

BASIC SCIENCES · PHYSIOLOGY

— STUDY NOTES

Veterinary ECG Interpretation

Veterinary ECG interpretation is a skill every clinician can learn, because a rhythm strip only ever shows three things: a **P wave** (the atria depolarising), a **QRS complex** (the ventricles depolarising) and a **T wave** (the ventricles repolarising) — the surface record of the heart's [action potentials](#). Read them with a fixed **six-step method** — rate, rhythm, a P for every QRS, the intervals, the waveform shape, then the axis — and you can name the rhythm in almost any species. This guide covers how the ECG is recorded, the normal complex and its intervals, the systematic approach, the common arrhythmias, and the crucial way ECGs differ between dogs, cats and large animals.

INSIDE THESE NOTES

- What a veterinary ECG records
- The P-QRS-T complex & intervals
- Normal rhythms
- Tachyarrhythmias & ectopics
- When to act
- Recording: leads, Einthoven & calibration
- A systematic read — six steps
- Bradyarrhythmias & AV block
- Species differences

LEVEL

Vets & veterinary students

EDITION

2026-07-02

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CONTENTS

- 1 What a veterinary ECG records
- 2 Recording: leads, Einthoven & calibration
- 3 The P-QRS-T complex & intervals
- 4 A systematic read — six steps
- 5 Normal rhythms
- 6 Bradyarrhythmias & AV block
- 7 Tachyarrhythmias & ectopics
- 8 Species differences
- 9 When to act

LEARNING OBJECTIVES

After working through these notes you will be able to:

- ✓ Explain what a veterinary ECG records and why P, QRS and T correspond to atrial depolarisation, ventricular depolarisation and ventricular repolarisation.
- ✓ Describe how an ECG is recorded — Einthoven's triangle, the bipolar limb leads, paper speed and calibration.
- ✓ Identify the waves, segments and intervals and give the normal canine PR, QRS and QT values.
- ✓ Apply the six-step systematic method to read any rhythm strip and calculate heart rate.
- ✓ Recognise normal sinus rhythm and respiratory sinus arrhythmia, and the ECG appearance of AV block, premature complexes, ventricular tachycardia and atrial fibrillation.
- ✓ Explain why the ECG is used for arrhythmias rather than chamber size in large animals.

TL;DR

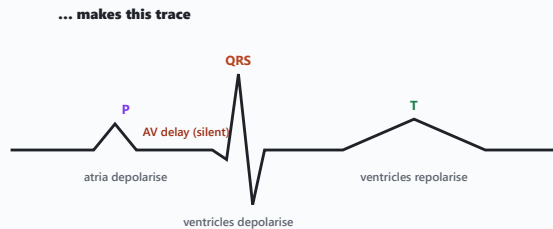
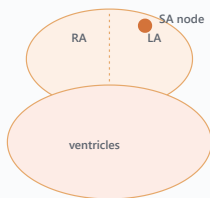
Veterinary ECG interpretation is a skill every clinician can learn, because a rhythm strip only ever shows three things: a **P wave** (the atria depolarising), a **QRS complex** (the ventricles depolarising) and a **T wave** (the ventricles repolarising) — the surface record of the heart's [action potentials](#). Read them with a fixed **six-step method** — rate, rhythm, a P for every QRS, the intervals, the waveform shape, then the axis — and you can name the rhythm in almost any species. This guide covers how the ECG is recorded, the normal complex and its intervals, the systematic approach, the common arrhythmias, and the crucial way ECGs differ between dogs, cats and large animals.

AT A GLANCE

WHAT THE ECG SHOWS	The heart's electrical activity at the body surface — rate, rhythm and conduction, not contraction directly
THE THREE WAVES	P = atrial depolarisation · QRS = ventricular depolarisation · T = ventricular repolarisation
WHY NO ATRIAL T WAVE	Atrial repolarisation is slow, small and hidden inside the QRS — it makes no visible wave
THE INTERVALS	PR (~0.13 s dog) = AV conduction · QRS (<0.1 s) = ventricular depol · QT (~0.2 s) ≈ ventricular AP
RECORDING	Einthoven's triangle, bipolar leads I/II/III (+ aVR/aVL/aVF); 25 or 50 mm/s; 1 mV = 10 mm
THE METHOD	A fixed 6-step read: rate → rhythm → P-for-every-QRS → intervals → morphology → axis
NORMAL VARIANTS	Normal sinus rhythm & respiratory sinus arrhythmia (normal in dogs)
KEY ARRHYTHMIAS	AV block (1°/2°/3°), APCs/VPCs, SVT, ventricular tachycardia, atrial fibrillation
SPECIES POINT	Large-animal ECG waves vary a lot → use it for arrhythmias, not chamber enlargement

