Identification of common equine cardiac murmurs

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Cardiac murmurs are commonly identified in horses as either an incidental finding during elective clinical examinations or when an animal is presented with clinical signs that may be consistent with cardiac disease; for example, poor performance evaluation and ventral subcutaneous oedema. To assess the significance of the identified murmur, the clinician needs to determine whether it is associated with normal physiological or pathological blood flow and, if the latter, whether it is likely to affect cardiac function and cause clinical signs. Of particular significance in equine cardiology compared to other companion animals is whether the horse is at risk of sudden death – an important consideration for rider safety.

The answer to the majority of these questions can be obtained from a combination of a thorough clinical examination and meticulous auscultation. This article gives a brief guide to the cardiac cycle, describes how to perform a cardiovascular examination and discusses the common murmurs in adult horses and their significance.

What is a murmur?

Cardiac murmurs are audible sound waves emanating from the heart and large outflow vessels that are distinct from the normal four heart sounds. To differentiate physiological flow murmurs (ventricular filling and ejection from the great arteries) from the common pathological murmurs, it helps to have a basic understanding of cardiac physiology and the blood pressure gradients throughout the cardiac cycle. Table 1 describes the sounds that can be heard as a result of events in the cardiac cycle and why they occur.

Physiological murmurs

An average 500 kg horse's stroke volume at rest is one litre. The high velocity blood flow and large diameter tubes and chambers required to facilitate this stroke volume create ideal conditions for turbulence, even in normal horses, such that diastolic inflow and systolic aortic ejection of blood can be audibly distinct from normal cardiac sounds.

The timing and short duration of physiological murmurs are crucial characteristics that enable them to be distinguished from pathological murmurs: physiological outflow murmurs only occur during early systole and diastolic filling murmurs only occur during early or late diastole. Physiological murmurs also tend to vary with physiology. For example, they will generally vary with exercise and changes in autonomic tone, and can appear more readily during periods of fever, colic, pain and severe anaemia. Murmurs that occur during ventricular ejection and ventricular filling are audible in up to 50 per cent and 15 per cent of normal horses, respectively (Patterson and others 1965).

Systolic physiological murmurs

Ventricular pressure exceeds aortic pressure only during the first two-thirds of ejection (Fig 1). The high-velocity outflow through the aorta that this causes corresponds with the murmur of physiological aortic ejection; it therefore occurs in the first part of systole only and always ends before S2. By comparison, left ventricular pressure exceeds left atrial pressure from the onset of S1 until after S2 (Fig 1) and mitral regurgitation can therefore start with S1 and continue past S2.

Diastolic physiological murmurs

The bottom section of the Wiggers diagram in Fig 1 demonstrates the ventricular volume throughout the cardiac cycle. Ventricular diastole is divided into three phases:
- Rapid ventricular filling (active);
- Passive filling (diastasis);
- Atrial contraction (active).

Ventricular diastole begins at aortic valve closure. Once the ventricles have relaxed and the atrial pressure...
exceeds the ventricular pressure, the atrioventricular valves open (Fig 1). Rapid ventricular filling ensues and this may be associated with an audible sound on auscultation (early physiological filling murmur). The end of rapid ventricular filling concludes with the third heart sound (S3). A period of low velocity passive filling then occurs, followed by active atrial contraction (S4), which again can lead to an audible sound coincident with this increased normal flow (late physiological filling murmur). Physiological filling murmurs only occur during the active filling phases of diastole – either during early rapid ventricular filling or atrial contraction, not during the middle passive filling phase (Fig 2).

Pathological murmurs

There are three major reasons for a murmur other than physiological flow:

- Incompetent valves;
- Stenotic (narrowed) valves;
- Inappropriate communications between cardiac chambers/vessels.

Stenotic valves are rare in horses and, unless a complex congenital abnormality is suspected, should be low on the differential diagnosis list. Lesions of the valve apparatus causing regurgitation are very common and include widening of the valve orifice (functional versus pathological), congenital dysplasia, fenestrations, degeneration, prolapse, endocarditis, ruptured chordae tendineae and papillary muscle dysfunction. Ventricular septal defects are the most common inappropriate communication but more complex congenital abnormalities are not uncommon. Pericarditis can also cause murmurs.

Cardiovascular examination and history

A good appreciation of the history and signalment may help to determine the significance of a cardiac murmur. Specific questions to ask an owner relating to their horse’s cardiovascular system include:

- What is the animal’s exercise tolerance/recovery times?
- Is any epistaxis present following exercise?
- Have there been any previous cardiac auscultations at vaccinations/presedation?
- Have there been any episodes of weakness or collapse?

