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THE EQUINE HEART: some congenital and acquired diseases

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CONGENITAL EQUINE CARDIAC DISEASE

The ventricular septal defect (VSD) is one of the most common congenital anomalies in the horse. The cause is not known, but a genetic component is suspected in Miniature horses (as in Limousine and Hereford cattle). The most common VSD shunt direction is from left to right [i.e. Left ventricular pressure (LV) > Right ventricular pressure (RV)], however, over time chronic pressure and volume overloads cause RV failure and the pressure may be sufficient to reverse the shunt direction (i.e. RV to LV - Eisenmenger’s complex).

A presumptive diagnosis of a VSD can be based upon clinical signs.

- Classically a murmur will be auscultated on both the right and left sides, but the point of maximum intensity (PMI) is on the right.
- The murmur is usually harsh, plateau-shaped, holosystolic and may have a palpable thrill associated with it (remember your grading system – usually we grade out of VI with V/VI and VI/VI both having a thrill).
- A split S2 may occur pathologically, due to pulmonary hypertension.
- A second component to the murmur may be heard during diastole, usually on the left side, due to secondary aortic insufficiency - this only occurs rarely.
- There may be a systolic murmur on the left (very cranial) due to relative pulmonary stenosis (due to left to right shunting)
- Clinical pathological results are largely unrewarding, however, in cases of either a complicated VSD (i.e. further anomalies) or a reversed VSD, polycythemia may be seen secondary to chronic tissue hypoxia (i.e. low PO2 and high erythropoietin).
- Definitive diagnosis may be made using echocardiography (i.e. direct image, colour-flow Doppler, even M-mode)

PROGNOSIS: Presently, it appears wise to recommend that the horse not be bred, as the hereditary component may be important and there is an increased risk of congestive heart failure (CHF), however, all you can do is advise the owners. Some horses have become performance horses and some have even raced with VSDs. However, the risks are always greater and I personally believe that it would be unadvisable to advise someone to continue performance with this horse, even when there is echocardiographic monitoring available.

The prognosis is improved if:

- there has been echocardiography performed and:
  - the lesion is less than 2 cm (-2.8 cm)
  - the shunt velocity is high (> 4 m/s)
  - the location is membranous or perimembranous (versus muscular location being worse)
- there are no other findings (eg. moderate to severe aortic insufficiency or other cardiac anomalies with the VSD.

Unfortunately there is no practical treatment in horses, although it is feasible that septal repair...
may be attempted on expensive foals one day. Therapy for Congestive Heart Failure (CHF) will be discussed later.

**Patent ductus arteriosus (PDA)** occurs when the ductus arteriosus (i.e. a vessel connecting the aorta to the pulmonary artery in the foetus, so as to bypass the non-inflated lungs) remains open. Some normal foals may have a PDA for 80-96 hours, although some sources quote up to 8 days. The normal duration that a premature foal can have a PDA is not known; currently there is concern by most internal medicine specialists at approximately 96 hours, but the accuracy of this is not known. Diagnosis is usually presumptive based on auscultation. In most cases a **continuous murmur can be ausculted on the left and right hemithoraces**, at intercostal spaces (IC) 3-4 at the shoulder level. Sometimes it is only possible to hear a holosystolic murmur, as the diastolic component is barely audible. The intensity of this murmur often increases as the heart rate elevates (i.e. pain, exercise or excitement).

Treatment can be nothing (most common in foals), but can include the use of prostaglandin inhibitors, such as the nonsteroidal anti-inflammatory drugs. Flunixin meglumine has been used at a dose rate of 0.5-1.0 mg/kg IV q24 hours for three days. Ketoprofen has also been used at a dose of 1.0 mg/kg IV q24 hours. The putative mechanism is by an alteration of eicosanoid balance in the favour of the vasoconstrictor thromboxane. The disadvantages of NSAID therapy include gastrointestinal ulceration, renal papillary necrosis and platelet dysfunction. As foals are prone to GI tract ulceration anyway, it would be wise to select cases greater than 96 hours old (i.e. in which it is strongly felt that the PDA may be significant) and to place foals on anti-ulcer medication (eg. omeprazole). Otherwise if the foal is clinically normal, check at day 8 and see if the continuous murmur is still present.

