WHAT’S THAT SOUND I AM HEARING?
GUIDE TO AUSSCULTATION OF MURMURS IN HORSES

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INTRODUCTION
The stethoscope is probably the diagnostic tool used most frequently on a daily basis. How often have you heard a sound that you were not totally sure what it meant? The purpose of this talk is to review the basics of hear sounds and the most common murmurs in horses. The story is not new, but the way in which the material will be presented will hopefully assist in your auscultation skills. Normal heart sounds and murmurs were recorded from patients, digitized, and inserted into QuickTime movies.

NORMAL HEART SOUNDS

Secret One: It’s okay to have a good stethoscope.
Frustration with cardiac auscultation can be avoided by use of a good quality stethoscope. Single, shorter tubing stethoscopes with both a bell and a diaphragm are recommended. The diaphragm of the stethoscope is most useful for detecting higher frequency or higher pitched sounds, such as the first and second heart sounds, whereas the bell of the stethoscope is more helpful for detecting lower frequency or lower pitched sounds, such as the third and fourth heart sounds.

Secret Two: The meaning of “lub-dub.”
Perhaps recognition of the first and second heart sound is not so much of a secret as they are the classic “lub” and dub” that almost everyone feels most comfortable with. However, when a murmur blends into or obscures the first or second heart sound, it complicates recognition of the sounds and accurate interpretation of the murmur. Perhaps the most helpful secret about the first and second heart sounds is the physical events that generate them and their relation to the cardiac cycle. The first heart sound, S1, is longer in duration and of lower frequency than the second heart sound, S2. Both S1 and S2 are audible in all horses. S1 occurs at the onset of systole and is generated by several events: closure of the atrioventricular (AV) valves, the initial contraction of the ventricles, opening of the semi-lunar valves, and ejection of blood into the aorta and pulmonary artery. S1 is most readily audible over the center of the left heart. S2 denotes the end of systole. This sound is generated by deceleration of blood flow in the aortic and pulmonary arteries and closure of their respective valves. S2 is easiest to hear over the left heart base. In a horse at rest, with a normal heart rate between 24-48 beats/minute, the events of systole and diastole are typically easy to detect relative to the generation of the audible events of S1 and S2: the shorter time period of systole occurs between S1 and S2 and the longer phase of diastole occurs between S2 and the next audible S1. When the heart rate increases, diastole shortens and clear detection of the events of systole versus diastole, based solely on the timing between S1 and S2, becomes more obscure. In comparison to the electrical events of the electrocardiogram (ECG), S1 occurs approximately at the time of generation of the QRS complex and S2 approximately occurs at the end of the T wave.
Secret Three: A key to distinguishing the third and fourth heart sounds is location.

Often three or even four sounds are clearly audible in normal horses. These “extra” sounds, like S1 and S2, are generated by normal physical events. The enormity of the equine heart causes the generation of a sound with these normal physical events, when in other smaller species, generation of a third or fourth heart sound is often considered pathologic, as it implies that the heart must have become abnormally enlarged in order to generate the sounds. If you hear three or four heart sounds in the heart, it typically is not too pressing of an issue to determine which of the sounds you are hearing. However, like S1 and S2, simply knowing the events that generate the sounds will help in their recognition. The third heart sound, S3, is frequently audible in younger or fit horses over the left apex of the heart. S3 is generated by the rapid deceleration of blood entering the filling ventricles and the abrupt stop in the ventricular wall relaxation in early diastole. Although the generation of S3 is typically considered to be a normal physiologic event, a pronounced S3 in conjunction with a murmur of insufficiency may be a sign of ventricular dilation. S4 is readily heard over the left heart base and coincides with the electrical event of P wave generation. Sometimes S4 is apparent as a soft, low isolated sound during the periods of asystole in a horse with second degree AV block. The secret to distinction between S3 and S4 is location: S3 is a ventricular event so will be loudest over the left apex. S4 is an atrial event and will be loudest over the heart base.

MURMURS

A murmur is any sound created at a point in the cardiac cycle that is normally silent. Murmurs most commonly are generated by turbulent blood flow or vibration of structural components of heart, such as the valves, chordae tendineae, or the myocardium. The turbulence may be physiologic, that is, there is nothing structurally wrong with the heart, or they may be pathologic. To ultimately determine the meaning of a murmur, several characteristics of the murmur must be defined including: point of maximal sound intensity, the timing (systole or diastole), knowledge of the normal physical events at the point of maximal intensity, and the intensity of the murmur (relative grade of loudness).  

Secret Four: Where is all that noise coming from?