A thorough examination should produce a diagnosis for the majority of cardiac murmurs. As well as cardiac auscultation, all aspects of the cardiovascular system should be examined, including mucous membranes, capillary refill time, arterial (rate, rhythm and quality) and jugular pulses (Video 1), respiration rate and effort, and the presence of subcutaneous oedema.

Subcutaneous oedema can be very subtle even in profound heart failure and efforts should be made not to miss this sign in horses with a long-hair coat; palpation is sometimes more accurate than visualisation to indicate its presence (Fig 3). Pulmonary and tracheal auscultation is performed to help identify pleural effusion (absent sounds), interstitial pulmonary oedema [harsh bronchovesicular sounds] or alveolar pulmonary oedema (crackles/tracheal fluid).

Cardiac auscultation

Recording heart rate, rhythm and the number of heart sounds (S1 to S4) present is an important starting
point to auscultation. In the presence of an 'exciting' murmur, these important pieces of information are often neglected in favour of the retrospective assertion that 'it was normal'. If a murmur has been identified, before considering the cause, its properties should be classified using the following five criteria:

- Timing;
- Grade;
- Point of maximum intensity;
- Radiation;
- Character.

Murmurs present on the left and right sides should be classified individually, even if it is thought that they are of the same origin and radiating across the chest. It is useful to have a standard form to note down the results of the examination (Fig 4).

**Murmur classification**

**Timing**

When considering the timing of murmurs, two main questions should be asked:

- Is the murmur diastolic, systolic or continuous? If the murmur encompasses all of the cardiac cycle are these separate systolic and diastolic components?
- Is the murmur audible in the early, mid, late or entire cardiac phase?

Holosystolic/diastolic murmurs refer to murmurs that occur throughout the entire cardiac phase, but do not include S1 and S2 heart sounds (e.g., a holosystolic murmur starts at the end of S1 and ends at the beginning of S2). Pansystolic/diastolic murmurs occur throughout the entire cardiac phase, but encompass S1 and S2 heart sounds (e.g., a pansystolic murmur begins at the start of S1 and ends at the end of S2). However, these terms are used interchangeably by some authors and the distinction is academic; the key fact is that these are long murmurs dominating a period when the heart is usually silent.

Potentially one of the commonest pitfalls of the examination is determining whether the murmur is diastolic or systolic. The phase of cycle is easily differentiated if the horse has a normal resting heart rate, as diastole is significantly longer than systole; however, if the horse is tachycardic (with reduced duration of diastole) then comparing the lengths of the cardiac phases is harder. Furthermore, if a horse has a loud murmur, obliterating the audibility of the normal cardiac sounds, this can also create difficulties. Listening to the heart remotely from the murmur and then gradually advancing towards the murmur is helpful. If the horse has a second-degree atrioventricular block, determining whether the murmur is present during the block (that is, prolonged diastole) is also helpful. For some examiners, palpating an arterial pulse while auscultating is useful; however,
the slight delay between cardiac systole and the distant arterial pulsation should be considered, which may cause further confusion if the horse is tachycardic. Murmurs should be listened for in the diastolic and systolic phases individually. Missing a murmur in, for example, diastole is possible if the clinician is concentrating on a loud systolic murmur.

Grade

Table 2 describes a six-point grading scale for cardiac murmurs. Although the scale is relatively subjective, some objectivity can be created by comparing the murmur to the high frequency S1 and S2 sounds and also identifying the presence of a palpable thrill. The intensity of the murmur is also governed by the ease of transmission of the sound through the tissues and poorly conditioned horses can have physiological murmurs up to grade 4/6. Likewise, obese horses or those that have gained body fat since their last examination may have a reduction in the grade of murmur auscultated.

Point of maximum intensity

The left cardiac chambers sit caudal in the chest while the right chambers wrap around cranially such that the right ventricular inflow (and therefore tricuspid valve) is located in the right hemithorax and the right outflow (pulmonary valve and artery) in the left hemithorax. The aorta exits near the centre of the heart, to the right of the pulmonary artery. On the left side, the point of maximum intensity is best described relative to the cardiac apex and base rather than counting intercostal spaces. The left cardiac apex is easily located by palpating for the ‘apex beat’.

The mitral valve is slightly dorsal to the ‘apex beat’ and at this point S1 should be at its loudest. Moving the stethoscope cranially and dorsally from the apex to the point where S2 is loudest identifies the aortic valve and the cardiac base. Sounds originating from the pulmonary valve are audible cranially and ventrally to the aortic valve.

