CHAPTER 12
ECG PATTERN ANALYSIS

In the previous chapter we learned about how the ECG waveform is formed. In this chapter we will learn how measuring the ECG in a few different places, we can discern many things about the nature of the electrical conduction in the heart.

Learning Objectives:

- **Einthoven's Triangle**
- **Vector Analysis**
- **Mean Electrical Axis and its Significance**
- **ECG analysis (Mean Electrical Axis Deviations)**
- **ECG Analysis (Arrhythmias)**

Figure 12-1 shows the typical measurements for a three-lead ECG measurement system. Clinical ECGs are measured using 12 leads and later in this chapter we'll learn why.

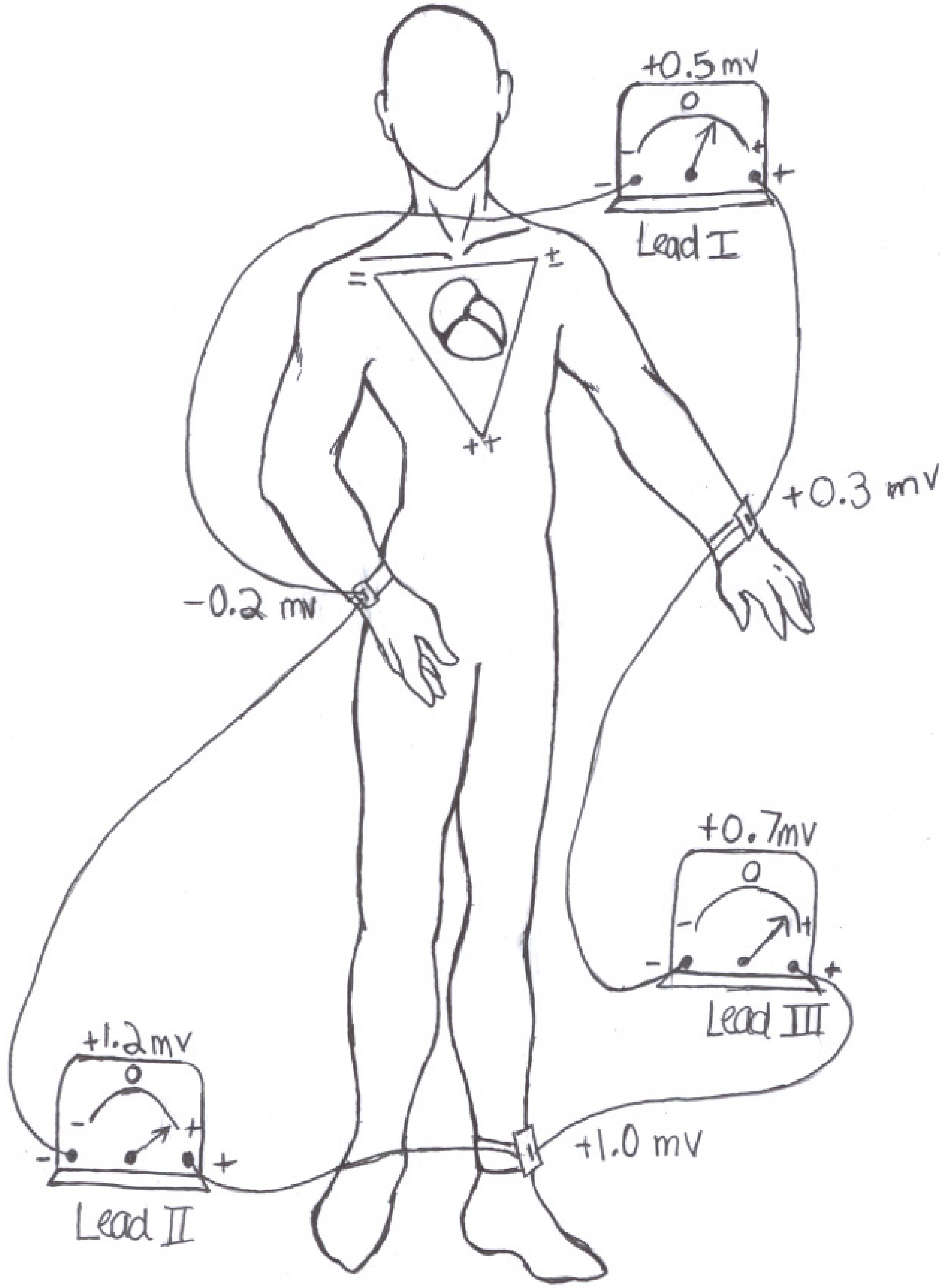

Figure 12-1

