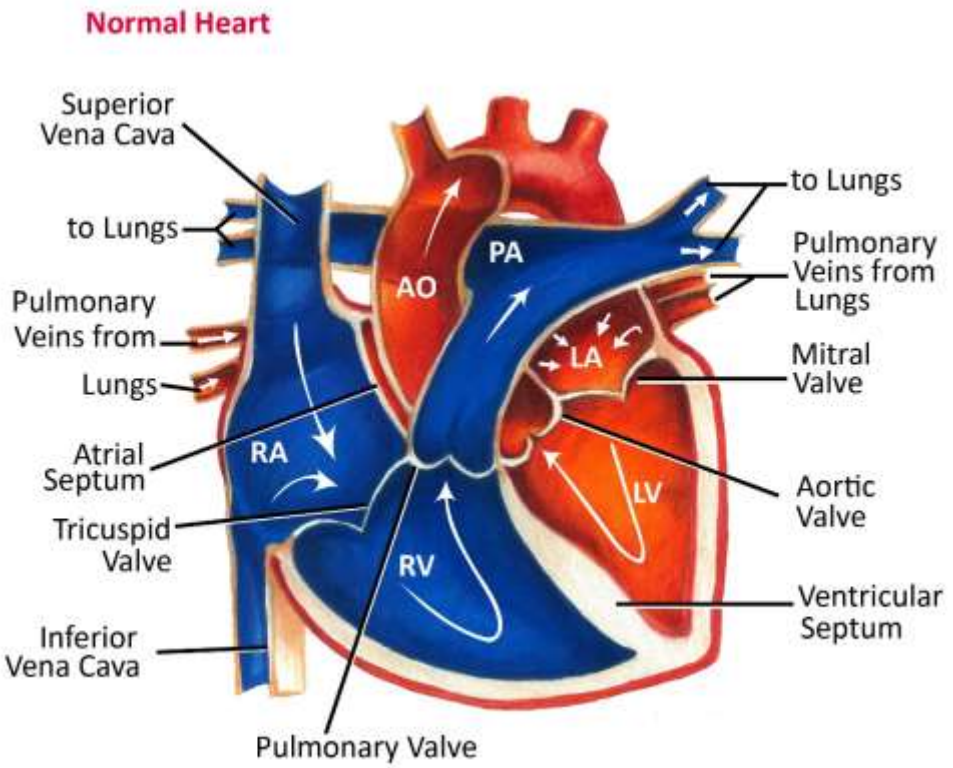
Patent Ductus Arteriosus (PDA)

How does the heart work?

The heart is the organ responsible for pumping blood to and from all tissues of the body. The heart is divided into right and left sides. The job of the right side is to pump oxygen-deficient blood returning from the body into the lungs where fresh oxygen is collected and carbon dioxide is removed. The oxygen-rich blood returning from the lungs enters the left side of the heart where it is pumped into the aorta then to the rest of the body via the arterial system.

Each side of the heart has two chambers, an upper atrium and a lower ventricle. Between the atrium and ventricle on each side lies a valve – the tricuspid on the right and the mitral on the left – that regulates blood flow into the chambers. As the heart pumps, these valves act as one-way gates allowing blood to flow from the atrium above to the ventricle below and preventing blood from flowing back into the atrium. From the ventricles, blood is then forced to flow out into the pulmonary artery (and then to the lungs) or the aorta (and then to the remainder of the body) through a second series of one-way valves called the pulmonic valve and the aortic valve, respectively.