Due to the cranial position of the right ventricular inflow, auscultation of the right hemithorax is performed far cranially, under the triceps muscle.

Radiation

From the point of maximum intensity, the direction (dorsal, ventral, cranial or caudal) and over what distance the murmur radiates must be defined. The distance may be described using the number of stethoscope heads; for example, from the point of maximum intensity the murmur radiates three stethoscope heads cranially and two ventrally.

Character

There are a plethora of terms used to describe the broad range of frequencies of murmurs. The most consistently described terms are soft, harsh, honking (low frequency), musical (high frequency) and high-pitched squeak.

Murmurs can also be termed crescendo, decrescendo (that is, increasing/decreasing in intensity, respectively) and/or plateau (similar intensity throughout) in nature.

Murmurs that are audible on both the left- and right-hand sides should be assumed to be of different origin until proven otherwise. Murmurs of the same origin radiating to the opposite thorax have the same general character but are quieter on the other side. Although murmurs of mitral regurgitation can be heard on the right side of the thorax, more commonly a coexisting tricuspid regurgitation is present. It should be remembered that the aorta sits centrally and can be of similar intensity within either hemithorax, although it is usually louder on the left.

Common murmurs in adult horses

Although common in small animals, stenotic valves are very rarely reported in isolation and, apart from a few other infrequently diagnosed murmurs such as aortopulmonary or aortocardiac fistulae, the remaining murmurs can be easily categorised into the following groups:

- Left systolic;
- Right systolic;
- Diastolic.

If more complicated murmurs are suspected or unusual sounds are noted that do not correlate with the classification above, then referral to an equine cardiologist is recommended. Fig 5 provides a decision tree that can be used to help diagnose the common murmurs that are encountered in adult horses.

Left systolic murmurs

There are two common left-sided systolic murmurs (Table 3) that must be differentiated:

- Mitral regurgitation;
- Physiological ejection of blood through the aorta.

Table 3: Common findings of the two main differentials for a left-sided systolic cardiac murmur

| Character | Mitral regurgitation | Physiological ejection |
|----------|----------------------|------------------------|
| Radiation | Localised to widely radiating (regurgitant jet is directed dorsally to the left atrium) | Localised (further in emaciated horses) |
| Exercise/sympathetic stimulation | No change to murmur | Murmur may disappear or is accentuated |
| Grade (scale of 1 to 6) | 1 to 6 | 1 to 3 (louder in emaciated horses) |
| Timing | Systolic: early, mid, late, pan, holos | Systolic: early to mid |
| Point of maximum intensity | Left apex (between the apex and base – direction of the regurgitant jet) | Left base |

Table 2: Six-point scale for grading cardiac murmurs

| Grade | Description |
|-------|-------------|
| 1     | Quiet localised murmur, heard after careful auscultation |
| 2     | Murmur intensity is less than that of the cardiac sounds |
| 3     | Murmur intensity is equal to that of the cardiac sounds |
| 4     | Murmur intensity is greater than that of the cardiac sounds |
| 5     | Murmur intensity is greater than that of the cardiac sounds and there is a palpable precordial thrill |
| 6     | Murmur is audible with the stethoscope lifted from the chest wall and there is a palpable precordial thrill |
Diagnosed as mitral regurgitation; however, a grade 2 early to mid-systolic murmur with a point of maximum intensity just caudal to the base could be either mitral regurgitation or physiological ejection. Physiological ejection murmurs in horses with colic can be of higher intensity than usual and radiate to the cardiac apex, making the diagnosis harder. However, these disappear as the horse recovers.

While the majority of aetiologies for mitral regurgitation are pathological [Fig 6], horses can develop ‘functional’ mitral regurgitation in response to high-level training.

If a loud murmur is also noted on the right side in systole, radiation of the right systolic murmur or a murmur of relative pulmonary stenosis (associated with perimembranous ventricular septal defect) should be considered as further differentials for a left-sided systolic murmur.

Right systolic murmurs
On the right side in systole, there are also two murmurs that are detected frequently (Table 4) and must be differentiated:
- Tricuspid regurgitation;
- Ventricular septal defect.

However, a murmur radiating from the left side should be considered if the murmur on the left is loud and the character is identical.

