TYPICALLY, congenital heart disease (CHD) is first detected when heart murmurs are auscultated during puppy health checks; the majority of these puppies are asymptomatic. Very severe heart defects are rarely compatible with life, resulting in stillbirth or neonatal death and therefore rarely presented to veterinary clinics.

Puppy murmurs are very common, and although the majority are “innocent”, their detection still causes concern for the owner and a dilemma for the attending veterinary surgeon. Thankfully, the prevalence of congenital heart disease is low (0.5-0.67% of the population).

Patent ductus arteriosus (PDA), subaortic stenosis (SAS) and pulmonic stenosis (PS) are the most common CHDs in dogs (together accounting for over 71% of all CHD encountered in dogs; 25.7%, 23.5% and 22.1% respectively). Ventricular septal defect (VSD), tricuspid dysplasia, mitral dysplasia, vascular ring anomalies, Tetralogy of Fallot and atrial septal defects are encountered less commonly (8.8%, 4.6%, 4.3%, 3.3%, 2.3% and 1.9% respectively).

Cardiac auscultation and heart murmurs

Murmurs are described according to loudness (intensity), timing (systolic, diastolic or both), position and character. Murmur intensity generally correlates with disease severity (exception being VSD), so it is useful to describe murmur intensity when first faced with a puppy heart murmur (see Figure 1).

As a general rule, innocent murmurs are quiet, usually grade I-II/VI. When auscultating a puppy’s heart, it is very important to listen over all valve regions, as some murmurs can be very localised and are therefore easily missed (see Figure 2).

The majority of murmurs we encounter in small animal practice are systolic, the most common exception being PDA, which is typically continuous, i.e. audible throughout the cardiac cycle. Describing murmur character can be helpful, for example pulmonic stenosis murmurs are often harsh and sound like someone sawing wood.

Diagnostic investigation

Although careful auscultation and knowledge of breed predilections (see Figure 3) may give a good indication as to likely cause of the murmur, it is important to establish definitive diagnosis in order to best advise the client on treatment/management and prognosis. All too often clients are unnecessarily advised to restrict a puppy’s exercise when a murmur is detected, because of concerns about potential heart disease. Conversely, many murmurs are discounted as “innocent”; tragically, many PDA’s are diagnosed too late to fix as a result.

Echocardiography is the diagnostic test of choice when investigating puppy murmurs. Although ultrasound is available to many vets in practice, echocardiographic evaluation of puppy murums is ideally performed by an experienced cardiologist, who can determine definitive diagnosis and assess disease severity.

Chest radiography will identify cardiomegally and congestive heart failure, but often is not very helpful in differentiating congenital diseases. Electrocardiography is usually not helpful diagnostically, although right axis shifts are often present in severe right heart disease, for example pulmonic stenosis.

Cardiac biomarkers, such as NT-proBNP or cardiac troponin-I, may be elevated with CHD, but do not help with definitive diagnosis.

Patent ductus arteriosus (PDA)

PDA occurs when the ductus arteriosus fails to close at birth, allowing left-to-right shunting of blood from the aorta (via the PDA) into the pulmonary circulation. Shunted blood is recycled back to the left heart, causing volume overloading and eventually congestive heart failure. It is classically described in small breed dogs (poodles, Chihuahuas, Pomeranians, Yorkshire terriers), but is also seen in other breeds (GSD, CKCS, spaniels, collies). Females are more commonly affected than males.

Typical presentation is a loud, continuous heart murmur heard loudest over the cranial heart base, often with a palpable thrill. A second murmur related to mitral insufficiency is often heard at the left apex. It is imperative that PDAs are identified and treated early, as prognosis is excellent with prompt correction. Sadly, many cases are identified later in life when congestive heart failure has developed and the outlook becomes significantly less certain.

Murmur grading

Grade I: very quiet murmur – only audible in a quiet patient and quiet environment, easily missed with cursory auscultation.