Lead one is defined as the negative electrode on the right arm and the positive electrode on the right arm. Lead two is defined as the negative electrode on the right arm and positive electrode on the left leg. Lead three is defined as the negative electrode on the left arm and the positive electrode on the left leg. This spatial arrangement creates a triangle termed Einthoven's triangle, Figure 12-2.

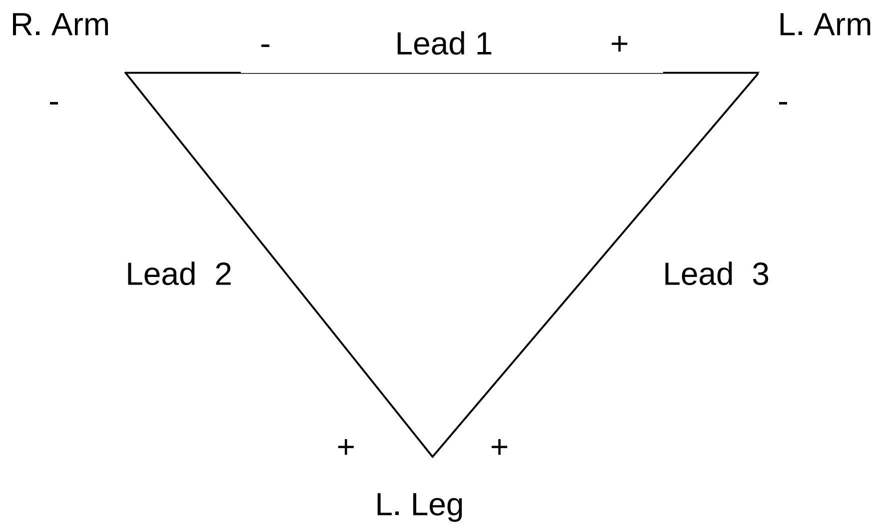

Figure 12-2 Einthoven's Triangle

The voltage measured on each lead is the projection of the direction of the overall electrical activity of the heart onto the direction represented by the lead. We can rearrange the leads to facilitate the ECG vector analysis.

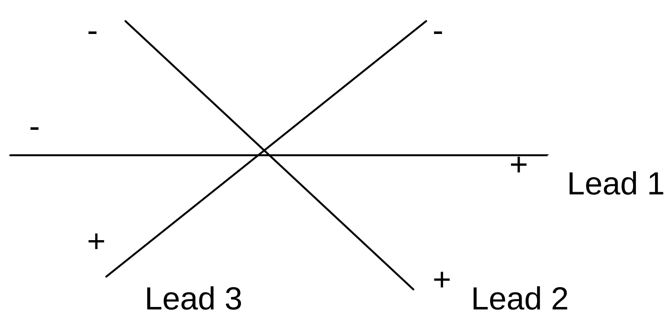

Figure 12-3 Vectorial Analysis Lead Arrangement

Figure 12-4 is a set of ECG recordings from each of the three leads.
As i normal, lead II has the largest QRS waveform.