Useful indicators as to the likelihood of right systolic murmurs can be given by the breed; for example, Thoroughbreds commonly have atrioventricular valve regurgitation, while Welsh section A ponies are predisposed to ventricular septal defects. The direction of radiation is a critical differentiating factor and ventricular

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**Fig 5:** Decision tree to help in the diagnosis of the commonly encountered murmurs in adult horses

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**Fig 6:** (a) Ruptured chordae tendineae of the anterior mitral valve leaflet. This horse presented with a grade 4/6 harsh, musical, plateau, pansystolic murmur with a point of maximum intensity over the mitral valve. This horse was in atrial fibrillation and had a concurrent dissecting fistula from the right coronary sinus to the right ventricle. (b) Marked regurgitant jet lesions within the left atrium, subsequent to the ruptured chordae tendineae. The musical quality of the murmur may have been the regurgitant jet striking the chamber wall.
LV Left ventricle, RV Right ventricle, Ao Aorta, PA Pulmonary artery

Ventricular septal defect murmur from the right thorax. A pansystolic murmur with a point of maximum intensity over the pulmonary valve was also ventrally, which was consistent with a ventricular septal defect. A grade 5/6, plateau, pansystolic murmur with a point of maximum intensity over the tricuspid valve, radiating also overriding the interventricular septum. This pony had a grade 5/6, harsh, plateau, the region below the septal tricuspid valve (ventricular septal defect). The aorta is portion of the ventricular septum, from the left ventricular outflow tract through to

Doppler (green indicates turbulence). There is a large defect in the perimembranous (Fig 7). Right parasternal long-axis echocardiogram of an equine aorta with colour flow (E and A waves) and are therefore invariably short murmurs. They can easily be differentiated from each other by the point of maximum intensity and timing during diastole, since filling murmurs will only occur at times of maximal filling (S2 to S3) or early (S2 to S1) systolic cardiac murmur

Table 4: Common findings of the two main differentials for a right-sided systolic cardiac murmur

| Signalment               | Tricuspid regurgitation | Ventricular septal defect |
|--------------------------|-------------------------|---------------------------|
| Common in Thoroughbreds  | Congenital predisposition in Welsh section A ponies, Shetlands, Arabs |

| Point of maximum intensity | Right apex | Ventral to right apex |
|----------------------------|------------|-----------------------|
| Timing                     | Systolic: early, mid, late, pan | Systolic: pan, holo |
| Grade (scale of 1 to 6)    | 1 to 6     | 4 to 6                |
| Radiation                  | Localised to widely radiating | Cranial and ventral |

Table 5: Common findings of the two main differentials for diastolic cardiac murmurs

| Aortic regurgitation     | Physiological ventricular filling |
|--------------------------|----------------------------------|
| Point of maximum intensity | Left base                       | Apex (left or right) |
| Timing                   | Diastolic: late, holo, pan       | Diastolic: early [S2 to S3] or presystolic [S4 to S1] |
| Grade (scale of 1 to 6)  | 1 to 6                           | 1 to 3 (louder in emaciated horses) |
| Radiation                | To the right                      | Localised |
| Characteristic           | Decrescendo, musical             | Musical, squeaking |
| Exercise/sympathetic stimulation | No change to murmur       | Murmur may disappear or is accentuated |

LV Left ventricle, RV Right ventricle, Ao Aorta, PA Pulmonary artery

septal defects are almost invariably associated with a left-sided systolic murmur that has a point of maximum intensity over the pulmonic valve and is heard as a result of relative pulmonic stenosis; that is, increased blood flowing through the pulmonic valve.

Tricuspid regurgitation

The same pathological aetiologies occur with the tricuspid valve as for the mitral valve and horses can also develop 'functional' tricuspid regurgitation in response to training. While the murmur of tricuspid regurgitation is the most common murmur identified in performance horses (Young and others 2008), due to the lower comparative pressures within the right cardiac chambers, significant tricuspid regurgitation is less prevalent.

Ventricular septal defects

Being congenital, ventricular septal defects are often identified in younger horses but should not be ruled out in older horses as the heart may not have been auscultated thoroughly on the right side. The majority are around the membranous portion of the septum, just below the right and non-coronary cusps of the aortic valve traversing through to the region below the septal leaflet of the tricuspid valve (Fig 7).

Diastolic murmurs

Regardless of whether the murmur is audible on the left or right side of the horse, only two main differentials need to be distinguished in diastole (Table 5):

- Aortic regurgitation;
- Physiological ventricular filling.

They can easily be differentiated from each other by the point of maximum intensity and timing during diastole, since filling murmurs will only occur at times of maximal filling (E and A waves) and are therefore invariably short murmurs.

