Veterinary Bioscience: Cardiovascular System

WEEK 1 – THE HEART IN THE THORAX

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INTENDED LEARNING OUTCOMES

It is hoped that this lecture will facilitate your understanding of the physiological basis of the electrocardiogram (ECG), and the electrical basis of some commonly occurring arrythmias. In particular, at the conclusion of this lecture you should be able to:

- Describe the cellular
- Describe the concept of Einthoven's triangle, vector analysis and the mean electrical axis of the heart.
- State the relationship between the electrical events of cardiac excitation and the P, QRS, and T waves, the PR interval and the ST segment of the electrocardiogram.
- Define the terms arrythmia, bradycardia, and tachycardia, flutter, fibrillation, and AV block, and understand in general terms, their mechanisms.

KEYWORDS

Electrocardiogram, (ECG) Einthoven's triangle, arrythmia, bradycardia, tachycardia , fibrillation, AV block.

LECTURE 5 – OBSERVING THE ELECTRICAL ACTIVITY OF THE HEART

The extracellular fluids contain salts, and therefore conduct electricity. As ECF is distributed throughout the body, the body acts as a volume conductor. When cardiac muscle depolarises, extracellular currents between depolarised and resting cells cause potentials that can be measured at the body surface.

The wave front of depolarisation can be thought of as a series of electrical dipoles (regions of charge separation). Each individual dipole is orientated in the direction of local wavefront movement. The net dipole movement at any instant in time points in the general direction of wavefront movement at that instant.

- The magnitude of the dipole depends on
- how many cells are depolarising at that instant vector analysis of simultaneous dipoles

THE EINTHOVEN HYPOTHESIS IS BASED ON THE FOLLOWING:

- electrical forces of the heart originate in a relatively small area at the centre of a homogenous volume conductor
- the regions where each arm and the legs join the trunk are points equidistant from each other
- the extremities behave as linear conductors connected to the trunk, so that an electrode placed anywhere on an extremity is equivalent to one placed at the junction with the trunk.
- electrodes placed on each arm and a leg are then considered to be located at the apices of an equilateral triangle, with the heart at its centre.
- differences in potential recorded between these points represent the projection of vector forces originating from a dipole at the centre of the triangle, onto lead lines drawn between its apices.

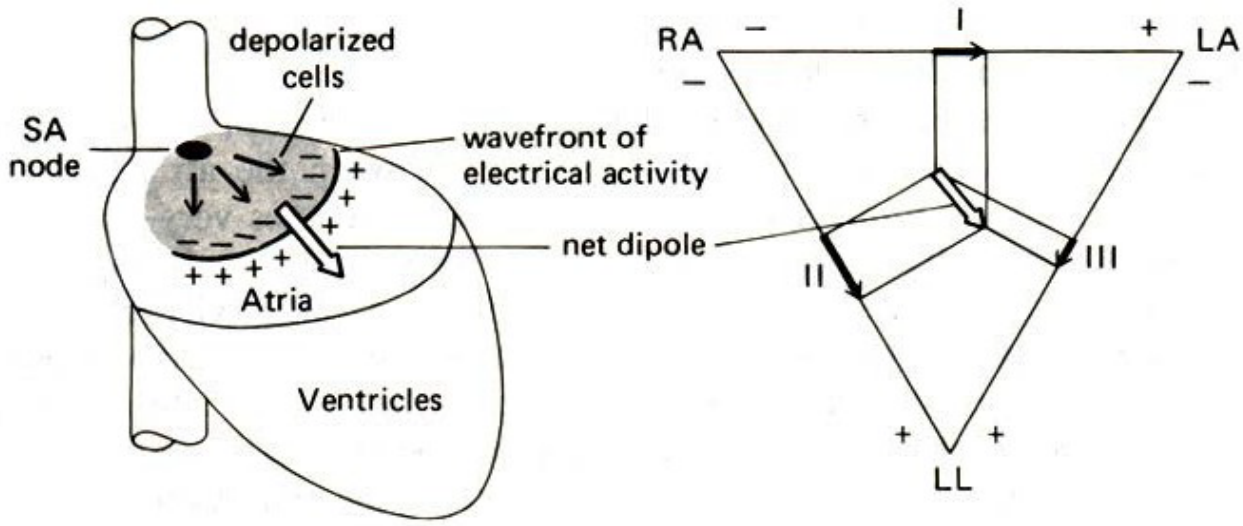
The Standard bipolar limb leads of the ECG approximate potential difference across the sides of Einthoven's triangle, and essentially look at the electrical activity of the heart from three different directions, separated by 60^0.

