The Equine Heart Part 2: Common Cardiac Disease

Horse owners have probably all experienced “heart” in a favorite horse, that indefinable quality that makes certain horses stand out. In the article The Equine Heart: Part 1, we examined the remarkable abilities of the equine heart, and its role in making horses superior athletes. In this article, we will examine some of the more common cardiac problems found in horses.

How the heart works (the boring part)

Horses, like all other mammals, have a four-chambered heart. The circuit can be divided into left and right portions. Blood is collected from the body into the right atrium, which acts as a reservoir to prime the main pump, the ventricle. From the atrium, the blood is pumped into the right ventricle, and from the right ventricle, the blood is pumped through the lungs where carbon dioxide (CO₂) is removed and oxygen (O₂) is added.
This oxygenated blood then continues back to the heart into the left atrium, and follows a similar course through the left ventricle. The left ventricle is the most muscular portion of the heart, having to pump blood throughout the entire body via the aorta. Blood is delivered to muscle, brain, and other organs, which then extract O$_2$ and add the waste product CO$_2$ back in. The unoxygenated blood then returns to the right heart via the vena cava, and the cycle is started again.

The atria and ventricles are composed of a type of muscle somewhat different from skeletal muscle. Cardiac muscular contraction is initiated by electrical impulses. The heart has a built-in pacemaker called the sino-atrial (SA) node, living at the top of the heart, which governs heart rate and rhythm under most circumstances. The SA node sends its impulse out in a wave across the atria, causing muscular contraction in a similar downward-moving wave, pushing blood downward into the ventricles. Once the electrical impulse reaches the bottom of the atria, the atrio-ventricular (AV) node is triggered, which sends an electrical impulse through the bundle of His, which carries the impulse down to the bottom of the heart. During this time, muscle tissue is bypassed. At the bottom of the heart, the Purkinje fibers carry the electrical impulse in an upward direction, causing the individual muscle fibers to contract in a coordinated upward wave towards the openings of the “great vessels” at the top of the heart (the aorta in the left ventricle and the pulmonary artery in the right ventricle).

The cardiac cycle is divided into two cycles: diastole, where the right and left atria contract, and systole, where the right and left ventricles contract.

Valves are present between the atria and ventricles, and between the ventricles and the “great vessels” to prevent significant backflow. The valves are flexible flaps of tissue which are pushed out of the way by forward flow of blood. When back pressure starts to develop, the valves start to push back, but are held in place by connective tissue bands called chordae tendinae, thereby sealing the valve opening and preventing backflow. The left atrio-ventricular valve is called the mitral valve, and the right one is called the tricuspid valve. The valves associated with the great vessels are the aortic valve on the left and the pulmonic valve on the right.

**Evaluation of the heart** (the slightly less boring part)

One of the simplest and most effective tools for evaluating the heart is the stethoscope. The heart gives important clues as to its function through its heart sounds. There are two main heart sounds that can usually be heard in the normal horse, which correspond with the closure of the valves. With the stethoscope under the left elbow (further forward than you might think), a lub-dub sound is heard, with a longer pause between dub and the following lub. The lub corresponds to mitral and tricuspid valve closure, while the dub corresponds to pulmonic and aortic valve closure. A normal cycle would sound like: lub-dub……... lub-dub……... lub-dub……... lub-dub.
In between the lub-dub sounds is systole, the period when the ventricles are contracting. The longer pause, between dub and the following lub, is diastole, when the atria contract to refill the ventricles. Each lub-dub accounts for a full cardiac cycle, or one beat. Typical heart rates in resting adult horses are between 32 and 40 beats per minute. (Count the number of beats for 15 seconds and multiply by 4) Exercise and anxiety are common causes for elevations in heart rate, while pain and cardiac problems can also cause elevations. The heart rate will stay elevated in horses with pain or cardiac disease, while the rate will come back to normal in the nervous or recently exercised horse. The heart rhythm in horses is typically stable, meaning that each beat occurs at a predictable interval. By tapping your foot to each beat while counting, deviations from the expected rhythm can be detected.

