Electrocardiography Workshop

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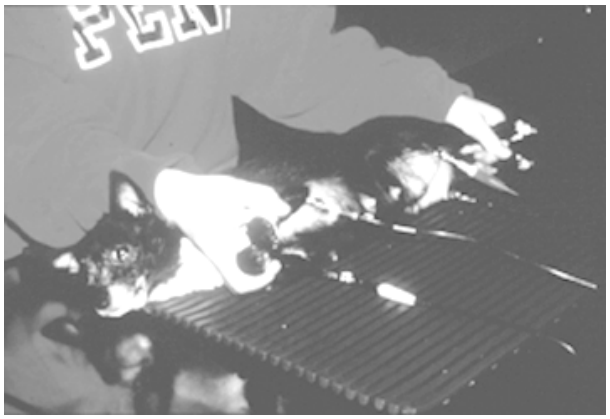
Uses of ECG

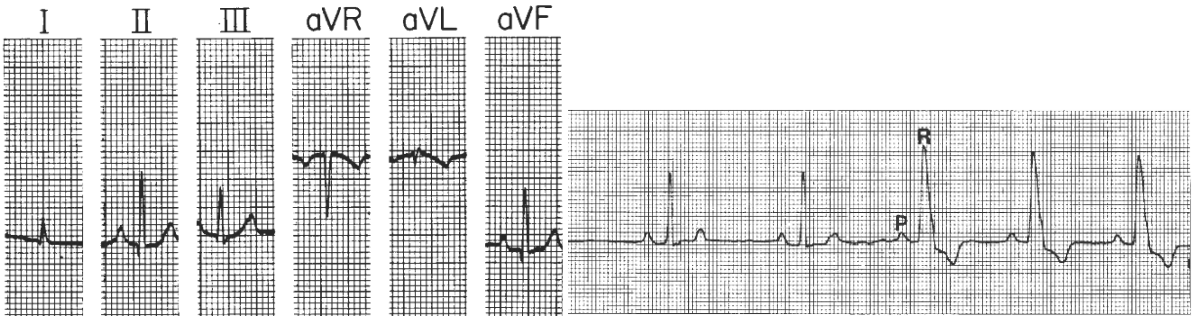
- Monitoring of animals under general anaesthesia
- Assessment / monitoring of acutely ill emergency / trauma patients
- Aid to diagnosis of auscultated cardiac abnormalities (*e.g.,* tachycardia, bradycardia, dysrhythmia, murmurs, abnormally quiet, dull or displaced heart sounds)
- Aid to diagnosis of patients with obscure lethargy, exercise intolerance, weakness, syncope, seizure-like events
- Base-line assessment and onward monitoring of animals with cardiac disease as determined by history, physical examination, chest radiographs, ±echocardiography
- Recheck assessments of animals receiving potent cardiac medications
- Routine pre-anaesthetic assessment (±)
- Routine, geriatric health check (±)

N.B. ECG does not replace the need for thorough, repeated physical examinations of ill cardiac patients and monitoring of parameters such as rectal temperature, respiratory rate and effort, mucous membrane temperature, colour and capillary refill time, appetite and thirst, attitude, exercise tolerance and general 'energy level'. The client's perceptions of their animal's attitude and energy levels are often very informative.

Recording the ECG



- Interpretation is easiest if animals are always positioned in the same way
- Conventional approach is right lateral recumbency, 4 limb leads. However, sternal is sometimes safer. Avoid doing it standing or sitting, if possible.
- Can do a cat in its basket / cage, if it is fractious, frightened, struggling. ± use pink pegs.
- Crocodile clips or short-term, sticky pad electrodes for longer-term monitoring. Bend the crocodile jaws so they grip, but not too tightly. May need to clip the fur any apply ethanol to achieve good electrical contacts
- A basic study would include lead II rhythm strip (30-60 secs) at 25 or 50mm/sec and a few seconds of each of 6 leads (I, II, III, aVR, aVL, aVF) at 25 or 50mm/sec (typically @ 1 cm=1 mV sensitivity).

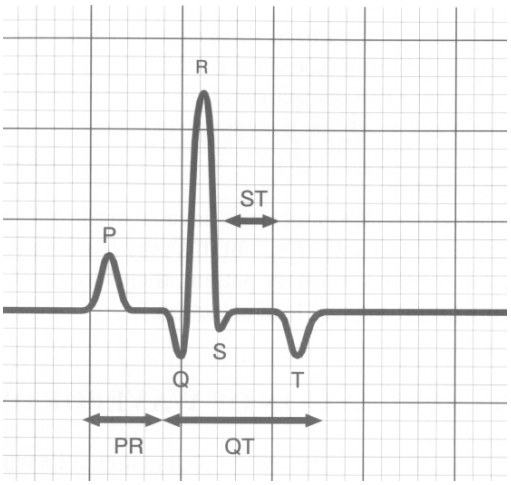


Troubleshooting

- Alternating current (AC) interference @ 50-60 Hz. If severe enough, you could check the machine is running on its battery, try switching off nearby electrical appliances and striplights, placing the patient and/or ECG machine on a rubber mat, or doing the ECG in another room.

