9 • Mean electrical axis (MEA) explained

Although depolarisation waves spread through the heart in 'all directions', the average direction and magnitude is represented by the QRS complex. If the QRS is predominantly positive (upwards), the average direction of the depolarisation waves is towards the +ve electrode. Conversely, if it is predominantly negative (downwards) then the depolarisation wave is moving away from the +ve electrode. When the QRS complex is equally positive and negative (and usually also small) then the depolarisation wave is moving at right angles to the +ve electrode.

The limb leads 'look at' the heart from six different directions. The average direction and magnitude of the depolarisation wave through the ventricles is termed the mean electrical axis (MEA) or the cardiac axis. As can be seen from Fig. 9.1, in which there is a normal axis, leads I, II, III and aVF have positive deflections and aVR and aVL are negative.

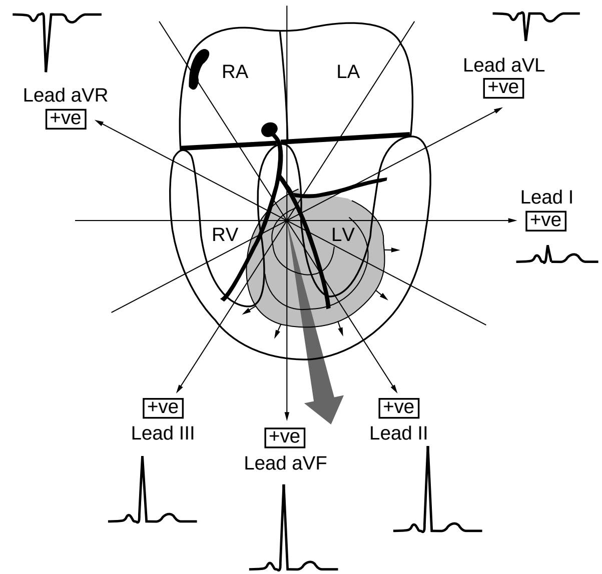

Figure 9.1 A normal mean electrical axis (large shaded arrow) and how this is 'seen' from the six limb leads. RA – right atrium; LA – left atrium; RV – right ventricle; LV – left ventricle.

Right axis deviation

If the right ventricle becomes enlarged as illustrated (either with hypertrophy or dilation), then the MEA swings to the right, because the large increase in muscle mass on the right side creates a large electrical potential difference during depolarisation.

In Fig. 9.2, for example, leads III and aVR become large and positive. Leads I, II and aVL become negative. Lead aVF is isoelectric in this example. This is termed a right axis deviation.

Left axis deviation

If the left ventricle becomes enlarged (either by hypertrophy or dilation), then the MEA swings to the left, because the large increase

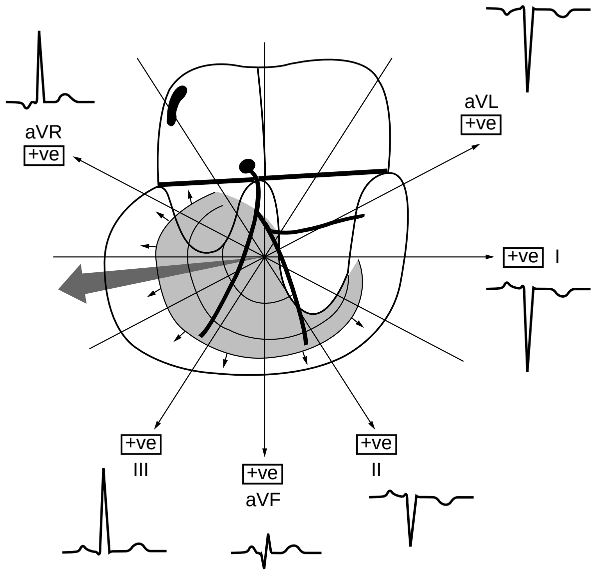

Figure 9.2 The mean electrical axis (large shaded arrow) in an animal with right ventricular enlargement (RVE) and how this is 'seen' from the six limb leads.

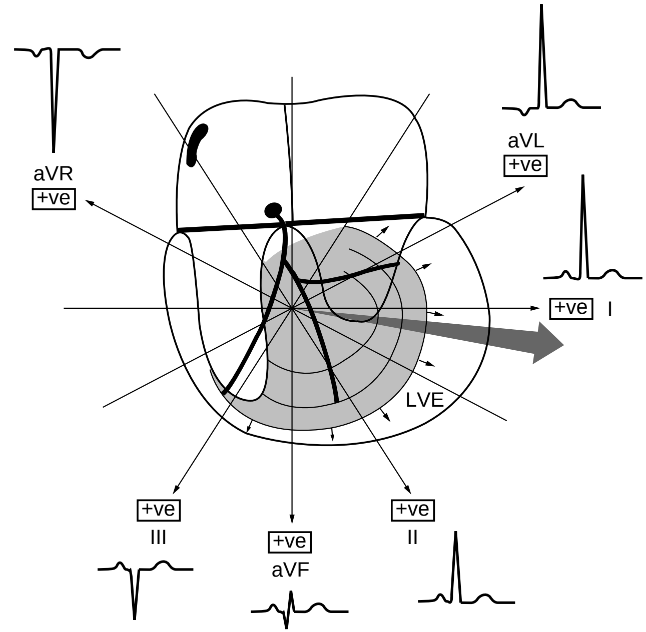

Figure 9.3 The mean electrical axis (large shaded arrow) in an animal with left ventricular enlargement (LVE) and how this is 'seen' from the six limb leads.

in muscle mass on the left side creates a large electrical potential difference during depolarisation.

