ECG Interpretation Part I: The Basics

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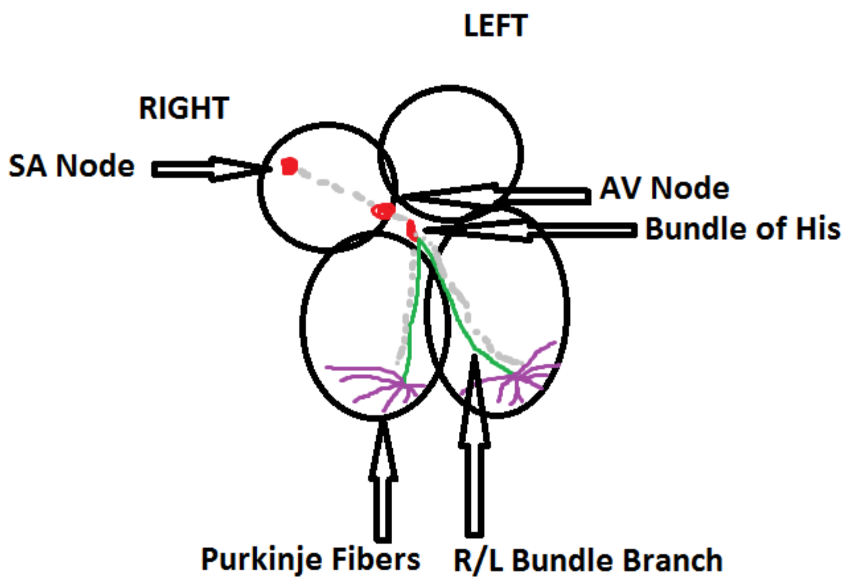
Introduction

The electrical conduction system of the heart serves to power the muscles of the heart to pump blood to the body. Basic muscle physiology dictates that nerves send signals from the central nervous system to innervate muscular contraction. The heart muscle is no different. In a normal patient, the electrical signals precede the mechanical contraction by fractions of a second. Electrocardiography, or ECG, monitoring can detect pathology of the electrical conduction system causing arrhythmias. These abnormal heart rhythms can affect organ perfusion and oxygen delivery if they are malignant and cause disturbances in cardiac output. Thus, monitoring the ECG is an essential tool for anesthesia, critical care, or cardiology practice. Veterinary technicians should be familiar with normal electrical physiology, as well as a uniform approach to interpreting abnormal heart rhythms.

Normal Cardiac Conduction

The electrical conduction system is made up bundles of nerves and fine nerve fibers that reach just about every cardiac myocyte in the heart muscle. The first large branch of nerves is called the sinoatrial, SA, node. The SA node lives in the atria and is responsible for starting the electrical flow across the heart. The electrical signal travels across the atria to the atrioventricular, AV, node. The AV node lives in the junction between the atria and ventricles and is the gatekeeper to ventricular contraction. It functions like a stop light, allowing only a regular amount of “traffic” to pass into the ventricles. From the AV node, the signal travels through a small nerve bundle called the Bundle of His and then is distributed to two large nerves on the right and left sides of the heart, called the right and left bundle branch. Each ventricle is so important that it gets its own conduction highway. From the bundle branches the signal propagates through purkinje fibers which are found throughout the ventricles. The electrical signal travels along this path for every heart beat and is coordinated to push blood from the atria into the ventricles, and then eject the blood from the ventricles to the body. Deviations in this normal pathway represent arrhythmias.

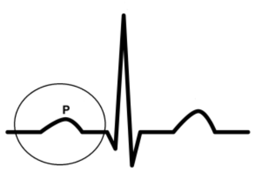
Figure 1- Cardiac Conduction System



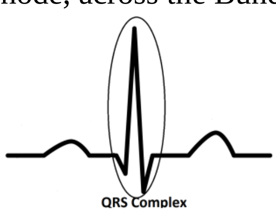
The normal “ECG”

A normal ECG has 5 characteristic wave: the “P” wave, the “Q” wave, the “R” wave, the “S”, wave, and the “T” wave. For simplicity, the Q, R, and S waves will be discussed as one unit, the “QRS” complex. These waves are described in more detail below:

“P” wave: This wave represents the travelling of electricity from the SA node to the AV node. Thus, this wave represents atrial depolarization.



“QRS” complex: This represents the travelling of the electrical signal through the AV node, across the Bundle of His, and down the right and left bundle branches.



"T" wave: This wave is ventricular repolarization. This is the "re-setting" of the ventricles. Atrial repolarization is hidden in the QRS complex.