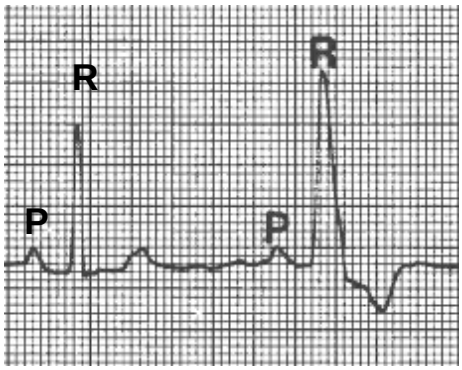
- Complexes look all wrong (say, negative in lead II). Could be due to cardiac disease, but it is always wise to double check that the leads are placed on the correct limbs.
- Interference or small complexes due to poor electrical contact(s). Often appears as an abnormally thick or wavering baseline. Could be due to inadequate clipping of fur, inadequate application of coupling gel or surgical spirit. Could be due to dirty or corroded clips, leading to poor electrical contact between the clip and the lead. Clean the clips, clean off / dissolve the rust, buy new clips and / or leads.
- Muscle tremors, panting, gross movement artefacts. Calm the patient down or try again later. Only if absolutely necessary, chemically restrain the patient. Reassess the need for an ECG before doing this.
- Also for movement artefact, or if the complexes are too small, try moving the clips more proximally on the limbs. Typically, the electrodes are attached over the olecranons on the forelimbs and at the level of the stifle on the hind limbs.
- If the complexes are too small, check the filter option is not selected unnecessarily.

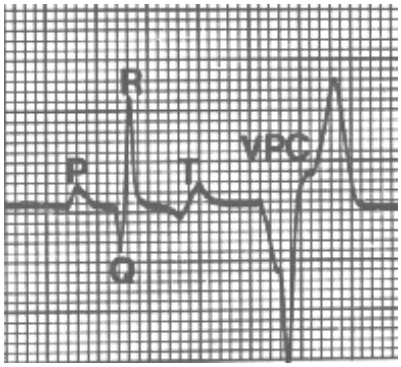
Interpretation



1. A methodical, stepwise approach is essential: it helps you avoid missing things.

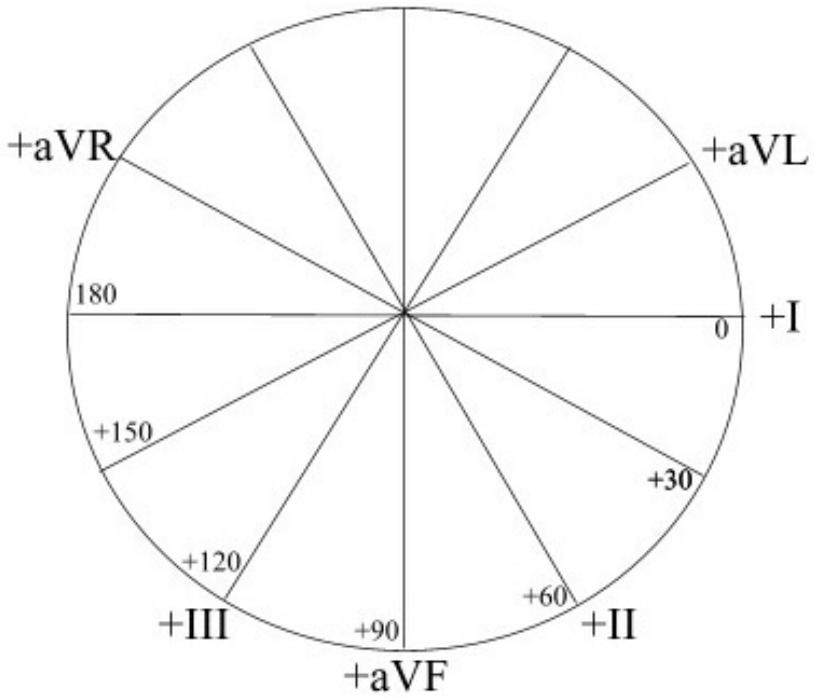
2. What is the heart rate? Is it abnormally high or low? If it varies enormously along the strip, take a few measurements at different places
   At 25 mm/sec, 15 large squares=3 seconds. Count the beats in 3 secs and multiply by 20
   At 50 mm/sec, 30 large squares=3 seconds. Count the beats in 3 secs and multiply by 20
3. Is the underlying rhythm regular, regularly irregular, or irregularly irregular?
   Remember sinus arrhythmia is normal in dogs, usually regularly irregular
4. Are there periods of marked tachycardia or bradycardia interspersed within a normal-looking rhythm, or is the whole strip roughly the same throughout?
   Could have a paroxysmal problem
5. Is there a P wave for every QRS and a QRS for every P?
   P waves without QRS: think about heart block
   QRS without P waves: think about atrial fibrillation
6. Are all of the QRS complexes upright and narrow (*i.e.,* normal) or are some wide and bizarre?
   Think about intraventricular conduction disturbances, VPCs, intermittent BBB





