Peer Reviewed

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Reading Electrocardiograms

The ECG is a record of the average electrical potential generated in the heart muscle at the body's surface.

The electrocardiograph amplifies and filters these small electrical signals and graphs this signal in voltage and time. These electrical signals are created by intracellular and extracellular ionic gradients that move across semipermeable membranes and result in cellular transmembrane action potentials. The action potentials occur in myocardial and autonomic tissues and vary on the basis of inherent characteristics of the tissue.

With continuous practice, reading ECGs can become a rapid and easy process in most cases. This article is meant only as a guide for stepwise assessment of ECGs.

INDICATIONS

The ECG is primarily used to detect and assess the normalcy of the heart's rhythm or to diagnose or monitor patients with arrhythmias. Historically, ECGs have also been used as an adjunct to detect cardiac chamber enlargement. However, echocardiography showed that ECGs are neither sensitive nor specific for identifying chamber enlargement; using them for this purpose is no longer recommended.

Other indications include using ECGs to assess acute antiarrhythmic and other cardiac drug therapy, to evaluate electrolyte and acid–base disturbances, and as part of a complete cardiovascular examination.

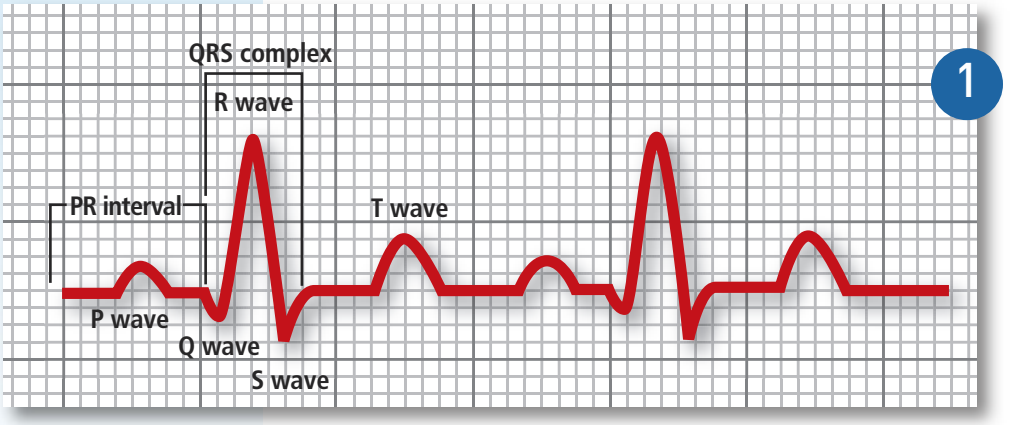

Figure depicting the various waveforms and intervals seen in an ECG

CONSIDERATIONS

Waveforms & Intervals

When reading an ECG, one should be familiar with normal variants in the species being examined. The recorded ECG waveforms and intervals that should be measured in the standard frontal plane leads (leads I, II, III, aVR, aVL, aVF) include the following (**Figure 1**):

- The **P wave** indicates atrial depolarization.
- This is followed by the **PR interval**, which is measured from the start of the P wave to the start of the QRS complex. It indicates the time of conduction from the sinoatrial node to the ventricles. Time in the atrioventricular node represents 75% of this interval.
- The **QRS** is a complex of 3 waveforms that represent ventricular depolarization. All 3 waves may not be present at a given time.
- The **Q wave** is the first negative deflection.
- The **R wave** is the first positive deflection after the P wave. It is typically the predominant waveform in left-facing leads (I, II, aVF, aVL, CV6LL, CV6LU).
- The **S wave** is the first negative deflection after a positive deflection.
- The last normal waveform present is the **T wave**, which represents ventricular repolarization and can be altered with electrolyte abnormalities, such as hyperkalemia.

Abnormalities in the height or duration of the QRS complex can indicate abnormal conduction or chamber enlargement.

ECG = electrocardiogram

EVALUATION

The Basics

- **Paper speed**—We usually set our paper speed to 50 mm/sec or 25 mm/sec.
- **Sensitivity**—We usually keep sensitivity standard (10 mm/mV). However, the sensitivity can be decreased to half (5 mm/mV) when complexes are too large or doubled (20 mm/mV) when complexes are too small. Many machines use an autoscale function, however, to adjust the sensitivities, and these should be noted on the readout to allow assessment of amplitude of the ECG complexes.
- **Leads**—Note which leads are provided. Standard lead II can be used for rhythm analysis.