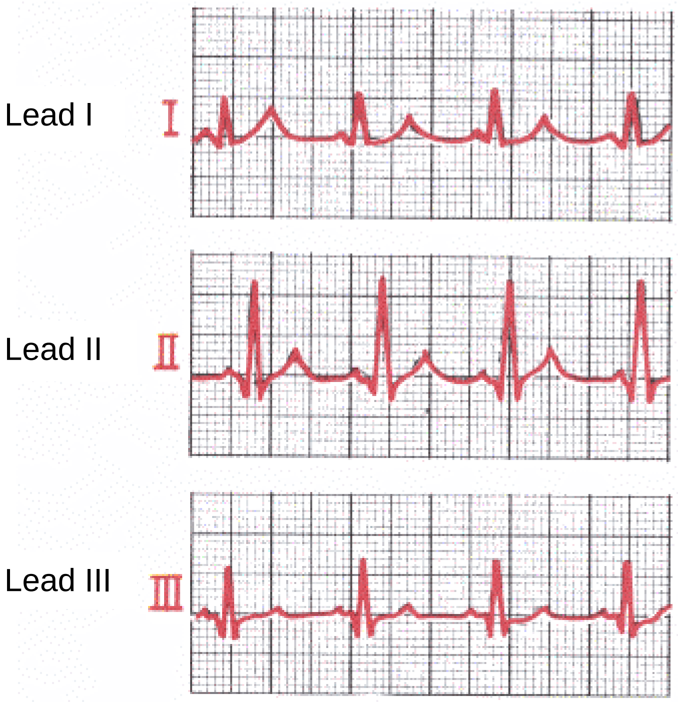

Figure 12-4

We can measure the height of the QRS waveform for each lead and plot the magnitudes on the vector analysis axes as shown in Figure 12-5. Here we take the magnitude for lead I and plot it from the intersection of the axes and to the direction of QRS, (positive or negative). Similarly we plot the magnitudes of the other two leads. In fact, we need only plot any two vectors and from that we can predict the magnitude of the third lead. In Figure 12-5 we've plotted the magnitude of lead I and III and by vectorial addition, we can calculate the mean electrical axis. We could have plotted lead II and lead III or lead I and lead II and gotten the same answer! What results is a new vector of about 59 degrees (almost the direction of lead II). This new vector represents the average dipole direction during the QRS event and normally it is about 60 degrees.

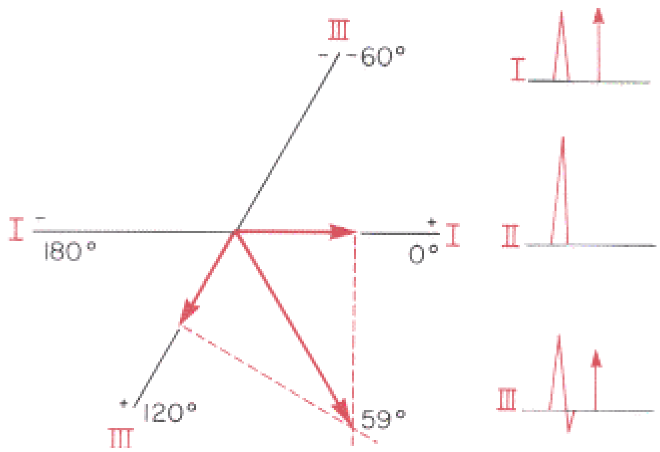

Figure 12-5 Plotting the mean electrical axis of the heart from two electrocardiographic leads

In fact, plotting the magnitude of any two leads at anytime represents the average direction of dipole motion. Figure 12-6 illustrates the production of the depolarization event during the QRS event. The dark shading represents the depolarized tissue and the three leads are plotted on the vectorial addition axes.

