

Cardiology – The clinical examination of the heart – heart murmurs and their significance – When and why to worry

Cardiac murmurs and arrhythmias are commonly found in horses, especially in equine athletes. The challenge is to determine whether the finding is physiological or pathological, and in the case of the latter, to what degree it may impact cardiac function and cause clinical symptoms, predict the further development, and give a prognosis for the future. A critical aspect in equine cardiology, unlike in small animals, is also assessing the risk of sudden cardiac death, or collapse.

A thorough medical history and clinical examination at rest are essential for any cardiac evaluation and selection of further diagnostic tools.

History and signalment

Relevant details from the medical history of a horse presented for cardiac examination include any presenting signs such as last auscultation, poor performance (consistent or intermittent), epistaxis, episodes of weakness or collapse, cough, and fever of unknown origin. In most cases, a heart murmur is an incidental finding during regular check-up or a pre-purchase exam.

Certain conditions are more common in specific breeds, such as aorto-pulmonary fistula in Friesian horses or ventricular septal defects in Welsh ponies. Additionally, the significance of some conditions can vary between young and older horses.

Auscultation of the heart

The complete cardiac area should be auscultated on both sides of the thorax. At the apex on the left side, S1 (closure of the atrioventricular valves and the beginning of systole) is loudest, S2 (closing of the semilunar valves and the end of systole) is quieter, and S3 may be heard. By advancing the stethoscope slightly dorsally and cranially towards the heart base S2 becomes louder and the intensity of S1 decreases. This is the area of the aortic valve where S2 is at its loudest. Sounds originating from the pulmonary valve are heard cranially and dorsally to the aortic valve area. Because of the more cranially positioned right ventricular outflow, the tricuspid area is auscultated far cranially under the triceps muscle on the right side of the thorax.

The heart rate is an important indicator of cardiac function and should be measured.

Heart rhythm

The rhythm should be evaluated to determine if it is regular or irregular, and if irregular, whether it is regularly irregular or irregularly irregular. The most common detected regular irregularity is second-degree AV block followed by sinoatrial block. Premature complexes (atrial or ventricular) are heard as early beats with or without compensatory pause and require an ECG for definite diagnosis.

An irregular irregularity is characteristic for atrial fibrillation. S4 is absent during atrial fibrillation.

Heart murmurs

Murmurs occur when blood flow becomes turbulent, causing vibrations in cardiovascular structures. These can be classified as either physiological or functional murmurs, which are associated with normal high-velocity blood flow, or pathological murmurs, which result from conditions such as valvular regurgitations or congenital cardiac disease. The loudness of the murmur does not necessarily correlate with the severity of the disease, especially in cases of congestive heart failure.

When diagnosing a murmur, it is important to identify its origine and assess its significance.

Classification of Murmurs

- Timing and duration:
 - Systolic (between S1 and S2), diastolic (between S2 and S1), or continuous.
 - Early, mid, late or entire cardiac phase?
- Grade: Graded from 1 to 6 compared to the heart sounds and the presence of a palpable thrill.
- Point of maximum intensity: Helps determine the origin of the murmur.
- Character: Low frequency murmurs such as soft, harsh, honking and high frequency murmurs such as musical and high-pitched squeaks. Also, descriptions such as crescendo-decrescendo or plateau.

Common murmurs in adult horses

Systolic Murmurs

- Left-sided Systolic Murmurs:
 - Ejection Murmur (Flow Murmur): Physiological, associated with the normal ejection of blood into the aorta. Typically grade 1-3/6, early to mid-systolic, and heard over the aortic valve area. Can occasionally also be heard in horses with fever, anaemia, sepsis or colic. The intensity can vary with sympathetic stimulation.
 - Mitral Regurgitation: Usually presents as a Grade 1-6/6 holosystolic plateau-type murmur over the mitral valve area at the apex, radiating dorsally. Can also be early, mid, late or pansystolic murmur. Can also present as a crescendo murmur due to valvular prolapse.
- Right-sided Systolic Murmurs:
 - Tricuspid Regurgitation: Present as early, mid, late, pan, holosystolic, grade 1-6/6 murmur with PMI over the right apex.
 - Ventricular Septal Defect (VSD): Presenting as a harsh, band-shaped holo- to pansystolic grade 4-6/6 murmur, often accompanied by a precordial thrill.

Diastolic Murmurs

- Physiological Diastolic Murmurs: Early (S2 to S3) or late diastolic (S4 to S1) grade 1-3/6 murmur caused by the rapid ventricular filling (early diastole) or active atrial contraction (late diastole). Heard over the apex of the heart, often associated with rapid ventricular filling. Musical, squeaking in character. The intensity can vary with sympathetic stimulation.
- Aortic Regurgitation: Late, holo- or pandiastolic grade 1-6/6 murmur best heard over the aortic valve area at the heart base, often musical or decrescendo in nature.