Performing an ECG

To perform an ECG the patient should ideally be placed in right lateral recumbency. Recumbency is not a huge issue if the leads are placed correctly. Each ECG machine has different color wire leads indicating the anatomical location of where they should be placed. There is typically a lead for each forelimb and each hindlimb (4 leads) indicated as "RA" (Right Arm), "LA" (Left Arm), "RL" (Right Leg), and "LL" (Left Leg). The leads MAY (but not always) have a uniform color so mnemonics can be used to remember where they go: "White on Right, Red, not White.." "Smoke before fire…"

Typically the WHITE lead is placed on the RIGHT ARM
The BLACK lead is placed on the LEFT ARM
The GREEN lead is placed on the RIGHT LEG
And the RED lead is placed on the LEFT LEG

The patient should be placed on a non-conductive surface (not a metal wet-table) or have a towel placed underneath them to reduce conduction interference. Ideally, the patient should be calm and not shaking. ECG leads typically have clamps at the end of them, and these clamps are placed at the various anatomical locations indicated above. Copious amounts of alcohol or electrolyte gel can be placed on the leads, and the ECG is turned on. Although a rhythm may be analyzed from the ECG monitor, it is best to print a strip for use in the patient's chart. Strips can be printed at 25 or 50mm/sec and it is important to note which speed was used. A rhythm strip can be as long as one minute.

The most commonly used "lead" organization system is the Lead II system. This represents the shape of the ECG above and is usually used for common arrhythmia analysis. Because the ECG is "directional" there are other possible leads but those are beyond the scope of this talk.

ECG Interpretation Part II: Arrhythmia Analysis
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Analyzing the ECG in a step-wise approach:

1- Determine the heart rate
2- Determine if there are P, QRS, and T-waves
3- Determine if there is a P-wave for every QRS complex
4- Determine if there is a QRS complex for every P wave
5- Determine if the complexes look "uniform" or the same- what are the differences?

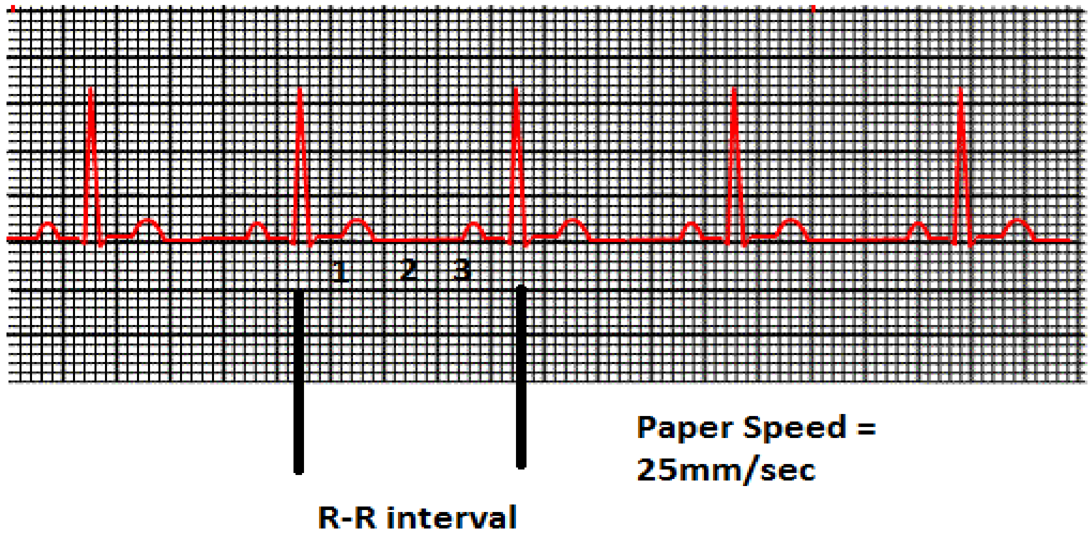
Determining heart rate:

This is easy to do from a rhythm strip knowing what paper speed you printed the strip at. Each SMALL square = 1mm and each LARGE square = 5mm. Heart rate is determined by looking at the distance between TWO R waves (the R-R interval).

For a 25mm/sec strip: Each small box represents 0.04 seconds. Take a look at the number of BIG boxes (5 mm) between two R-R intervals. Divide 300 by this number, that is your heart rate. Example: 4 BIG boxes between two R-R intervals. 300/4= 75 beats per minute.

For a 50mm/sec strip: Each small box represents 0.02 seconds. Take a look at the number of BIG boxes (5 mm) between two R-R intervals. Divide 600 by this number, that is your heart rate. Example: 4 BIG boxes between two R-R intervals. 600/4= 150 beats per minute.

Practical example:



So there are 3 full BIG boxes, and two “half” boxes. This equals FOUR full boxes. Since the paper speed is 25mm/sec this means you take 300/4 = 75 BPM.

Analyzing arrhythmias:

Remember to apply the same steps as above while you work through these examples:

Example 1:

PAPER SPEED: 25mm/sec.

Step 1- Determine the HR HR: ______________________________

Step 2- Are there P, QRS, and T-waves? If not, which is missing:___________________________

Step 3- Are there P-waves for every QRS complex? YES NO

Step 4- Are there QRS complexes for every P-wave? YES NO

Step 5- Do the complexes look uniform? YES NO

Interpretation:

Example 2:

PAPER SPEED: 25mm/sec.

