GENESIS AND INTERPRETATION OF THE
ELECTROCARDIOGRAM *

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This paper is an introduction to the fundamentals and recent important
advances in electrocardiography. It is hoped that the question and
answer method employed here will be of benefit.

1. What events in the heart cause the major deflections or waves of
electrocardiographic tracing?

By means of its physiological action, the heart sets up an electrical
potential within its walls. One region of the cardiac musculature
possesses most electrons and the opposite pole the least. Depolariza-
tion, therefore, implies that the electrons stream to the pole of lowest
electron content in an effort to distribute the negative charge equally.
This wave of depolarization and the restoration of potential or re-
polarization are the impulses recorded on the electrocardiogram. De-
polarization, however, does not proceed physically from base to apex
of the heart as the casual observer might infer. Reference to figure 1

![Diagram of heart showing SA node, auricle, AV node, left ventricle, and right ventricle.]

will assist in visualizing the pathway. Depolarization is initiated in
the SA (sino-auricular) node and enters and descends the entire auricu-
lar muscle. The portion of the impulse which adjoins the AV (atrio-
ventricular) node activates this tissue. The AV node and bundle sit
astride the septum and transmit depolarization down each bundle
branch to the apex of the heart which is, therefore, the first portion of
lateral ventricular musculature to be enervated. However, the septum

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receives the wave before the apex because, as indicated, the left bundle branch sends a filament to the interventricular septum.

Figure 2 reveals that after the apex takes up the impulse of depolarization, it transmits the wave from endocardium to epicardium. This depolarization from endocardium to epicardium begins at the apex and then proceeds up both lateral ventricular walls toward the base.

Figure 3 is a summation of all the electrical events of the ventricle thrown together and recorded on the electrocardiographic tracing. In point of time, the direction of depolarization is first from left to right because of anatomical innervation of the septum. Then follows the second, and from our standpoint at this phase of the explanation, the only other ventricular wave of depolarization. The diagram indicates that the wave travels from right to left. The reason for this is that the small arrows which proceed from endocardium to epicardium in the left wall are neutralized by arrows going in the opposite direction in the right wall. However, the arrows of depolarization traveling down and slightly to the left which occur in the apex are not neutralized because the orifices of the heart lie opposite to the apex, and they do not possess an electrical impulse. As the left ventricular wall is thicker than the right, its depolarization is not completely nullified and will influence the direction of the composite electrical axis more to the left.

The answer to the first question, therefore, is that the wave of depolarization down auricular muscle forms one wave, the P wave. That traversing the whole of both ventricles usually gives two waves of opposite direction, one for the septum and one for the lateral walls of both
ventricles. The septal wave may be absent if the position of the electrons cannot pick it up. Modification of this concept will follow. The double wave appears on the tracing either as $\uparrow$ (QR), or $\downarrow$ (RS). The wave above the base line is positive, that below, negative. The base line is termed "iso-electric."

The wave of repolarization will be discussed later.

2. What are the bipolar leads?

Two electrodes placed over different areas of the heart and connected to the galvanometer will pick up for recording purposes the electrical events between them. Thus, if under the first electrode a wave of 0.2 millivolt and under the second electrode a wave of 0.6 millivolt occur over the same period of time, then two electrodes will record the difference between them, that is, a wave of 0.4 millivolt. A bipolar lead, therefore, records all electrical events between the two terminals by revealing the changes of one electrode over and above the changes affecting the other.

For the purpose of simplifying the electrical positions of the heart, the cardiac base may be regarded as located near the center of the chest, opposite the right shoulder. If the heart is horizontal, its electrical axis faces the left shoulder; if neutral it points to the left foot, and if vertical the axis or apex is directed towards the pubis. By employing the limbs to hold the electrodes, the leads are eminently satisfactory because they are equidistant from the heart, because they are remote enough not to influence one electrode unduly, and finally, they are located in the three directions stated above. It follows that standard lead I lies in the axis of the horizontal heart, and terminals are placed on the right arm and left arm (RA and LA); lead II is in line with the neutrally placed heart and consists of right arm and left leg electrodes (RA and LF), and lead III is in line with the vertical heart and connects the left arm and left foot (LA and LF).