7. Are the different parts of the PQRST complex of normal size and duration?
   Could point to heart block, atrial enlargement, pericardial effusion

8. What is the mean electrical axis?



The mean electrical axis

The mean electrical axis (MEA) is a tool for determining whether there is an enlargement of the right or left ventricles or a conduction abnormality such as a bundle branch block. The two most reliable ways of determining the MEA is by finding the isoelectric lead or by calculating and plotting the lead I and III vectors.

Finding the MEA by the isoelectric lead technique…

- Which is the isoelectric lead?
- Which lead is perpendicular to the isoelectric lead?
- Is this lead positive or negative?
- If it is positive then the MEA is directed towards the positive end of the isoelectric lead. If it is negative it is directed away from the positive end of the isoelectric lead.

Finding the MEA by the vector technique…

- Use this technique if there is no isoelectric lead.

- In lead I, subtract the height (in small boxes) of the negative deflection from the height (in small boxes) of the positive deflection of the QRS complex.
- In lead III, subtract the negative deflection from the positive deflection of the QRS complex.
- Mark off the net values obtained from the above from the centre of the circle field diagram along leads I and III.
- Draw perpendicular lines from these points.
- The intersection of the perpendicular lines represents the direction of the MEA.

Measure the complexes and the intervals

P wave width and height

- Tall P waves (>0.4 mV) in lead II indicate right atrial enlargement. This is also termed ***P pulmonale*** because it commonly occurs with chronic pulmonary disease.
- Wide P waves (>0.04 s) are seen in left atrial enlargement. This is also termed ***P mitrale*** because it is seen commonly in mitral insufficiency.
- Absent P waves are seen in atrial standstill (usually associated with a bradycardia) or in atrial fibrillation / flutter (usually associated with a tachycardia). In the latter case the normal P waves are replaced by oscillations called f (=flutter) waves which may be coarse (saw-tooth) or very fine (sometimes hard to detect).

P-R interval

- Represents the time required for the impulse to travel from the SA node to the ventricle.
- Measured from the beginning of the P wave to the beginning of the Q wave (R wave if there is no Q wave present).
- Varies with heart rate: the faster the rate, the shorter the interval.
- A prolonged PR interval is called **first degree atrioventricular (heart) block**.
- 1st degree AV block occurs with digitalis intoxication, hyperkalaemia, hypokalaemia and with treatment with some cardiac drugs (*e.g.,* Beta blockers).

QRS complex

- Represents depolarisation of the ventricles.
- Tall R waves and wide QRS complexes represent left ventricular enlargement.
- Low voltage QRS complexes often indicate pericardial effusion.

S-T segment

- Represents the time from the end of the QRS complex to the onset of the T wave (*i.e.,* from the end of ventricular contraction to the onset of ventricular repolarisation).
- We are interested in whether the S-T segment is above (elevated), on, or below (depressed) the baseline or isoelectric line.
- The baseline is taken as between the end of the T wave and the beginning of the next P wave.
- The S-T segment is said to be depressed if it is > 0.2 mV below the baseline and elevated if it is > 0.15 mV above the baseline.

  S-T segment depression can occur with…

  - Myocardial ischaemia (inadequate circulation)
  - Acute myocardial infarction
  - Cardiac trauma
  - Hyperkalaemia
  - Hypokalaemia
  - Digitalis (results in a ‘sagging’ of the S-T segment)

  S-T segment elevation can occur with…

  - Myocardial infarction
  - Pericarditis
  - Myocardial hypoxia (oxygen deficiency)

T wave

- Normally slightly assymetrical.
- Should not be sharply pointed or notched (think electrolyte abnormalities)
- In the cat, should be less 0.3 mV in height.
- In the dog should be less than a quarter of the amplitude of the R wave.

T wave abnormalities commonly occur with…

- Ventricular enlargement
- Electrolyte imbalances (large, spiked T waves in hyperkalaemia)
- Digitalis toxicity
- Anaemia, shock, uraemia, ketoacidosis, hypoglycaemia, fever

Q-T interval

- Represents ventricular depolarisation and repolarisaton (systole).
- The interval is inversely proportional to the heart rate.
- It is not a particularly useful measurement in companion animal medicine.

Limitations of ECGs

- Should only ever be interpreted in light of the clinical picture.
- Cannot be used to definitively diagnose diseases of the valves, coronary arteries, endocardium or pericardium. Typically, cannot reliably evaluate prognosis.
- There is no distinct division between normal and abnormal; don't over-read ECGs!
- Body conformation may alter the accepted standard measurements
- Recordings must be complete and accurate with a stable baseline. This is sometimes more easily said than done!