Calculate Heart Rate (**Figure 2**)

- **Instantaneous heart rate calculation** is a convenient method because it is fast and can be used to calculate the rate of arrhythmias of short duration. However, it is inaccurate with irregular rhythms. To perform this count, take the number of millimeters between 2 consecutive R waves and divide this number into 3000 (50 mm/sec) or 1500 (25 mm/sec).
- For the **standard heart rate calculation**, count the number of R waves in a given period of time and multiply by an appropriate integer to equal 60 seconds (ie, 3 seconds × 20 or 6 seconds × 10). This calculation is helpful with gradual rate changes over time but tends to be inaccurate for very short-lasting arrhythmias.

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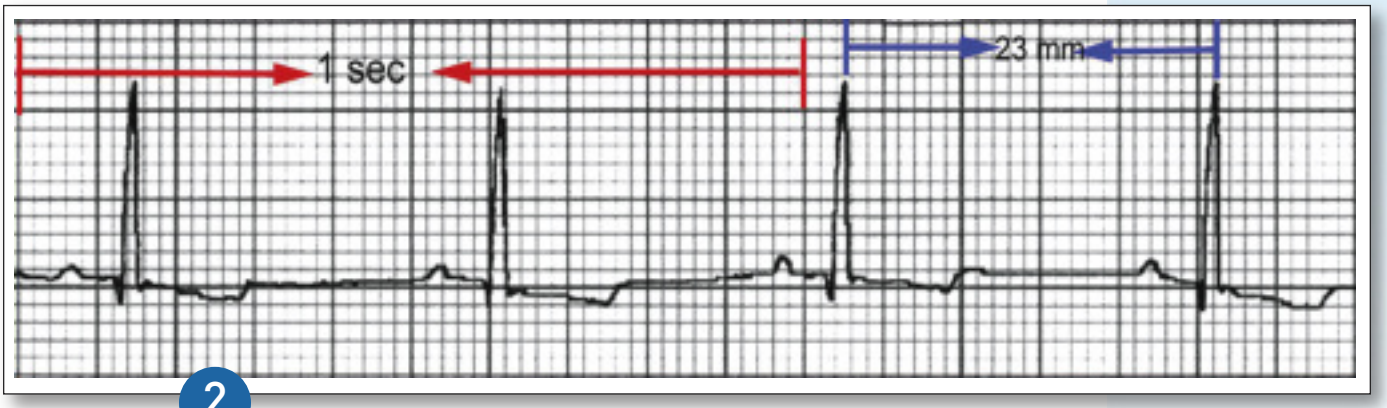

2

Heart rate calculation (paper speed = 50 mm/sec, sensitivity = 10 mm/mV): Instantaneous heart rate = 130 beats/min (3000/23); Standard heart rate = 120 beats/min (3 x 60)

DETERMINE OVERALL RHYTHM

- With a regular rhythm, the RR interval, the time elapsed between 2 consecutive R waves, does not vary much (< 10%).
- Irregular rhythms display variation in the RR interval.
- Determine whether there is a pattern (dubbed "regularly irregular") to the variation of the RR interval. This usually indicates a sinus arrhythmia, which is common and considered normal in dogs.
- If no pattern can be ascribed to the variation in the RR interval, this may indicate advanced arrhythmias, such as atrial fibrillation (depending on the presence of other criteria).

IDENTIFY SPECIFIC WAVEFORMS, TIMING, & MORPHOLOGY

- Assess whether the P wave, QRS complex, and T wave are present and related to each other by appropriately timed intervals.
- Answering the questions "Is there a P wave for every QRS complex and a QRS complex for every P wave?" and "Is there an appropriate relationship based on the PR interval?" may help make a diagnosis. For example, if a P wave without a QRS complex is present, the tentative diagnosis is second-degree atrioventricular block. This step can be difficult at times; however, here are some other caveats that may help:
  - There must be a T wave after every QRS complex, a feature that helps identify the QRS complex (sometimes working backward helps).
  - P waves generally look the same except in the case of atrial premature contractions and respiratory sinus arrhythmia.
  - P waves and T waves may overlap in atrial tachycardias.
  - Rule out the possibility that artifacts are interfering with the readout. These are usually related to patient movement, electrical interference, or poor electrode contact with the patient.
- Note whether there are any QRS complexes that appear earlier than expected (premature) or later than expected (escape rhythms) (**Figures 3 and 4**). The origin of these complexes can generally be discerned (with some exceptions) by the QRS morphology.