The answer to question 2 is: The bipolar leads are the standard leads I (LA-RA) left arm to right arm, II (LF-RA) left foot to right arm, and III (LF-LA) left foot to left arm.

3. What are the two unipolar leads?

Again, two terminals are employed, but because one is inactive and has very slight electrical changes occurring in its vicinity, the electrocardiographic tracings mirrors potential alterations taking place only in the vicinity of the other or active electrode.

Two types of unipolar leads are employed. The first or precordial lead utilizes an active electrode to explore the right ventricle, the septum and left ventricle. Position 1 is fourth interspace, just to the right of the sternum; position 2 is just to the left of the sternum, same interspace; position 3 is between 2 and 4; position 4 is the midclavicular line, fifth interspace presumably over the apex in the average cardiac location; position 5 is anterior and position 6 is the midaxillary line, same interspace.
The inactive electrode may be placed on any of the limbs, and is inactive by virtue of the fact that the active terminal is relatively so close to the heart. If "C" designates "chest," the inactive electrode may be placed on the left arm (CL), the right arm (CR), or the left foot (CF). However, the inactive electrode may consist of wires from all the limbs joined together as one terminal, the purpose being to make it as inactive as possible by neutralizing electrical charges of one limb against another. This lead is the most popular and is called CV. All precordial leads CL, CR, CF or CV have the same significance and only one is selected for use opposite the six exploring positions. The only difference between these chest leads is one of height, which rarely affects the interpretation.

The second type of unipolar lead consists of an active terminal on each of three limbs in succession and an inactive electrode on the limbs joined to one terminal or V. The tracing is magnified or augmented somewhat by electrical means. Thus, the three tracings are AVL, AVR and AVF, which designate augmented V left arm, augmented V right arm and augmented V left foot.

The answer to question 3 is: The two unipolar leads are (1) the chest leads which consist of a choice of CV, CL, CR or CF with their six tracings of the six positions of the active electrode, and (2) the three augmented limb leads with their three successive tracings AVL, AVR and AVF.

4. What is the wave of repolarization?

In a wire, depolarization is recorded conventionally as a positive wave by the galvanometer \( \Delta \). Repolarization would begin at the same point, and since this phenomenon is exactly opposite, a negative wave of the same amplitude is inscribed. The complete cycle of electrical changes in a wire appears thus: \( \Delta \rightarrow \Delta \). In living cardiac muscle, however, repolarization (T wave) normally originates at the pole opposite to the point where depolarization began. Therefore, this negative wave of repolarization travels in a negative direction and is ordinarily inscribed as a positive wave.

The answer to question 4 is: Repolarization is the T wave, ordinarily positive on most tracings.

5. What are the conventional designations for the various waves?

The height of a wave is determined solely by the voltage or strength of the electrical charge. Each horizontal line is 1 mm. above the next, which is equivalent to 0.1 millivolt. The string galvanometer is so standardized before electrocardiography is performed that a current of 1.0 millivolt causes a deflection of 10 mm. A wave must take a certain period of time from beginning to end, and this time is measured by counting the vertical lines. The vertical lines are also 1 mm. apart, and each millimeter represents an elapsed time of 0.04 second.

Auricular depolarization forms the P wave which may be positive or negative. No auricular deflection of repolarization is ordinarily
described. Ventricular depolarization creates the QRS complex. The Q wave is always negative and precedes the R, which is always positive. The S wave is always negative and must follow R. If the initial deflection is positive, it is termed the R wave, and no Q exists. If the only deflection is negative, it is termed the QS wave.

The ventricular wave of repolarization is designated the T wave, and may be positive or negative. If either the P or T deflection has both a positive and negative component, the contour is termed diphasic. This does not apply to QRS, because this is a complex of more than one wave.

The answer to question 5 is: The designations of the various waves are the auricular P; the ventricular depolarization complex QRS which is usually in the form of QR or RS where R is always positive and Q and S always negative, and finally the T wave of ventricular repolarization which may be positive or negative.

Incidentally, depolarization serves to stimulate muscle contraction, and precedes systole. Depolarization is intimately associated with contraction, and when the latter is weak, the former inscribes a small wave.

