

The Equine Heart: Power Plant Unequaled!

This Horse Report was made possible by the invaluable contributions of the following veterinary faculty: Dr. Bill Thomas, Dr. Gary Magdesian, Dr. Gregory Ferraro, Dr. Claudia Sonder, Dr. Mary Beth Whitcomb, Dr. Tania Kozikowski-Nicholas, and Dr. Monica Aleman.

For as long as horses have been bred, raised and used by humans, their owners and caretakers have praised their "heart". This reputation for quality or quantity of "heart" is obviously based on a horse's psychological rather than anatomical characteristics: stoicism, bravery, dedication and nobility of character. In fact, these attributes of character also reflect the typically robust nature of the horse's anatomical heart and cardiovascular system as well.

A horse's heart supplies blood to all parts of one of the largest domesticated land mammals (1,000 pounds or more), not only at rest and during routine activities, but also during periods of extreme physical stress such as encountered during performing, racing and the training required for those activities. It is a power plant unequaled in any other creature! That it is able to do so attests



to the system's remarkable efficiency and adaptability.

The cardiovascular system of a horse consists of a pump (the heart), a distribution system (arteries), exchange areas (capillary beds), and a collection and return system (veins). The heart of a 1,000-pound adult horse is about the size of a large melon and weighs about 10 pounds. As in all mammals, it consists of the left and right atrial receiving chambers, left and right atrioventricular inflow valves, left and right pumping ventricles, and aortic and pulmonic semilunar outflow valves, plus attached inflow veins and outflow arteries (see photos on page 4).

The left heart collects blood returning from the lungs via the pulmonary veins and pumps it to the body via the aorta. The right heart collects blood returning from the body via the large veins and directs it to the lungs via the pulmonary artery. The output of each ventricle in an adult horse at rest is about 25 to 40 liters/minute (approximately 7 to 10 gallons), compared with 4 to 5 liters/minute in an average adult human (1 liter ≈ 1.05 quart).

This *Horse Report* describes some conditions most often encountered by

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DIRECTOR'S MESSAGE



Dr. Claudia Sonder

In the steady gaze of the horse shines a silent eloquence that speaks of love and loyalty, strength and courage. It is the window that reveals to us how willing his spirit, how generous his heart.

As a veterinarian, and the daughter of a man who lived with heart disease, I have long been fascinated with the resilience and simplicity of the four chambered heart. Most of us take it for granted that this marvelous biological pump within us functions for years on end without our conscious input or control. What manufactured device can exist under pressure and perform at variable speeds for eighty to one hundred years without a tune up? We attribute many qualities to our hearts and we do the same to animals. The words heart and horse go together. Throughout history, horses have been praised for their hearts- in terms of valor, loyalty, and strength. I have known horses with incredible work ethics that are devoted and committed despite physical limitations and I described these animals as having a great deal of heart. The truth is that horses need good hearts. Greater than 50% of their body mass is skeletal muscle and they evolved as prey animals

who needed to move quickly to stay alive. Horses have incredible cardiac reserve. They can contract their spleens in moments of excitement and nearly double their oxygen carrying capacity. Their heart rates can jump from 30 beats per minute (bpm) at rest to 240 bpm in maximal exercise. On top of that, heart disease is relatively rare in horses.

Examination of the cardiovascular system of the horse has come a long way, and yet the art of cardiac auscultation, or listening to the heart carefully with a stethoscope, remains the mainstay of detection of cardiovascular disease. In the 1800s, it was a veterinary scientist that first described the heart sounds and their source within the equine heart, and this work was extrapolated to human medicine. The detection of abnormal heart sounds or rhythms, especially in performance horses, is often a cause for concern and raises questions about future athletic potential and performance. Many a pre-purchase exam has come to a halt upon the identification of a murmur. As cardiac ultrasound has become

Despite all of our advanced testing and diagnostic capabilities in veterinary medicine, heart rate continues to be one of the best prognostic indicators associated with diseases such as colic in the horse.

more advanced and accessible, we now know that there are physiologic murmurs that can be quite loud and that are not associated with underlying heart disease or pathology. These murmurs often dissipate with exercise. We know that there are flow murmurs that occur under physiologic stress that are transient and of little consequence to athleticism. Cardiac ultrasound can reveal the source of a pathologic murmur, whether it be a leaky valve or area of blood vessel constriction leading to or from the heart.

Veterinarians will often recommend a second exam 4 to 6 months after the original cardiac ultrasound to evaluate the heart muscle's response to altered flow and establish prognosis for athleticism. Occasionally, foals are born with congenital heart defects including holes in the wall that divides the left and right ventricles or pumping chambers. These are known as a ventricular septal defect and the size and location of the defect determines the long-term prognosis of these horses.

Advancements in technology have allowed us to fit Holter monitors to horses to observe the electrical activity of the heart under different degrees of exercise. We have improved ability to diagnose arrhythmias and track normal cardiac responses to extremes of exercise. Endurance and three-day event riders use heart rate monitors to direct fitness training and monitor physiologic stress in competitions. We now have the capability to look at cardiac enzymes such as troponin in horses to detect evidence of heart

muscle injury. Human pacemakers have been installed in horses with arrhythmias and the prospect of biological pacemakers introduced through gene therapy has been investigated in dogs. Thankfully, the incidence of heart disease continues to be lower in horses than in other species and is not associated with obesity as it is in humans. Because of their size and their poor tolerance of thoracic surgery, open-heart surgery and treatment with advanced pharmacology is still not on the immediate horizon. Sadly, horses with congestive heart failure pose a

safety issue for those around them and options for treatment are limited. Early detection and management of cardiac disease carries with it the best chances for long term survival, which for the average horse is 630,720,000 heart beats in a lifetime.

