How to Record and Interpret an ECG

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Electrocardiograms (ECG) recordings can be quite daunting for the veterinary nurse to interpret. However amongst the squiggly lines, there is an organized pattern of electrical conduction, which shows the depolarisation and repolarisation of the heart tissue via waveforms and intervals on our ECG screens. The technique of how to record an ECG trace is very important. The recording needs to be as clear as possible from artefacts such as skeletal muscle movement or panting, because this may hide smaller parts of the ECG complex potentially hampering interpretation. A logical and systematic approach to ECG interpretation is recommended. This article has been written with this in mind to help the reader obtain the best quality ECG trace and a logical approach to basic ECG interpretation.

What is an ECG?
An ECG records the electrical activity (depolarisation and repolarisation) of the cardiac muscle, as it pumps blood around the body.

How to record an ECG
Correct positioning of the ECG electrodes is vital. If electrodes are misplaced, misdiagnosis may occur.

The correct positioning is as follows: -
Red = right forelimb
Yellow = left forelimb
Green = left hindlimb
Black lead = right hindlimb

This colour coding is the most common placement of electrodes, but some machines can vary so check with each individual machine that this is correct. This is particularly important for US machines, for which colour coding is different.

What is artefact?
Artefact is any interference that affects the baseline of the ECG recording. Common artefacts are respiration or limb tremors, movement, electrical interference or poor electrode contact. Simple ways to avoid this are: -
- Do not allow the leads to cross the thorax (which will minimise panting and respiration artefact);
- Steady the limbs to reduce movement. Try and keep the patient as calm and relaxed as possible and hold the legs apart so that they do not touch.
- Position the patient in right lateral recumbency on a thick blanket or other insulated surface. (If the patient is in respiratory distress, the ECG can be taken in sternal recumbency, but consideration should be given as to whether it is an appropriate test for a patient with respiratory distress).
- Ensure good electrode contact with the patient (use a good amount of conductive gel or spirit).
- Switch off unnecessary electrical equipment (i.e. fans, clippers).

The ‘normal’ (sinus) complex
It is important to understand the different characteristics that make up the sinus complex. The sinus complex consists of a P wave, a QRS complex (which should be viewed as a whole entity) and a T wave. What this represents in real terms is depolarisation and repolarisation of the heart, shown as an electrical stimulus.

The P wave – The sinoatrial (SA) node starts the depolarisation process and the impulse spreads from right to left across the atria. When the whole of the atria have depolarised, the electrical difference returns to baseline.

P – R interval – The atrioventricular (AV) node slowly conducts from the atria to the ventricles to allow delay between atrial and ventricular contraction.

Q Wave – This represents the depolarisation of the ventricular septum.

R Wave – The large muscle mass of the ventricles are depolarised through the His-Purkinje fibre network.

S Wave – Finally, the basal regions of the ventricles are depolarised.

T Wave – Repolarisation of the ventricles. T wave morphology can vary largely from patient to patient and therefore is of little diagnostic utility. In some circumstances, e.g. hyperkalaemia, T wave changes may occur. However their sensitivity and specificity is not as reliable as measurement of serum potassium on a biochemistry analysis.
**Approach to ECG interpretation**

Once a good quality trace has been obtained, a logical and systematic approach can then be employed to interpret the ECG.

To help with ECG analysis there are 6 basic questions that need to be followed:

1. What is the heart rate (bradycardia? normal? tachycardia?)?
2. What is the rhythm (regular, regularly irregular, irregular)?
3. Is there a QRS complex for every P wave?
4. Is there a P wave for every QRS complex?
5. Are they consistently and reasonably related?
6. What is the morphology of the QRS complex (narrow and upright or wide and bizarre)?

This approach should be followed every time an ECG is interpreted, and practice will make this process a lot easier!

**1. What is the heart rate (HR)?**
A lot of machines will record the HR automatically, however this should not be relied on. A quick method of calculating the HR is to measure a 6 second interval (15cm at a paper speed of 25mm/s, or 30cm at a paper speed of 50mm/s), count the number of QRS complexes within this period and multiply by 10 to reach number of beats per minute.