01 What a veterinary ECG records

- **The ECG is a surface graph of the heart's electrical activity** — the spreading action potentials, not contraction. It records only a **moving dipole**; when the heart is uniformly at rest or depolarised the trace is **flat (isoelectric)**.
- **Three waves:** **P** = atrial depolarisation · **QRS** = ventricular depolarisation · **T** = ventricular repolarisation. Atrial repolarisation makes no wave (small, slow, hidden in the QRS).

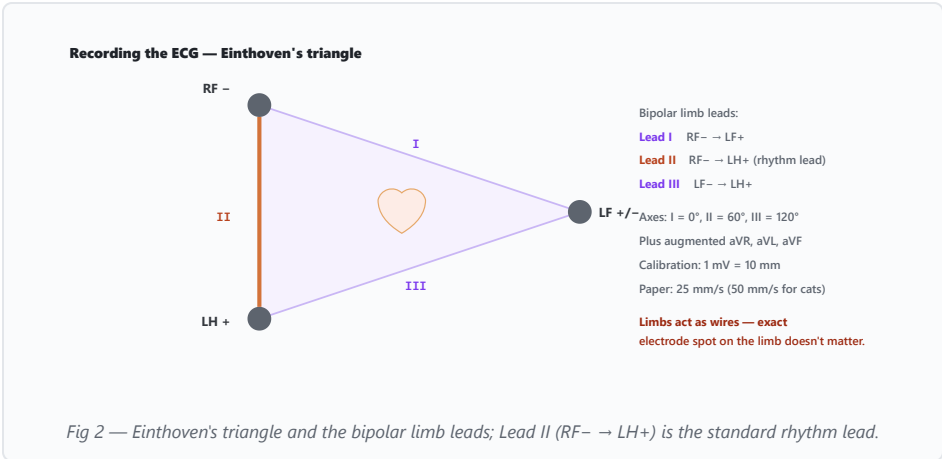


The AV node, bundle and Purkinje fibres are too small to make their own waves — they show only as the flat PR segment.

Fig 1 — Atrial depol → P, AV delay (silent), ventricular depol → QRS, ventricular repol → T.

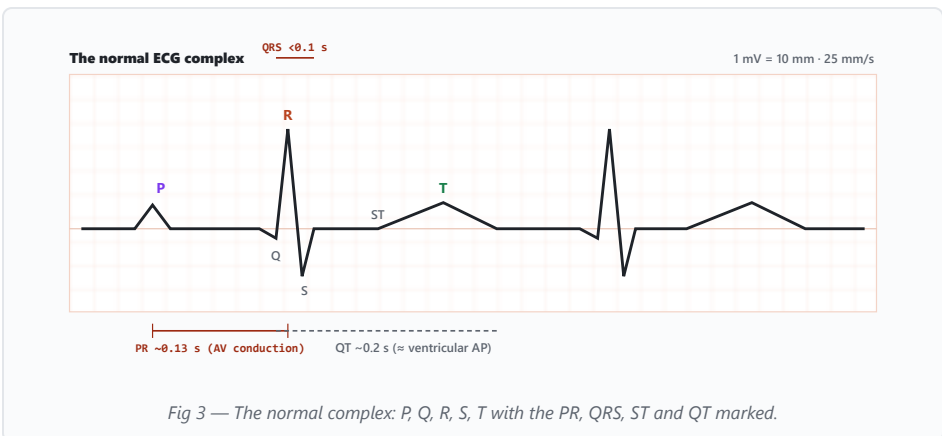
02 Recording: leads, Einthoven & calibration

- **Einthoven's triangle** = the two forelimb + one hind-limb electrodes. Bipolar limb leads: **I** (RF- → LF+), **II** (RF- → LH+, the rhythm lead), **III** (LF- → LH+); plus augmented aVR/aVL/aVF.
- **Calibration:** 1 mV = 10 mm. **Paper speed:** 25 mm/s (50 mm/s for fast hearts like cats). Limbs act as wires — the exact electrode spot doesn't matter.