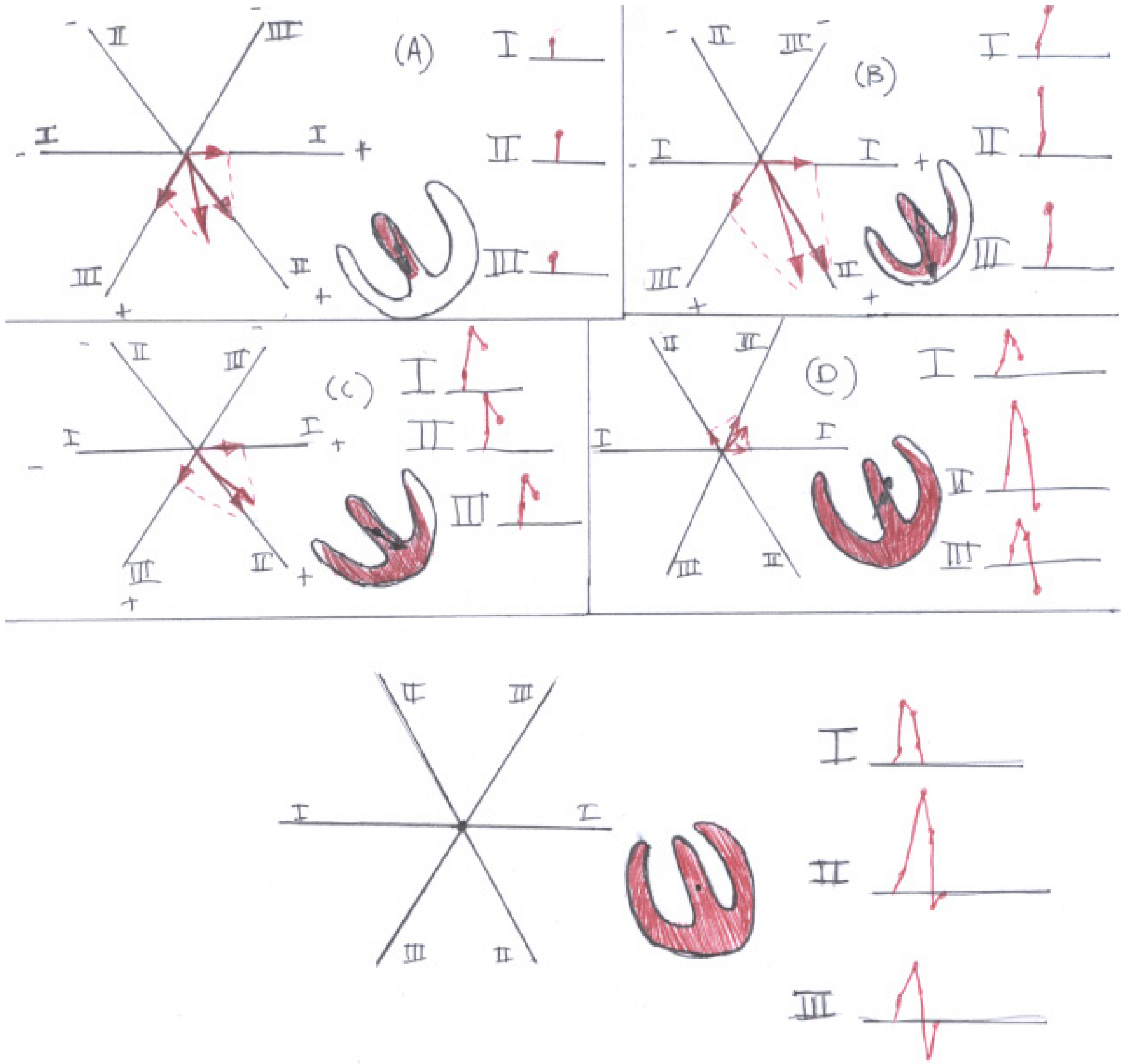

Figure 12-6

Figure 12-7 depicts the production of the T wave from a vectorial addition viewpoint.