This *Horse Report* reviews the anatomy and functionality of the equine heart and discusses several of the most common equine heart problems. The videos contained in the electronic *Horse Report* (Zmag) will guide the horse owner and serve as a reference tool for veterinarians as to the normal sounds of the equine heart and the process of auscultation. The Cardiology Service at UC Davis works closely with the Large Animal Ultrasound department to identify underlying heart disease and offer guidance and treatment options for horses with abnormalities detected in the field.

We encourage horse owners to buy a stethoscope and practice listening to your horse's heart. Despite all of our advanced testing and diagnostic capabilities in veterinary medicine, heart rate continues to be one of the best prognostic indicators associated with diseases such as colic in the horse. Having the ability to communicate accurate heart rate to your veterinarian in an emergency situation can make the difference between life and death. *



MESSAGE FROM DR. GREGORY FERRARO



Dr. Gregory Ferraro

Late last year while thinking about how far the Center for Equine Health has advanced during my tenure and where it needed to go in the future, it suddenly dawned on me that at the end of 2012, I would have been its Director for 15 years. As rewarding and satisfying as my job has been, 15 years is a sufficient tenure for political office holders, Deans, Chancellors and Center Directors. At that point I realized that a change in leadership at the CEH was necessary and that a planned transition in that leadership was the proper course of action.

Consequently, a formal recruitment process seeking an individual who could lead the CEH well into the future was begun. One of our applicants was Dr. Claudia Sonder, a graduate of the UC Davis School of Veterinary Medicine, a well-respected sport horse veterinarian, and an individual with strong leadership qualities and intellectual capacity. Dr. Sonder was initially hired as my Assistant Director and has been working with me and the CEH staff for the past 12 months. During that period, she has excelled at every task assigned to her and has developed an intimate knowledge of the needs and operations of the CEH.

Therefore, with Dean Lairmore's endorsement, Dr. Sonder has taken the reins of the CEH directorship effective January 15, 2013, while the formal recruitment process is completed. This is a change that I welcomed and facilitated because I sincerely believe it is in the best interests of the CEH, the School of Veterinary Medicine and the horse enthusiasts we serve. I ask that you welcome Dr. Sonder to her new position and provide her with the same enthusiastic support that you have given to me during my tenure. I am certain that with your help she can take the Center to new heights.

As for me, I'm not going anywhere. I will continue my participation in the CEH as a senior advisor for as long as needed to effect a smooth and productive leadership transition. I am also currently serving the School of Veterinary Medicine as the Associate Director of its Large Animal Clinic and will be participating in any other areas of administration that Dean Lairmore may assign. This institution has been good to me and I am committed to participating in its success for as long as I remain a productive member of the team.

Finally, I want to thank each and every one of you, both University personnel and the public I have tried to serve, who have helped and supported me in my role as CEH Director. You all are responsible for any successes I may have achieved. I will always cherish my relationship with you and hope to continue serving you all in a different capacity. Together our future looks bright and I am excited to explore new possibilities for personal and institutional growth.

Sincerely,
Gregory L. Ferraro, DVM

The Equine Heart

— From page 1

equine cardiologists, including some common congenital defects, some causes of heart problems, and the diagnostic methods that are currently used. In general, however, horses have excellent cardiac health.

Cardiac Disorders

Horses generally do not have the same types of cardiac problems experienced by humans, such as coronary heart disease (atherosclerosis) and heart attacks. But because most horses are not kept as companion pets and are expected to perform work or athletic feats with a rider, the consequence of any kind of cardiovascular disease in a horse may be greater than it might be in a dog or a cat. In addition to the potential effect of a cardiac problem on performance, the safety of the rider must also be considered in determining the future of the horse.

The main observable signs of a heart problem in horses include:

- Loss of condition
- Increased fatigue during exertion
- Shortness of breath
- Increased rate or effort of breathing
- Weakness occasionally resulting in collapse or fainting
- Signs of fluid accumulation in the abdomen or beneath the skin of the lower thorax

Depending on the severity of the problem, these signs may initially appear only when the horse is subjected to moderate or strenuous exercise. With a severe cardiac disorder, these signs may appear during normal, nonstrenuous activities or even at rest.

