CLINICAL RECORDING OF THE ELECTROMOTIVE FORCE OF THE HEART IN THE FRONTAL PLANE

The body may be viewed as a cylinder from which information about the electrical changes taking place within it are derived by leads properly oriented in any of its three planes (Fig. 9). By convention, the electrocardiogram is derived from two of these three planes, the frontal and the horizontal. Leads 1, 2 and 3 and the unipolar limb leads constitute the frontal plane leads. The precordial chest leads, the V leads, constitute the horizontal plane leads.

Standard Leads (L1, L2, L3). The frontal plane leads are connected to the extremities, the right arm, the left arm and the left leg. The right leg lead is used to ground the body to the direct writing electrocardiograph and does not contribute any voltage to the electrocardiogram. Lead 1 measures the difference in the electrical potential between the right arm and the left arm (Fig. 10). The right arm is connected to the negative pole of the galvanometer, the left to the positive pole. A positive voltage oriented toward the left arm causes an upright deflection in the electrocardiogram.

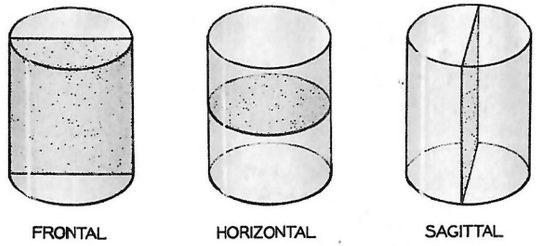

FIGURE 9. Diagrammatic illustration of the three planes of a cylinder representing the human torso.

Lead 2 measures the difference in the electrical potential between the right arm and the left leg (Fig. 11). The right arm is connected to the negative pole of the galvanometer, the left leg to the positive. A positive voltage oriented toward the left leg causes an upright deflection in this lead.

Lead 3 measures the difference in the electrical potential between the left arm and the left leg (Fig. 12). The left arm is connected to the negative pole of the galvanometer and the left leg to the positive. A positive voltage oriented toward the left leg causes an upright deflection in this lead.

These three leads, called the "standard limb leads"–L1, L2, L3; or S1, S2, S3; or I, II, III–may be considered to form an equilateral triangle when projected on the body–the Einthoven triangle. Because of the arrangement of the polarity of these leads, as arbitrarily fixed by Einthoven, the sum of the potentials of lead 1 and lead 3 will always equal lead 2, regardless of the magnitude, direction or sense of the electromotive forces generated at the center of the triangle. Mathematically, these facts may be represented by the following simple equation:

$$\begin{array}{rrl} \text{Lead 3} & + \text{ Lead 1} & = \text{ Lead 2} \\ (\text{LL} - \text{LA}) & + (\text{LA} - \text{RA}) & = (\text{LL} - \text{RA}) \\ \text{LL} & - \text{RA} & = \text{LL} - \text{RA} \end{array}$$

Three assumptions are made in clinical electrocardiography in relation to this triangle. They are:

1. That the leads form a true equilateral triangle;
2. That the heart is in the center of this triangle;
3. That the medium surrounding the heart and extending to the body surface is a uniform volume conductor.

None of these assumptions is altogether correct, as Einthoven recognized. Nevertheless, they are sufficiently accurate to serve as a working hypothesis in electrocardiography.

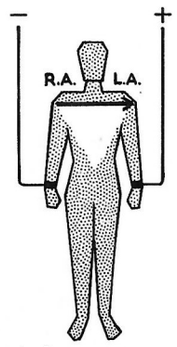

FIGURE 10. Electrical connections of standard lead 1.

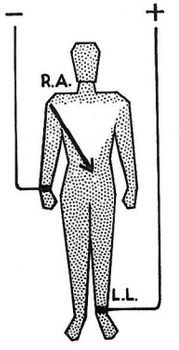

FIGURE 11. Electrical connections of standard lead 2.

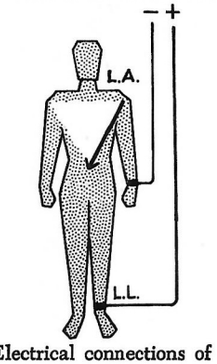

FIGURE 12. Electrical connections of standard lead 3.