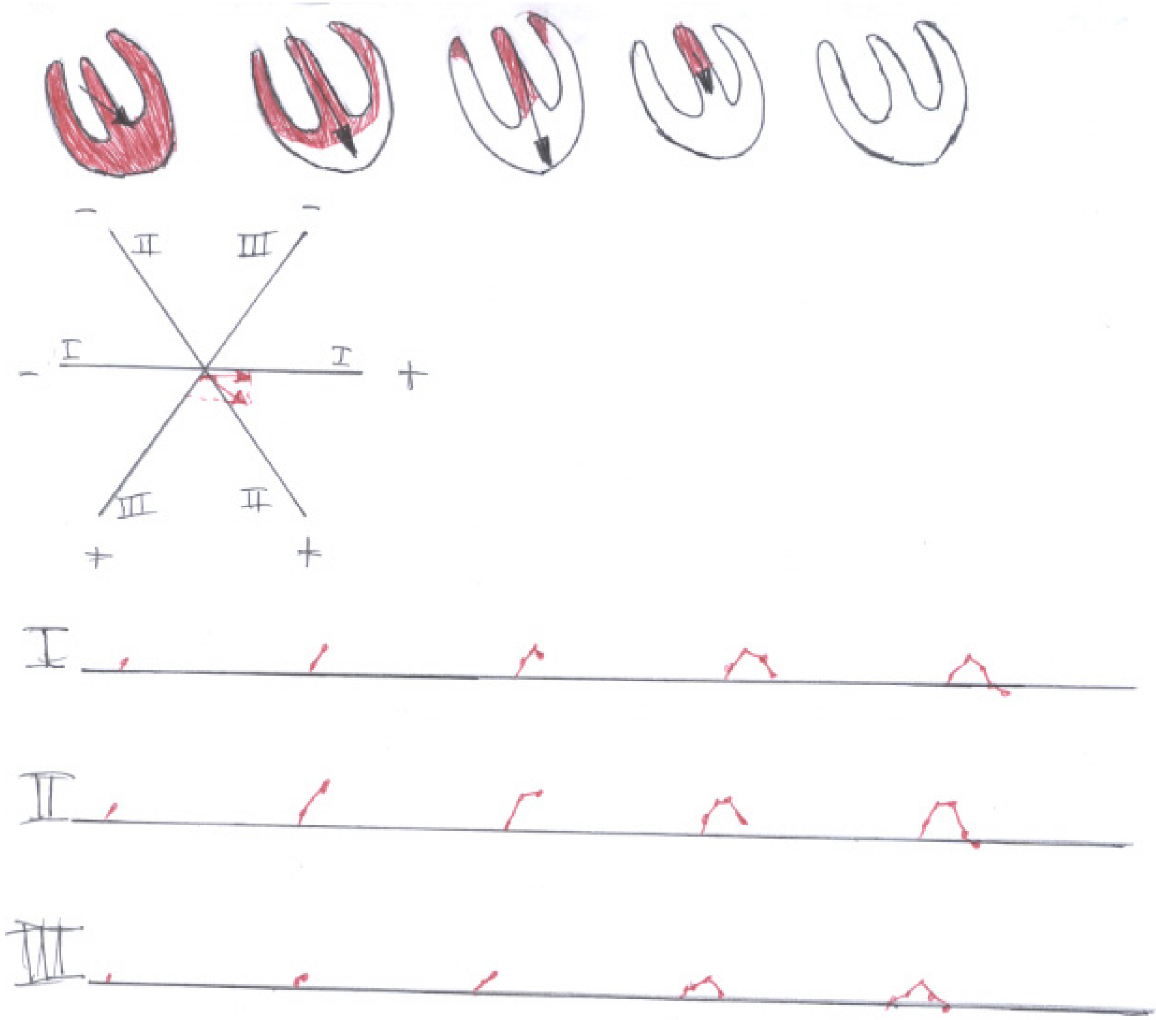

Figure 12-7 T-wave production

Armed with this information we can start to examine alterations in the mean electrical axis. If the left bundle branch is blocked, we'd expect the depolarization of the left side to be delayed. The QRS should be prolonged and the mean electrical axis (MEA) should swing to the left because of the delay on the left side. Figure 12-8 is a recording of a patient with an LBB.