A physical examination in a horse with cardiac disease will usually

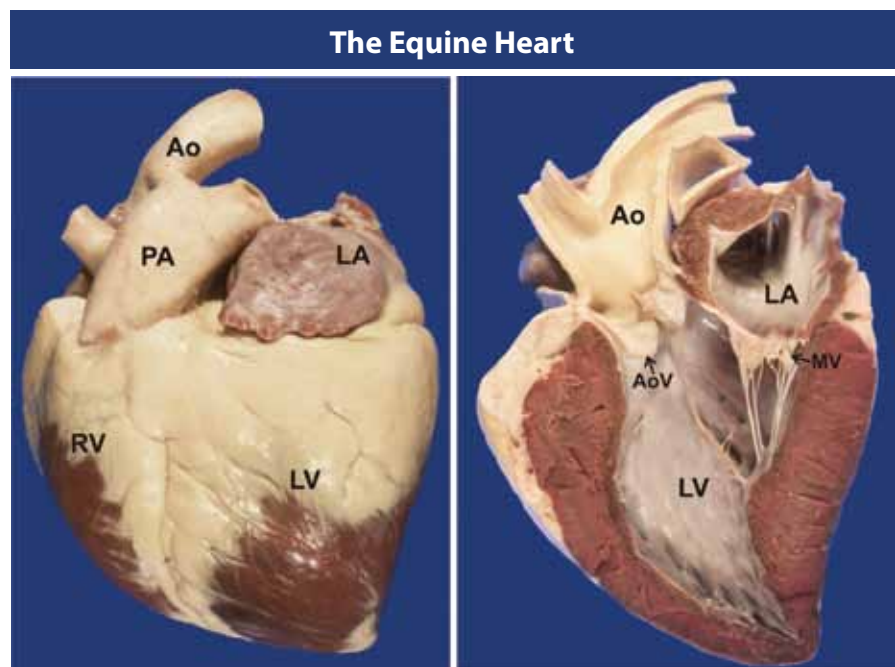


Photo on the left shows the outside of a horse's heart. Photo on the right shows the inside of the left heart. Ao = aorta, PA = pulmonary artery, LA = left atrium, LV = left ventricle, RV = right ventricle, MV = mitral valve, AoV = aortic valve.

reveal an abnormality in the audible heart sounds or in the heart rate and rhythm. When an abnormality is suspected, further evaluations by electrocardiogram (EKG) and echocardiogram (ultrasound imaging) may be performed to more precisely identify the nature and severity of the abnormality. Chest radiographs may also be used to help determine heart size and abnormalities in the lungs and chest cavity, but these are often difficult to obtain with conventional equipment in adult horses because of their large body size.

Heart Murmurs

During an examination of a horse's chest and heart with a stethoscope, a veterinarian may detect an abnormality by the sound of a heart murmur, which is the sound of turbulent blood flow usually caused by an abrupt increase in the velocity of blood flow. When blood moves smoothly through the heart and blood vessels, very little sound is produced (like water flowing smoothly through a hose).

Most heart murmurs are caused by blood flow that becomes turbulent because of increased velocity due to a leak or obstruction in one of the heart valves or because of abnormal communication between different parts of the heart (like the increased velocity and spraying sound you get when you put your thumb across the end of the hose). However, there are some soft, short, variable heart murmurs that may be heard with no other detectable evidence of heart disease. Such murmurs are referred to as normal or "innocent". If there is uncertainty about the origin or significance of any heart murmur, further evaluation is usually performed by echocardiography, which provides detailed images of the inside of the heart and can detect abnormal blood flow patterns.

Heart murmurs are graded on a scale of Grades 1 to 6, as follows:

Grade 1 – Very soft murmur that requires extended auscultation to detect.

Grade 2 – Readily audible murmur that is softer than S1 or S2.

Grade 3 – Readily audible murmur that is moderately loud and similar in volume to S1 and S2.

Grade 4 – Readily audible murmur that radiates widely and is louder than S1 or S2.

Grade 5 – Very loud murmur with a palpable thrill (vibration) that is detectable with fingertip pressure over the heart.

Grade 6 – Very loud murmur associated with a palpable thrill that is audible with the stethoscope held just off the chest.

Heart murmurs are further classified by when in the cardiac cycle they occur—during ventricular filling (diastole, after S2 and before S1) or during ventricular contraction (systole, between S1 and S2). Finally, they are described by their length and musical qualities.

The majority of heart murmurs heard in the horse are physiologic or benign. These murmurs can increase in intensity with submaximal exercise and can also be heard with high vagal tone or when the horse is in an excited state. One classic example of this is colic. Often during a painful colic episode a murmur can be heard with a stethoscope that has not been heard before and that will resolve when the colic resolves.

It is important to know which heart murmurs merit further diagnostics and which heart murmurs can be considered incidental. In general, heart murmurs should be assessed by a specialist, especially when accompanied by other signs of cardiac dysfunction or illness. In addition to listening to the murmur

with a stethoscope, a cardiologist will be able to assess the heart via echocardiography (cardiac ultrasound). Blood flow through the heart can be analyzed through color flow echocardiography, pinpointing the cause or causes of the murmur. Additionally, the whole heart can be scanned to assess chamber size and contractility.

Congenital Heart Defects

Congenital heart defects are abnormalities that are present at birth. They occur much more commonly in humans and dogs than in horses. These abnormalities are often discovered within the first few weeks to months of life when a heart murmur is heard during stethoscopic examination of the chest and heart.

Although rare, congenital heart defects can prevent the development of an athletic career and in some cases can be life-threatening. For this reason, every newborn foal should receive a thorough cardiac examination.

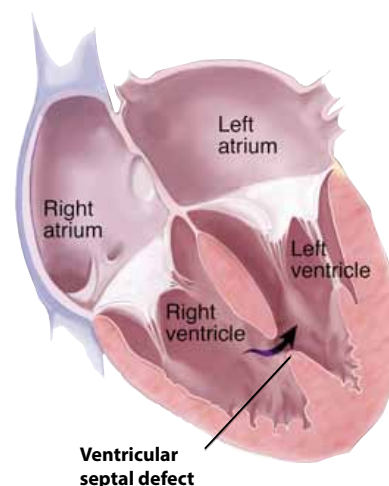
A wide variety of simple or complex congenital heart defects may occur, but only a few have been recognized often enough to be reported in more than a few individual horses. The most accurate technique for identifying specific defects and evaluating their severity is two-dimensional echocardiography (ultrasound imaging) supplemented by Doppler echocardiography (imaging of blood flow within the heart and associated blood vessels).