Continuous Murmurs

- Aortocardiac Fistula: Presents as a continuous machinery murmur with bounding arterial pulsation and ventricular tachycardia.
- Aortopulmonary Fistula: Typically seen in Friesian horses, presenting with a combination of systolic and diastolic murmurs and associated with bounding arterial pulsation.

Once a murmur is detected, no matter the origine, it is recommended to perform routine annual cardiac auscultation to monitor for any progression, changes in the murmur, or the occurrence of arrhythmia.

Clinical examination

While the auscultation of the heart is a key part of evaluating cardiac function, it is also important to assess the peripheral circulation by examining the mucous membranes, capillary refill time, jugular veins, palpation of the arterial pulse, and possible presence of oedema. Assessment of pulse quality is particularly useful in aortic regurgitation, where a hyperkinetic pulse is a sign of ventricular volume overload in advanced cases. Pulse deficits may occur when there is a very short beat to beat interval, as during a premature beat or atrial fibrillation. Evaluation of the respiratory system should also be performed as for example acute left-sided heart failure can result in pulmonary oedema.

A preliminary diagnosis should be made after the clinical examination and auscultation, which will determine the need for further examinations. The challenge is to distinguish between horses where valvular regurgitation has a negligible effect on performance and quality of life, and those where it is linked to moderate or severe valvular pathology.

When is further diagnostics recommended

Echocardiography is the modality of choice to identify the aetiology of the identified murmur, evaluate the progression of the disease through the evaluation of the dimensions of the heart and function, and lastly to predict further disease progression. If the murmur has been diagnosed as physiological ejection or filling murmur, no further diagnostics are required.

For the pathological murmurs, it is dependent on the murmur and the most likely aetiology.

Atrioventricular regurgitations

Atrioventricular regurgitations murmurs (mitral and tricuspid regurgitations) are often detected in athletic horses possibly due to physiological remodelling and dilatation of the heart. Studies have reported prevalences of 80-90% for tricuspid regurgitations and 40-60% for mitral regurgitations in adult racehorses. In standardbreds, tricuspid regurgitations are also the most frequently detected valvular regurgitation.

Mitral regurgitations are the most prevalent valvular regurgitation in warmblood horses. In the majority of cases, mitral regurgitation is not performance limiting but will often slowly progress over time. However, it is also the valvular disease most often associated with atrial fibrillation and in some cases of severe mitral regurgitation congestive heart failure.

In general, in cases of atrioventricular valve regurgitation, a murmur that is longer, louder, and radiates more widely is typically more clinically significant.

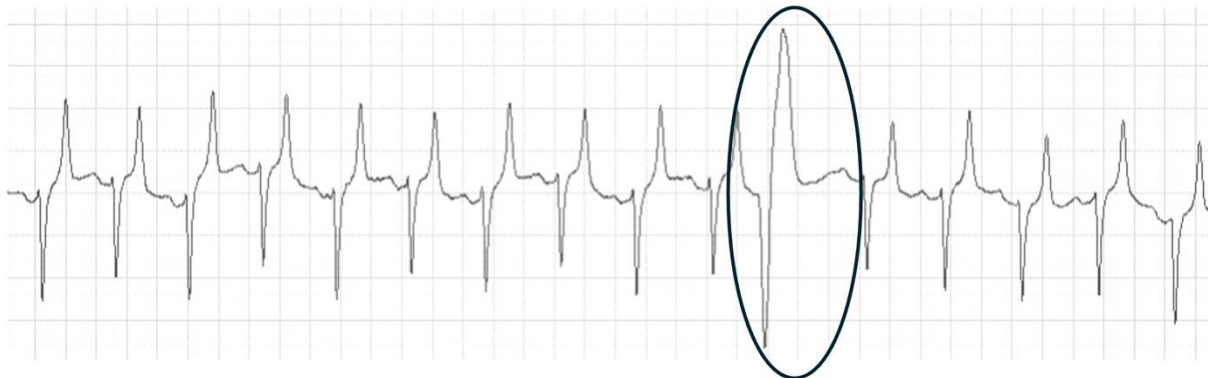
The general recommendation is echocardiography in following scenarios of atrioventricular murmurs (according to the 2014 ACVIM consensus statement):

- Mitral regurgitations murmurs grade 3/6 and above
- Tricuspid regurgitation murmurs grade 3/6 and above in athletic breeds
- Tricuspid regurgitation murmurs in pleasure horses or ponies
- Less athletic breeds with clearly audible murmurs
- Musical murmurs (possible chordal rupture)
- If associated with poor performance or signs of impaired cardiac function
- Pre-purchase examinations
- Fever of unknown origine

Aortic regurgitation

Aortic regurgitation is the most frequently detected valvular disease diagnosed in older horses due to degenerative changes of the aortic valves. The grade of an aortic regurgitation murmur does not correlate with the severity of the disease. In cases of more clinically significant aortic regurgitations, a hyperdynamic arterial pulse can be palpated as sign of left ventricular volume overload.