6. What is the normal for the unipolar chest lead?

By convention, a wave is inscribed above the iso-electric line (positive) when depolarization travels toward the active electrode from a remote area. It follows, therefore, that when an active electrode is placed over the right ventricle (figure 4), it will receive an initial positive (A in the diagram) electrical impulse from septal depolarization, and a delayed negative impulse (B) from ventricular wall depolarization as indicated. The tracing of the right ventricular wall, therefore, is A or RS wave.

Similarly, a left ventricular wall complex is composed of an initial negative septal current and a later positive lateral wall current A or QR wave (figure 5).

Because of the relationship of the cardiac septum to the chest wall, the Q wave normally is rarely deep. Therefore, as the exploring elec-
trode is moved from the right ventricle over the chest to the left, the tracing evolves from the RS wave toward the QR complex. This progression from right to left is characterized by a gradual elevation of the R as the S becomes more shallow until R about equals the S in magnitude as the electrode overlies the septum. Farther left, S becomes very small, and in many tracings S will disappear and leave the QR complex in position 6, thus completing the evolution. Figure 6 indicates these changes. The smoothness of progression of the QRS complex is influenced by a third factor besides the septal and lateral wall currents. This is the positive tendency of endo-epicardial depolarization taking place directly under the electrode.

The answer to question 6 is: The three salient normal features of the unipolar chest lead in its six positions may now be stated. (a) From right to left, there is a gradual increase in magnitude of R and decrease in depth of S, with the frequent appearance of Q in the left chest. R in positions 5 and 6 may not be quite as tall because the heart recedes from the chest wall as the axilla is approached. If R suddenly becomes small in any position as observation is made from right to left, disease is present. (b) T wave in positions 1 and 2 may be negative but must be unalterably upright beyond position 2. (c) The interval between the QRS complex and T wave, termed the ST interval, must normally vary between iso-electric and plus 2 mm. The ST interval must never be negative or higher than 2 mm.

These three characteristics dictate the interpretation of the chest leads. Other pathological changes are not confined to the precordial leads, but become obvious after standard lead interpretation is taken up. Of less importance is the fact that R should not exceed 25 mm. and that P, like T, may be negative in positions 1 and 2.

7. What is the normal for the unipolar limb leads AVF, AVL and AVR?

Simply stated, the unipolar limb leads are employed usually to ascertain the anatomical position of the heart and the standard leads to determine the electrical position or axis deviation. Difficult diagnoses, such as left ventricular hypertrophy in a vertical heart, and
other positional problems may thus be solved. The few other diagnostic aids will be discussed later.

In the neutral position the anterior cardiac surface is largely right ventricle, and the apex and left border are composed of left ventricular wall. When the heart becomes horizontal, that is, when left axis deviation exists, the heart rotates so that the left ventricle occupies more of the anterior surface, and the right ventricle faces the left foot. The apex, which is left ventricle, faces the left arm because the heart is horizontal (counterclockwise rotation as viewed from below). Therefore AVL (left arm) resembles the QR or left ventricular curve, and AVF (left foot) the RS or right ventricular wave.

NORMAL PRECORDIAL LEAD

![Diagram of normal precordial leads](image)

Fig. 6.

When the heart becomes vertical, the opposite event occurs, and AVL tends to the RS curve (right ventricle), and AVF (left foot) toward a KR deflection (left ventricle). When the heart occupies a neutral position, the curves of AVL and AVF tend to be the same (either $\uparrow$ or $\downarrow$).

The only significant feature of the AVR lead, on the other hand, is that it always has a greater negative $Q$ or $S$ than a positive $R$, and the $T$ is inverted normally. In short, AVR normally is negative.

The AVR curves to be described rarely enter the field of interpretation, but they are included here to complete the understanding of the entire tracing. Normally, the AVR active electrode always faces some aspect of the cavity of the heart. It will be seen from figure 7 that the
septal current runs mostly or entirely perpendicular to the electrode and causes a small deflection or none at all. The lateral wall, however, produce a negative curve because depolarization travels away from the electrode which faces the cavity. Deep negative and small positive waves, therefore, characterize AVR terminals.