**ACQUIRED HEART DISEASE**

**VALVULAR HEART DISEASE**

**Congenital valvular disease in the horse**

- is rarely recognized.

**Acquired valvular disease is the most common form of valvular disease in the horse**

- An abattoir study revealed that 23% (356/1557) of horses were affected.
- Bacterial endocarditis is one form of acquired disease; the valves affected most commonly vary in different studies however, in one study the aortic and mitral valves were more commonly affected with the tricuspid less commonly and rarely the pulmonic.

- Degenerative changes may also be found, however, these are not always associated with incompetency. Other changes include valvular damage secondary to viral infection, inflammation, trauma, immune - mediated disease (not documented in the horse), rupture of valve leaflets, rupture of chordae tendineae, neoplasia, cardiac dilation with secondary valve insufficiency.

- Diagnosis of bacterial/degenerative endocarditis is usually made using echocardiography. The horse may first be noticed because of a **cardiac murmur**.

- It is extremely important to document whether the horse is **tachycardic** [i.e. may indicate compensation for poor stroke volume (SV) due to congestive heart failure (CHF)]. Other signs of CHF include jugular venous distension, subcutaneous edema, ascites, jugular venous
pulsations (i.e. if there is tricuspid valve regurgitation). -Signs of bacteremia including recurrent fever, tachypnea, tachycardia, anorexia and weight loss are important to document in order to assist in the diagnosis of bacterial endocarditis, and multiple blood cultures should be performed. It is best to try to document whether fevers are cyclic and perform multiple blood cultures approximately an hour prior to the perceived, predicted fevers. Further examination of the horse is warranted to help confirm bacterial endocarditis; signs of disseminated sepsis (i.e. lameness, joint distension, coughing, pneumonia, hematuria, pyuria and mastitis) and chronic disease are suspicious in cases with murmurs. Clinical pathology may assist in that there may be a leukocytosis with a neutrophilia (however, it could also be within normal limits) and a hyperfibrinogenaemia (i.e. elevated fibrinogen).

- **Treatment** can be initiated for bacterial endocarditis; however, the prognosis remains guarded to poor if signs of CHF already exist, however, if it is relatively acute (e.g. fever and leukocytosis in the last few weeks, then offer intensive (and therefore expensive) treatment. Sudden death can occur even on therapy.
  - It is best to base antimicrobial therapy on blood culture and sensitivity results, however, if these are not yet available or did not grow, then initial therapy should be based upon the likelihood of *Streptococcus* and *Actinobacillus* species. Unfortunately too few cases of equine endocarditis have been reported to effectively establish the organisms most frequently involved. *Streptococcus* sp., *Actinobacillus equuli*, *E. coli*, *Pseudomonas* and *Serratia* spp. have been isolated in various cases.

**Diagnosis summary:**
- Mitral valve insufficiency: systolic & left
- Aortic valve insufficiency – diastolic and left
- Tricuspid insufficiency – systolic and right

**Treatment Summary:**
- Antimicrobials (broad spectrum, but if you can base your choice on blood culture and sensitivity results)
- NSAIDs (I like using aspirin at 10 mg/kg once daily PO). The aim of using aspirin is to try to decrease platelet function and aspirin does this irreversibly, so platelet function is diminished for their lifespan. This means that there should be less adherence to the damaged valve and we hope that it will not increase in size and we hope that the degree of insufficiency will stabilize.
- Drugs to help control the CHF (if present) including ACE inhibitors (like enalapril)
- Gastric ulceration medication since you are using long term NSAIDs (eg. omeprazole), although it is my impression that aspirin at this dose is often not associated with gastric ulceration
- An appropriate anthelmintic program.

**MYOCARDIAL DISEASE**
Myocarditis in horses is often not diagnosed ante mortem, but we need to become more aware of it and investigate poor performance and collapse horses to a greater degree, using physical exam, ecg at rest and telemetric ecg at the track/arena or on the treadmill, echocardiogram, troponin measurement etc.).