Echocardiography is recommended in all cases of aortic regurgitations murmurs to evaluate the effects on the heart. Additionally, an exercise test with ECG is recommended due to the risk of ventricular premature complexes, possible ventricular tachycardia which could ultimately lead to sudden cardiac death. If ventricular arrhythmias are detected and/or severe enlargement of the left ventricle and/or aorta is present, affected horses are not safe to ride.



Ventricular premature complex (circle) during exercise in a horse with aortic regurgitation

An additional useful diagnostic in horses with aortic regurgitations is non-invasive blood pressure measurement.

Ventricular septal defects

Ventricular septal defects are the most common congenital cardiac defect in horses and is more commonly seen in Welsh-mountain ponies. In the majority of cases, it is located in the semi-membranous or membranous part of the interventricular septum just below the aortic root. Echocardiography is necessary to evaluate the severity of the disease. The size of the defect and the blood flow velocity through the flow is assessed to evaluate the severity and effect on performance. Horses with VSD should not be used for breeding because of the hereditary component.

Arrhythmias

Cardiac arrhythmias are common in horses, both at rest, during and after exercise. They can range from benign to potentially life-threatening, impacting the performance and health of the horse and influence rider-safety.

Common Types of Arrhythmias

Arrhythmias are common in horses and can range from benign to potentially life-threatening conditions. Understanding the types of arrhythmias prevalent in horses is crucial for effective diagnosis and management.

- Sinus Arrhythmia and Atrioventricular Block: These are physiological arrhythmias, including sinus arrhythmia and first- and second-degree atrioventricular block, which typically resolve after stress or exercise. High-degree (more than 2 in a row) second-degree AV-blocks and third-degree AV-blocks are pathological.
- Atrial Premature Complexes (APCs): APCs are generally not linked to poor performance but can trigger atrial fibrillation (AF).
- Atrial Fibrillation (AF): The most common pathological arrhythmia in horses associated with poor performance.
- Ventricular Premature Complexes (VPCs): These can be benign but may also indicate a risk for more severe arrhythmias like ventricular tachycardia or fibrillation, especially if associated with structural heart disease.
- Ventricular Arrhythmias (VAs): Often incidental, VAs can be linked to systemic disease and are the most common cause of sudden cardiac death in horses

Arrhythmias During Exercise

Exercise-induced arrhythmias are common, with studies showing a significant occurrence during and immediately after high-intensity activities.

Their significance is dependent on the type of arrhythmia, if singular or multiple, signs of structural heart disease detected on echocardiography and if it is an incidental finding or if the horse has a history of poor performance or even weakness or collapse during exercise.

Diagnostic workup of a horse with arrhythmia

The recommended diagnostic workup for a horse with arrhythmia involves a combination of clinical examination, ECG, and potentially advanced monitoring techniques.

- Electrocardiography is crucial to confirm the presence and type of arrhythmia. While some arrhythmias can be confirmed instantaneously, other may require Holter ECG recordings.
- Exercise ECG is important in the majority of arrhythmias to determine if the arrhythmia is exacerbated by physical activity or overruled by sympathetically stimulation, which can be critical for assessing safety and performance implications.
- Heart Rate Variability (HRV) analysis can be helpful to identify arrhythmias, particularly during exercise, by analysing ECG-derived data.
- For prolonged monitoring, Implantable Loop Recorders are useful for detecting paroxysmal atrial fibrillation and can provide continuous monitoring

over extended periods. Other possibilities are ECG patches or smart textile, which can record ECG data over several days.

- Echocardiography is indicated in the majority of pathological arrhythmias to identify possible structural changes which may explain the arrhythmia.
- The measurement of myocardial Troponin I can be useful in cases where a myocardial injury is suspected.

Arrhythmias associated with poor performance

Atrial fibrillation

Atrial fibrillation (AF) is the most common arrhythmia affecting performance with a prevalence of up to 2.5 % in some populations. A hereditary component has been identified in some standardbreds.

Atrial fibrillation can occur as paroxysmal atrial fibrillation, where spontaneous conversion occurs within 24-hours or persistent atrial fibrillation.

Atrial fibrillation is the result of a combination of electrical triggers, such as atrial premature beats and a susceptible substrate, such as the large atrial mass and high vagal tone in horses. Atrial fibrillation can exist as lone atrial fibrillation in the absence of detectable underlying heart disease or as a sequel to valvular regurgitations.