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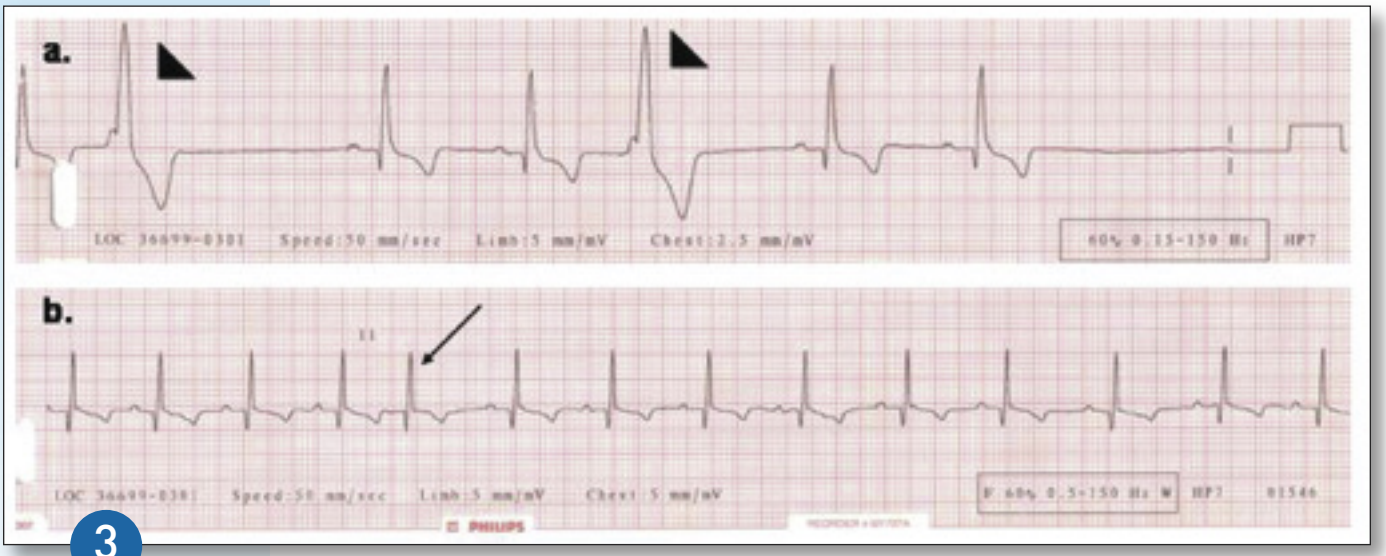

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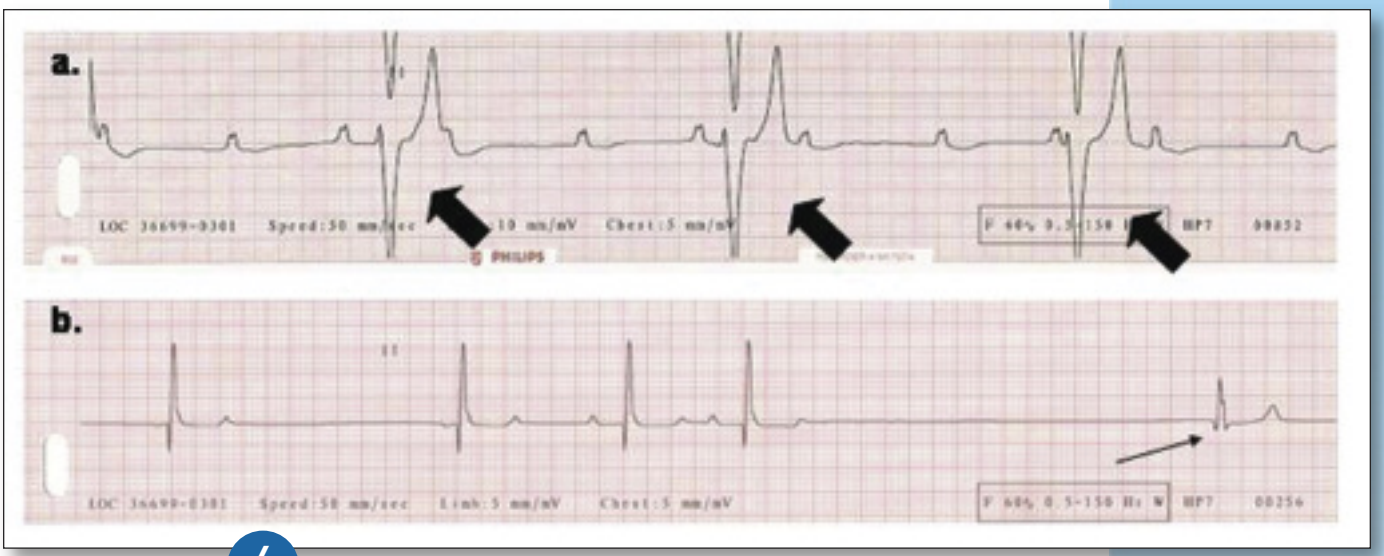
Lead II rhythm strips: Ventricular premature complexes (VPCs)—Note the wide and bizarre nature of the complexes that originate earlier than expected on the basis of the RR interval of the more normal (narrow) QRS complexes (**arrowheads**) (**a**); atrial premature complex (APC)—Note the fifth narrow QRS (**arrow**) that enters the rhythm earlier than expected (**b**). Also note in this APC that the P wave preceding this complex has a different morphology than P waves associated with the normal sinus rhythm.