As the electrode is moved more posteriorly, a slightly more complicated state of affairs exists. It then faces not only part of the ventricular orifices or cavity, but also the posterior wall itself. The electrode is still perpendicular to the septum and so septal current occurs. The cavity still produces a negative wave. The posterior wall current just over the electrode, however, proceeds as usual from endocardium to epicardium and, therefore, toward this posterior electrode. A late positive wave results. The complex for the posterior wall of the heart is thus deep QR. The important feature here is the existence of a cavity Q wave, which is characterized by its depth. The septal Q previously described is shallow normally (1.5 mm. or less).

The answer to question 7 is: The normal AVF and AVL complexes are those of the right or left ventricular walls, or any intermediate position simply depending upon the position of the heart. T waves are usually positive and will be discussed later. The normal AVR lead complex is always mainly negative and the T is downward. A new complex has been introduced, namely as usually deep Q, low R wave V, which characterizes the posterior heart. This is the cavity Q as contrasted to the septal shallow Q. Other essentially negative waves, such as QS V or low R, deep S V, characterize the base of the heart and are as yet unimportant for adequate interpretation.

8. What is the normal for the standard leads I, II and III?

The PR interval represents the time taken for depolarization to traverse the AV node and bundle.

The answer to question 8 is: Lead III is labile and any negative deflection may be normal.

P should be upright in I and usually in II.
PR interval is normally not less than 0.12 second and not over 0.2 second.
Q must be small (septal), possibly even in lead III.
QRS complex is not over 0.08 second wide.
R should be at least 5 mm. high in any one of the three tracings and no higher than 15 mm. in any lead.
The ST interval must not be displaced more than 1 mm. above or below the iso-electric line.
T should be upright in lead I and II or possibly diphasic in II. It should be high enough in any one lead to be clear-cut (about 2 mm. high).

9. How is axis deviation indicated on the electrocardiogram?
The position of the heart and dilatation or hypertrophy of one ventricle influence axis deviation. Electrical deviation is indicated by the standard leads. Cardiac position by unipolar extremity leads has been dealt with, and there remain the standard leads to consider.

In figure 8 the usual electrical cardiac axis is indicated by arrow RA-LF, the length depending on the voltage. Its direction indicates an electrode hook-up of right arm to left foot. This axis can be broken up into its horizontal or lead I and vertical or lead III vectors or components; the former consisting of the dotted line RA-LA (right arm-left arm), and the latter LA-LF (left arm-left foot). Since a positive wave is inscribed when depolarization proceeds from RA to LF, then its two components, namely, RA toward LA, and LA toward LF are similarly positive.

When the electrical axis of a heart shows left axis deviation of marked degree, the horizontal axis points not only toward the left shoulder, but above this landmark. Such left axis deviation is illustrated in figure 9. Lead I reveals positive depolarization from RA to LA, but lead III indicates a negative wave in that depolarization travels from LA away from LF. Left axis deviation, therefore, mani-
fests itself in a large R, possibly with a small Q in lead I, and a negative complex or small R and very deep S in lead III (fig. 10).

In marked right axis deviation, the electrical axis points to the right of the vertical, and therefore the QRS complex in lead I is negative (from LA to RA) and that in lead III is positive.

**LEFT AXIS DEVIATION**

![ECG tracings](image)

**Fig. 10.**

The more negative the ventricular complex in lead I, the greater is the right axis deviation, and the same is true for lead III in left axis deviation. Negativity is produced by the S wave, not the Q wave which would imply not axis deviation but necrosis and scarring of myocardial tissue.

It was shown that leads I and III are the vectors of lead II, and therefore the waves in lead II are always an addition of the other leads.
Thus, if T is 2 mm. in I, and 1 mm. in III, then T in lead II is 3 mm. The same is true of QRS, but simultaneous leads must be performed to reveal this. However, if QRS is added together for each lead (Q is −1 mm.; R is 8 mm., addition of QRS complex is 7 mm.), then the addition of QRS of lead I and lead III equals lead II.

The answer to question 9 is: Right axis deviation is characterized by upright QRS in lead III and negative (small R, deep S) complex in lead I. Left axis deviation is the opposite.