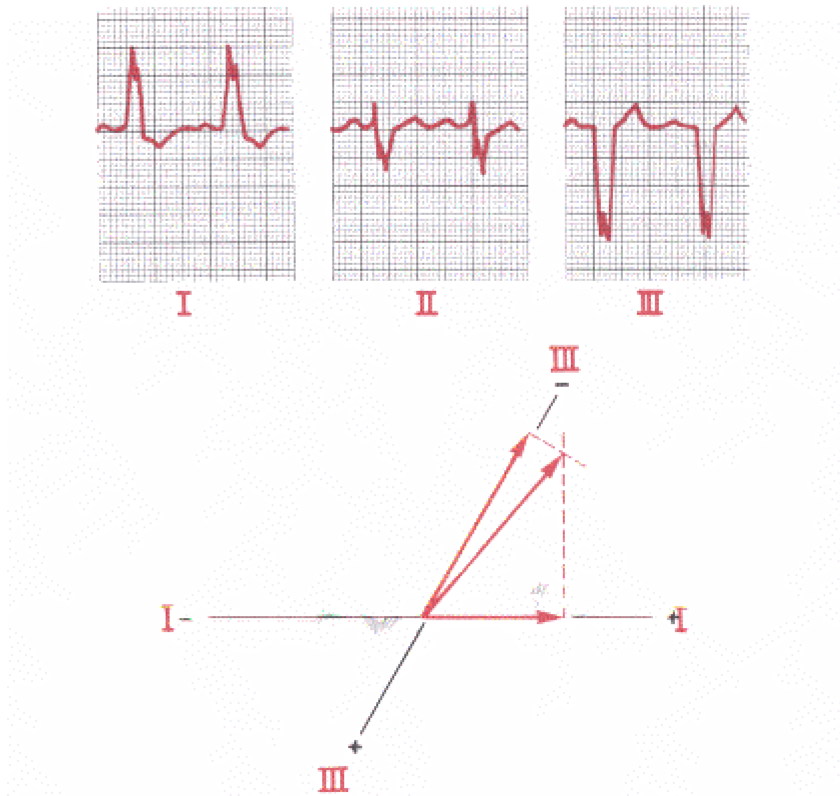

Figure 12-8 Left Bundle Blocked

If the right bundle branch is blocked, the depolarization of the right side is delayed and the QRS will be prolonged as well. We expect that the mean electrical axis (MEA) will swing to the right as shown in Figure 12-9.

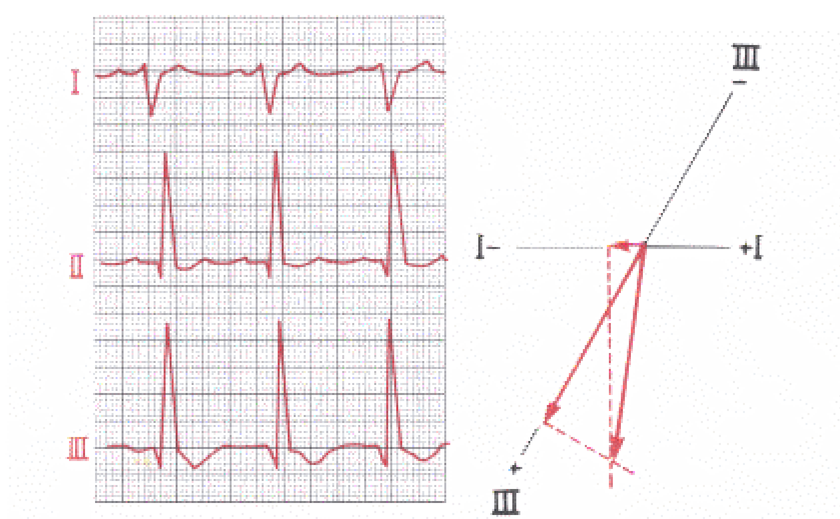

Figure 12-9 Right Bundle Blocked

If the left ventricle becomes hypertrophied (more muscular) then, there will be a predominant effect of the left side due to its sheer size. In this case there can be a dramatic shift of the MEA to the left as depicted in Figure 12-10.