Disease of the heart muscle occurs when there is inflammation of the myocardium by:
  - **bacteria** (including *Streptococcus equi*, *Staphylococcus aureus*, and possibly, although
this remains very doubtful, the spirochete - *Borrelia burgdorferi*, as in humans)

- **viruses** (including EIA, EVA, equine influenza, African horse sickness – still be thinking about viruses even in lucky Australia)
- **parasites** (including *Strongylus vulgaris* and *Onchocerca* spp in horses)
- **toxicities** [ionophores and cantharidin from the Blister beetle (*Epicauta* species) in the USA and Canada and snake envenomation]
- **deficiencies** (vitamin E and selenium)
- **foreign bodies** – eg. intravenous catheter fragments – RARE
- **neoplasia**

The **diagnosis is difficult to make** (especially in the early stages) because of the lack of specific cardiac signs. The horse may be febrile and tachycardic (often relating to the primary disease, eg. strangles; although the tachycardia could also be due to a supraventricular or ventricular dysrhythmia or CHF). If the myocarditis is acute, then the horse may have myalgia and be reluctant to move. There may also be signs of CHF. Electrocardiographic (ECG) alterations may accompany myocarditis, but they are not consistent. Myocarditis is often likely to progress to CHF, therefore signs of this may alert you to an underlying myocarditis or even dilated cardiomyopathy (which occurs on a chronic basis with effects on the ventricular myocardium, yet without valvular, septic or pulmonary disease).

**Treatment** is directed at the underlying disease process if that is recognizable. Stall rest of the horse is obviously beneficial, and may be combined with NSAIDs, corticosteroids (only if one is certain that the disease process is untreatable, and no viral/bacterial etiologies are suspected) and antimicrobials. Therapy for CHF may be necessary (eg. we often use ACE-inhibitors).

**NEOPLASIA**

**Neoplasia** of the myocardium and pericardium occurs rarely. Neoplastic infiltration of the myocardium may be followed by secondary cardiomyopathy. Death usually occurs within 6-12 months. The different neoplasms described include lymphosarcoma (most common), hemangiosarcoma, mesothelioma, fibrosarcoma, adenocarcinoma, squamous cell carcinoma and an infiltrative cardiac lipoma.

**PERICARDIAL EFFUSION**

Pericarditis is the most commonly encountered pericardial disease in the horse. It refers to inflammation of the pericardium, which then may lead to fluid/exudate between the visceral and parietal pericardium. The originating aetiology may be:

1. hematogenous infection
2. extension of infection from the pleura/lung
3. viral infection (EVA, equine influenza virus)
4. neoplasia
5. idiopathic (an aseptic inflammation quite frequently diagnosed in horses)
6. external wounds (rare)

**Pericarditis** should be suspected whenever there are **muffled heart sounds**.

- Various other signs may occur including fever, anorexia, depression, weight loss, pericardial friction rubs (but not the typical “washing machine murmur” found in bovine pericarditis, due to the accumulation of gas and liquid), congestion and cyanosis of the mucous membranes,
prolongation of the capillary refill time, jugular venous distention/pulsation and an arterial pulse
with a low amplitude (whereas this would be expected in cases of pleural effusion).
• Clinical pathological data may support clinical findings in that there may be an inflammatory
leukogram, hyperfibrinogenemia and hyperglobulinemia.
• The **ECG findings can assist in the diagnosis of pericardial fluid.** Often a decrease in the
QRS amplitude (< 1.5 MV in the base apex) is observed; and there may also be signs of ST
segment elevation/slurring (whereas depression could also indicate myocardial disease), electrical
alternans (i.e. an altered configuration of P, QRS or T waves on a regular basis). **However,**
sometimes there are no ECG alterations at all.
• The most definitive method of diagnosis is to perform echocardiography. Sometimes you will
see the pericardial effusion and it is already chronic, fibrinous and restrictive (the solid material in
the pericardial sac restricts RV and LV distension and therefore their filling, and therefore stroke
volume and cardiac output (despite tachycardia) is low.
• Pericardiocentesis is useful to obtain a sample for culture and sensitivity. This is best performed
under echocardiographic.