A heart murmur is an abnormal sound caused by turbulent blood flow. The murmur itself is not a disease, but is merely a physical finding. Most murmurs are associated with turbulence created from leaking valves. Turbulent blood flow can sometimes be created in normal highly fit horses, causing a ‘physiologic flow’ murmur. During a cardiac examination, the lungs sounds are also evaluated, since certain heart disease conditions can lead to a buildup of fluid in the lungs.

Palpation of pulses can be useful in counting the heart rate without a stethoscope, and in evaluating the strength and character of ventricular contraction.

Electrocardiography (ECG or EKG) works by detecting and mapping out the electrical flow patterns throughout the cardiac cycle. A normal ECG traces atrial contraction (P-wave), ventricular contraction (QRS waves), and re-polarization (T wave) in a uniform cycle. Deviations in the shape of a wave, distance between waves, or lack of certain waves give important information about the function of the heart.

The use of ultrasound to visualize the physical structures of the heart is called echocardiography. Echocardiography provides a dynamic image, which allows for evaluation of the valve structures, quality of movement of the ventricles, and chamber size throughout the cardiac cycle. Normal measurements of the different cardiac structures have been well documented. Abnormal measurements help to define what problems are present, and the degree to which the heart is affected.

A useful tool in echocardiography is Doppler ultrasonography (like the Doppler radar shown by weather reporters), which shows direction, volume, and speed of fluid movement. This helps in detecting abnormal blood flow patterns, particularly with leaking valves. Doppler ultrasonography can also measure the speed of blood flow, which can help to determine the severity of a leak. Visual mapping of blood flow patterns and measurements of flow rate help to define the character and severity of the leak.
Color Doppler echocardiographic image of the left atrium (purple outline) and left ventricle (white outline) during systole in a horse with moderate to severe mitral regurgitation. The red/blue/green area represents turbulent backflow of blood from the ventricle through the mitral valve (which sits at the junction of white and purple), causing enlargement of the atrium. During systole, there should be no flow through the mitral valve. (Image obtained from the left side of the horse.)

**Congenital Heart Problems**

A congenital problem is a problem present at birth. The normal fetal heart is very different from the adult heart. If problems occur during the transitional stages from fetal to adult circulation, certain openings between structures that are normal in the fetus can persist. Other congenital problems occur early in fetal development, causing abnormalities that are not normal under any circumstances. Congenital problems occur fairly infrequently in horses when compared with dogs.

By far the most common congenital heart problem in the horse is a ventricular septal defect (VSD). In this condition, an opening is present between right and left ventricles. The right ventricle works under low pressure, since there is little resistance to blood flow through the lungs. The left ventricle works under high pressure, since the kidneys require high pressure to function properly and the large volume of muscle and other tissue leads to resistance to flow. This pressure difference leads to blood flow from the left ventricle into the right ventricle. Horses with VSDs are often smaller than expected, and may be poor athletes. Coarse sounding murmurs heard during systole are typically found on both sides of horses with a VSD, usually louder on the right. Depending on the size of the defect, some affected horses can perform well, while others are at high risk for developing congestive heart failure. Normal heart rate and rhythm are typically seen with smaller defects, while larger defects may be accompanied by elevations in heart rate, abnormal rhythms, visual pulsations in the jugular veins, and/or other abnormalities. Monitoring the heart with echocardiography is helpful in guiding medical treatment options and prognosis.

Many other congenital abnormalities have been described in horses, including Tetralogy of Fallot, atrial septal defects, and patent ductus arteriosus, among others, but all are rare in occurrence. In humans and dogs, abnormally small (stenotic) valve openings are relatively common congenital conditions, but these too are rarely seen in horses.

