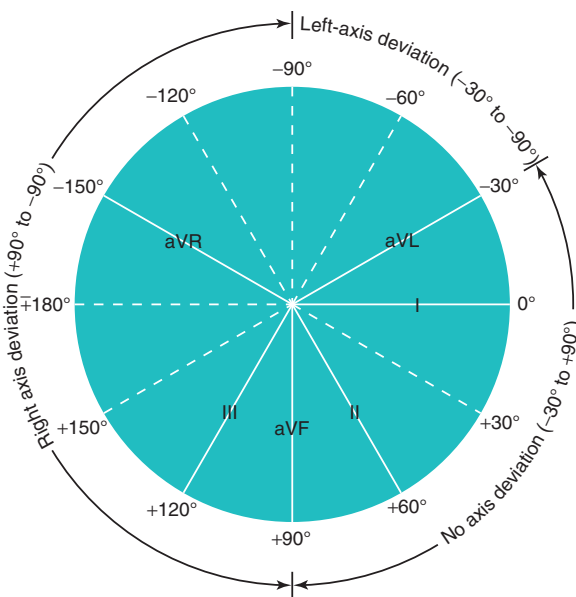


**FIGURE 4-3** Normal 12-lead electrocardiogram.



**FIGURE 4-4** Hexaxial reference figure for frontal plane axis determination, indicating values for abnormal left and right QRS axis deviations.

in leads I and aVF suggests a normal QRS axis between 0 and 90 degrees.

The six standard precordial leads ( $V_1$  to  $V_6$ ) are attached to the anterior chest wall (Fig. 4-5). Lead placement should be as follows:  $V_1$ : fourth intercostal space, right sternal border;  $V_2$ : fourth intercostal space, left sternal border;  $V_3$ : midway between  $V_2$  and  $V_4$ ;  $V_4$ : fifth intercostal space, left midclavicular line;  $V_5$ : level with  $V_4$ , left anterior axillary line;  $V_6$ : level with  $V_4$ , left midaxillary line. The chest leads should be placed under the breast.

Electrical activity directed toward these leads results in a positive deflection on the ECG. Leads  $V_1$  and  $V_2$  are closest to the right ventricle and interventricular septum, and leads  $V_5$  and  $V_6$  are closest to the anterior and anterolateral walls of the left ventricle. Normally, a small R wave occurs in lead  $V_1$ , reflecting septal

depolarization, along with a deep S wave, reflecting predominantly left ventricular activation. From  $V_1$  to  $V_6$ , the R wave becomes larger (and the S wave smaller) because the predominant forces directed at these leads originate from the left ventricle. The transition from a predominant S wave to a predominant R wave usually occurs between leads  $V_3$  and  $V_4$ .

Right-sided chest leads are used to look for evidence of right ventricular infarction. ST-segment elevation in  $V_{4R}$  has the best sensitivity and specificity for making this diagnosis. For right-sided leads, standard  $V_1$  and  $V_2$  are switched, and  $V_{3R}$  to  $V_{6R}$  are placed in a mirror image of the standard left-sided chest leads. Some groups have advocated the use of posterior leads to increase the sensitivity for diagnosing lateral and posterior wall infarction or ischemia—areas that are often deemed to be *electrically silent* on traditional 12-lead ECGs. To do this, six additional leads are placed in the fifth intercostal space continuing posteriorly from the position of  $V_6$ .

## ABNORMAL ELECTROCARDIOGRAPHIC PATTERNS

### Chamber Abnormalities and Ventricular Hypertrophy

The P wave is normally upright in leads I, II, and F; inverted in aVR; and biphasic in  $V_1$ . Left atrial abnormality (i.e., enlargement, hypertrophy, or increased wall stress) is characterized by a wide P wave in lead II (0.12 second) and a deeply inverted terminal component in lead  $V_1$  (1 mm). Right atrial abnormality is identified when the P waves in the limb leads are peaked and at least 2.5 mm high.

Left ventricular hypertrophy may result in increased QRS voltage, slight widening of the QRS complex, late intrinsicoid deflection, left axis deviation, and abnormalities of the ST-T segments (see Fig. 4-5A). Multiple criteria with various degrees of sensitivity and specificity for detecting left ventricular hypertrophy are available. The most frequently used criteria are given in Table 4-1.

Right ventricular hypertrophy is characterized by tall R waves in leads  $V_1$  through  $V_3$ ; deep S waves in leads I, aVL,  $V_5$ , and  $V_6$ ;