Electrocardiograms can be intimidating. The goal of this presentation will be to familiarize technicians with the components of ECGs and how to diagnose common arrhythmias in the veterinary patient.

Review of the conduction system:
Cardiac impulses start at the sinoatrial (SA) node, located within the right atrium, near the cranial vena cava. The SA node is known as the primary pacemaker of the heart. When this impulse is generated, after dispersing through the atria, it converges on the atrioventricular (AV) node. The AV node conducts the signal to the muscle fibers within the left ventricle, causing them to contract.

Most ECG recordings have 3-6 leads labeled I, II, III, aVL, aVR, and aVF. Lead II is most familiar. Lead II represents positive polarity from the left hind limb electrode to negative polarity from the right axillary electrode. Using different leads allows investigation of electrical activity in the heart from various angles.

How to interpret the wave forms:
Each heart beat on an ECG is represented by three main waveforms: the P wave, the QRS complex, and the T wave. The P wave represents atrial depolarization and the PR interval represents conduction through the AV node. The QRS complex represents contraction of the ventricles. The ST segment represents the time interval between the depolarization of the ventricles and the beginning of repolarization. The T wave represents ventricular repolarization.

Assessment of the ECG:
1. Calculate the heart rate. In most cases, this can be done by counting the number of heart beats that occur within 6 seconds, and then multiplying this by 10. It is important to note the paper speed at the bottom or top of every ECG recording. At a paper speed of 50mm/sec, 10 blocks span 1 second, or 60 blocks span 6 seconds. Once a span of 6 seconds has been marked off on the ECG, each QRS complex that falls within that span can be counted. The total
number of QRS complexes counted within the 6 second span is then multiplied by 10. This will equal the heart rate.

2. Assess the regularity of the heart rate. To do this, the R-R interval should be determined. This can be done using a piece of paper to mark the R-R interval between two waveforms, and then moving the paper to another R-R interval to see if the marks line up.

3. Identify waveforms—are P waves present? Sinus rhythm will always have a P wave followed by a QRS complex.

4. Assess the association of P waves to the QRS complexes. P waves may not be followed by a QRS in AV block. A QRS may not be preceded by a P wave with premature beats.

5. Assess the QRS complexes. If the QRS complexes appear upright and narrow, this indicates that the impulse is supraventricular (generated above the ventricles). If the QRS complexes are wide and bizarre, this indicates the impulses are ventricular (generated from within the ventricles).

Review of common arrhythmias:

Sinus rhythm
The ECG is characterized by a normal P wave followed by a normal QRS complex. The heart rate in the patient will be normal and the R-R interval will be regular.

Sinus arrhythmia
Sinus arrhythmia is a variation in heart rhythm, often associated with respiration. On ECG it is characterized by a normal P wave followed by a normal QRS complex. On inspiration, the heart rate increases. On expiration, the heart rate decreases. This finding is common in dogs with high vagal tone: brachycephalic breeds, athletic dogs, or patients with chronic gastrointestinal or respiratory disease. Sinus arrhythmia is rarely found in cats.

Sinus bradycardia
Sinus bradycardia is an abnormally slow rhythm that follows a normal conduction pathway (P wave, QRS, T wave). It originates from the SA node, but is inappropriately slow.

Sinus tachycardia
Sinus tachycardia is an abnormally fast rhythm that follows a normal conduction pathway (P wave, QRS, T wave). It too originates from the SA node, but is inappropriately fast. Generally, there is a reason for sinus tachycardia. Sympathetic nervous stimulation from extreme excitement in an exam room is the most common cause for sinus tachycardia in an otherwise healthy pet. Dehydration, pain, systemic disease, etc. can also be causes of sinus tachycardia.
Wandering pacemaker
A wandering pacemaker is a benign finding. It is characterized on ECG by varying amplitudes of the P wave. The rest of the waveform will appear normal. This is usually due to varying vagal tone.

Atrial fibrillation
Atrial fibrillation is the most common supraventricular arrhythmia seen in dogs. Atrial fibrillation is characterized by a rapid and irregular rhythm. When a patient is in A-fib, the AV node receives several hundred impulses and filters them. Atrial fibrillation can reach heart rates of over 300bpm. In atrial fibrillation, the P wave is absent. Auscultation is commonly described as “shoes in a dryer”. In most dogs, and all cats, atrial fibrillation is due to underlying structural heart disease. One exception to this rule is giant breed dogs. Irish Wolfhounds, Scottish Deerhounds, Great Danes, etc. can develop lone atrial fibrillation. This rhythm develops in the absence of underlying heart disease and is usually a slower, irregular rhythm. However, this is a very rare finding.

Ventricular premature complexes
VPCs are classified by premature beats that originate from the left ventricles. The QRS complexes are wide and bizarre, and may be upright or upside down, depending on the origin of the electrical impulse. VPCs may be presented as singles, couplets (two in a row), or triplets (three in a row). Infrequent or occasional VPCs in an otherwise healthy animal may be considered benign. Frequent VPCs usually indicate a serious underlying disease. Primary structural heart disease, neoplastic disease, and injuries are the most common causes of VPCs.

Ventricular tachycardia
Ventricular tachycardia is characterized by a very rapid rhythm where a group of 4 or more VPCs are recorded. In order for a rhythm to be diagnosed as V-tach, the ventricular rate must be faster than 160bpm. The QRS complexes will be wide and bizarre, and the P waves are usually buried in the complexes. V-tach may be intermittent or sustained. This is a very serious and life-threatening arrhythmia and requires immediate treatment.

Supraventricular tachycardia
SVT is classified by a rapid, regular rhythm with upright and narrow QRS complexes. Heart rates usually exceed 250bpm. The R-R interval will be regular. SVT may be prolonged or short runs may be seen. SVT is most commonly caused by underlying structural heart disease or serious systemic disease.

1st, 2nd, and 3rd degree atroventricular block
First degree AV block is characterized by a prolonged P-R interval. First degree AVB is clinically insignificant and is most often caused by high vagal tone.
2nd degree AVB is caused by an occasional failure of impulse conduction through the AV node. On ECG, it is characterized by P waves not followed by a QRS complex. The severity of 2nd degree AVB determines the need for treatment.

3rd degree AVB, or complete heart block, occurs when none of the impulses generated by the atria reach the ventricles. On ECG, there is no relationship between the P waves and QRS complexes. 3rd degree AVB may be due to injury to the AV node, neoplasia, fibrosis, hypoxia or electrolyte abnormalities. Surgical implantation of a pacemaker is indicated if the pet is collapsing.

References