The point of maximal intensity (PMI) defines the location over the heart where the sound of the murmur is most readily apparent. The point of maximal intensity can be as simple as the left versus the right side of the chest or the apex versus the heart base. Further localization of sound principally revolves around the points of auscultation over the 4 major heart valves. The sounds generated by the mitral valve are located at the left 5th intercostal space about 1/3 of the distance from the point of the elbow to the point of the shoulder. This typically falls in about the same parallel plane as the caudal edge of the triceps muscle. Sounds over the pulmonic valve are audible at the left 3rd intercostal space, directly rostral to and slightly above the mitral valve. The aortic valve sound is located between the pulmonic and mitral valves at the left 4th intercostal space and slightly more dorsal, closer to the point of the shoulder. To hear sounds over the aortic and pulmonic valves, the stethoscope must be tucked under the triceps muscle or the left foreleg must be pulled forward. Over the right heart, the tricuspid valve is located at the 4th intercostal space, about half way between the distance between the point of the elbow and the point of the shoulder. Some murmurs radiate or may be heard over a larger range of intercostal spaces. In those situations, moving the stethoscope over all the points of auscultation is helpful to attempt identification of the loudest point of origin.
Secret Five: It’s all about timing.

The timing of the murmur refers to whether the murmur is audible during the period of systole or during the period of diastole. The slower resting heart rate in the horse greatly facilitates identification of timing, as diastole is the longer period between generation of the normal heart sounds, S2 and S1. If one simultaneously feels the pulse over the facial artery while listening over the heart with a stethoscope, the pulse is palpable during the time period between S1 and S2. This “trick” of feeling the pulse while listening to the heart can be very helpful in detecting systole and the timing of a murmur. The term “holo” as a prefix, indicates that the murmur is audible between normal heart sounds. For example, a holosystolic murmur refers to one in which S1 and S2 are both distinctly audible, with the murmur occurring between them. The prefix “pan” refers to a murmur that blends in with the normal heart sounds. For example, a pansystolic murmur is one that starts with S1 and continues through S2. Murmurs can also be categorized by whether they occur early, mid or late during systole or diastole. A presystolic or end-diastolic murmur refers to one that is occurring just prior to S1. Finally, murmurs may be continuous, that is they are audible during both systole and diastole. In general, murmurs of longer duration (i.e. throughout systole or diastole) are more likely to carry significance than shorter duration murmurs (i.e. those in early or late systole or diastole).

Secret Six: No really, what created that murmur?

To ultimately determine the meaning of a murmur, using the PMI, the timing, knowing what that valve should be doing during that time, and how common the lesion is for the signalment will get you started down the path of differential diagnoses (see Table 1). For example, during systole, the semi-lunar valves should be open and the atrioventricular (AV) valves should be closed. If a murmur is audible during systole over a semi-lunar valve, it would imply that the valve is not all the way open or is stenotic (which is rather rare in horses) or relatively stenotic (such as an ejection murmur in young horses). If the murmur is audible during systole and is located over one of the AV valves (mitral on left and the tricuspid on the right), it would imply that the valve is not closed all the way and blood is leaking retrograde: the valve has insufficiency (which is common in the horse). The same logic applies during diastole (see Table 1). Diastolic murmurs over the AV valves imply stenosis, which are almost unheard of in the horse. By far, the most common reason for an acquired pathologic murmur in the adult horse is the presence of an insufficient valve: either mitral or tricuspid valve insufficiency creating a systolic murmur over the left and right heart, respectively, or an insufficient aortic valve, creating a diastolic murmur over the left heart base. Diastolic murmurs of aortic valve insufficiency are decrescendo and have a “dive bomber” sound to them. Mitral and tricuspid valve insufficiencies are crescendo-decrecendo. Honking, loud squeaking, or “musical” murmurs are often created by insufficiency valves that are prolapsing or flail.

Table 1. Interpretation of murmurs created by altered valves.

<table>
<thead>
<tr>
<th>PMI</th>
<th>During systole, the valves are</th>
<th>Causes of the murmur</th>
<th>During diastole, the valves are</th>
<th>Causes of the murmur</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV valves</td>
<td>closed</td>
<td>*insufficiency</td>
<td>open</td>
<td>stenosis</td>
</tr>
<tr>
<td>Semi-lunar valves</td>
<td>open</td>
<td>stenosis</td>
<td>closed</td>
<td>*insufficiency</td>
</tr>
</tbody>
</table>

*Most common reason in large animals
Secret Seven: How loud a murmur sounds may give important information about its significance.