Grade II: quiet murmur – not as loud as transient* heart sounds and usually only heard at point of origin.

Grade III: moderately loud murmur – equal loudness to transient heart sounds and audible as soon as you apply the stethoscope.

Grade IV: loud heart murmur – louder than transient heart sounds.

Grade V: very loud murmur – palpable thrill obvious and murmur still heard when stethoscope lifted away from chest wall.

*Transient heart sounds – S1 and S2 (or lub-dub) sounds heard in a normal dog.

Figure 1. Grading system for heart murmur intensity (loudness).

PDA murmurs can be very localised and therefore missed with cursory auscultation technique; therefore, it is important to listen carefully over the pulmonic area.

Treatment of choice for the most common forms of PDA (type IIA & IIB) is occlusion using an ACDO (Amplatz Canine Duct Occluder – Figures 4 and 5), which is delivered percutaneously through the femoral artery. This procedure is offered by a number of specialist cardiology centres in the UK. Interested readers can view a short video showing ACDO deployment on the following link: www.scvspecialists.co.uk/our-services/cardiorespiratory.html.

Surgical ligation is generally required for small patients (less than 3kg) and dogs with type III ductus (interested readers are referred to Miller et al for detailed description of PDA classification). Success and complication rates are similar for the two procedures.

Figure 2. Auscultation technique and heart valve position.

On the left hemithorax palpate apex “base”, place stethoscope at position of apex (usually 6-7th intercostal space) inward to costochondral junction and forward to 5th intercostal space where you will hear the mitral area (M) best. Move dorsal and forward another rib space to aortic area (A); note that S2 (+dup) becomes relatively louder. Move forward into armpit (3rd intercostal space) and slightly more ventral to hear pulmonic area (P) best. On the right hemithorax place stethoscope at level of costochondral junction and move between 3rd and 6th intercostal spaces – this is where the tricuspid area (T) is heard best, also VSD murmurs.

Subaortic stenosis (SAS) and aortic stenosis (AS)

Subaortic stenosis, a narrowing just below the aortic valve, has been reported as the most common CHD in Europe. It has a particularly high prevalence in certain breeds, notably the boxer, but is also encountered in Newfoundlands, Golden Retrievers, GSDs and Rottweilers.

Aortic valve stenosis, usually a result of aortic valve malformation, causes identical pathology to SAS but is much less common. SAS/AS is often detected during puppy health checks; however, SAS lesions can become relatively more severe over time and therefore murmurs are sometimes detected later in the dog’s life, typically 1-2 years of age.

Murmur intensity is correlated with disease severity; therefore, murmurs louder than 3/6 should be investigated.

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**Table 1: Breed predisposition for congenital heart disease**

<table>
<thead>
<tr>
<th>CHD</th>
<th>Breed predisposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent Ductus Arteriosus</td>
<td>Bichon Frise, Chihuahua, CKCS, Cocker Spaniel, Collie, English Springer Spaniel, GSD, Beethoven, Labrador, Maltese, Pomeranian, Poodle, Shetland Sheepdog, Yorkshire Terrier</td>
</tr>
<tr>
<td>Sub-aortic stenosis</td>
<td>Rosser, GSD, GSHF, Golden Retriever, Great Dane, Newfoundland, Rottweiler, Samoyed (Bull Terrier)</td>
</tr>
<tr>
<td>Pulmonic stenosis</td>
<td>Alsatian Terrier, Beagle, Boykin Spaniel, Chihuahua, Cocker Spaniel, English Bulldog, Mastiff, Miniature Schnauzer, Samoyed, Scottish Terrier, WHWT</td>
</tr>
<tr>
<td>Tricuspid dysplasia</td>
<td>Labrador Retriever, Golden Retriever, GSD</td>
</tr>
<tr>
<td>Mitrail dysplasia</td>
<td>Bull Terrier, Golden Retriever, GSD, Newfoundland, Mastiff, Rottweiler</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
<td>English Bulldog</td>
</tr>
<tr>
<td>Tetralogy of Fallot</td>
<td>English Bulldog, Keesond, Wire Haired Fox Terrier</td>
</tr>
<tr>
<td>Persistent right aortic arch</td>
<td>GSD, Great Dane, Irish Setter</td>
</tr>
</tbody>
</table>