Key:

RA: right atrium
RV: right ventricle
PA: pulmonic artery
LA: left atrium
LV: left ventricle
AO: aorta

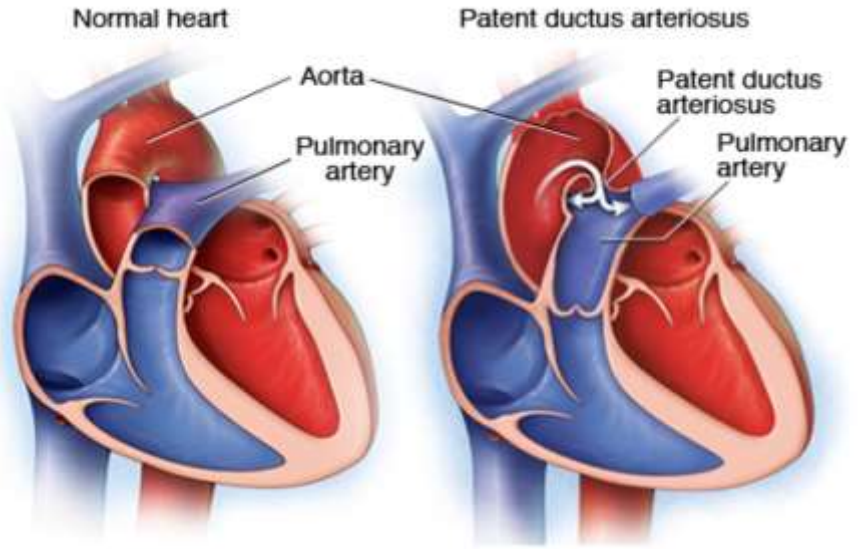
What is a PDA?

The ductus arteriosus is a normal vessel in any mammalian foetus. Following birth, it should close, however occasionally it can remain open, if this happens it becomes known as a patent ductus arteriosus.

A developing foetus relies on the umbilical circulation to supply oxygen (rather than through the lungs). The foetal lungs are subsequently not fully developed and are non-functional. It is important the blood pumped by the foetal heart has a way of bypassing these non-functional lungs and that is where the ductus arteriosus comes in. The ductus arteriosus is a small channel/vessel connecting the pulmonary artery (which will one day carry blood to the lungs) and the aorta (which already carries blood to the rest of the body). Since the lungs are still developing (and full of fluid), blood vessels within the lungs have a high resistance to blood flow. In other words, it would take a lot of force from the heart to pump blood through these lung vessels. Since there is a low resistance channel wide open (i.e. the ductus arteriosus), blood diverts through it instead, bypassing the lungs and circulating through the rest of the foetal body.

At birth, everything changes. The animal takes its first breath. The lungs begin to work as they were meant to: exchanging gases. They fill with air and resistance within the lung vessels drops. Blood can now flow through the lungs and stops flowing through the ductus. The ductus closes within the first 3 days of life and is securely closed by 10 days.

Blood now flows the way it is supposed to: from the right side of the heart to the lungs to collect oxygen then back to the left side of the heart to the body to deliver the oxygen. Or at least that is what is supposed to happen. Sometimes the ductus does not close. It remains open, or patent. When the ductus stays open, a portion of the blood leaving the left side of the heart flows directly through the ductus to the lungs (rather than all the blood being pumped into the aorta to the tissues of the body). This is called a left to right shunt and it creates an assortment of problems.



What are the consequences of a PDA?

As a result of the left to right shunt of blood from the aorta into the lungs there is an additional volume of blood entering the left side of the heart (blood that is pumped to the lungs always returns to the left side of the heart before being pumped to the rest of the body). This additional blood volume, if significant (which in turn will depend on the size of the PDA), can cause a volume overload of the left heart chambers. This volume overload causes the heart chambers to stretch which over time can trigger growth and enlargement of these chambers. This enlargement is initially compensatory because it increases the volume of blood ejected by the left side of the heart which subsequently increases the delivery of oxygen-rich blood to the tissues of the body. Eventually however, no more enlargement is possible which causes the pressures in the heart to increase. The result is 'backing up' or pooling of blood in the lungs which ultimately causes fluid to leak out of vessels and accumulate in the lungs (this is called left-sided congestive heart failure and causes breathing problems).