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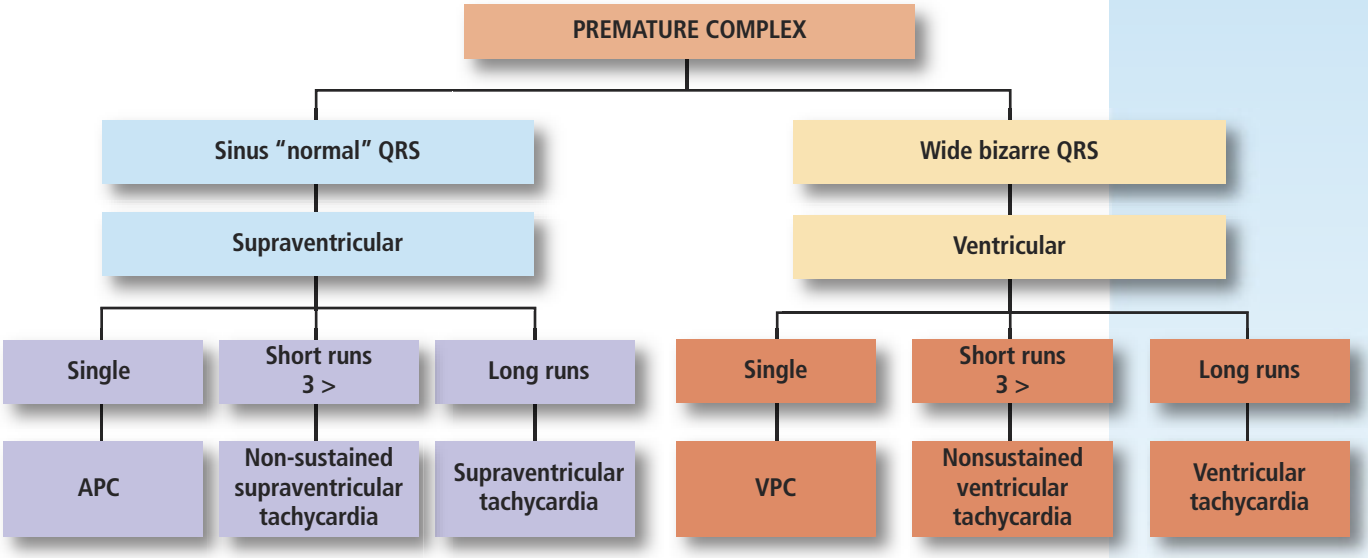
Lead II rhythm strips: Third-degree atrioventricular blockade with 3 ventricular escape rhythms (**thick arrows**) (**a**); sinus pause with a junctional escape beat at the end of the strip (**thin arrow**) (**b**).



5

Chart demonstrating nomenclature applied to premature complexes

APC = atrial premature complexes; VPC = ventricular premature complexes

- **Supraventricular (atrial or junctional)** complexes demonstrate a normal, usually narrow, QRS morphology, and those originating in the ventricles typically appear wide and bizarre.
- **Premature rhythms**, depending on frequency and origin, can result in reduced stroke volume and thus may compromise cardiac output. As a result they should be further assessed. **Figure 5** provides some basic nomenclature for premature complexes.
- **Escape rhythms** are life-saving depolarizations that occur after long delays in the normal beat and always occur secondary to some primary rhythm disturbance, such as sinus arrest or third-degree atrioventricular block. Thus, by definition escape rhythms are never a diagnosis by themselves. They can originate from junctional (nodal) or ventricular Purkinje cells.

Following these simplified guidelines regularly when analyzing an ECG will help create a process for interpretation.

ADVANTAGES

ECGs are easy to obtain. The ability to record and read an ECG prevents treatment delays that could occur if a patient is sent to a secondary facility or there is a wait for interpretation from secondary and tertiary sources.

DISADVANTAGES

Surface ECG may not detect infrequent arrhythmias if it is not recorded for sufficient periods of time.

ECONOMIC IMPACT

Minimal—ECGs need to be obtained on patients demonstrating abnormal rhythm on auscultation and those with signs potentially related to abnormal heart rhythms.

RELIABILITY OF RESULTS

As stated previously, the ECG is highly reliable for evaluating the heart's rhythm and monitoring for disturbances in rhythm. It is not as sensitive for detecting chamber enlargement.

See Aids & Resources, back page, for references & suggested reading.

ECG = electrocardiogram