The most commonly reported congenital heart defect in horses is **ventricular septal defect**, described below. Another defect, **patent ductus arteriosus**, which is common in humans and dogs, is relatively rare in horses beyond 1 to 2 weeks of age. The ductus arteriosus—a large blood

vessel in the fetus that connects the pulmonary artery with the aorta, bypassing the lungs—closes more slowly after birth in horses than in humans and dogs, so that a soft, continuous murmur can be heard in newborn foals up to about a week of age. Horse owners should not panic if their veterinarian pronounces that their newborn foal has a heart murmur, although a follow-up exam should be conducted to make sure the murmur disappears.

Ventricular Septal Defect (VSD).

Ventricular septal defect consists of a hole in the muscular wall between the two ventricles and is the most commonly recognized congenital heart defect in horses. It also occurs as one part of more complex defects.



In simple cases, the hole results in the passage of oxygen-rich blood from the higher pressure left ventricle to the lower pressure right ventricle and pulmonary artery, primarily during ventricular systole. Because some of this blood bypasses the lungs, it is not fully oxygenated. A systolic heart murmur is usually heard on the right side of the chest over the cranial part of the heart.

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The Equine Heart

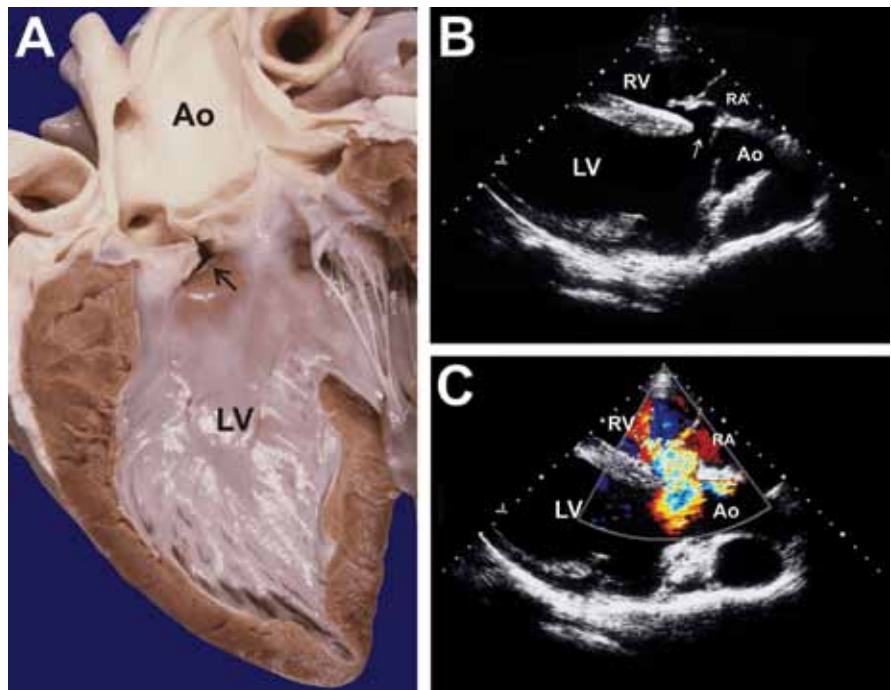
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Depending on the size of the hole and the amount of blood passing through it, the pulmonary arteries and veins and the left atrium and ventricle are subjected to an increased workload because of this extra volume of blood. If the hole and the resulting shunt are small, the adverse effect on cardiac function may be minimal, and the horse may be fully capable of engaging safely in moderate physical activities without evidence of fatigue or shortness of breath. If the hole is larger and the shunt is greater, there may be signs of cardiac insufficiency with minimal exertion, and the horse may be very limited in its athletic ability. The nature of the defect can usually be confirmed using two-dimensional and Doppler echocardiography.

Patent Ductus Arteriosus

(PDA). The ductus arteriosus is a large blood vessel connecting the fetal pulmonary artery to the descending aorta, allowing blood from the right ventricle to bypass the nonfunctioning lungs and be directed toward the abdomen and placenta. In all mammals, the ductus constricts at or shortly after birth, eliminating this fetal connection and allowing for the normal development of the blood vessels in the lungs.

Unlike most other domestic animal species, persistent slight opening of the ductus arteriosus is quite common in newborn foals. Because the pressure in the aorta is higher than that in the pulmonary artery throughout the cardiac cycle, blood flows through the ductus from the aorta to the pulmonary artery, and a “continuous” murmur can be heard over the pulmonary artery on the left side of the chest.



Ventricular septal defect (VSD). Photo on left (A) shows a small VSD in the upper ventricular septum just below the aortic valve (arrow). Photo top right (B) shows an echocardiogram with the VSD opening between the left ventricle and aorta (arrow). Photo bottom right (C) shows the same view but with multicolored, disorganized turbulent flow through the VSD into the right ventricle during ventricular systole. RA = right atrium, RV = right ventricle, LV = left ventricle, Ao = aorta.

Closure of the ductus usually occurs within the first week of life, and the murmur disappears. If the ductus remains open beyond the first week, it is called a **persistent or patent ductus arteriosus**. The resulting shunt may cause blood volume overload in the pulmonary arteries and veins and the left atrium and ventricle. Although slight patency (an open state) in the first week is very common in foals, patency beyond the first week is rare.

Complex Defects. Congenital heart defects are uncommon in horses, but when they occur, multiple or complex defects appear to be more common than in other species such as dogs and cats. These may occur as combinations of embryologically unrelated defects, or as recognized combinations such as **tetralogy of Fallot** (consisting of a ventricular septal defect, pulmonic stenosis, rightward malpositioning of the

origin of the aorta, and right ventricular hypertrophy/thickening) or **truncus arteriosus** (consisting of a ventricular septal defect and a single large arterial trunk exiting both ventricles).