Lead 1 right arm -ve, left arm +ve

Lead 2 right arm -ve, left leg +ve

Lead 3 left leg +ve, left arm –ve

By convention, positive current flow indicates current flow from negative to positively charged area. The trace records the *difference* in potential between the two leads. Einthoven arranged the polarity of lead 2, so that ventricular activation would produce a positive deflection in all three leads of most normal records.



LIMITATIONS OF EINTHOVEN'S HYPOTHESIS

The body does not form a true homogenous electrical conductor, so dispersion of electrical currents is not uniform.

In addition, the heart is often not in the centre of an equilateral triangle, so recording electrodes are not equidistant from the heart.

Finally, in quadrupeds limb arrangement is much less like an equilateral triangle, the anatomical attachment of forelimbs to the body is different so that moving the limbs may alter the amplitude and direction of potentials. For all of these reasons the ECG trace produced in animals is less reliable than that produced in humans.

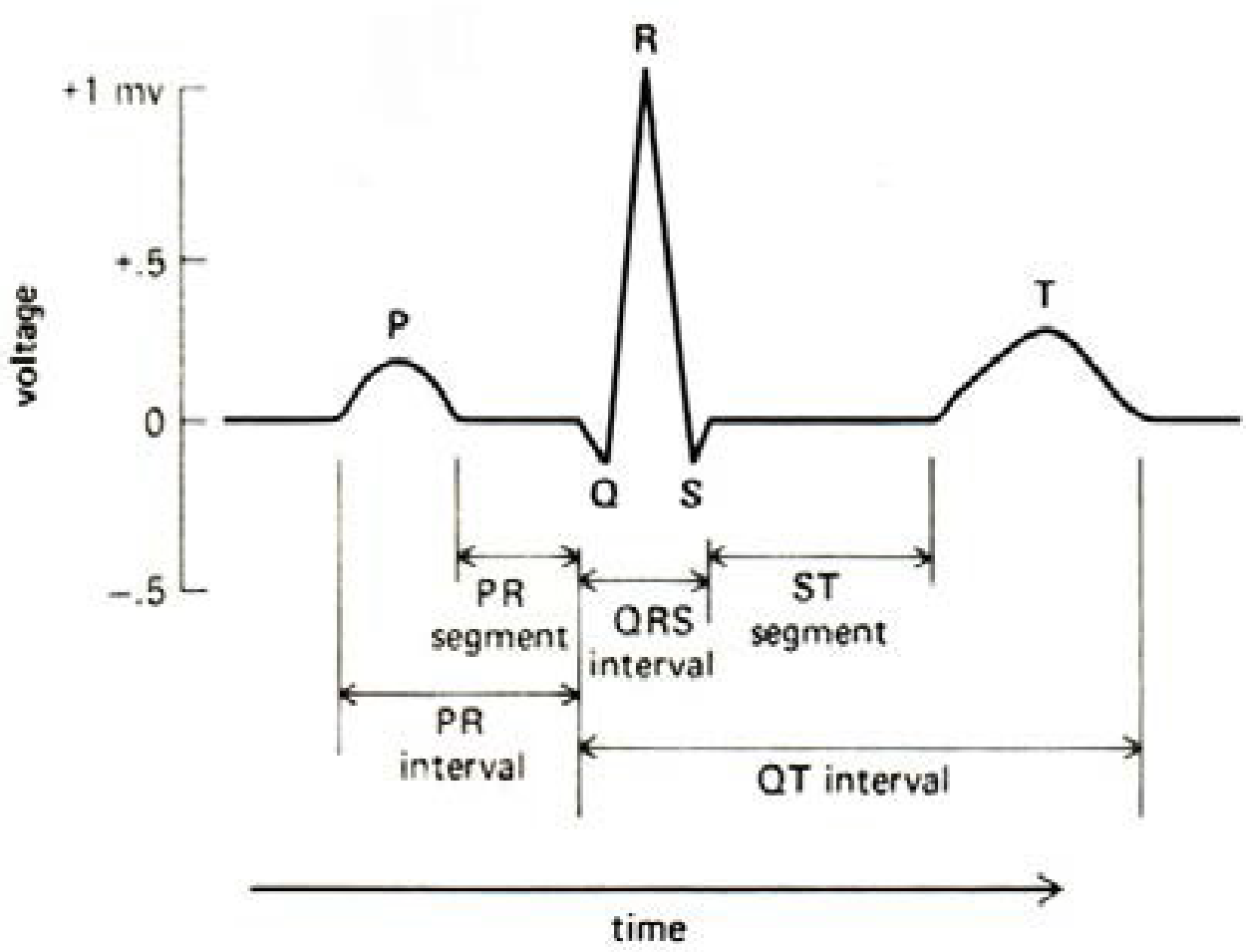
GENERAL FEATURES OF THE ECG

The ECG trace represents the net depolarisation and repolarisation of the heart over time. The shape of the trace depends on the net direction of the wave front of depolarisation, and the amount of tissue that is depolarising.