Although pulmonic regurgitation is common, the relatively low-velocity flow is not normally audible, nor is it generally clinically significant.

Aortic regurgitation

Aortic regurgitation is a relatively common finding in older horses (more than 10 to 15 years of age) and in most cases is due to degenerative changes in the aortic valve leaflets (Figs 8, 9). The musical character sometimes associated with aortic regurgitation can be due to vibrations of the aortic root, aortic valve, interventricular septum or anterior mitral valve leaflet.

Assessing significance

Echocardiography is recommended to try to attain the possible aetiology of the localised pathological murmur (eg, ruptured chordae tendineae, degenerative thickened aortic valve leaflet), identify progression of the disease (chamber/great vessel dilatation) and predict further disease progression. If the murmur has been diagnosed as a physiological ejection or diastolic filling murmur, then it is of no consequence and no further investigations are required, but other murmurs may warrant further investigation, depending on the aetiology and grade. Furthermore, non-physiological murmurs that are detected as part of a prepurchase examination or new murmurs in horses that were previously ‘murmur free’ may warrant investigation whatever the likely severity. Table 6 lists the possible sequelae of the common pathological murmurs.
Atrioventricular valve regurgitation

One of the difficulties in assessing equine atrioventricular valve murmurs is that not all horses diagnosed with regurgitation will have significantly diseased valve apparatus that is likely to progress. Athletic horses have a high prevalence of atrioventricular valve regurgitation that is clinically insignificant and likely to be a consequence of physiological remodelling/dilation associated with the ‘athletic heart’: so-called functional regurgitation (Young and others 2008). This explains why a murmur in an individual horse may increase a grade or so in training compared to when it is out of training (Young and Wood 2000, Lightfoot and others 2006). In general with atrioventricular valve regurgitation, the longer, louder and wider radiating the murmur, the more likely it is to be clinically significant. High-grade murmurs should, therefore, always be viewed with suspicion and investigated further, but with low-grade murmurs it is very difficult to distinguish between low-grade valve disease and functional regurgitation. The following tips may help:

- If the horse is of an athletic breed then it would generally be considered common to hear tricuspid or mitral regurgitation of a severity of less than or equal to grade 3/6. However, the clinical context must be taken into consideration; for example, routine evaluation/prepurchase examination versus evaluation for poor performance.
- Tricuspid regurgitation is less likely to be significant compared to mitral regurgitation.
- In cases of severe mitral regurgitation, a loud filling murmur and emphatic S3 sound are often present, helping determine severity further.

Fig 8: (a) Right parasternal long-axis echocardiogram of an equine aorta. The left coronary valve leaflet is thickened, which is consistent with degenerative valve disease of the aorta. This horse had a grade 3/6, decrescendo, holodiastolic murmur with a point of maximum intensity over the left heart base. (b) Right parasternal long-axis echocardiogram of the aorta with colour flow Doppler. The regurgitant jet (yellow and green) corresponds to the audible murmur of a turbulent jet flowing through the narrow orifice of an incompetent aortic valve.

LV Left ventricle, RV Right ventricle, Ao Aorta, PA Pulmonary artery

Fig 9: (a) Endocarditis of the three semilunar leaflets of an aortic valve. All three leaflets are thickened and have irregular vegetative lesions. (b) Normal semilunar valve leaflets of the pulmonary artery in the same horse, for comparison. (c) Right parasternal long-axis echocardiogram of the aorta showing marked thickening of the aortic valve leaflets. The left ventricle is dilated and rounded. This pony had a grade 5/6, harsh, pandiastolic murmur with a point of maximum intensity over the aorta, consistent with aortic regurgitation. LV Left ventricle, Ao Aorta, PA Pulmonary artery
Less athletic breeds of horse and ponies with clearly audible atrioventricular valve regurgitation should probably be assessed further as they are less likely to have functional regurgitation.

Murmurs that have a musical quality – a feature that is usually caused by vibration of a structure within the heart rather than the regurgitation itself – should always be assessed.

Murmurs of severe atrioventricular regurgitation can reduce in intensity as a horse develops cardiac failure; the heart rate will invariably be above normal in this situation.

The most likely progression for a horse in atrioventricular regurgitation is single-sided or biventricular congestive cardiac failure with atrial fibrillation, which is unlikely to be a risk of sudden cardiac death.

Whatever the situation, once a murmur is detected, routine annual cardiac auscultation to determine whether any progression is evident is advisable since the future cannot be predicted in every case.