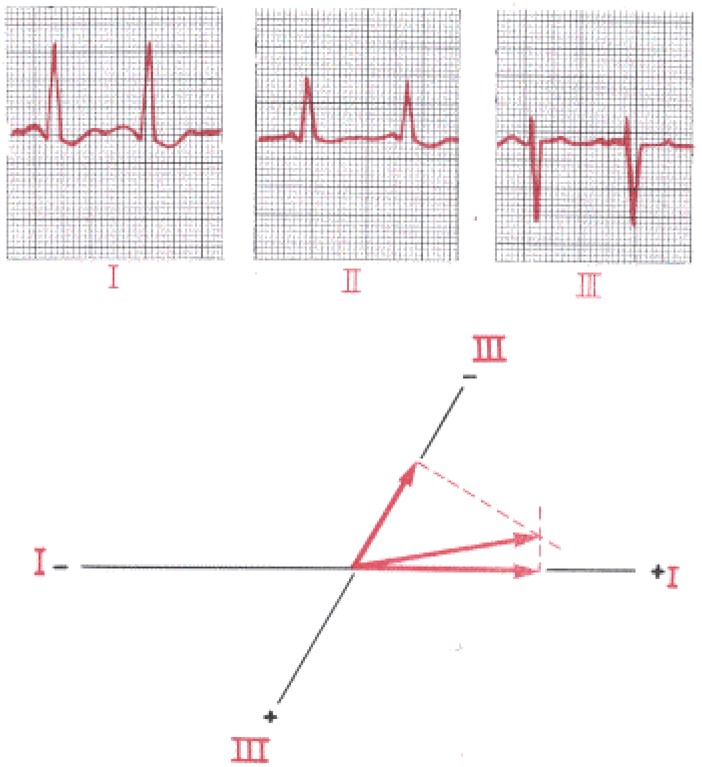

Figure 12-10 Hypertrophied Left Ventricle

Sometimes the pulmonary valve becomes stenotic (doesn't open all the way and thus a high valvular resistance). To overcome the increased valvular resistance, the right ventricle may become hypertrophied. As a result of the increased muscle mass on the right, the MEA will be displaced towards the right as shown in Figure 12 -11.