If the PDA is diagnosed and treated (see below) at an early stage, significant heart enlargement and congestive heart failure (CHF) can generally be avoided. If not treated early, roughly two thirds of dogs with PDA will develop CHF by 1 year of age.

Rarely, the flow of blood through the PDA can reverse (shunting right to left) causing clinical signs of hypoxia (decreased oxygen levels in the body). These animals may experience some or all of the following: lethargy, weakness, exercise intolerance, collapse, laboured breathing and even sudden death. There is no definitive treatment for reverse PDA (fortunately it is rare).

How do we diagnose a PDA?

A characteristic murmur (abnormal heart sound) can be heard in dogs with a patent ductus arteriosus. The murmur is described as being continuous (i.e. constantly present rather than stopping and starting). The presence of this characteristic murmur, particularly in puppies and young dogs (albeit older dogs are occasionally diagnosed with PDA), leads to a high index of suspicion of PDA. Some dog breeds are also known to have a predisposition to PDA (suggesting a genetic/heritable basis in these breeds). These breeds include German Shepherds, Miniature Poodles, Border Collies, Cocker Spaniels, Pomeranians and Shetland Sheepdogs.

A definitive diagnosis however, can normally only be made by echocardiography (cardiac ultrasound). In addition to making a definitive diagnosis, echocardiography has many other benefits including: assessing the severity of heart enlargement, the risk of congestive heart failure developing in the short-term, ruling out concurrent heart defects and providing valuable pre-operative information (if treatment is being considered). Other diagnostic tests such as radiographs and ECG may be supportive

of a PDA but cannot provide a definitive diagnosis. Radiographs are useful to confirm the presence of congestive heart failure (i.e. fluid in the lungs).

How is a PDA treated?

If there are signs of congestive heart failure, this has to be treated first and foremost. The main medication used in this setting is the diuretic, frusemide. This causes the kidneys to expel more water than usual which in turn eliminates the fluid in the lungs. Once stabilised the patient may then be a candidate for definitive therapy (described next). Cardiac medications can generally be weaned/stopped following definitive therapy.

Once a PDA is diagnosed it is normally advised to proceed with definitive therapy sooner rather than later. It is certainly not recommended to wait until signs of congestive heart failure develop.

The traditional method of repair is surgical ligation. This is normally performed by a specialist surgeon and involves opening the chest cavity and 'tying' off the PDA using a piece of suture material. Although invasive, the complication rate is quite low with this approach, and in the hands of an experienced surgeon leads to cure in most animals. This is also the treatment of choice for cats with PDA (their small size precludes the endovascular approach described below). The main limitation of this approach is the post-operative recovery and care required (in contrast to the endovascular approach).

A newer approach is now available. Endovascular occlusion of PDA's has become the treatment of choice in dogs. This involves a small incision over the right groin region to expose the femoral artery. Long catheters and wires are passed through the femoral artery and advanced toward the PDA under fluoroscopic guidance (real-time x-ray). An occluding device (the most commonly used device is the 'ACDO') can then be placed inside the PDA, completely stopping all blood flow through the PDA. This device stays in place for the life of your pet. The catheters and wires are removed, and the small skin incision is sutured closed. The main advantage of this approach is the much more rapid post-operative recovery. However, this technique can generally only be performed by experienced veterinary cardiologists so is not always readily available. Furthermore, not all dogs are candidates for endovascular occlusion e.g. if the PDA is too big or the patient is very small, endovascular occlusion may not be possible and surgical ligation may be the only option.

ACDO (or Amplatz Canine Duct Occluder)
The most common device used to occlude canine PDA's

What is the prognosis following surgical ligation or endovascular occlusion?

Following successful treatment, the prognosis is considered excellent for most canine patients, regardless of the approach used. Essentially your pet is considered cured with a normal life expectancy. Complications following treatment and full recovery are reported but luckily very rare.

Additional Resource:

http://vetmed.tufts.edu/heartsmart/

This is a very useful and well-written resource, providing pet owners with a clear and credible source of information about veterinary cardiology.