The intensity of the murmur refers to how loud the murmur sounds. Murmurs are typically “graded” on a scale of 1 to 5 or 6. In either grading system, a grade of 4/5 or 5/6 means that a palpable thrill can be felt over the heart at the PMI. A grade 1/5 murmur is a soft or quiet murmur that is very local in origin and can only be heard after prolonged and careful auscultation. A grade 2/5 murmur is a quiet murmur that is also focal in origin, but can be heard immediately. A grade 3/5 murmur is a moderately loud murmur that may radiate. A grade 4/5 murmur is a loudly radiating murmur that has an associated palpable thrill and a grade 5/5 murmur is one that can be heard with the stethoscope raised off the chest. Although the intensity of a murmur does not always directly correlate to its clinical significance or prognosis, in general, murmurs ≤ grade 2/5 are less worrisome.

Secret Eight: All murmurs are not created equal.

A murmur does not automatically imply that something is directly wrong with the heart. Physiologic murmurs, also referred to as innocent flow murmurs, are generated from turbulence created by change in blood viscosity (i.e. anemia or dehydration), alterations in cardiac output, or turbulence created by the flow of blood from larger volume chambers of the heart (like the ventricles) to narrower diameter chambers (like the aorta or pulmonary artery). The latter murmur, is often called an ejection murmur, as it occurs during systole over the semi-lunar valves. It is very common in neonatal foals, due to their higher resting heart rates. These innocent ejection murmurs can also be found in adult horses and typically are low grade (< grade 2). Occasionally mid or end diastolic innocent flow murmurs are audible. A pathologic murmur implies that there is a structural abnormality with the heart that is creating turbulent blood flow. The single most common cause of an acquired pathologic murmur in a horse is valvular insufficiency: the valve is not completely closing. Again here, remember what is most common: mitral valve insufficiency (systolic murmur with PMI over the mitral valve), aortic valve insufficiency (diastolic murmur with the PMI over the left heart base), tricuspid valve insufficiency (systolic murmur over the right heart). Pathologic murmurs can also be created by shunts in the heart creating turbulence. These are typically congenital defects, with the most common example in a horse being a ventricular septal defect (VSD). The most common murmur with a VSD is a right sided systolic murmur. Finally, pathologic murmurs may be associated with myocardial failure. Loss of “tone” in failing myocardium can result in loss of valve “tone.” Typically, this generates the sound of a murmur of insufficiency. Endocarditis is uncommon in the horse, but when it does occur, it typically causes valvular insufficiency and most frequently affects the mitral and aortic valves.

Secret Nine: When should I worry about a murmur?

Specifically concentrating on the pathologic murmurs, a common question that arises is “when should I worry about the presence of a murmur?” Mitral valve and aortic valve insufficiency are the most commonly acquired murmurs in middle aged and older horses. The most common reason for valve insufficiency is degenerative or myxomatous changes within the valve, though endocarditis, and myocarditis may also be associated causes of acquired valve failure. The exact cause of myxomatous change is not known. Although mitral or aortic valve insufficiency may lead to signs of left-sided heart failure (exercise intolerance, coughing, tachycardia, tachypnea, pulmonary crackles, and serous to foamy nasal discharge), more typically
mitral or aortic valve insufficiency progress slowly over many years, if they progress at all.\textsuperscript{1,2} Tricuspid valve insufficiency is less common, but if it does develop and progress, signs of right-sided heart failure would include jugular distension with pulsation, dependent edema, tachycardia, and lethargy. Further evaluation of the heart with echocardiography would be recommended for any horse with: 1) a cardiac murmur $\geq$ grade 3/5, 2) exercise intolerance or any signs of cardiac disease, 3) sudden onset of a murmur, 4) a murmur that is accompanied by a change in pulse quality, 5) a murmur that is accompanied by a pathologic arrhythmia, and 6) a fever of unknown origin, especially when accompanied by a murmur.\textsuperscript{2} Advances in echocardiography have greatly enhanced our understanding of the meaning of murmurs and have helped to establish prognostic criteria that are useful not only for pre-purchase evaluation, but also for therapeutic strategies. An in-depth discussion on echocardiography is beyond the scope of this seminar. For an equine heart, a 2-4 MHz sector scanner with a depth display of 20 to 30 cm and Doppler capability is most commonly used.

**Secret Ten: Practice makes perfect (or at least better).**

The ultimate key to accurate interpretation of cardiac sounds is practice. Equine cardiac sound recordings are commercially available.\textsuperscript{3}

**REFERENCES**
\textsuperscript{1}Patterson, M. *Equine Cardiology*. London: Blackwell Sciences, 1996.