–114.
- Rodríguez J, Martínez M, Graus J. 2012. El tórax. Cirugía en la clínica de pequeños animales. 2nd ed. Navarra (Spain): SERVET - Grupo Asís Biomedia S.L. 380 p.
- Tobias A, Stauthammer C. 2010. Minimally Invasive Per-Catheter Occlusion and Dilation Procedures for Congenital Cardiovascular Abnormalities in Dogs. Vet Clin Small Anim 40:581–603
- Weisse C, Berent A. 2015. Veterinary Image-guided Interventions. 1st ed. Ames (IA): WILEY Blackwell. 666 p.