**Treatment** for pericarditis may include:
- antimicrobials (preferably chosen secondary to a culture and sensitivity of the pericardial
fluid and given for 3-15 weeks)
- NSAIDs.
- Corticosteroids may be used in cases of idiopathic pericarditis with no growth or evidence
of bacteria.
- ACE-inhibitors can be useful
- Diuretics are **not** a sound idea, as they decrease preload by reducing venous return, which
often causes deleterious effects.
- Pericardiocentesis with lavage using sterile 0.9% saline and instillation of local antibiotics
may be helpful, but there are no controlled data available. Also dysrhythmias can occur at any
time during pericardiocentesis, so it is valuable to have the horse monitored using an ECG.

**ACUTE HEMORRHAGE INTO THE PERICARDIAL SPACE** can occur with aortic ring
rupture, and pulmonary artery rupture. The former is invariably fatal and is usually accompanied
by a history of a breeding stallion falling off a mare dead at the beginning of the breeding season
or dying at the time of erection pre-mount.
• **Pulmonary artery rupture** has occurred rarely in stallions in the early breeding season, with
signs of cardiac tamponade immediately post breeding. These horses should not be confused with
colic. These horses can survive, and require stabilization and then removal of the serous fluid via
pericardiocentesis, as soon as the hemorrhaging has subsided (eg. 12 hours later if possible).
Echocardiography is essential to view the fluid in the pericardial sac, but it is unlikely that the
rupture will be documented.

**NOTE:** For endocarditis, myocarditis and pericarditis cases, it is important to define the
therapeutic regime and prognosis to the owner of the horse prior to initiation of treatment,
as antimicrobial therapy may need to be carried out for three to fifteen weeks, making
expense and effort significant.
DYSRHYTHMIAS AND ARRHYTHMIAS

These appear more common in the horse than any other species, which may be due to the larger heart size and myocardial circuit, allowing re-entry. There are many arrhythmias that are considered benign at rest, and that disappear as vagal tone is abolished as the heart rate increases (excitement/exercise) or with administration of a parasympatholytic (eg. atropine at 0.02 mg/kg subcutaneous).

The benign arrhythmias include:
1) some sinus dysrhythmia
2) sinus block
3) wandering pacemaker
4) 1st degree atrioventricular (AV) block (i.e. progressive prolonged PR)
5) 2nd degree AV block. There are 2 types; Mobitz type I (Wenckebach), in which there is progressive lengthening of PR and then QRS is skipped, this is the most common form in the horse; and Mobitz type II, in which there are regular PR intervals and then QRS is skipped.

There are pathological dysrhythmias and arrhythmias that may be caused by pathologic conditions of the heart (eg. myocarditis, endocarditis, conduction system abnormalities, pericarditis etc.), although sometimes electrolyte abnormalities are implicated and the conduction problems they induce are not always fully understood. These pathologic dysrhythmias include:

1) advanced 2nd degree AV block, which occurs if the arrhythmia persists at a heart rate of > 50 bpm (i.e. was not abolished) or if syncope occurs (i.e. due to prolonged periods of block - > 6-10 seconds). Note there are exceptions to this rule in very fit horses. Sometimes exercise telemetry is required to show that the arrhythmia does not occur at high speed and maximal heart rates.

2) 3rd degree AV block = complete heart block. This can be diagnosed when P waves are detected without associated QRS - T complexes (i.e. AV dissociation) with an independent junctional/ventricular escape rhythm. All this means is that there is no AV node conduction, therefore another pacemaker is required (i.e. junctional/ventricular), so that the ventricles continue to contract (even if it is not at the same rate as sinoatrial node firing).

- The ECG is the best way to diagnose these arrhythmias, as auscultation is not sufficiently sensitive.
- Treatment is not needed for 1st or uncomplicated 2nd degree heart block; however, complicated 2nd degree and 3rd degree AV block require intervention. These pathologic AV blocks may be secondary to inflammatory or degenerative AV node disease and may benefit from corticosteroid therapy (eg. dexamethasone and then prednisone). Corticosteroids used parenterally in horses have been associated with laminitis, and therefore stall rest with deep bedding, monitoring and possibly frog supports could be recommended, whilst using dexamethasone. The 3rd degree AV block may also be treated with dobutamine or vagolytic drugs (especially if it occurs during anesthesia) and cardiac pacemaker implantation (which has been successfully performed in the
horse).