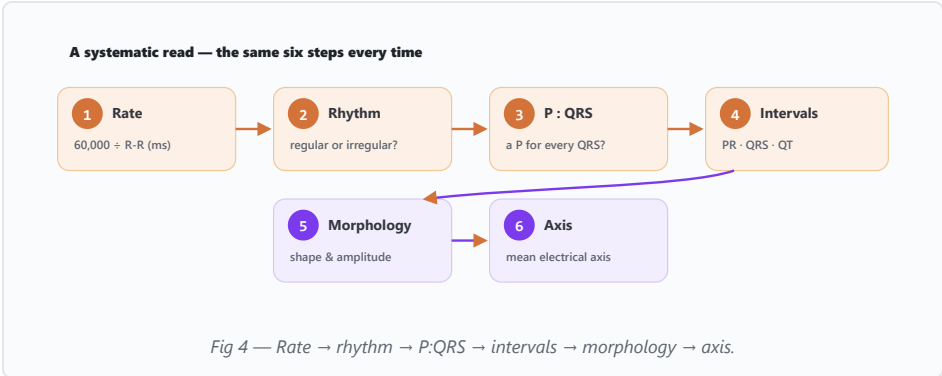
03 The P-QRS-T complex & intervals

- **P** (atria) · **QRS** = **Q** (septum) + **R** (big, positive — LV mass + leftward axis) + **S** · **T** (repolarisation; normally + or -).
- **Intervals:** **PR** ~0.13 s (AV conduction) · **QRS** <0.1 s (ventricular depol) · **QT** ~0.2 s (≈ ventricular AP). An **ST** shift = ischaemia/injury.
- **Heart rate** = 60,000 ÷ R-R (ms). In a normal heart, atrial rate = ventricular rate.



04 A systematic read — six steps

- **1 Rate** → **2 Rhythm** (regular?) → **3 P for every QRS?** → **4 Intervals** (PR/QRS/QT) → **5 Morphology** (shape) → **6 Axis**.
- The first three steps identify most arrhythmias on their own. Same drill every trace.



05 Normal rhythms

- **Normal sinus rhythm:** regular, a P before every QRS, fixed PR, narrow QRS.
- **Respiratory sinus arrhythmia = NORMAL in dogs:** rate rises on inspiration (vagal), disappears on exercise. Underlying complexes are normal — benign.

06 Bradyarrhythmias & AV block

- **Sinus bradycardia** (slow but normal); SA arrest / sick sinus (pauses, no P).
- **AV block:** **1°** = long PR (all conduct) · **2°** = some P not followed by a QRS (dropped beat) · **3°** = complete AV dissociation, ventricles on a slow escape (~20–40 bpm in a dog).

07 Tachyarrhythmias & ectopics

- **APC** = early P + normal QRS. **VPC** = early, **no P, wide/bizarre** QRS + compensatory pause. A sustained run = **ventricular tachycardia** (emergency).
- **Atrial fibrillation:** **no P waves**, low f-wave baseline, **irregularly irregular** QRS. Common in horses & big dogs; quinidine converts.



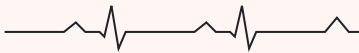
Fig 5 — Normal sinus · sinus arrhythmia · 2° AV block (dropped QRS) · atrial fibrillation · ventricular tachycardia.

08 Species differences

- **Large-animal rule:** the ECG reads **arrhythmias, not chamber size**. In horses/cattle wave shape varies between individuals (less-consistent depol paths) — unreliable for hypertrophy, but excellent for rhythm (any lead with clear P-QRS-T).
- **Resting HR:** dog 60–170, cat 140–220, horse 28–44, cattle 60–80. A resting horse's dropped beat (physiological 2° AV block) is normal.