10. How can myocardial strain be diagnosed?

Superimposed upon axis deviation, there will be other features which indicate strain. (a) The R is likely to exceed 15 mm. in one of the standard leads because of the generation of excess voltage.

When the myocardium is severely hypertrophied, or strained, it has been conjectured that the wave of repolarization or T wave is so retarded in its progress through the affected myocardium that other areas set up their own wave of repolarization. Consequently, a reverse progression occurs which imparts to the tracing a negative T. (b) The result of strain is a downward T after a tall R, and frequently an ST below the iso-electric line.

The third and last important feature of strain is often easily discernible, but sometimes not, even by trained observers. It is based on the fact that almost all of the voltage changes concerned with the R wave in the chest leads normally take place during the upstroke. The downstroke of the R merely represents the time it takes for the taut galvanometer wire to return to the midline with no electric current flowing. In heart strain, delay in depolarization results in voltage changes even during the downstroke so that from the peak of R down to the base line, a longer than normal time elapses. This downward stroke is termed the intrinsioicoid deflection, and ordinarily its measurement is not performed. (c) When the intrinsioicoid deflection is slurred in the chest lead, however, the delay characteristic of hypertrophy is obvious without measurement.

It should be recalled that unipolar limb leads indicate anatomical position, more or less, and standard leads reveal the electrical axis. Thus, a vertical heart will have a high R or even QR in AVF, but if the left ventricle is hypertrophied, the ventricular complex of lead III will be negative, indicating left electrical axis deviation, that is, left axis deviation in a vertical heart.

The answer to question 10 is: Heart strain may be diagnosed in all leads (fig. 11).

In the standard leads, the T and ST interval will be opposite in direction to the main deflection, which shows either right or left axis deviation. The R is usually over 15 mm. in either lead I or III, depending on the axis deviation.

In the precordial leads, the very same changes occur. With left strain, high R and negative ST and T occur in left ventricular positions,
that is, positions 5 and 6. With right strain these characteristics are manifest over the right heart, positions 1 and 2 (where a normal negative T must be differentiated). In the precordial leads, a slurred or prolonged intrinsicoid (downward) deflection of R may also be apparent in the positions noted.

In the unipolar limb leads, only left ventricular strain can be diagnosed by the high R, negative ST and T, because here the deeply negative T (20 per cent or more of the height of the R) is abnormal only
following a large R, and there is no large R in the right ventricular tracing. A negative T may be perfectly normal for the right ventricle in unipolar limb leads.

Since right ventricular hypertrophy may on occasion cause depolarization to travel from left to right because of marked rotation of the apex to the right side of the chest, other alterations may occur, namely in AVR. The diagnosis, therefore, may be made when the QRS complex of AVR is more positive than negative, and about 50 per cent of all patients with an R as high as 4 mm. have right heart strain no matter how negative the Q or S may be. A positive T in AVR is abnormal, and may indicate right strain or infarction.

11. What are the characteristics of myocardial infarction?

The acute pathognomonic features are usually easily recognized, and of exceedingly great accuracy. Infarction probably results in three physiologically abnormal zones. The center is the zone of necrosis, the surrounding area is the zone of injury wherein either healing or necrosis will result, and around this is the zone of ischemia. The necrotic center affects the tracing in two major ways. (a) The R will be small or absent when the electrode subtends necrotic tissue, because depolarization is minimal or absent, and (b) there will be a prominent, often wide Q wave because the dead tissue presents an open window to the electrode which now is electrically directly on the septum, or into the cavity of the heart.

The second, or zone of injury, causes the ST interval to be elevated if the electrode is directly over the area, or depressed if more remote. This change may be compared to the electrical capacity of a condenser when one plate (that is, the damaged myocardium) is made smaller. The initial voltage is great as the charge travels to the smaller plate, but the latter cannot accept as many electrons and when the electrical wave is completed, a new base line has been established. However, with repolarization, the original large plate holds its usual number of electrons, and the taut wire of the apparatus assumes its normal base line position (iso-electric).

The ischemic zone causes inversion of the T, which has previously been described.

Thus, there are 4 changes: (1) small R, (2) deep Q, (3) positive or negative ST, and (4) inverted T.