**Developmental Cardiac problems**

Developmental diseases are, as the name implies, not present at birth, but occur later in life. The most common developmental diseases in horses involve the valves. Leaky aortic and mitral valves are the most common, with the tricuspid valve affected
Valvular disease

Slowly progressive scarring of the valve margins is relatively common in older horses in the aortic and mitral valves, which can lead to poorly functioning valves and variable degrees of leaking. Tearing in the valve leaflets, buckling of the leaflets, or ruptured chordae tendinae lead to improperly functioning valves as well. Rarely, bacterial infections can occur on or near the valves, which can severely affect cardiac function, and can be life threatening.

Leaking of the aortic valve (aortic regurgitation) is common in older horses, and is often tolerated well. The backflow causes an overload in volume in the left ventricle, but in early stages the ventricle does a good job of adapting. Murmurs are present during diastole (after the ‘dub’), present on both sides, but louder on the left. The murmur can sometimes have a ‘divebomber’ sound, which likely occurs from vibrations of the aortic valve leaflets. Long term aortic regurgitation can lead to stretching of the ventricle and the mitral valve opening, which can cause leaking in this valve as well.

Leaking of the mitral valve (mitral regurgitation) is also relatively common. The backflow causes the left atrium to enlarge, which causes a backup of blood into the pulmonary vein. Murmurs are during systole (between ‘lub’ and ‘dub’), and are heard on the left side of the horse. Most mitral valve leaks can be tolerated well if the onset is slow, allowing the lungs to compensate for the increase in blood pressure. Sudden-onset mitral valve leaks, such as with ruptured chordae tendinae, are more difficult for the body to handle, because sudden backflow causes a sudden pressure increase in the lungs, which causes fluid to leak into the air sacs of the lung. In this situation, the outcome is usually poor, while small or slowly progressing leaks can often be managed medically.

Leaking of the tricuspid valve (tricuspid regurgitation) occurs less commonly and is typically well tolerated by horses. Backflow can sometimes be seen as prominent jugular pulses, prominence in other blood vessels, or edema in the legs or abdomen. Murmurs are during systole (between ‘lub’ and ‘dub’), and are heard on the right side of the horse. Leaks in the tricuspid valve are most commonly caused by enlargement of the inside of the right ventricle, which can happen from resistance through the lungs in chronic respiratory conditions or mitral valve regurgitation. The right ventricle can also be enlarged in certain athletic disciplines such as in the sustained aerobic effort of Standardbred racehorses. Tricuspid regurgitation is more common in athletic humans as well.

Aneurysm

Aortic root aneurysm is a very rare, but serious condition. The typical aneurysm is an abnormal bulging of the aorta, which is at risk of rupturing. This can lead to collapse or sudden death, usually when the horse is exercising. Aneurysms in the blood vessels leading to the intestines can be caused by the parasite Strongylus vulgaris (large strongyle), but this is easily prevented by proper de-worming practices.

Myocarditis

Damaged or inflamed heart muscle (myocarditis), usually occurs in horses as a result of certain viral infections or toxins. Monensin is a feed additive found in some
cattle feeds, which is extremely toxic to horses. Oleander, Yew, and avocado branches and leaves are among other plants that are cardiotoxic to horses. Very rarely, coronary artery disease leading to myocarditis can be caused by infections within the heart. Cholesterol plaques, which cause coronary artery disease in humans, are not seen in horses. While myocarditis is rare in horses, coronary artery disease is the leading cause of death in humans.

**Arrhythmias**

Abnormal cardiac rhythms, or *arrhythmias*, are uncommon in horses. Second-degree AV block is common in horses, but is almost always considered normal. In this rhythm, the horse’s heart actually skips a beat. The SA node sends its signal, but the AV node decides that the heart is functioning efficiently, and does not send the signal through for one beat. In the normal situation, only one beat is skipped, and the normal rhythm is resumed. This sounds like: *lub-dub*…….*lub-dub*……. (pause)…….*lub-dub*…….*lub-dub*. If keeping rhythm by tapping your foot, you should detect a gap when you expect a beat, but then find the following beat with one more foot tap.