3) atrial fibrillation, which may be acute or chronic

4) atrial premature depolarization

5) ventricular premature depolarization

6) supraventricular tachycardia (i.e. sinus tachycardia is a type, but not all supraventricular tachycardias are sinus)

7) ventricular tachycardia

ATRIAL FIBRILLATION is the most common, clinically significant arrhythmia in horses. It usually occurs without evidence of underlying cardiac disease, especially in racehorses. Many putative causes/predisposing factors exist including heat, sweating losses, electrolyte imbalances (which appear related) and the Standardbred breed is possibly more predisposed. However, atrial fibrillation also can occur secondary to atrial disease, and sometimes this is suspected when echocardiography reveals evidence of atrial dilatation and the horse is in CHF.

Diagnosis is based on auscultation and confirmed with an ECG. The heart sounds are often of variable intensity, but the most important and obvious finding is an irregular irregularity, so not only does the horse appear dysrhythmic, but it appears to follow no rhyme, nor reason. No S4 can be ausculted in cases of atrial fibrillation. The ECG reveals fibrillation waves (“f” waves, not P waves), and irregularly spaced QRS-T complexes of normal configuration (unless the underlying cardiac disease is responsible for alteration of the complex configuration eg. pericarditis). In cases of atrial fibrillation with no underlying cardiac disease, the resting heart rate is usually normal. Tachycardia with heart rates > 60 bpm and murmurs (> III/V mitral or tricuspid insufficiency) are poor prognosticators, as these are indicative of a primary cardiac problem, and these horses are notoriously difficult to convert (exceptions always exist).

Therapy depends on whether the horse has simple acute (<7 days) atrial fibrillation; simple chronic atrial fibrillation; atrial fibrillation with apparent underlying cardiac disease and on whether the horse has been converted before. The drug of choice is Quinidine, which is a class Ia Vaughn-Williams (i.e. Ia VW) sodium - channel blocker that is a negative inotrope and a positive chronotrope, however, it has been associated with numerous toxic effects including:
1) severe hypotension (smooth muscle of vessels is affected, due to the sodium - channel blocking).
2) lamiitis
3) nasal edema, leading to dyspnea - can occur with administration of small doses
4) ataxia
5) soft feces/diarrhea
6) depression
7) nervousness
8) anorexia
9) AV block, which is a direct effect of the quinidine at high doses

Therapeutic monitoring should be performed, especially if the horse has to be digitalized as well;
in these cases therapeutic monitoring of the digoxin should also be performed, as quinidine also causes reduced renal excretion of digoxin, thus enhancing the likelihood of toxicity. Therapeutic concentrations of quinidine range between 0.5 - 5.0 ug/ml.

**Acute atrial fibrillation therapy**

**Nasogastric protocol:** 4 mg/kg quinidine sulfate (i.e. ~ 2 g for a 500 kg horse) can be given as a test dose via the mouth or nasogastric tube approximately 12-24 hours prior to the commencement of conversion. If there is no nasal oedema etc. noticed, then one can proceed with the conversion. A nasogastric tube is placed (i.e. indwelling for the day) and then quinidine sulfate tablets at a dose rate of 20-22 mg/kg (i.e. ~ 10-11 g) is given. Then further 10-11 g boluses are given every 2 hours (usually until conversion or a maximum of 60 g is reached. Some owners may elect to take greater risks if the horse to be converted is a racing gelding and has no other purpose). I prefer to attach horses to telemetry, so that their heart rhythm can be constantly monitored; however, obviously this is not widely available and attaching the horse to an ECG every 2 hours prior to administration of the next dose will suffice and is essential. The ECG also provides valuable information regarding toxicity. Quinidine is working if the QRS interval is prolonged, however, if prolongation is >50% (some old sources quote >25% of the original, but I rarely convert them until it is about 25% over original), it is getting to the toxic stage and the therapy should be discontinued. Close to conversion, the “f” waves often become coarse.

An **intravenous protocol** is also available using quinidine gluconate (i.e. 1.0 -1.5 mg/kg bolus injections every 10 - 15 minutes to a total dose of 1.8 -5.8 g / horse, using 3 to 11 doses). It appears safe and adequate plasma levels occur.