It has three main components:

- P wave depolarisation

- QRS complex ventricular depolaristation
- T Wave ventricular reolarisation



The wave form of the ECG trace represent the net vector of depolarisation and repolarisation of the heart over time.

The shape of the trace depends on the net direction of the wave front of depolarisation, and the amount of tissue that is Depolarising

P-R Segment and S-T segment: are normally iso-electric i.e. no current flowing because tissue (either atria or ventricles) are either all depolarised or all at rest

P-R interval: delay between atrial and ventricular depolarisation, dt delay in AV node. Prolongation suggests atrial damage or AV block

S-T segment: plateau of ventricular muscle action potential

T wave: is extremely variable in domestic animals. Can be positive, negative or notched in normal animals.

MEAN ELECTRICAL AXIS OF THE HEART

The orientation of the ECG vector at its maximum amplitude is called the electrical axis of the heart. It corresponds to depolarisation of the main mass of the ventricles. The mean electrical axis will be altered by change in the position of the heart, increase in the mass of one of the ventricles (e.g left ventricular hypertrophy leads to left axis deviation). Mean electrical axis can be calculated by mathematical analysis of three bipolar leads.

CARDIAC ARRYTHMIAS

An arrythmia is an alteration in normal rate or rhythm. The ECG can be used to identify arrythmias.

ALTERED SINUS RHYTHMS – ALTERATIONS IN RATE OF SA NODE DISCHARGE

- Sinus bradycardia - due to increased vagal tone- seen during sleep and in the well trained athlete
- Sinus tachycardia - acceleration of heart rate- due to release from vagal tone and increased sympathetic tone, that is normal during exercise, anxiety states, fever etc
- Sinus arrythmia - variations in heart rate synchronous with respiration, due to alterations in vagal tone on SA node with respiration – normal in dogs. HR increases towards end of inspiration, decreases towards end of expiration, disappearing with increasing HR.

ABNORMAL RHYTHMS RESULTING FROM BLOCK IN IMPULSE CONDUCTION

Sino-atrial Block - impulse blocked before it enters the atrial muscle. This results in cessation of P waves. The ventricle picks up new rhythm so that QRS and T are not altered. This may be due to action of vagus nerve on SA node, (or potassium disturbance).

Atrio-ventricular Block - impeded conduction through the AV node, that may vary in degree.

First degree block - unusually slow conduction through AV node, detected by abnormally long PR interval Second degree block - some but not all impulses are transmitted through the AV node. The atrial rate is often faster than ventricular by a certain rate (e.g.2:1, 3:1)

Third degree block - complete block, with complete dissociation of P wave and QRS complex. An area of conducting tissue in the ventricles (often in bundle branch) assumes pacemaker role. The ventricular rate likely to be slower than normal

ABNORMAL RHYTHMS CAUSED BY PREMATURE BEATS

Premature atrial contractions are caused when an area in the atria escapes normal pacemaker domination and becomes an ectopic pacemaker. This causes early and irregular contraction that may or may not be followed by a ventricular contraction.

Ventricular premature contractions (VPC's) can also occur- not preceded by P wave. These are quite common in small animals and are often followed by missed beat as muscle is still refractory when normal impulse emerges. The premature beat has a reduced stroke volume, the delayed beat larger than normal stroke volume, due to increased ventricular filling.

Paroxysmal Tachycardia is a tachycardia arising from an ectopic site in the heart, with an onset and termination that are normally abrupt.

Paroxysmal Atrial Tachycardia (supra ventricular tachycardia) as tachycardias arising from atria and AV node are indistinguishable. Paroxysmal Ventricular Tachycardias develop as a result of ectopic pacemaker in the ventricle. This is much more serious than atrial tachycardia, as ventricular filling and contraction is impaired. Ventricular tachycardia may progress to fibrillation

FIBRILLATION REFERS TO COMPLETELY DISORDERD CONDUCTION PATTERN IN EITHER THE ATRIA OR VENTRICLES.

Atrial fibrillation leads to an irregular ventricular rhythm, with an absence of P waves on ECG trace. It is compatible with life (because atrial contraction not necessary for ventricular filling) and can be reversed by drugs

Ventricular fibrillation is much more serious. It may result from electric shock, major myocardial infarction, (loss of blood supply) certain anaesthetic agents, handling the heart during surgery. It results in loss of consciousness within a few seconds and requires resuscitation with electric shock. This places the entire myocardium in a refractory state and gives SA node chance to take over as pacemaker again

FURTHER READING

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