In the most severe cases, there may be shunting of oxygen-poor, darker venous blood from the right heart chambers to the left heart, bypassing the lungs and causing cyanosis (a bluish color to the membranes of the mouth and eyes) at rest or during exertion. These defects can be diagnosed accurately only by X-ray angiography or, more recently, two-dimensional and Doppler echocardiography.

Heart surgery is rarely performed in horses. Congenital heart defects can now be accurately diagnosed using sophisticated ultrasound imaging, but treatment options are very limited for the types of defects horses tend to get.

Acquired Heart Disease

Generally speaking, acquired heart disease is relatively uncommon in horses, although it is encountered slightly more frequently than congenital heart defects. It occurs most often in horses older than 5 years and only occasionally in younger horses. Degenerative changes affecting the heart valves, myocardium and lungs are associated with aging, increasing in frequency with age.

The most commonly diagnosed conditions are heart rhythm irregularities and leaks in one or more heart valves. The most common signs associated with heart disease include a reduction in exercise capacity (exertional fatigue), shortness of breath especially following exertion, or the detection of a heart murmur, irregular heart beat, or other audible abnormality in a horse without other signs of illness.

Identification of the electrical rhythm of the heart requires recording of an

electrocardiogram, shown below. The normal resting heart rhythm of horses is usually slow (28 to 48 beats per minute) and regular (called **sinus rhythm**). Many horses also have short pauses in their resting heart rhythm caused by “dropped beats” (called **second degree AV block**). These are considered to be normal if they disappear during exercise.

Atrial Fibrillation. Atrial fibrillation is an electrical disorder of the heart rhythm—also known as an **arrhythmia**. There are different kinds of arrhythmias, but the most commonly recognized one associated with diminished athletic performance or more serious signs of cardiac insufficiency is atrial fibrillation. With this arrhythmia, the normally regular, organized atrial electrical waves become irregular, disorganized and chaotic, and the atria fail to contract normally. This results in a very unpredictable, irregular heartbeat.

Although atrial fibrillation often develops in horses with advanced structural heart disease and atrial

dilation, horses most often develop this arrhythmia with minimal or no detectable additional signs of heart disease. Draft breeds are more commonly affected. In such cases, signs of cardiac insufficiency are usually not recognized at rest or with mild to moderate exertion, but become apparent at more strenuous levels of exercise.

Accurate diagnosis of arrhythmias requires evaluation of an electrocardiogram, where the lack of normal atrial waves and the very irregular ventricular waves can be readily identified. Further evaluation of the structure and mechanical function of the heart by echocardiography is also recommended, because the prognosis for treatment, recovery and return to previous activity levels is directly related to the presence or absence of underlying mechanical cardiac dysfunction.

If there is little or no evidence of underlying cardiac dysfunction,

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Normal sinus rhythm



Second degree AV block



Atrial fibrillation





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administration of oral or injectable drugs, especially quinidine, is often successful at converting the arrhythmia to a normal rhythm. Most of these horses are able to return to their previous levels of activity and performance, although some experience one or more recurrences of the arrhythmia, necessitating retreatment or retirement from strenuous activity. Quinidine can become toxic to horses at higher dosages and occasionally treatment must be suspended before conversion of the rhythm can occur. A newer, catheter option for cardioconversion exists for cases that do not respond to quinidine treatment. This option requires general anesthesia and specialized equipment and is still in the developmental stages.

If serious cardiac disease with atrial dilation is present, the prognosis for functional recovery is poor and conversion of the arrhythmia is usually unsuccessful or temporary. Treatment of the signs of cardiac insufficiency with drugs such as digitalis and diuretics may be considered in selected cases where little physical activity is expected.

Valvular Heart Disease. The most commonly recognized acquired structural heart disorders in horses are degenerative valvular deformities. The process causes thickening and deformity of valve leaflets. These defects result in incompetence and insufficiency of one or more heart valves, associated heart murmurs, and dilation of the chambers that must handle the extra regurgitated blood on either side of the incompetent valve. If the valve leak is severe enough, the pressure in the veins

leading to the affected side of the heart increases to the point where fluid accumulation (edema) occurs.

Valvular disease is initially diagnosed by the detection of a heart murmur during a physical examination. It is very important, however, to understand that soft, “innocent” murmurs are often heard in normal foals and adult horses. In order to advise an owner or rider about the significance of any heart murmur, it is critical to distinguish between a normal murmur and a pathologic murmur of valvular regurgitation, and to assess the severity of any suspected valve leaks. Two-dimensional and Doppler echocardiography are the most accurate and least invasive methods to help make such determinations.

In general, mild to moderate valvular insufficiency in a horse without

reported signs of illness is compatible with continued use for mild to moderate physical activity. More severe valvular disease, especially when it is accompanied by obvious signs of cardiac insufficiency, atrial fibrillation, or severe enlargement of the heart, is cause for a poor prognosis and a strong recommendation against any riding or forced physical activity.

Myocardial Disease. Myocarditis is occasionally suspected in a horse that develops an arrhythmia or other electrical disorder following an infectious disease such as strangles, influenza or an internal abscess. Toxic damage to the heart muscle may also rarely occur as a result of severe dietary deficiency of vitamin E and selenium, or as a result of ingesting the chemical monensin (usually from cattle feed).

Vascular Disease. Horses are known to develop several types of disorders that affect primarily their blood vessels. However, atherosclerosis—vascular disease associated with high blood pressure, high cholesterol and fats in humans—is exceptionally rare in domestic animals, including horses. Therefore, the consequences of this condition in humans, including heart attack, stroke and other peripheral arterial disease, are also rare in horses.