**Figure 3. Breed predispositions for congenital heart disease in dogs.**

The murmur is typically loudest at the left heart base over the aortic valve area and tends to have an “ejection” quality — similar in character to many “innocent” murmurs and particularly difficult to differentiate without echocardiographic assessment.

Affected dogs often remain asymptomatic, but severe cases can die suddenly, secondary to ventricular arrhythmia. Surgical intervention is generally not recommended in the UK/Europe as medical management appears to have equal benefit, although there has been significant interest in cutting balloon valvuloplasty in the US recently.

Moderate to severely affected cases are usually managed with beta-blockers, typically atenolol.

**Pulmonic stenosis (PS)**

Pulmonic stenosis occurs as a result of pulmonary valve malformation. This may involve partial fusion of valve leaflets (type A) or narrowing of the valve annulus (type B). Because the right ventricular outflow is narrowed, a pressure load is created and the right ventricle becomes hypertrophied. Mild and moderate pulmonic stenosis cases are often asymptomatic and have a normal life expectancy. Severe cases may develop signs such as reduced exercise tolerance, collapse, right-sided congestive heart failure and sudden death.

Balloon valvuloplasty is a palliative procedure, which is performed in severe cases, with the aim of reducing pressure gradients across the stenotic valve, leading to an improved quality of life and reduced risk of sudden death. Balloon catheters are introduced through the jugular vein or femoral vein and positioned over the stenotic valve, then inflated, causing fused valve leaflets to separate. This procedure is more effective for type A PS cases.

Sometimes pulmonic stenosis is caused by abnormal coronary anatomy, in which case balloon valvuloplasty cannot be performed safely. This is common in Bulldogs.

**Ventricular septal defect (VSD)**

VSD is the most common CHD in large animal species and cats, but is less common in dogs. VSDs are usually found in the membranous septum close to the aortic valve.

Defects are often small, resulting in a low volume but high pressure jet of blood ejecting from the left ventricle into the right outflow tract, causing a loud murmur heard loudest over the right hemithorax. Small defects are usually fairly benign and will occasionally close over time.

Larger defects allow larger volumes of blood to shunt, exposing the right heart to pressure and volume overloading.

**Tricuspid and mitral dysplasia (TD and MD)**

Malformation of the left and right anterioventricular inflow valves leads to insufficiency and sometimes stenosis. Tricuspid insufficiency can cause quite dramatic volume overloading and right heart dilation, but is often fairly well tolerated.

In Laboratories, it is sometimes associated with conduction pathway abnormalities (accessory pathway) leading to supraventricular tachycardia.

Mitrail dysplasia, common in the English Bull Terrier, causes mitral insufficiency and mitral stenosis, and in more severe cases leads to left atrial dilation and ultimately left-sided congestive heart failure.

**Tetralogy of Fallot (ToF)**

Fairly rare CHD in dogs, tetralogy refers to four defects: VSD, PS, right ventricular hypertrophy and dextroaxial aortic root (aortic root straddles left and right ventricles).

It is in effect a large ventricular septal defect combined with pulmonic stenosis; right ventricular hypertrophy is secondary to pressure over-loading of the right heart. Affected dogs develop polycythaemia secondary to cyanosis. A surgically created systemic to pulmonary shunt (e.g. Blalock-Taussig) can be palliative.

**Other congenital heart defects**

A detailed description of all congenital heart disease in dogs is beyond the scope of this article, but interested readers will find the first three references (available by request) extremely useful.

**Summary**

Puppy heart murmurs are common, although the majority are innocent. Generally murmur intensity correlates with severity; therefore all murmurs...