If toxicity does occur with either PO or IV protocols, then it may be useful to administer isotonic (1.2%) NaHCO₃ solution at a rate of 0.5 - 1.0 meq/kg IV. This may assist by increasing the pH and thus increasing the binding of quinidine to protein, so decreasing the active drug in the plasma. Intravenous fluids are also useful to counter the decreased blood pressure.

**Chronic (> 1week) atrial fibrillation therapy**

These horses are sometimes difficult to convert. It is wise to warn owners about the additional risks (i.e. higher doses are often required; toxicity; the possibility of not converting the horse; possible underlying, undiagnosed cardiac disease and the possibility of relapsing into atrial fibrillation again). It is also advisable to suggest echocardiography on these horses, even in the absence of a murmur or clinical signs of CHF. These horses may benefit from chronic dosing with quinidine sulfate (10 g for a 500 kg horse PO every 24 hours for 3-7 days after conversion; however, there are no controlled studies to support this).

**Therapy for atrial fibrillation with underlying cardiac disease**

These horses should usually be digitalized first, although this substantially increases the risk of toxicity, as quinidine decreases the renal excretion of digoxin. Thus it is important to utilize therapeutic quinidine and digoxin monitoring. Also the ECG should be scrutinized carefully for QRS interval prolongation, fast supraventricular dysrhythmias (> 100 bpm) and ventricular rhythms. A dose regime that works well is 0.01 mg/kg PO BID of digoxin for 3 days and then start the quinidine conversion. Some veterinarians continue the digoxin therapy at a lower dose.
and increased interval during the conversion (eg. 0.004 - 0.005 mg/kg q24 hours); and some horses require digoxin for the rest of their life.

Other medications have been described but carry a high risk of side effects; so many equine internal medicine specialists continue to use quinidine sulphate regimens.
Goals of treatment of congestive heart failure (CHF) in the horse

1) Positive inotropy (i.e. increasing stroke volume through increasing contractility) is the first aim of CHF therapy.
   - Digoxin is the drug most often used for this purpose. Signs of digoxin intoxication include an increase in the P-R interval, atioventricular block, and prolongation of the QRS complex. Digoxin toxicity can be also manifested by a variety of arrhythmias, the most commonly seen including sinus bradycardia, ventricular premature depolarizations, ventricular tachycardia, and ventricular fibrillation. Other manifestations of digoxin toxicity include obtundetmentation, inappetance and diarrhea. To minimize the unpleasant and potentially fatal effects of digoxin, regular monitoring of serum digoxin levels should be included in the therapeutic regime, and the dosage altered as needed to maintain levels between 0.5-2.0 ng/ml of plasma. It should be remembered that extreme care must be taken when combining digoxin and quinidine therapy, as quinidine decreases renal excretion of digoxin. Administration of both drugs simultaneously greatly increases the risk of digoxin toxicity.

2) Negative chronotropy (i.e. decreasing heart rate) is the second goal of therapy. In addition to being a positive inotrope, digoxin is also a negative chronotrope.

3) Reduced preload is the third objective of CHF therapy. Use of venodilators and arteriodilators has been poorly evaluated in horses. Diuretics (eg. Furosemide) are most commonly chosen for this purpose; however, great care must be taken when using furosemide, as tissue perfusion can be further compromised.

4) Reduced afterload is the fourth aim of therapy in CHF. The angiotensin converting enzyme (ACE) inhibitor, enalapril (Enalfor®) has been shown anecdotally to be beneficial in horses. It works by decreasing vasoconstriction of both veins (thereby reducing preload) and arteries (thus reducing afterload). ACE inhibitors also minimize fluid retention via a decrease in aldosterone, which also decreases preload. –Dose rate: Enalapril (Enalfor®) - 0.5 mg/kg once daily to twice daily PO. In time we may change to new generation ACE-inhibitors, as used in human and small animal medicine, but currently we do not have data to support this.

5) Control of atrial and ventricular dysrhythmias is the fifth goal of CHF therapy. Quinidine and Lidocaine are two treatment options. Specific therapy is dictated by the type of dysrhythmia.

6) Thoracocentesis/abdominocentesis with drainage - for ascites, pleural fluid.