*Atrial fibrillation* occurs when the normal wave of electrical impulses that moves across the atria is broken up into many random waves, moving in different directions at the same time in an uncoordinated manner. This causes the atria to contract in a random uncoordinated manner, and does not provide the AV node with a reliable signal. The rhythm of the ventricles must be taken over by the AV node, which usually does not create a predictable rhythm. This typically sounds something like: *lub-dub*. *lub-dub*………….. *lub-dub*…….*lub-dub*….*lub-dub*………….. *lub-dub* in an unpredictable pattern.

ECG findings are characteristic, exhibiting no P waves, but an undulating baseline (f-waves), and random distribution of otherwise normal QRS complexes.

![ECG of a horse in atrial fibrillation. Note random distribution of QRS complexes (red arrows) with no associated P-waves and the presence of an undulating baseline (‘f-waves’, blue brackets)]](image)

Electrolyte abnormalities, particularly low potassium and/or magnesium levels may predispose a horse to atrial fibrillation. Enlargement of the atria, most commonly from mitral regurgitation, also increases risk. Echocardiography should be performed to help define any underlying problems. Horses with severe cardiac enlargement or longstanding atrial fibrillation are less likely to be able to convert to a normal rhythm, and if they do convert, may revert back into atrial fibrillation. Typical treatment is with quinidine sulfate administered through a stomach tube or, in horses with a very short history of atrial fibrillation, injectable quinidine gluconate is used. Recently, electric conversion of atrial fibrillation has been performed.
Atrial premature contractions are relatively common, while ventricular premature contractions are relatively rare. Both of these conditions occur when there is localized myocarditis. The conditions can sometimes be differentiated by carefully listening to rhythm abnormalities, but definitive diagnosis is made with an ECG. Both conditions require a period of rest and anti-inflammatory medications, as well as investigation into any underlying causes of disease.

Ventricular tachycardia and ventricular fibrillation are rare and generally are associated with serious underlying disease processes.

Management of Horses with Cardiac Disease (a little good news)

Depending on the severity and type of abnormality, most common heart conditions in horses are manageable. In fact, most horses can compete effectively in all but the most rigorous events with mild to moderate valvular problems. Horses with valvular disease should be evaluated periodically with a thorough physical examination and echocardiography to monitor progression of disease. Horses with mild to moderate valvular disease often benefit from exercise. The amount of exercise should be tailored to the individual horse, based on age, fitness, degree of cardiac dysfunction, and soundness.

Depending on the type of disease present, horses may need to be maintained on daily medications. Enalapril and furosemide (Lasix), with or without digoxin, are common choices for treatment of ongoing conditions. The use of these medications in some horses may delay the progression of cardiac disease, and can often alleviate some of the clinical signs seen in moderately affected horses. Severely affected horses may improve somewhat, but typically have a poor prognosis even with aggressive treatment.

Insignificant aortic and mitral regurgitation are commonly found cardiac problems, typically with only a subtle murmur, and no other abnormal findings on a physical examination. In these mildly affected horses, medical therapy is not necessary, but the murmur should be monitored at each examination for signs of progression.

Final word

Horses are remarkably athletic creatures, in large part due to their incredible hearts. Fortunately, significant heart disease is uncommon in these amazing creatures, allowing us to enjoy our equine friends for many years. We are enriched by their company, we marvel at their physical abilities, and we always remember that special horse with lots of “heart.”

Matt Durham, DVM grew up in Reno, Nevada. During the summers growing up, Dr. Durham worked in the Sierra Nevadas as a backcountry guide at McGee Creek and Mammoth Lakes Pack Outfits, where he met his wife, Tiffany. He attended Cal Poly, San Luis Obispo, and obtained a degree in Animal Science. After graduating from veterinary school at UC Davis, he performed a one year internship at Alamo Pintado Equine Medical Center in Los Olivos, California. After four years in practice, he performed a one year fellowship in large animal cardiology and ultrasound at the University of Pennsylvania's New Bolton Center. Dr. Durham has been at Steinbeck Country Equine Clinic since 2001.