In the precordial leads, an acute infarction presents all these changes when the anterior wall of the left ventricle is involved. Distinct alterations do not occur in posterior infarction because the active electrode is too remote, but depressed ST intervals should make the physician investigate posterior infarction in the other leads.

The right ventricle is very rarely involved.

If any or all of these features occur in only a few positions of the usual six, then the adjacent cardiac area is involved. Very low, or
absent R, elevated ST and depressed T over positions 5 and 6 reveal lateral wall infarction; over position 2 or 3, or possibly 1 also, septal infarction.

In old infarctions, the ST usually reverts to the iso-electric base line, but the other changes tend to remain.

**ANTERIOR WALL INFARCTION**

![Graphs showing anterior wall infarction](image)

In the standard leads, elevation of ST occurs rapidly after anterior infarction in lead I. As the infarction becomes older, the ST descends toward the base line, but it carries the negative T with it in a characteristic curve, called the cove-plane. Here, the final part of the QRS complex goes downward into the initial segment of the negative T with a convexity directed upward. Digitalis toxicity causes the opposite trend—a concavity directed upward in the initial segment of the T.
A Q in lead I occurs in anterior infarction, but the R is not too much affected. Thus a Q and negative T in lead I, with an iso-electric ST indicates an older infarction. This is abbreviated as Q, T1.

Where Q, T1 occurs, posterior infarction is a possibility, but in lead III it may be a normal finding. If the ST segment is elevated more than 1 mm., a diagnosis of posterior infarction can be made, and if the Q is wider than 0.04 second (1 mm.), an old lesion exists in the presence of an iso-electric ST.

**POSTERIOR WALL INFARCTION**

![Graphs showing electrocardiogram tracings for different leads (I, II, III, V1, V2, V3, V4, V5, V6, AVR, AVL, AVF).]

Usually old posterior, left ventricular infarction cannot be diagnosed positively from standard lead III or from the chest leads, if Q is 0.03 second or under (as is most often the case). It is here that unipolar limb leads assist us, because AVF, in part, faces the posterior heart (since the heart ordinarily tilts along its long axis with the apex anteriorly and the base posteriorly). When AVF reveals a deep
Q, cove-planing ST, negative T in conjunction with Q_{III} T_{III}, a posterior wall infarction exists. Perhaps of most significance here is a Q longer than 0.04 second in AVF as indicated above, whether or not it is deep. It will be recalled that a posterior electrode normally traces a deep Q, small R, and rarely this is a normal possibility in AVF. Therefore, a wide Q is doubly important in revealing posterior infarctions.

**LEFT BUNDLE BRANCH BLOCK**

![Waveforms](image)

**LEAD I**

![Waveforms](image)

**LEAD II**

![Waveforms](image)

**LEAD III**

![Waveforms](image)

**V1**

![Waveforms](image)

**V2**

![Waveforms](image)

**V3**

![Waveforms](image)

**V4**

![Waveforms](image)

**V5**

![Waveforms](image)

**V6**

![Waveforms](image)

**AVR**

![Waveforms](image)

**AVL**

![Waveforms](image)

**AVF**

![Waveforms](image)

Fig. 11.

The answer (fig. 12) to question 11 is: Anterior wall infarction is characterized by Q_{I}, T_{I}, and very low or absent R, depressed T and Q in some positions of the chest lead. Elevation of ST points to a recent infarct. A reciprocal depression of ST in lead III usually is found.

Posterior wall infarction causes a Q_{III} T_{III}, type tracing, and a Q and inverted T in AVF (fig. 13).
12. What are the electrocardiographic changes in heart block?

Almost all block occurs (1) in the AV (atrioventricular) conduction tissue; (2) in the bundle branches or (3) in the intraventricular muscle tissue.

In the AV system, three grades of block may occur. First degree block is a prolongation of the PR interval (over 0.2 second). Second degree block is an occasional dropping out of the QRS complex. Thus,

to every three P waves, only two QRS waves may be seen. The PR interval may progressively widen until two P waves succeed each other. Third degree or complete AV block reveals P complexes occurring at regular intervals, and R waves at regular intervals, but the two bear absolutely no relationship to each other as would be expected when the auricles and ventricles beat independently of each other. Some P waves will be buried in other complexes, but they can be recognized by
an irregular contour to the complex at the exact interval in which P would be expected.