Clinical signs in horses with atrial fibrillations are reduced exercise performance, as evidenced by decreased maximum velocity and increased heart rate during exertion. This is especially evident in horses competing at high speed and may be less obvious in horses exercised at sub-maximal level. Some horses with atrial fibrillation also show abnormal QRS-complexes during exercise. Other clinical signs infrequently observed in horses with atrial fibrillation are epistaxis (due to increased pressure in the left atria and subsequently in the lung), rarely collapse and reported sudden cardiac death although the latter is very rare.

Atrial fibrillation is diagnosed through auscultation where it is characterised by an irregularly irregular heart. ECG is used to confirm the diagnosis of AF with irregular R-R intervals, absence of p-waves and the presence of f-waves.

In cases of paroxysmal atrial fibrillation, where the occurrence is intermittent, diagnosis can be more challenging and can require long-term ecg monitoring, such as implantable loop recorders.

An echocardiogram is recommended to identify any underlying structural heart disease and assess cardiac enlargement.

Additionally, an exercising ecg should be performed to evaluate the heart rate response during exercise and the possible presence of additional ventricular arrhythmias.

Current advances including metabolic studies, cardiac mapping and implantable ECG devices, are being explored to investigate the aetiology, improve detection and management.

Treatment options include pharmacological and electrical cardioversion, with varying success rates. The recurrence rate is lowest in lone atrial fibrillation of short duration and increases with the duration of time spent in AF as well as in horses with underlying cardiac disease. Factors such as atrial size and duration of AF episodes influence recurrence risk. In general, cardioversion or retirement is recommended in horses with atrial fibrillation used for riding/driving, if heart rate in exercise exceed 220 beats/min or if concurrent ventricular arrhythmias are detected during exercise. In horses with persistent atrial fibrillation, where treatment is not an option, safety is a concern, and management should be decided on an individual basis.

Ventricular arrhythmias

A high number of horses show ventricular premature complexes (VPC) during and especially after exercise without any signs of impact on performance, which makes the evaluation of the possible impact on performance challenging, especially because ventricular arrhythmias can also potentially lead to severe outcomes like sudden cardiac death in the presence of complex ventricular arrhythmias.

Studies in poor performing racehorses have reported ventricular arrhythmias, including VPC and complex ventricular arrhythmias during and after exercise. These arrhythmias have been associated with increased age, higher lactate levels, and hypercapnia during peak exercise.

Premature complexes can be detected on auscultation as early beats interrupting an otherwise regular rhythm. VPC are often followed by a compensatory pause.

Ventricular tachycardia is when 3 or more concurrent ventricular beats follow each other. Auscultation of ventricular tachycardia is characterised by a rapid, usually regular rhythm with variable intensity heart sounds. Abnormal jugular pulses are frequently detected during ventricular tachycardia.

The definite diagnosis is made through an ecg, where ventricular beats are characterised by the absence of an associated p-wave and an abnormal configuration of the QRS complex. Features of complex ventricular arrhythmias are polymorphic QRS-complexes, short coupling intervals, sustained abnormal rhythm, rapid ventricular rate (over 120/min at rest), and repetitive ectopic activity. Complex ventricular arrhythmia is considered malignant and a sign of increased electrical instability with a higher risk of hypotension and sudden cardiac death.

The clinical work-up of a horse with ventricular arrhythmia includes a Holter ecg, echocardiogram for detection of any structural changes and exclusion of aortic aneurism or fistula, measurement of cardiac troponin I and exercise test with ecg. Horses with systemic disease or ventricular tachycardia at rest should not be exercise tested.

Recommendations for horses with ventricular arrhythmias are in general the following:

- Identification and treatment of the possible underlying cause, such as systemic disease.
- Horses with occasional VPC at rest or during exercise can be exercised by an informed adult.
- Horses with sustained monomorphic or complex ventricular tachycardia should be rested and treated. A repeat Holter ecg and exercise test should be performed before ridden work.
- In horses with ventricular arrhythmias and structural heart disease, rigorous exercise is not recommended and they should only be ridden by an informed adult.

While the occasional VPC (monomorphic) which disappears during exercise or only occur during the recovery period is usually not the cause for poor performance, ventricular arrhythmias are also prevalent in poorly performing horses, especially during recovery from exercise. While their exact impact on performance is not fully established, they are considered a potential risk factor for poor performance and safety concerns due to the association with sudden cardiac death.

In conclusion, the clinical examination of the heart, particularly the identification and evaluation of heart murmurs and arrhythmias, is a critical aspect of equine cardiology. Differentiating between physiological and pathological findings is essential for determining the impact on cardiac function, predicting disease progression, and providing a prognosis.

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