The only common condition affecting the veins of horses is **thrombophlebitis** of the jugular vein(s) caused by repeated jugular vein puncture, injection of material outside the vein, or use of a jugular vein catheter. The resulting chemical or physical irritation or infection in or around the vein causes inflammation, swelling and tenderness, followed by formation of a firm clot in a small portion or long segment of the vein. Treatment involves removing the cause and applying symptomatic treatment for discomfort and any associated infection. Note that

thrombophlebitis can occur in other large veins in the horse.

Several conditions may affect the systemic arteries in horses. The most common condition is parasitic arteritis (inflammation of the walls of the arteries) due to the vascular migration of the larval forms of the intestinal parasite *Strongylus vulgaris*. The resulting dilation and thrombosis (and potential obstruction) usually occur at the origin of the large arteries to the intestines, although other arteries may be affected. Fortunately, this condition can usually be treated or prevented by an appropriate antiparasitic drug treatment program. The incidence of this problem declined significantly with the introduction of ivermectin dewormer in the 1980s.

The other most commonly recognized arterial disorder is called **aorto-iliac thrombosis**. In this condition, a clot develops at the point where the abdominal aorta branches toward the hind legs. The resulting restriction of blood flow to the hind limbs can cause signs of lameness, stiffness, weakness and abnormal gait that develops during exercise and usually disappears at rest. Unfortunately, this condition is often progressive and rarely reversible, markedly limiting the athletic uses of an affected horse. Finally, degenerative changes in the wall of large arteries may weaken a vessel and predispose to rupture and bleeding. The most commonly reported sites of such rupture are the root of the aorta in stallions and the uterine artery in mares.

Summary

The causes of heart disease in horses are often multiple and difficult to determine in individual cases. There is increasing evidence that genetic background may play a major role in a horse's susceptibility to developing

disease. Some heart muscle disorders have clearly been shown to have a major genetic component, and familial or breed tendencies in some conditions strongly suggest that genetics play a role in these conditions.

Unlike in humans, diet and exercise have not been shown to be factors in heart disease in horses, since horses almost never develop atherosclerotic vascular disease leading to stroke or heart attack. Almost all heart diseases except the congenital defects tend to increase with age in horses, just as they do in humans, dogs and cats.

There are no known preventive strategies to reduce the likelihood of heart disease in horses. However, owners of all animals should avoid inbreeding, which may increase the risk of congenital heart defects. We strongly urge owners not to breed any animals with known congenital defects of any kind, including heart defects. It is probably wise to also avoid breeding horses that have developed an acquired heart disorder relatively early in life, as this may indicate an increased susceptibility for that condition in offspring. *



Baby Kaya Gets a Pacemaker

A Case Study from the William R. Pritchard Veterinary Medical Teaching Hospital

Kaya, a three-week-old miniature donkey, presented to her local veterinarian because of episodes of fainting. The veterinarian performed a complete physical examination and heard dropped beats that he believed were associated with the fainting. Additionally, he heard a systolic heart murmur. After an electrocardiogram confirmed an abnormal heart rhythm, the veterinarian referred Kaya to the William R. Pritchard Veterinary Medical Teaching Hospital at UC Davis.

Here, Kaya was seen by both the Large Animal Internal Medicine Service and the Cardiology Service. They learned that not only was Kaya experiencing fainting episodes, she was also an unusually quiet donkey baby. She never bucked or played like a normal baby.

When UC Davis veterinarians listened to her heart with a stethoscope, both her abnormal heart rhythm and the heart murmurs described by Kaya's veterinarian were confirmed. To understand the causes of these abnormal findings, both an electrocardiogram (ECG) and an echocardiogram (cardiac ultrasound) were performed.

The ECG showed an abnormal rhythm (arrhythmia) consistent with third-degree AV block,

which is a failure of the inherent pace-keeping mechanism of the heart. The ultrasound showed that the mitral, tricuspid and aortic valves were slightly leaky but that the overall structure and size of the heart were normal. Routine lab work ruled out infection or electrolyte disturbances as the underlying causes of the arrhythmia.

Given these findings, it was suspected that Kaya's third-degree AV block might be congenital (present at birth as a result of hereditary or environmental influences).

To treat the arrhythmia, Kaya was placed under general anesthesia and a pacemaker was installed. The evidence of the pacemaker's success was seen immediately, as Kaya bucked for the first time that evening!

There were some important considerations for Kaya's health regarding the placement of the pacemaker. First, given Kaya's age, it was likely that she would outgrow her pacemaker and a second surgery would be required. Second, it was critical that the jugular vein used for the



Baby Kaya

pacemaker placement would never be used to administer intravenous medications or to draw blood.

The first of these considerations proved to be true, as six months after her initial pacemaker was placed, Kaya needed to return for a second, larger pacemaker to be placed. Her second pacemaker surgery was uneventful and Kaya is a happy donkey again! ✨

The Art of Listening to Your Horse's Heart

Auscultation is the action of listening to sounds from the heart, lungs, or other organs, typically with a stethoscope. In human medicine, cardiac auscultation, long considered the centerpiece of the cardiac clinical examination, is becoming a lost art. Some physicians believe that the availability of high-tech diagnostic and therapeutic methods, both more elaborate and more expensive, has replaced auscultation to a large degree. They also believe that there is no substitute for cardiac auscultation and that, when used properly, the simple stethoscope remains a valuable and cost-effective tool that allows physicians to make a rapid and accurate cardiac diagnosis.