Bundle branch block exists when the QRS deflection lasts longer than 0.1 second. Usually the T wave is opposite to the main part of the QRS complex. The tendency is for left bundle branch block to deviate like left axis deviation, but the exceptions necessitate a search for other criteria. An S in lead I means right bundle block, but the chest leads are the most revealing. In left block, since there is a great delay in the electrical impulse reaching the left ventricle, a double R (or "M" shaped) wave results over left cardiac electrode positions. Presumably, the second R represents delayed depolarization of the left ventricle itself. Over the right ventricle, a deep S wave is inscribed. The reverse is true for right bundle branch block, wherein positions 1 and 2 show a double R deflection, and positions 5 and 6 a deep S (figs. 14 and 15).

Intraventricular block is diagnosed simply by QRS deflections which last from 0.05 second to 0.10 second; they are normal or slurred in appearance and do not possess the changes enumerated for bundle branch block.

The answer to question 12 is: The curves indicative of heart block have been described as almost self-explanatory once the nature of the block is understood.

13. The different types of rhythms which the tracings so precisely diagnose are actually most easy to comprehend, and reference to any text of electrocardiograms is more practical than presentation in this discussion. A few introductory remarks, however, may serve to orient the reader in the matter of cardiac rhythms, but space prevents the inclusion of tracings.

Diagnosis of rhythms is a matter of pure logic, as will be seen. The greatest difficulty in interpretation lies in recognizing the P wave, which is abnormal in shape when the sinus node does not originate auricular depolarization. The QRS and T complexes should be identified and any distortion which occurs may be an abnormal P, which may be negative or diphasic. By placing marks on a slip of paper held below, the exact interval is measured between suspected P deflections, preferably when one appears normal. If a distortion appears at regular intervals in conjunction with some normal P waves but this distortion is haphazardly superimposed on any and all of the QRS and T deflections, then a complete AV block exists with no relationship between auricles and ventricles. If such distortions show no regularity, no normal P waves, and again fall haphazardly on different parts of the tracing, then there can be no other diagnosis except a wandering auricular pacemaker (with no normal SA node impulses).

If the QRS complex appears normal and narrow, ventricular depolarization has occurred from an impulse above the ventricles. (1) When such a normal appearing QRS deflection is preceded by an ab-
normal P (negative or diphasic in leads I and II) with a PR interval of 0.12 second or more, the pacemaker is auricular. Such may be a premature auricular contraction, or auricular paroxysmal tachycardia. In the latter, however, the rhythm is so fast that the abnormal P lies buried in a preceding T. If each T wave were not so misshapen, an absence of P altogether might be suspected. (2) When an abnormally shaped P precedes regularly a normally appearing QRS by less than 0.12 second, or follows or is superimposed on the QRS, then AV nodal rhythm exists. This rhythm may be a tachycardia.

Auricular fibrillation is characterized by absence of P waves, but the rate is usually irregular because irregular fibrillatory waves get through the AV node only after the latter has recovered from its refractory period.

Suppose no P waves exist and the rate is regular, then auricular fibrillation is present with complete AV block. (1) If with this picture the QRS appears normal in shape, AV nodal rhythm must be stimulating the ventricles. (2) If the QRS is grossly distorted (as in bundle branch block) in this tracing of auricular fibrillation with complete AV block, then either the pacemaker is within the ventricles (idioventricular rhythm), or the exceedingly rare combination of bundle branch block with AV nodal rhythm is the ventricular mechanism, while auricular fibrillation is the auricular rhythm.

Auricular flutter is similar to fibrillation, except that the iso-electric base line possesses large waves or flutter waves.

An intraventricular beat is so large and abnormal that it stands out, and appears exactly like a good specimen of bundle branch block deflection. Therefore, premature ventricular contractions and ventricular tachycardia are identified with ease.

The tracing of ventricular fibrillation consists of irregular undulations which resemble a child’s scribblings. No P, QRS or T waves are discernible.

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