**Recommendation**
The general recommendation frequently cited is to have all murmurs of mitral regurgitation graded 3/6 and above, and all tricuspid regurgitation murmurs of 4/6 and above evaluated by echocardiography (Reef and others 2014) but, if in doubt, further investigations are warranted. It is best to evaluate all musical atrioventricular regurgitation murmurs to identify their true nature.

**Aortic regurgitation**

Due to its frequent musical quality, the intensity of an aortic regurgitation murmur rarely allows predictions of severity and echocardiography is warranted in almost all cases. A clinical clue to the severity of aortic regurgitation comes from palpation of the arterial pulses, which represent the difference between systolic and diastolic pressure. Arterial diastolic pressures are reduced due to regurgitation of blood during diastole and systolic pressures are increased subsequent to an increase in volume of blood ejected from the ventricle, resulting in a bounding or hyperkinetic pulse in clinically significant cases of aortic regurgitation.

Degenerative aortic regurgitation is well documented to be progressive and the consequence of severe aortic regurgitation is an enlarged left ventricle, which can lead to ventricular premature depolarisations and possible ventricular tachycardia and sudden cardiac death.

**Recommendation**
Echocardiography and an exercising electrocardiogram should be performed in all cases of aortic regurgitation to allow judgements to be made on the safety of riding these horses.

**Ventricular septal defect**
The significance of ventricular septal defects cannot be assessed from the murmur alone and echocardiography is generally warranted. Indeed, due to the physics of flow, in an attempt to equalise pressure (left ventricle to right ventricle), smaller ventricular septal defects are often louder than larger defects due to the increased speed of flow across the former. Larger ventricular septal defects are more likely to have other murmurs associated with them and to have progressed to more significant clinical disease, but full evaluation requires ultrasonographic examination.

**Recommendation**
Echocardiography is required for any horse/pony that is going to be ridden.

**Is the horse in cardiac failure?**

If presented with a horse with subcutaneous ventral oedema and a grade 4/6 murmur consistent with mitral regurgitation, the clinician needs to determine whether the horse is in biventricular cardiac failure or whether the murmur is incidental to the swelling. If the horse is not tachycardic [heart rate above 50 beats/minute], it is unlikely to be in cardiac failure. Table 7 lists the clinical signs that are consistent with heart failure.

Horses have a remarkable cardiac reserve and often, if not exercising, horses in compensated congestive cardiac failure, especially left sided, can easily go unnoticed by their owners.

**Summary**
Cardiac murmurs in adult horses can usually be divided into three categories: left-sided systolic, right-sided systolic and diastolic. Each of these categories only has two main differential diagnoses and, with careful

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**Table 6: Possible sequelae of the main pathological murmurs**

| Cardiac chamber that initially fails | Congestive cardiac failure development | Arrhythmia that may develop |
|-------------------------------------|---------------------------------------|-----------------------------|
| **Mitral regurgitation**            | Left atrium                           | AF                          |
| **Tricuspid regurgitation**         | Right atrium                          | AF                          |
| **Ventricular septal defect**       | Left atrium/ventricle                 | AF, VPD and VF              |
| **Aortic insufficiency**            | Left ventricle                        | VPD and VF                  |

AF = Atrial fibrillation, VPD = Ventricular premature depolarisation, VF = Ventricular fibrillation.

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**Table 7: Clinical signs consistent with cardiac failure**

| Reduced cardiac output (forward failure) | Pulmonary venous hypertension (left-sided backwaters failure) | Systemic venous hypertension (right-sided backwaters failure) |
|-----------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Poor exercise tolerance                 | Tachypnoea                                                    | Jugular vein distension                                      |
| Tachycardia                             | Coughing                                                      | Distension of other peripheral veins (eg, lateral thoracic)   |
| Pale mucous membranes                   | Crackles (alveolar pulmonary oedema)                         | Pulsation of the jugular vein extending beyond the caudal    |
| Weak arterial pulses                    |                                                               | third of the neck                                             |
| Cold extremities                        |                                                               | Subcutaneous oedema                                           |
| Syncope                                 |                                                               | Absent respiratory sounds (pleural oedema)                    |
| Cachexia                                |                                                               | Ascites                                                       |
examination, the aetiology of the murmur can be diagnosed in most cases. Physiological ejection and filling murmurs can easily be differentiated from pathological murmurs by understanding that they occur in the cardiac cycle at specific times. While further diagnostics are recommended for murmurs that are not physiological and are moderate or severe, all horses with aortic regurgitation should have an echocardiogram taken and an exercising electrocardiogram performed to determine their future safety when ridden.