Listening to your horse's heartbeat is also valuable for horse owners. It is another way of learning about your horse's health status and to know what is normal for your horse. Stethoscopes come in a range of prices and quality and can be purchased in many places, including online. The average horse owner can do very well with an inexpensive one. An inexpensive stethoscope will allow you to hear the classical "lub-dub" of the heart but will probably not allow you to hear more subtle sounds. Owners of draft horses or very well-conditioned horses may need to spend a little more on a higher quality stethoscope because the heartbeat is more difficult to detect in these animals with larger muscle mass.

The normal resting heartbeat of a horse is between 28 and 48 beats per minute (bpm). Every individual horse has its own "normal," so you should become familiar with what is normal for your horse. The basic heart sounds (known as S1 and S2) sound like a *lub-dub*. This is considered ONE BEAT. Two additional sounds (known as S3 and S4) may or may not be heard as they are usually much softer in intensity. A normal heartbeat could sound like *lub-dub* or it could include the two additional softer sounds to form a sound like *pa-lub-dub-uh*. In any case, this would be considered one beat.

The horse's heart is best heard on the LEFT side behind the elbow and below the triceps muscle. Before applying the stethoscope, use the palm of your hand to feel for the horse's heartbeat (see video contained in the Zmag edition of this *Horse Report*, accessed via our website, www.ucdavis.edu/ceh). With the stethoscope head placed under

the triceps muscle (requires pushing under the muscle), locate the loudest point of the heartbeat in order to get a reliable and consistent heart rate. Each *lub-dub* equals one heartbeat. Horses have a slow heart rate and a typical novice mistake is to double count. Note that the heartbeat of a human is 60 to 80 beats per minute, almost twice as fast as that of a horse.

To simplify the process of determining your horse's resting heart rate, listen to his heartbeat for 15 seconds and then multiply that number by four to arrive at bpm. In Part 2 of the video contained in the Zmag edition, Peppy's heart rate for 15 seconds was 10 beats, so her resting heart rate was 40 bpm.

Increased heart rates can be heard in many conditions including colic, laminitis, late-term pregnancy, and illness. During an emergency, the heart rate of your horse can be a valuable piece of information for your veterinarian. If your colicky horse has a heart rate of 36 bpm and pink mucous membranes, it is likely that it is safe for your veterinarian to quickly finish the call they are on. If, however, your horse has a heart rate of 80 bpm and muddy mucous membranes, your veterinarian may want to head to out to see him immediately. A persistently increased heart rate can be a sign of cardiac disease.

Happy auscultating!





Cash: The Little Horse with a Big Hole in His Heart

Thanks to Dr. Mary Beth Whitcomb of the UC Davis School of Veterinary Medicine for this story and the accompanying ultrasound images of Cash's heart murmur.

Among the permanent residents of the Center for Equine Health is a little horse named Cash who was born with a ventricular septal defect, or a hole in his heart. He has been living here since he was 2 years old and is now a thriving 14-year-old. For the past 12 years, Cash has been performing a valuable service for the UC Davis School of Veterinary Medicine by being a model for veterinary students.

A ventricular septal defect means that Cash has an opening between the right and left ventricles of his heart, which causes blood to flow from the left to the right ventricle when the heart contracts (see illustration). Similar to other species, VSDs are the most common congenital heart defect in horses. It is not known whether these types of congenital defects are hereditary.

While the condition may sound severe, it is important to realize that many horses can live full lives with a normal or near-normal life expectancy as long as the hole is smaller than 2.5 cm (about 1 inch) in diameter. Horses



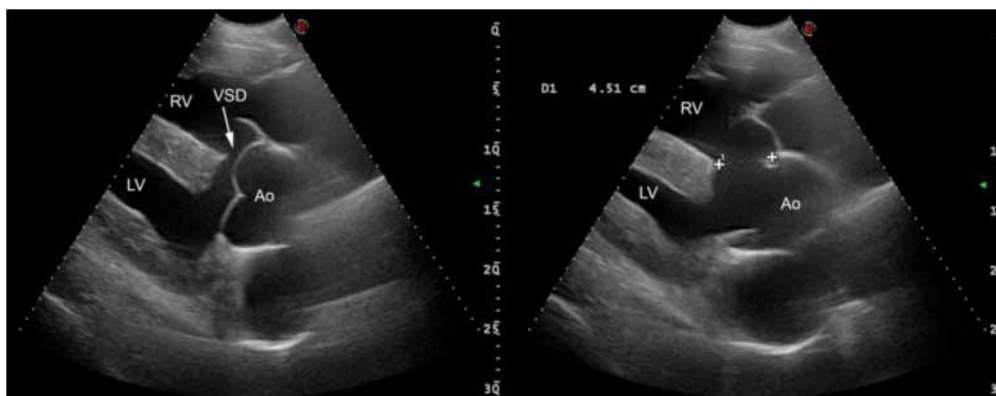
Cash, pictured here with CEH Director Dr. Claudia Sonder, has lived at the Center for Equine Health for 12 years.

with a VSD larger than that often live a shorter life but may not show any symptoms until later in life. While Cash did have exercise intolerance when put into training as a 2-year-old, he is otherwise healthy and shows no outward symptoms in his less demanding career as a TA (teaching assistant) at the Center for Equine Health.

Since 2001, Cash has helped teach the art of cardiac auscultation (listening to the heart with a stethoscope) and echocardiography (cardiac ultrasound) to over 250 veterinary students. The students learn to hear and characterize the heart murmur and then see the structural changes that produce it. Cash also has helped many residents in internal medicine to refine their skills in cardiac ultrasound

so that more veterinarians will be skilled and familiar with this important condition.