In Fig. 9.3, for example, lead I becomes taller than lead II. Lead aVL is also positive. Leads III and aVR are negative and aVF is isoelectric. This is termed a left axis deviation.

How to calculate the mean electrical axis

This is of limited value in small animals, in part because the vector in the frontal plane (which is the plane that is measured from limb leads) is less representative of the true direction of the vector in three dimensions, compared with humans. The MEA is used mainly to assist in the assessment of ventricular enlargement and in the recognition of intraventricular conduction defects.

The value in exactly measuring the MEA in every case is questionable; a rough estimate of whether it is right or left is usually sufficient. However, the understanding of how it is measured and how it varies provides a better understanding of the 'electricity of the heart'.

How to estimate the MEA

There are a few methods of measuring the MEA; two are described here.

(1) Eyeballing the MEA

Using this method provides a quick system and, with practice, the MEA can often be 'eyeballed' to see whether it is normal or abnormal. Look again at the previous diagrams describing right and left axes, and how the amplitude of the QRS complex varies in leads I, II and III with these.

(i) Using all six limb leads and the hexaxial lead system, find the lead in which the QRS complexes have the greatest (positive) net amplitude – the MEA is approximately in this direction.
(ii) Similarly, find the most negative complexes, the MEA is opposite in direction to this.
(iii) Alternatively, find the lead in which the QRS complex is equally positive and negative (and usually small) – this is called the isoelectric lead. The MEA will be perpendicular to this. Find which of the six limb leads is perpendicular to the isoelectric lead. If the perpendicular lead is positive, then the MEA is in that direction. If the perpendicular lead is negative, then the MEA is in the opposite direction to that lead.

(2) Triangulation

Using two leads from a good-quality tracing, commonly leads I and III are used to measure the net amplitude of the QRS complex in each lead. In other words, measure the amplitude of the QRS complex that is positive and the amplitude that is negative. Subtract one (the smaller) from the other – this is the net amplitude. Plot this, to scale, on the hexaxial lead system shown below (Fig. 9.4). Draw perpendicular lines from each point. Where the two lines meet is the direction of the MEA from the centre point.

In fact, if the net amplitude in all six leads is calculated and plotted on the hexaxial lead system, the lines that are drawn perpendicular from each point *should* all meet at approximately the same point.

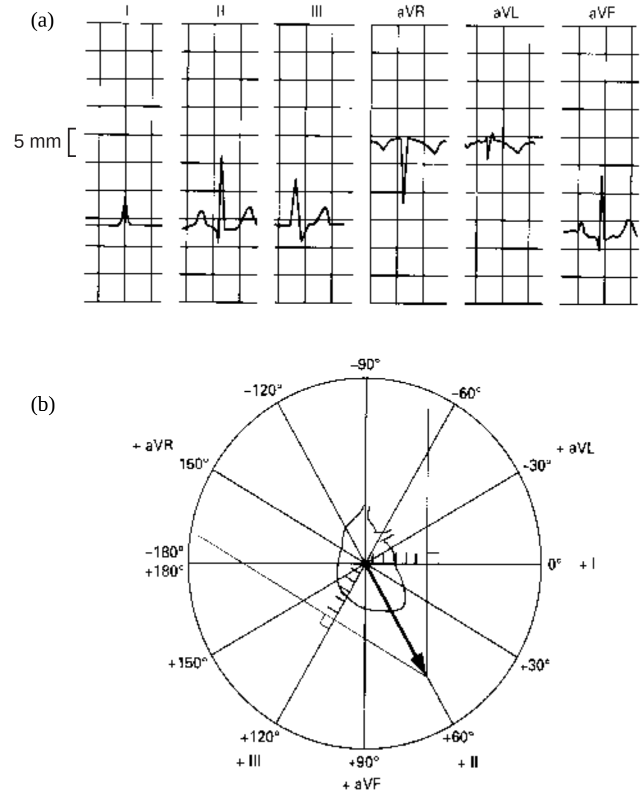

Figure 9.4 Estimation of mean electrical axis. (a) *Method 1.* In this normal canine ECG, lead aVL is the most isoelectric lead. Perpendicular to this is lead II. Lead II is positive and therefore the MEA is towards the positive pole of this line, i.e. +60°. (b) *Method 2.* In the same ECG. The net amplitude in lead I is +6 ($Q = 0$ and $R = +6$). Plot 6 points along lead I in the hexaxial lead system diagram and draw a perpendicular. The net amplitude in lead III is +6 ($S = -2$ and $R = +8$). Plot 6 points along lead III and draw a perpendicular. Draw an arrow from the centre to where the two perpendicular lines intersect. This is the direction of the MEA, i.e. +60°.