Reading ECGs across species

Dog / cat — consistent shape



Horse / cattle — varies a lot



Resting heart rate (bpm)

Dog	60–170
Cat	140–220
Horse	28–44
Cattle	60–80

In large animals the ECG reads **ARRHYTHMIAS, not chamber size**.

Depolarisation takes less-consistent paths, so wave shape/amplitude vary between individuals. Unreliable for hypertrophy — but the event sequence is constant, so rhythm diagnosis is excellent.

Fig 6 — Dog/cat complexes are consistent; horse/cattle vary. Resting rates + the large-animal caveat.

09 When to act

- Emergencies: **ventricular tachycardia, complete AV block**, symptomatic bradycardia, or any arrhythmia with **collapse / weakness / a pulse deficit** — ECG, stabilise, refer.

RED FLAG

Ventricular tachycardia, complete AV block, a sudden fixed bradycardia, or any arrhythmia with collapse or a pulse deficit is an emergency — obtain an ECG, stabilise and refer for rate/rhythm control or pacing.

Read every ECG the same way — rate, rhythm, a P for every QRS, then intervals, shape and axis — and the rhythm names itself.

— after Cunningham 6e Ch 20 & PDA 3e Ch 11.

KEY TERMS — QUICK GLOSSARY

ECG (electrocardiogram)

A body-surface graph of the voltage changes produced as action potentials spread through the heart.

P wave

Atrial depolarisation.

QRS complex

Ventricular depolarisation; the R wave is the large positive deflection (left-ventricular mass + leftward axis).

T wave

Ventricular repolarisation; may be positive or negative normally, and varies between animals.

PR interval

Start of P to start of QRS — AV-node conduction time (~0.13 s in a dog; <0.14 s).

QRS duration

Time for the ventricles to depolarise (<0.1 s); widened when conduction is slowed.

QT interval

Start of Q to end of T (~0.2 s) — approximates the ventricular action-potential duration.

ST segment

The flat period when the ventricle is uniformly depolarised; shifts with myocardial ischaemia/injury.

Einthoven's triangle

The frontal-plane triangle of the two forelimb and one hind-limb electrodes around the heart.

Lead II

Bipolar lead with the right forelimb negative and the left hind limb positive; the standard rhythm lead.

Mean electrical axis

The average direction of the ventricular depolarisation vector (dog ~70°; cat 0–160°).

Sinus arrhythmia

A normal, vagally-driven cyclic change in rate (faster on inspiration) — common in dogs.

AV block

Impaired AV conduction: 1° (long PR), 2° (some P not conducted), 3° (complete AV dissociation).

Atrial fibrillation

Chaotic atrial activity: no P waves, low f-wave baseline, and an irregularly-irregular QRS rhythm.

QUICK REVISION — REMEMBER THESE

- 1 **Veterinary ECG interpretation** rests on three waves: the **P wave** is atrial depolarisation, the **QRS complex** is ventricular depolarisation, and the **T wave** is ventricular repolarisation — the surface trace of the heart's action potentials.
- 2 The ECG records only **spreading** depolarisation or repolarisation (a moving electrical dipole); when the heart is uniformly at rest or uniformly depolarised the trace is **flat (isoelectric)**.
- 3 Read the **intervals**: the **PR interval** (~0.13 s in a dog) is AV-node conduction time, the **QRS** (<0.1 s) is ventricular depolarisation, and the **QT** (~0.2 s) approximates the ventricular action-potential duration.
- 4 Use a fixed **six-step method** on every trace — **rate, rhythm, a P for every QRS, the intervals, the waveform shape, then the axis** — and the rhythm names itself.
- 5 **Lead II** (right fore negative, left hind positive) is the everyday rhythm lead; standard paper speed is 25 or **50 mm/s** (faster for cats), and 1 mV calibrates to 10 mm.
- 6 Learn the pattern of each arrhythmia: **AV block** (long PR, dropped or dissociated QRS), **premature complexes** (early beats, wide for ventricular), and **atrial fibrillation** (no P waves, an *irregularly irregular* QRS).
- 7 In **large animals** the ECG waveforms vary widely between individuals, so the ECG is used to diagnose **arrhythmias, not chamber enlargement** — unlike in dogs and cats.