Acknowledgements
The authors thank Karen Blissitt and Lesley Young for allowing the use of two of their audio cases.

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Audio quiz: Identification of equine cardiac murmurs

Listen to each of eight audio files of cardiac murmurs that have been selected to illustrate various common murmurs that occur in adult horses and determine the following for each case:
1. Heart rate
2. Heart rhythm
3. Which heart sounds? (S1, S2, S3, S4)
4. Is there a murmur?
If a murmur is present, classify:
5. Timing
6. Grade (the presence of a precordial thrill will be absent, so classify as at least grade 4 where appropriate)
7. Character

Then, based on the information obtained, decide what the most likely diagnosis is.

Answers on next page
Case 1  
1. 40 beats per minute (bpm)  
2. Regular  
3. S4, S1 and S2  
4. Yes  
5. Holodiastolic  
6. 3/6  
7. Decrescendo, soft  

**Diagnosis**: Aortic regurgitation. The murmur is present during the longest phase of the cardiac cycle so it is diastolic. As it encompasses the entirety of diastole, it must be aortic regurgitation. The decrescendo nature of the murmur is a classical characteristic for aortic regurgitation.

Case 2  
1. 52 bpm  
2. Regular  
3. Heart sounds are obliterated by the murmur  
4. Yes  
5. Pandiastolic  
6. At least 4/6; if there was a precordial thrill it would be higher  
7. Decrescendo, harsh, musical  

**Diagnosis**: Aortic regurgitation. The heart sounds have been obliterated by the murmur, making the timing harder to classify. The cardiac phase during which the murmur is present is of longer duration, which means this is a diastolic murmur. This is an example of a harsh musical aortic regurgitation.

Case 3  
1. 100 bpm  
2. Regular  
3. Heart sounds are obliterated by the murmur  
4. Yes  
5. Pansystolic  
6. At least 4/6; if there was a precordial thrill it would be higher  
7. Plateau, harsh  

**Diagnosis**: Ventricular septal defect. Due to the tachycardia, it is difficult to determine whether this murmur is present during diastole or systole. In a real case situation, auscultating remote from the PMI would help to classify the murmur as systolic. The character of this murmur is typical of a ventricular septal defect.

Case 4  
1. 40 bpm  
2. Regular  
3. S1, S2 and S3  
4. Yes  
5. Short early diastolic  
6. 3/6  
7. High-pitched squeak  

**Diagnosis**: Early physiological filling murmur. This diastolic murmur is only present during early rapid ventricular filling. It is too short to be aortic regurgitation and the squeak is a classical characteristic for this type of murmur.

Case 5  
1. 32 bpm  
2. Regular  
3. S1 and S2  
4. Yes  
5. From early systole to S2  
6. At least 4/6; if there was a precordial thrill it would be higher  
7. Crescendo  

PMI = left-hand side  

**Diagnosis**: Mitral regurgitation. Considering the two main differentials for a left-sided systolic murmur, as this murmur extends to S2 it must be mitral regurgitation. It does not start at S1 and there is a gap between S1 and the start of the murmur.

Case 6  
1. 48 to 58 bpm  
2. Irregularly irregular  
3. Heart sounds are obliterated by the murmur  
4. Yes  
5. Pansystolic  
6. At least 4/6; if there was a precordial thrill it would be higher  
7. Plateau, harsh and musical  

PMI = midway between left apex and base  

**Diagnosis**: Mitral regurgitation. This horse has atrial fibrillation. Evaluating the murmur during periods of prolonged diastole makes the diagnosis of a systolic murmur easier. As the murmur extends to S2 it must be mitral regurgitation. The PMI is midway between the apex and base as the regurgitant jet is directed back to the left atrium.

Case 7  
1. 34 bpm  
2. Regular  
3. S1 and S2  
4. Yes  
5. Pansystolic and short early diastolic  
6. At least 4/6 (systolic) and 3/6 (diastolic)  
7. Plateau, harsh (systolic) and high pitched (diastolic)  

PMI = left apex  

**Diagnosis**: Mitral regurgitation (systolic) and early physiological filling murmur (diastolic).

Case 8  
1. 26 to 28 bpm  
2. Regularly irregular  
3. S4, S1 and S2  
4. No  
5. n/a  
6. n/a  
7. n/a  

**Diagnosis**: Second degree atrioventricular block. The fourth heart sound is easily heard during the blocked beat, differentiating this dysrythmia from a sinoatrial node block.