Cash always has a great demeanor, is very cooperative, and knows his job. During ultrasound exams, he will stand with his right leg forward to ease placement of the probe as long as it takes for someone to get an image. He is well liked by everyone. ✨



These are ultrasound images of Cash's heart. The left image shows his defect (VSD, shown by arrow) in the muscle between the left ventricle (LV) and right ventricle (RV). The defect, known as ventricular septal defect or VSD, allows blood to flow through it from the left to right ventricle when the heart contracts. The right image represents the same view, but now the aortic valve (Ao) is open. This allows us to better measure the size of Cash's VSD (4.51 cm).

Cardiology Service at the William R. Pritchard Veterinary Medical Teaching Hospital (VMTH)



THE CARDIOLOGY SERVICE at UC Davis has board-certified veterinary cardiologists, residents-in-training and a highly skilled technical staff dedicated to providing compassionate care to animals with known or suspected heart disease. Faculty on the Service include Dr. Leigh Griffiths, Service Chief, and Dr. Joshua Stern.

Many patients are dogs and cats, but the Service regularly examines horses and other species. Common reasons for seeking the expertise of a cardiologist include heart murmur, irregular heart beat, respiratory (breathing) problems, exercise intolerance, and weakness or fainting. Routine evaluations include the history and review of prior records, physical examination, an electrocardiogram, and an echocardiogram (cardiac ultrasound).

Appointments for horses may be made by calling the Large Animal Clinic at (530)752-0290. Appointments are usually for Tuesdays and Thursdays, but other arrangements may be made on an individual basis. Referring veterinarians are encouraged to discuss a case with one of the cardiology faculty or residents on duty prior to the appointment if possible. Owners are asked to bring any available records or results of prior examinations for review and comparison.

One More Word About Miniature Horses

IN OUR DECEMBER 2012 *Horse Report* on Miniature Horses, we failed to include the American Miniature Horse Association (AMHA) among the organizations devoted to small equines. AMHA is the world's leading Miniature Horse registry, with nearly 200,000 horses and more than 12,000 members in 38 countries and provinces. Founded in 1978, AMHA promotes the breeding, use and perpetuation of a standard of equine excellence in miniature, separate and apart from ponies and other small equine. Horses registered with AMHA must meet the Association standard of perfection and cannot exceed 34 inches in height at the withers as measured from the last hairs of the mane. For more information, please visit their website at www.amha.org.



Oleander Poisoning: The Preventable Illness

Oleander is an evergreen shrub that seems to grow everywhere in California—in yards, parks and along freeways. It is often grown as a hedge that can reach up to 20 feet tall. The leaves are thick, leathery and dark green. White, pink or yellow flowers that are sweetly scented grow in clusters at the end of each branch.

Oleander is one of the most poisonous plants and contains numerous toxic compounds, many of which can be deadly to people and animals. ***It is especially dangerous to horses, as it is sweet. Symptoms of a poisoned horse include severe diarrhea, colic and abnormal heartbeat.***

The primary toxins in oleander are cardiac glycosides, which affect the heart. Cardiac reactions consist of an irregular heart rate, sometimes characterized by a racing heart that subsequently slows to below normal further along in the reaction. The heart may also beat erratically with no sign of a specific rhythm. Other toxic effects include nausea, excess salivation, abdominal pain, diarrhea (sometimes with blood), kidney failure and colic in horses. Poisonings from this plant can also affect the central nervous system and cause drowsiness, tremors, seizures, collapse, and even coma that can lead to death.

Several years ago, a sick four-year-old Standardbred racehorse was brought to the William R. Pritchard Veterinary Medical Teaching Hospital. The owner reported that it had stopped

eating the day before and was clearly unwell. The horse appeared to be in shock, judging from the color of its mucous membranes, a heartbeat racing at 160 beats per minute (bpm), and a slightly elevated temperature. (Normal heartbeat for a horse is 28 to 44 bpm.) It also had significant discomfort from ileus—a condition in which the bowel does not move the contents at normal rates of flow because of lack of neuromuscular control. The ileus had caused a backward flow of fluid and intestinal contents back into the stomach. Since horses cannot vomit, this poses a serious problem. To treat this condition, a nasogastric tube was inserted into the horse to drain the accumulating fluid while tests were performed to determine the underlying problem.

An electrocardiogram (ECG) revealed that the horse had ventricular tachycardia, which is an irregular and overly rapid heartbeat. Pleural effusion—fluid in the chest around the lungs—and pericardial effusion—fluid around the heart—were signs that the horse's heart was failing. This condition was treated as an emergency with lidocaine administered intravenously to slow the heart rate. Eventually the heart rate was brought down to 60 bpm, substantially closer to the normal rate of 40 bpm than before, and the arrhythmia was converted to a normal sinus rhythm.

Blood work and urinalysis results then indicated a build-up of toxins and renal failure. By now, the



Just four oleander leaves (shown above) can kill an adult horse. This plant is just as deadly dry as it is live.

horse was quite weak and was staggering. It was immediately put on intravenous fluids to flush out the toxins and eventually was stabilized. Meanwhile, testing continued to determine the exact cause of illness.

The diagnosis of toxicity was confirmed by laboratory tests, which showed the presence of oleander in the blood, feces and stomach fluid. The owners of the horse had not realized that the pasture the horse had been turned out in days before was surrounded by oleander. Fortunately, this story has a happy ending. With continued intensive treatment and supportive care, the horse began to recover and was eventually released from the VMTH. Three months after this incident, the owner reported that the horse was doing very well and was back in training.

Not every case ends this well, so remember that preventing exposure to oleander is by far the best course of action for your horses and other animals. ❄

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