MEMORY AIDS

P-QRS-T — **P** = atria depolarise · **QRS** = ventricles depolarise · **T** = ventricles repolarise. Atrial repol is hidden in the QRS.

Rate-Rhythm-Relationship — The read: **Rate** → **Rhythm** → **Relationship** (P for every QRS) → then intervals, shape, axis. Three R's first.

PR = AV, QT = AP — **PR** interval = AV-node conduction time. **QT** interval ≈ the ventricular **Action Potential** duration.

AF = no P, irregularly irregular — **Atrial fibrillation** = **no P waves + irregularly irregular** QRS. The classic 'chaotic baseline, random beats'.

Big animals = rhythm only — In horses/cattle the ECG reads **arrhythmias, not chamber size** (variable depolarisation paths). Any lead with clear P-QRS-T will do.

TEST YOURSELF — ACTIVE RECALL

Cover the answers and try to retrieve each one from memory first — self-testing beats re-reading.

1. What do the P wave, QRS complex and T wave represent on a veterinary ECG?
2. Why is the ECG flat (isoelectric) between waves?
3. Give the normal canine PR, QRS and QT values and what each represents.

4. List the six steps of a systematic ECG read.
5. How do you calculate heart rate from a strip, and what is Lead II?
6. How does atrial fibrillation look on an ECG, and why is the rhythm irregular?
7. Contrast first-, second- and third-degree AV block on the ECG.
8. Why is the ECG used for arrhythmias rather than chamber size in horses and cattle?

ANSWERS

1. P = atrial depolarisation; QRS = ventricular depolarisation; T = ventricular repolarisation. (Atrial repolarisation makes no visible wave — it is slow, small and hidden within the QRS.)
2. Because the ECG only records a moving dipole — spreading depolarisation or repolarisation. When the whole myocardium is uniformly at rest or uniformly depolarised there is no net dipole, so no voltage is recorded.
3. PR \sim 0.13 s (<0.14 s) = AV-node conduction time; QRS <0.1 s = ventricular depolarisation; QT \sim 0.2 s = start of ventricular depolarisation to end of repolarisation (\approx ventricular action-potential duration).
4. 1) Rate; 2) Rhythm (regular or irregular?); 3) Is there a P for every QRS and a QRS for every P?; 4) Measure the intervals (PR, QRS, QT); 5) Waveform morphology (shape/amplitude); 6) Mean electrical axis.
5. Rate (per min) = 60,000 ms \div the R–R interval in ms (or count QRS in 6 s \times 10). Lead II is the bipolar limb lead with the right forelimb negative and the left hind limb positive — the standard rhythm lead.
6. No discernible P waves (replaced by a low-amplitude f-wave baseline) and normally-shaped QRS complexes that are irregularly irregular — because the fibrillating atria bombard the AV node with random impulses, some conducted and some blocked by its refractory period.
7. 1°: every P conducts but the PR interval is abnormally long. 2°: some P waves are not followed by a QRS (dropped beats). 3° (complete): no relationship between P waves and QRS — AV dissociation, with the ventricles driven by a slow escape pacemaker.
8. In large animals cardiac depolarisation follows less-consistent paths, so wave polarity and amplitude vary widely between individuals — unreliable for detecting hypertrophy/enlargement. But the sequence of electrical events is consistent, so the ECG is excellent for detecting and characterising arrhythmias.

WHEN TO REFER OR ESCALATE

- Sustained **ventricular tachycardia** (fast, wide, bizarre QRS), or beats landing on the previous T wave — a pre-fibrillation emergency; treat and refer urgently.
- **Complete (third-degree) AV block** or a symptomatic fixed bradycardia (e.g. a dog at \sim 30–40 bpm) — often needs a pacemaker; refer.
- An **irregularly-irregular** rhythm with a pulse deficit (atrial fibrillation) — work up the underlying heart disease and refer for rate control or conversion.
- Any arrhythmia with **collapse, syncope, weakness or exercise intolerance** — a cardiac emergency; stabilise and refer.
- Frequent premature complexes (APCs/VPCs) — characterise them on a full ECG and investigate the cause before treating.

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