<table>
<thead>
<tr>
<th>Bradycardia</th>
<th>Normal</th>
<th>Tachycardia</th>
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</thead>
<tbody>
<tr>
<td>Sinus bradycardia</td>
<td>Sinus rhythm</td>
<td>Sinus tachycardia</td>
</tr>
<tr>
<td>Sinus arrest</td>
<td>Sinus arrhythmia</td>
<td>Atrial fibrillation</td>
</tr>
<tr>
<td>Atrioventricular (AV) block</td>
<td>Atrial fibrillation</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>Atrial standstill</td>
<td>AV block</td>
<td>Ventricular premature complexes (VPCs)</td>
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<td></td>
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<td>Supraventricular premature complexes (SVPCs)</td>
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<td></td>
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<td>Supraventricular tachycardia</td>
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</table>

**2. What is the rhythm?**
A sinus rhythm is a normal heart rhythm where a P wave is consistently followed by a QRS-T complex. Sinus arrhythmia is regularly irregular, because it always has a P wave (although this may vary in amplitude), followed by a normal QRS complex, but the rate can vary. It is associated with high vagal tone and often corresponds with respiration, particularly in dogs. It
is rarely seen in cats but occasionally can be seen in cases of upper respiratory tract obstruction or ethylene glycol poisoning.

<table>
<thead>
<tr>
<th>Regular</th>
<th>Regularly irregular</th>
<th>Irregular</th>
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<tbody>
<tr>
<td>Sinus rhythm</td>
<td>Sinus arrhythmia</td>
<td>Sinus arrest</td>
</tr>
<tr>
<td>Sinus bradycardia</td>
<td>2(^{nd}) deg AV block</td>
<td>Atrial standstill</td>
</tr>
<tr>
<td>3rd deg AV block</td>
<td>Bigeminy/trigeminy</td>
<td>Atrial fibrillation</td>
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<tr>
<td>Supraventricular tachycardia</td>
<td>SVPCs</td>
<td>VPCs</td>
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3. 4 & 5. What is the P and QRS relationship?
As already discussed, every P wave should be followed by a QRS complex, and there should be a consistent relationship between them both at all times.

6. What is the morphology of the QRS complex?
If there are any normal sinus complexes they should be examined so that any abnormal complexes can be compared to them. If there is anything that does not look like a normal sinus complex, consider in what way it is abnormal. If it
is narrow and upright then it will be predominantly atrial or supraventricular in origin, i.e. arising from above the ventricles – either in the atria, the atrioventricular junction or the bundle of His, or if it is wide and bizarre then it will be either ventricular in origin or conducted abnormally through the ventricles.

**Why does ECG interpretation matter?**
Accurate interpretation of an ECG means that arrhythmias can be treated in an appropriate and timely manner.

Severe arrhythmias may result in haemodynamic compromise which can cause clinical signs or sudden death. The 3 arrhythmias that are immediately life threatening and require urgent attention are cardiac arrest rhythms. These are:

- Asystole (no QRS complexes)
- Pulseless electrical activity (ECG rhythm present, but no discernable pulses)
- Ventricular fibrillation (erratic, irregular ventricular depolarisations)

Less severe arrhythmias may not require immediate intervention, however some can be a precursor of more severe arrhythmias. There are some arrhythmias that need urgent treatment because they are haemodynamically unstable. These are:

- Ventricular tachycardia – These arrhythmias are unstable because they are either too fast (>160 beats/minute) for proper and organized ventricular contraction or they are firing from many different foci within the ventricles and have a varied appearance on ECG.
- Supraventricular arrhythmias – These are usually associated with structural heart disease and are haemodynamically unstable when very fast (>250-300 beats/minute). These arrhythmias can be life threatening when associated with heart failure.
- Atrioventricular block – 3rd degree AV block is potentially life threatening because they can be haemodynamically and electrically unstable when very slow (e.g. <40 bpm)

The veterinary nurse is often in a position to record ECG traces. It is therefore important that correct technique is followed so that all traces are of good quality to save time and misdiagnosis. A nurse that can alert the veterinary surgeon to arrhythmias of clinical significance is exceedingly helpful to any practice, as well as making the job much more rewarding. With practice, the 6 questions can become part of a systematic and logical approach to ECG interpretation, which will make the ECG much less daunting.

**Suggested reading:**