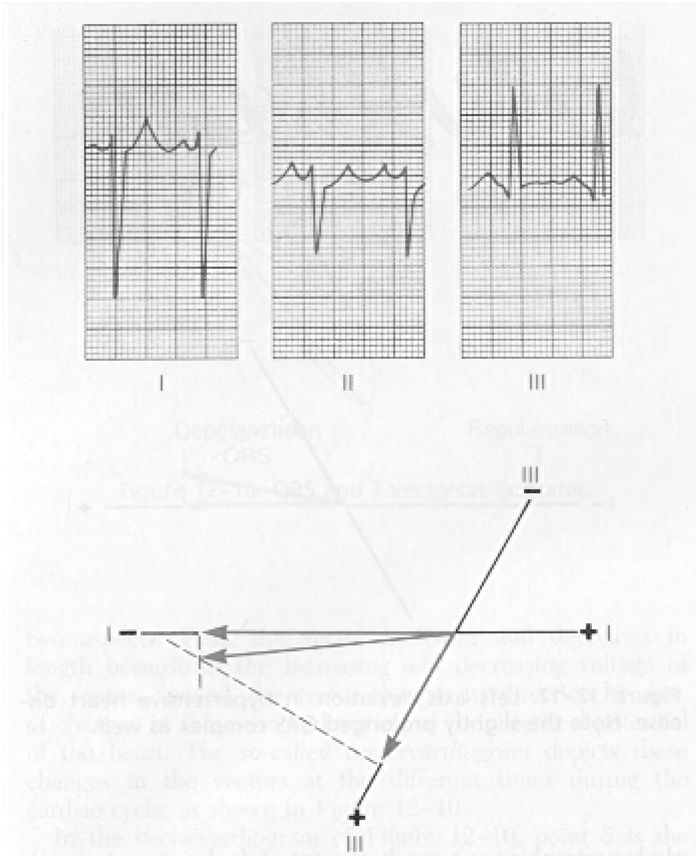

Figure 12-11 Hypertrophied Right Ventricle due to Valve Stenosis

In addition to MEA deviations, other types of electrical pathologies can be determined by observing various types of arrhytmias. For example, if the PR interval is prolonged, we describe this as a 1^{o} heart block. This means that the AV node is likely delaying too long (Figure 12-12).

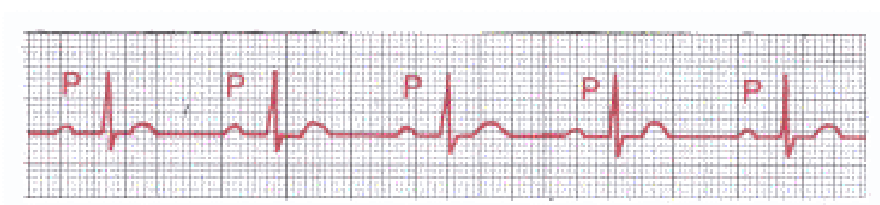

Figure 12-12 Prolonged PR interval

If the conduction through the AV node is occasionally blocked, it is termed 2^{o} heart block (Figure 12-13)

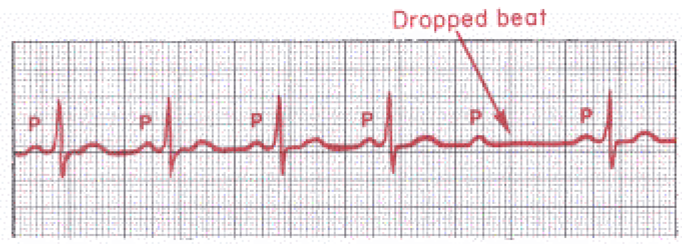

Figure 17–6. Second degree incomplete atrioventricular block (lead V_3).

Figure 12-13 Second degree

Third degree heart block is when asynchrony exists between the P waves and the QRS wave (Figure 12-14)

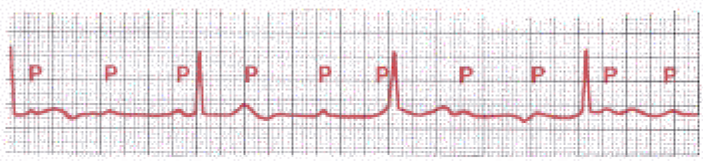

Figure 17–7. Complete atrioventricular block (lead II).

Figure 12-14

Ventricular fibrillation is a devastating condition where there is no coordinated electrical activity. Multiple sites in the cardiac tissue act as theior own pacemakers and as a result no coordinated contractions occur. Unless quickly corrected the patient will die (Figure 12-15).

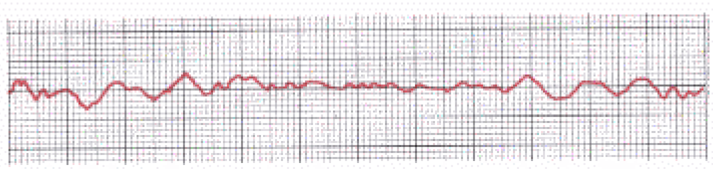

Figure 17–16. Ventricular fibrillation (lead II).

Figure 12-15