### Answers to audio quiz: Identification of equine cardiac murmurs

#### Case 1  
- Heart rate: 40 bpm  
- Rhythm: Regular  
- Heart sounds: S4, S1 and S2  
- Presence of S4: Yes  
- Phase of heart cycle: Holodiastolic  
- Intensity: 3/6  
- Pattern: Decrescendo, soft

- Diagnosis: Aortic regurgitation. The murmur is present during the longest phase of the cardiac cycle so it is diastolic. As it encompasses the entirety of diastole, it must be aortic regurgitation. The decrescendo nature of the murmur is a classical characteristic for aortic regurgitation.

#### Case 2  
- Heart rate: 52 bpm  
- Rhythm: Regular  
- Heart sounds: Obliterated by the murmur  
- Presence of S4: Yes  
- Phase of heart cycle: Pandiastolic  
- Intensity: At least 4/6; if there was a precordial thrill it would be higher  
- Pattern: Decrescendo, harsh, musical

- Diagnosis: Aortic regurgitation. The heart sounds have been obliterated by the murmur, making the timing harder to classify. The cardiac phase during which the murmur is present is of longer duration, which means this is a diastolic murmur. This is an example of a harsh musical aortic regurgitation.

#### Case 3  
- Heart rate: 100 bpm  
- Rhythm: Regular  
- Heart sounds: Obliterated by the murmur  
- Presence of S4: Yes  
- Phase of heart cycle: Pansystolic  
- Intensity: At least 4/6; if there was a precordial thrill it would be higher  
- Pattern: Plateau, harsh

- Diagnosis: Ventricular septal defect. Due to the tachycardia, it is difficult to determine whether this murmur is present during diastole or systole. In a real case situation, auscultating remote from the PMI would help to classify the murmur as systolic. The character of this murmur is typical of a ventricular septal defect.

#### Case 4  
- Heart rate: 40 bpm  
- Rhythm: Regular  
- Heart sounds: S1, S2 and S3  
- Presence of S4: Yes  
- Phase of heart cycle: Short early diastolic  
- Intensity: 3/6  
- Pattern: High-pitched squeak

- Diagnosis: Early physiological filling murmur. This diastolic murmur is only present during early rapid ventricular filling. It is too short to be aortic regurgitation and the squeak is a classical characteristic for this type of murmur.

#### Case 5  
- Heart rate: 32 bpm  
- Rhythm: Regular  
- Heart sounds: S1 and S2  
- Presence of S4: Yes  
- Phase of heart cycle: From early systole to S2  
- Intensity: At least 4/6; if there was a precordial thrill it would be higher  
- Pattern: Crescendo

- Diagnosis: Mitral regurgitation. The murmur is present during the longest phase of the cardiac cycle so it is diastolic. As it encompasses the entirety of diastole, it must be aortic regurgitation. The decrescendo nature of the murmur is a classical characteristic for aortic regurgitation.

- **PMI**: Mid-left side

#### Case 6  
- Heart rate: 48 to 58 bpm  
- Rhythm: Irregularly irregular  
- Heart sounds: Obliterated by the murmur  
- Presence of S4: Yes  
- Phase of heart cycle: Pansystolic  
- Intensity: At least 4/6; if there was a precordial thrill it would be higher  
- Pattern: Plateau, harsh and musical

- Diagnosis: Mitral regurgitation. Considering the two main differentials for a left-sided systolic murmur, as this murmur extends to S2 it must be mitral regurgitation. It does not start at S1 and there is a gap between S1 and the start of the murmur.

- **PMI**: Midway between left apex and base

#### Case 7  
- Heart rate: 34 bpm  
- Rhythm: Regular  
- Heart sounds: S1 and S2  
- Presence of S4: Yes  
- Phase of heart cycle: Pansystolic and short early diastolic  
- Intensity: At least 4/6 (systolic) and 3/6 (diastolic)  
- Pattern: Plateau, harsh (systolic) and high pitched (diastolic)

- Diagnosis: Mitral regurgitation (systolic) and early physiological filling murmur (diastolic).

- **PMI**: Left apex

#### Case 8  
- Heart rate: 26 to 28 bpm  
- Rhythm: Regularly irregular  
- Heart sounds: S4, S1 and S2  
- Presence of S4: No  
- Phase of heart cycle: N/a  
- Intensity: N/a  
- Pattern: N/a

- Diagnosis: Second degree atrophicventricular block. The fourth heart sound is easily heard during the blocked beat, differentiating this dysrythmia from a sinoatrial node block.