Step 1- Determine the HR HR: ______________________________

Step 2- Are there P, QRS, and T-waves? If not, which is missing:___________________________

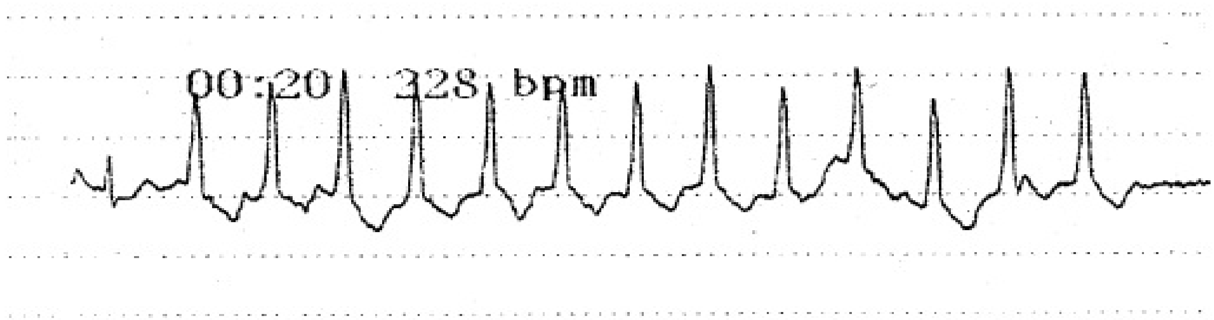
Step 3- Are there P-waves for every QRS complex? YES NO

Step 4- Are there QRS complexes for every P-wave? YES NO

Step 5- Do the complexes look uniform? YES NO

Interpretation:

Example 3:



PAPER SPEED: 25mm/sec.

Step 1- Determine the HR HR: ______________________________

Step 2- Are there P, QRS, and T-waves? If not, which is missing:___________________________

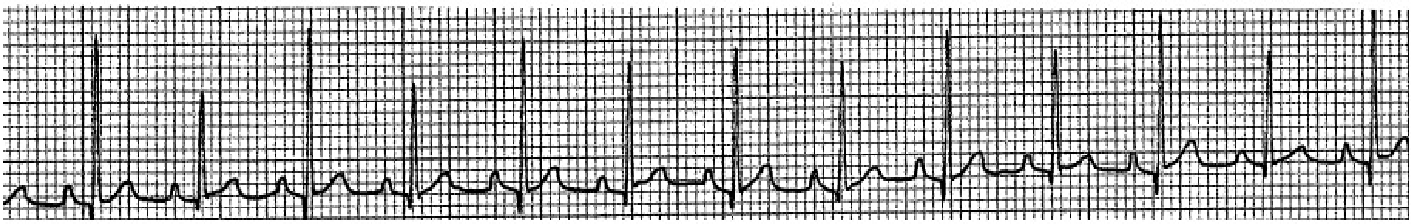
Step 3- Are there P-waves for every QRS complex? YES NO

Step 4- Are there QRS complexes for every P-wave? YES NO

Step 5- Do the complexes look uniform? YES NO

Interpretation:

Example 4:



PAPER SPEED: 25mm/sec.

Step 1- Determine the HR HR: ____________________________

Step 2- Are there P, QRS, and T-waves? If not, which is missing:_________________________

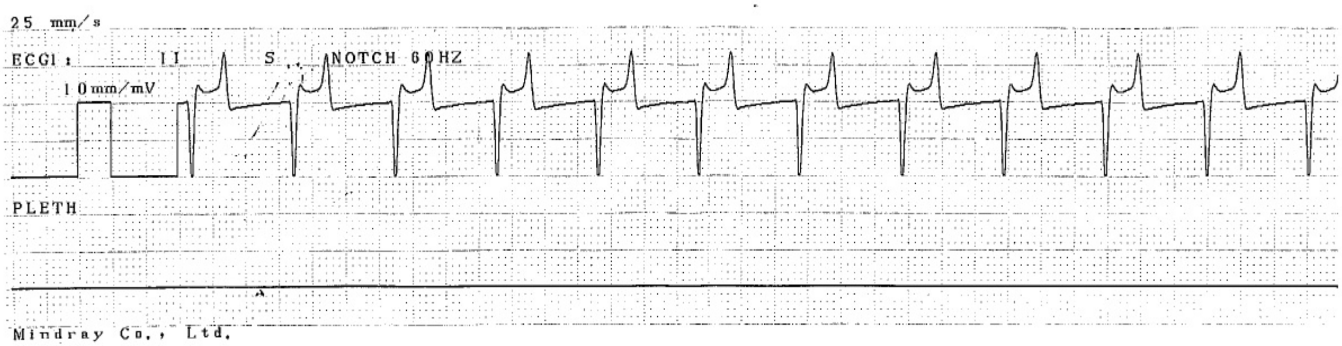
Step 3- Are there P-waves for every QRS complex? YES NO

Step 4- Are there QRS complexes for every P-wave? YES NO

Step 5- Do the complexes look uniform? YES NO

Interpretation:

Example 5:



PAPER SPEED: 25mm/sec. HINT: FELINE PATIENT!!!

Step 1- Determine the HR HR: __________________________

Step 2- Are there P, QRS, and T-waves? If not, which is missing:_________________________

Step 3- Are there P-waves for every QRS complex? YES NO

Step 4- Are there QRS complexes for every P-wave? YES NO

Step 5- Do the complexes look uniform? YES NO

Interpretation: