

# ANALYSIS OF FIFTY NORMAL ELECTROCARDIOGRAMS INCLUDING LEAD IV

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An analysis of the electrocardiograms of 50 normal women students between the ages of 20 and 27, attending the Royal Free Hospital, is given. Originally the records of 100 students were taken, but later it was decided to select 50 that showed a normal relation between weight and height and were physically fit. Special attention was directed to lead IV and its possible relations to the three standard leads. In all our work lead IV R has been used, i.e. left arm electrode at the extreme outer border of the apex beat as the exploratory electrode and right arm electrode as the distal indifferent electrode, this following the recommendations of the joint report of the Cardiac Society of Great Britain and Ireland and the American Heart Association in 1938.

It is proposed to analyse the duration, form, and amplitude of each wave. A number of tables, frequency curves, percentage relations, and mean values have been constructed for these in each lead; only a few of them have been selected for reproduction in the text.

## THE P WAVE

All the measurements given in the text have been made according to the standard method except where otherwise stated. The earliest accurate measurements of the amplitude and duration of the P wave were made by Lewis and Gilder (1912) and by Goodall and Richards (1914).

*Form.* Table I shows that this is very variable, the round and pointed forms being most prevalent. The large preponderance of the pointed shape in lead II and the great variation in lead III are also noticeable. Bifid waves were found only in lead I. In two records the form was not the same in each cycle, varying between the pointed and round shape. We cannot give a satisfactory explanation of the factors responsible for the variation from cycle to cycle, and one must assume that in every cycle the excitation wave follows a slightly different path. At the same time the summation of the electrical activity of both auricles is not symmetrical and smooth. As a result the P wave curve changes its form from round to notched, bifid, or pointed.

TABLE I  
FORM OF P WAVE IN 50 CASES (PERCENTAGES)

Form	Lead I	Lead II	Lead III	Lead IV
Round .. .. .	36	24	32	56
Pointed .. .. .	50	70	38	40
Round or pointed ..	—	6	8	2
Inverted .. .. .	—	—	12	2
Bifid or flat .. ..	14	—	10	—

Shiple and Hallaran (1936), in an analysis of the electrocardiograms of 200 normal men and women, recorded smooth and round P waves in 67 per cent. and pointed in 33 per cent. Notching was present in 30 per cent., but only in one record was it found in all leads. P was inverted in 5 per cent. of their records, but only in lead III. A diphasic P was met once in lead II and 32 times in lead III. When P was inverted, T was also inverted; and when P was diphasic in lead III, T was also diphasic. We found a similar relationship, but in one record P was inverted in lead IV and T was upright. In subsequent tracings inversion of P was noted in other leads or cycles, whereas in lead IV the auricular deflection was upright. This was a case of wandering pace maker. The association of the amplitude of P greater than 2 mm. and notching was not met with in our cases, nor in those recorded by Shiple and Hallaran, and we agree with them and others that this association is one of the signs of mitral stenosis.

*Amplitude.* Originally Lewis and Gilder gave the following values for the P wave deflection in 52 healthy subjects; lead I=0.52 mm., lead II=1.16 mm., and lead III=0.81 mm. More recently Burnett and Taylor (1936) gave an analysis of 1276 electrocardiograms taken from 167 children, aged 3 weeks to 12 years, of whom 85 were boys and 82 girls. The amplitude was higher than in adults (upper limit 2.5 mm. and lower limit 0.5 mm.). The girls showed a higher amplitude than the boys, but after the age of ten there was less variation in all leads. In résumé the authors state that P showed higher and lower deflections in children than in adults, more frequently high in girls than in boys, but that the average did not show any notable departure from the average value found in the adult.

Shiple and Hallaran give the average amplitude of the P wave for men as 1.41 mm., and for women as 1.30 mm. in lead II, which showed the greatest deflection of P in 90 per cent.

In comparing the average value of our 50 students, we found much higher figures than those given by previous investigators (see Table II). The mean value of P in the four leads was 1.74 mm. ; and the greatest value, in lead II, 2.3 mm. The maximum and minimum deflections of P in our records were 5 mm. and 0.5 mm. This shows that large P waves occur quite often and have no abnormal significance. The highest average deflection was found in lead II, and the next in lead IV.

TABLE II  
AMPLITUDE OF P WAVE IN 50 CASES (PERCENTAGES)

Range of Amplitude in mm.	Lead I	Lead II	Lead III	Lead IV
0-1	6	—	24	2
1-2	72	36	48	58
2-3	20	38	26	34
3-4	2	18	2	6
4-5	—	8	—	—

*Duration.* Our measurements for the duration of the P wave fit in to some extent with those of other investigators and with those of Shipley and Hallaran, who give the value of 0.08-0.12 sec. for the duration of P for men and women alike. Their average is 0.09 sec. and the longest duration 0.12 sec. The average values found by us were 0.08 sec. in each lead, except in lead I where it was 0.07 sec.; and the mean value for the four leads was 0.076 sec. This value is lower than that reported by the above mentioned investigators, and our view is that in young women the duration tends to be shorter than in men. From our measurements it appears that there is no definite relation between the amplitude and the duration of the P wave.

THE P-R INTERVAL

*P-Q Duration.* This was measured from the end of P to the Q deflection. The mean value for each lead was 0.06 sec., except in lead III where it was 0.07 sec.

The mean value for the four leads was 0.064 sec. The longest duration was in lead III, 14 per cent. being between 0.09 and 0.12 sec., and 70 per cent. between 0.06 and 0.09 against the 50 per cent. in the other leads. In comparison with the values exhibited by the normal heart, cases of mitral stenosis tend to show a short P-Q duration.

*P-R Interval.* The value of the P-R interval 0.13-0.21 sec. established by

TABLE III  
DURATION OF P-R INTERVAL IN 50 CASES (PERCENTAGES)

Range of duration in seconds	Lead I	Lead II	Lead III	Lead IV
0.09-0.12	22	4	6	6
0.12-0.15	58	50	32	54
0.15-0.18	16	42	52	38
0.18-0.21	2	4	6	2
Mean value (seconds) ..	0.13	0.14	0.15	0.14

Lewis and Gilder (1912) has been adopted beyond criticism as a normal range. Lewis showed that for cats it is 0.06-0.08 sec., and for dogs 0.08-0.10 sec. Paul

White in his book gives the normal value for adults 0.20 sec. (average 0.16 sec.) and for infancy and childhood 0.08–0.18 sec. (average 0.125 sec.). The results of our analysis of P–R are reproduced in Table III, and the frequency curves in Fig. 1. The range of duration was between 0.09 and 0.21 sec. In lead I most cases fell within the range 0.12–0.15 sec., with a large number of small duration,

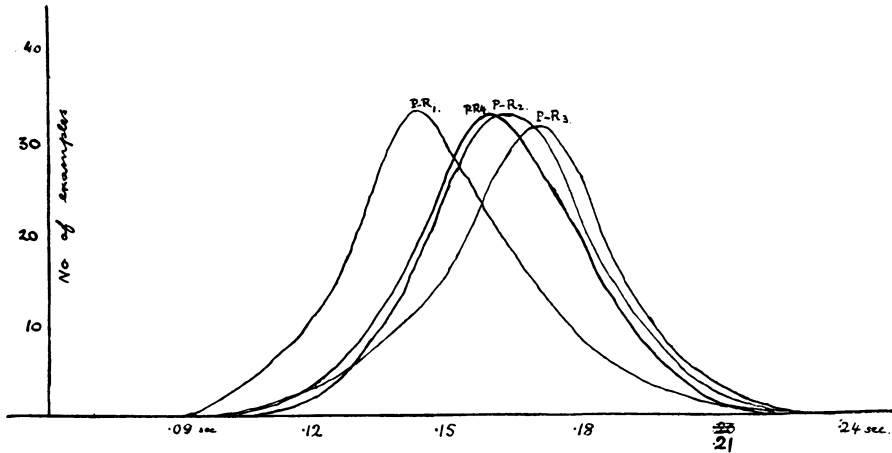


FIG. 1.—Frequency curves of the duration of the P–R interval in the four leads.

0.09–0.12 sec. In the other three leads the greatest number of cases were between 0.12–0.18 sec.

#### THE QRS COMPLEX

The most variable part of the QRS complex and that on which a considerable number of investigations has been published, especially in relation to coronary disease, is the initial ventricular deflection, the Q wave. The first wave of the ventricular complex is designated as Q by Einthoven, if it points down, and as R if it points upwards. S denotes the downwards wave that comes after the upward R, and where there is no upward wave the downward wave is designated as S. Lewis in his book (1925) states that Q is “beyond question a ventricular event, occurring as it does in curves of complete dissociation of auricle and ventricle as part of ventricular complex, as was first pointed out by Einthoven.” If QRS is inverted, as in dextrocardia or in abnormal axis deviation, Q and S will also be inverted and point upwards. Besides that, as we shall see, there are normal curves in which the initial ventricular deflection is such that it is difficult to distinguish Q and whether it points downwards or upwards. Sometimes Q is absent or flat or represented as a thickening at the beginning of the R wave, in which case it is called fused. Finally Q may be replaced by an initial diphasic phase at the beginning of the R wave. The electrocardiograms, Fig. 2, A and B, are examples of “inverted” Q according to some American authors; Fig. 2C is an example of Q fused to R, or flat; and Fig. 2D is an example of “diphasic” Q.

Paul White (1937) states that Q is usually absent in lead II or may be a

short point, projecting 1–2 mm. below the base line, and that in infants and young children it may form a more appreciable part of the QRS complex being as much as 3–4 mm. in amplitude. In lead I, according to him, the QRS complex is such that it is often impossible to tell whether we are dealing with an upright Q, an inverted R, or an upright S, and such variations certainly occur in some cases.

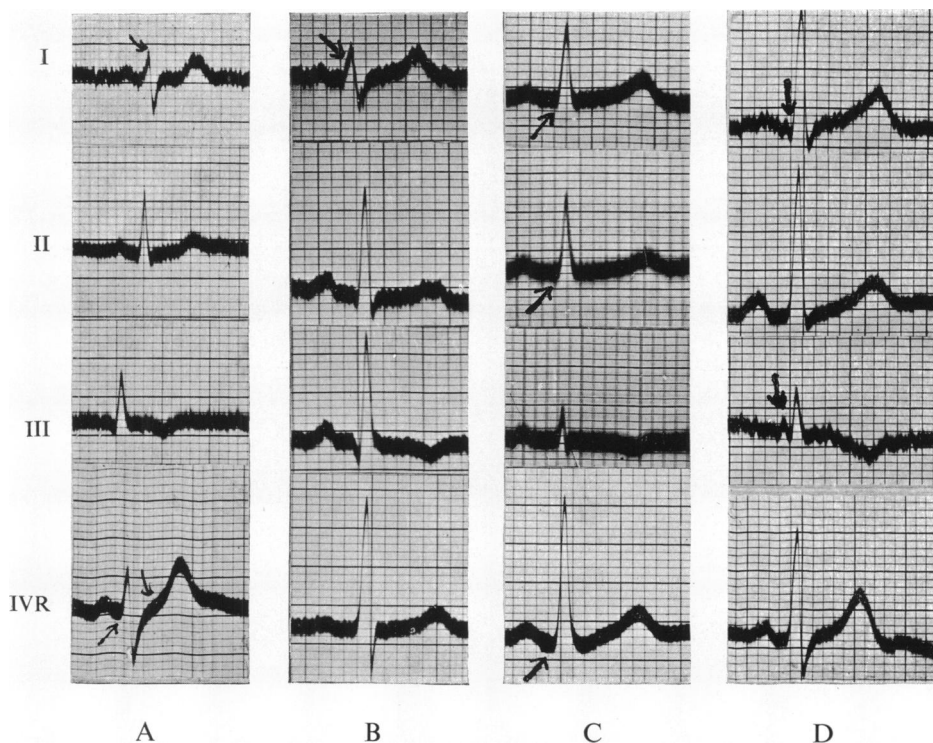


FIG. 2.—Cardiograms selected to show different types of deflections discussed in the text : (A) and (B) show inverted Q in lead I ; (C) shows Q fused to R ; (D) shows diphasic variation of Q in leads I and III.

Pardee (1933) has drawn attention to a deep  $Q_3$  as an indication of myocardial disease. Kossman, Shearer, and Texon (1938) affirm that normal subjects with a deep  $Q_3$  rarely show the other criteria of Pardee. In a combined series of reports from Lewis and Gilder, Cohn, Master, Pardee, and Edeiken and Walwerts a deep  $Q_3$ , according to the above criteria, was found twice in the electrocardiograms of 1102 young men, including 116 normal athletes.

We have investigated  $Q_3$  according to Pardee's criteria in all our cases. A deep  $Q_3$  was of frequent occurrence and was more frequent in young women and children than in adult males. But in no electrocardiogram did we find the Pardee criteria followed, except in one (Fig. 3C). It is from a woman, 21 years of age, who shows clinically no heart abnormality and is in perfect health. There is a deep  $Q_3$ , of over 4 mm., which is more than 25 per cent. of the

largest QRS complex in any lead. There is also a conspicuous Q in leads I and II and low voltage in lead IV. The arrow in the record is pointing to show "fusion" between S and R in lead III, according to the interpretation of Hurxthal and others. There is also an inverted or isoelectric P wave and an inverted T in lead III. We consider this electrocardiogram is a rarity because it follows Pardee's criteria although it is from a normal person.

We feel that unless we know all the possible variations of Q in normal persons it is difficult to accept with confidence its diagnostic value as suggested by the American investigators in coronary infarct. Table IV shows the analysis of the form of Q deflection.

TABLE IV  
FORM OF Q WAVE IN 50 CASES (PERCENTAGES)

Form	Lead I	Lead II	Lead III	Lead IV
<i>Down</i> (or down -fused or -diphasic) . . . . .	52	64	50	24
<i>Upright</i> * (or upright-fused) . . . . .	4	—	16	4
<i>Flat</i> * (or flat -fused or -diphasic)	44	36	34	72

\* The terms upright, flat, fused, or diphasic, are adopted from the works of certain American authors, e.g. Hurxthal, but their acceptance is not yet general.

Recently Kossman, Shearer, and Texon (1938) have reported the detailed study of the incidence and quantitative relationship of the Q deflection of the three standard leads of the electrocardiograms of 178 normal subjects in order to find a standard for comparison for any type of heart disease. In either the sitting or recumbent position and during either phase of respiration, 40 per cent. showed a Q deflection in lead I, 60 per cent. in leads II or III, and 40 per cent. (or slightly less) in both leads II and III.

*R Deflection.* The R wave follows immediately the initial ventricular deflection. According to the general view it is composed of two projections, an upright which starts from Q and a downwards which ends in S, the final deflection. The amplitude of R in our curves was measured from the isoelectric line to the summit, and the slight or deep downwards deflections produced by Q or S were ignored. However, in some records especially in lead III, R is diphasic or may take the shape of M or W. The R deflection is considered diphasic when the projection, instead of starting from a downward or flat Q, starts from an upright (inverted Q) and finally goes downwards to a deep S wave.

The diphasic R should not be confused with an inverted R met with in left or right preponderance. In this case the R deflection starts from the isoelectric line from an inverted Q, projects downwards, and then ascends back to the isoelectric line to an inverted or fused S wave. A diphasic R has a positive phase which is above the isoelectric line and a negative phase which is underneath

the isoelectric line. This interpretation is not generally accepted, but we consider it necessary. In some records the positive part of a diphasic R is very small on account of a big initial Q inversion (see Fig. 2B). In other records it starts from a smaller inverted Q and descends to a deep S (see Fig. 2A, leads I and IV). However, it is sometimes very difficult to differentiate between a diphasic R wave and an inverted Q wave. For example, in Fig. 3A in

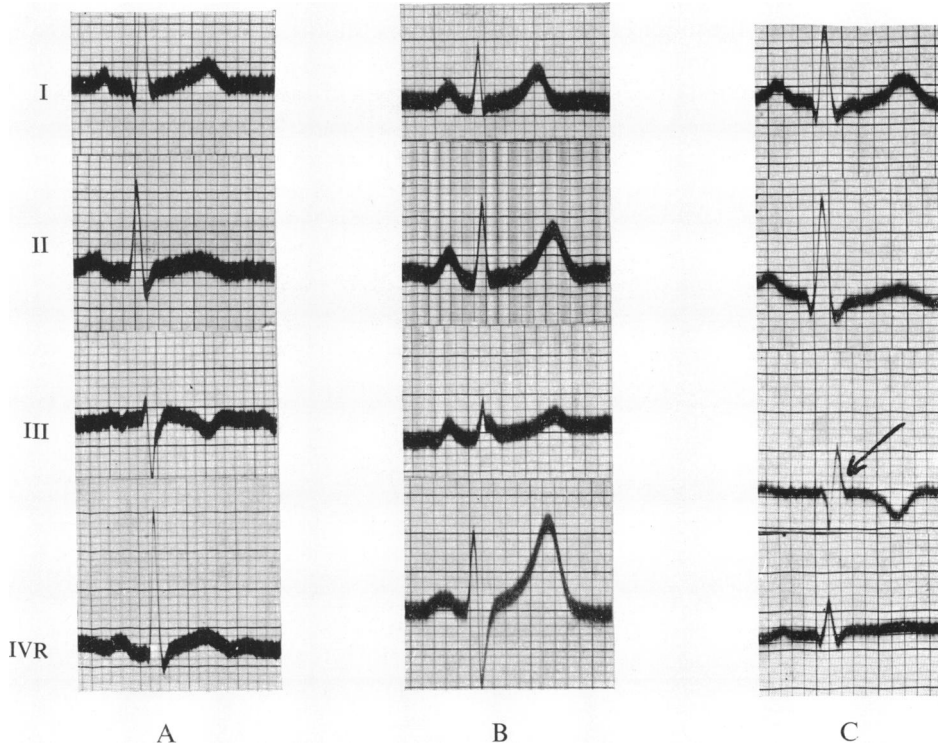


FIG. 3.—(A) Upright Q in lead III : (B) S fused in lead III when Q is fused or upright in lead I : (C) Example of Pardee criteria found in a normal subject.

lead III there is an upright Q and an inverted R, but there are no other signs of left preponderance. The R wave in lead II is not diphasic and there is a medium projection of R in lead I. The record is from a young student who is a good athlete. All that can be said is that she has a well developed left ventricle.

The relation between Q in lead I and S in lead III is considered significant. In our records it was found that almost always when  $Q_1$  was upright or fused,  $S_3$  was fused (Figs. 2, A and B, and 3B). An exception to this rule was observed in only 3 out of 50 electrocardiograms. It does not follow, however, that when  $S_3$  is fused  $Q_1$  is also fused. In 20 records out of 50,  $S_3$  was fused while  $Q_1$  was not.

According to Hurxthal (1933), in left axis deviation,  $Q_1$  points down markedly and  $Q_3$  shows a distinct upright deflection. In right axis deviation  $Q_3$  points downwards ( $Q_1$  being upright) and, if  $R_1$  is slightly upwards, slurring of the origin of R will be found. One can reasonably assume this to be a

fusion of upright Q and R. Also he states that if the law of Einthoven can be applied to separate phases of QRS this will be helpful for correct identification of a deflection, as very often somatic tremor or other irregularities or abnormalities make it difficult to separate various components.

Paul White gives as limits for the R deflection in normal adults 5–35 mm. and in infants 5–10 mm. Pardee sets the lower limit at 7 mm. and by most authors smaller deflections than this are considered as low. Steuer (1933), taking 7 mm. as the lower limit reviews 50 cases with low voltage, all having had post-mortem examinations. All showed severe myocardial lesions due to coronary disease, tertiary syphilis, rheumatic heart disease, or nephro-sclerosis, or in a few cases miscellaneous causes such as acute or chronic infections, cancer, etc. Shipley and Hallaran record low voltage electrocardiograms under 7 mm. in three apparently normal subjects. In the Burnett and Taylor (1936) series, the results were : 55 cases, 17 mm. or over ; 44, 7 mm. or below ; 4, 3 mm. or below.

We accept the view that a deflection of R under 5 mm. in all leads (including lead IV) is rare and is a sign of serious myocardial damage. Below are recorded the values found in our 50 cases analysed according to leads :

TABLE V  
SIZE OF R WAVE IN 50 CASES (PERCENTAGES)

Size of Deflection	Lead I	Lead II	Lead III	Lead IV
5–7 mm.	24	2	18	2
7–17 mm.	72	76	56	44
17–31 mm.	4	22	2	44
Mean value (mm.) ..	9.8	13.5	6.5	1.74

In 12 records the deflection of R in lead III was under 5 mm., 2 records being just under 2 mm.; in 6 it was between 3–4 mm., and in 4 between 4–5 mm. The maximum deflection of 31 mm. was found twice in lead IV. No slurring or notching was seen in our series of cases.

*Duration of QRS.* The earliest work on QRS duration was done by Lewis and Gilder (1912), who state that the normal duration must not be over 0.10 sec. We are reproducing here the values for QRS duration according to different investigators quoted from the paper of McGinn and Paul White (1933). Ferguson and O'Connor (1926) in 1812 young people report a duration of over 0.10 sec. only in 2 records ; Jensen, Smith, and Cartwright (1932), found a duration of 0.06–0.08 sec. in 50 patients. Seham (1921) reports the following values in children : birth to one year, 0.036 sec. ; one to five years, 0.05 sec. ; over five years, 0.07 sec. Lincoln and Nicolson (1928) give 0.06 in 222 normal school children. McGinn and Paul White, using the Lucas comparator described in detail by Lewis (1925), find the following figures : 50 males, average 0.083



(66 per cent. over 0.08 sec.) ; 50 females, average 0.072 (20 per cent. only over 0.08 sec.). The average for all cases and all ages was 0.078 sec. Eleven persons were tall, 10 of whom had a duration of QRS more than 0.083 sec. In 50 normal children under 12 years, 26 boys and 24 girls, the average QRS duration was 0.072 sec. The duration tends to be slightly longer in boys than in girls. Shipley and Hallaran (1936) found a smaller difference between the average QRS duration in males (0.087) and in females (0.085).

The values of the QRS interval found in our 50 normal cases differ to some extent from those reported by previous authors. In general the duration is shorter. The mean values were 0.06 sec. in the three limb leads and 0.05 sec. in lead IV. The shortest duration was 0.03 sec. and the longest 0.09 sec., both in lead III. Although lead IV shows the largest voltage, the QRS duration was the shortest in this lead. The measurements were made from Q or the beginning of the ascending spike of R to the beginning of S or in absence of S to the fusion of R and S. If Q and S deflection were "fused" with R or absent, the measurements were made at the level of the fused part on the base line. When R was diphasic the measurements were made from Q to the tip of the lower deflection of S.

It was thought that one of the reasons for the short duration of QRS was the fast rate found in most of our records, but no relationship between the duration of QRS and the duration of whole cycle could be established.

*S-Wave.* The variations of S are less frequent than those manifested by Q. There appears to be no definite relation between Q and S with regard to their form, nor is there at present any satisfactory explanation of the variations of the form of the S wave.

*Amplitude.* The S deflection is in general more conspicuous than Q and is greatest in lead IV, in contrast with Q which is smallest in this lead. The mean values that were found for S are shown in the first column following :

Lead	mm.	mm.
I	1.08	2.06
II	0.79	2.23
III	0.08	1.73
IV	3.28	—

The figures in the second column show the average values found by Lewis in normal adults. Burnett and Taylor (1936) report that S is deeper in children than in adults and that it decreases in size with age in all leads.

#### THE SECOND VENTRICULAR DEFLECTION OR T WAVE

We have analysed here separately the S-T segment (the interval between S to the beginning of T), the T wave itself, and the classical S-T duration. According to Lewis (1925, p. 119) there is always a definite relation between the direction of T and the direction of either Q or S, usually the latter. An upright T is always preceded by a downwards S, and if T is inverted S is usually upright, but if not, Q is upright. Since Lewis's work many investigations have been published

on the significance of the T wave and its relation to the initial deflections of the ventricular complex. According to Craib's (1930) conception there is no constant relationship between the direction of the T deflection and the direction of any deflection of the initial group, because the QRS deflection is recorded before there is any material movement of the myocardium, whereas the end deflection of T is recorded when there is a gross displacement of the myocardium. He held the view that the human electrocardiogram is composed of an initial quick deflection recorded before contraction and a prolonged end deflection recorded when the whole ventricular mass is in contraction. Theoretically each deflection is the result of multiple simultaneous contributions from all parts of the heart, and only the part of the summation that is in the same direction as the lead is recorded. Craib explains the electrical events recorded during ventricular activity by referring to his mathematical hypothesis of doublets, which is based on the view that currents flowing about active tissue must flow between anodes and cathodes localized at the affected part of the tissue.

*S-T segment (S to beginning of T).* Shipley and Hallaran (1936) point out that the level between QRS and T is influenced not only by the ventricular events but also by the so-called auricular T wave. We have measured in our records the deviation of the S-T segment from the P-R level. The S-T segment was most often raised in leads I and II, depressed in lead III, and slightly raised in lead IV. We cannot, however, draw a definite conclusion at present as we found difficulty in the identification of the auricular T effect.

*Duration.* On recording the duration of the S-T segment great difficulties are met with on account of the variation of form. The greatest value found was 0.24 sec. in lead III, and, as already stated, the segment was absent in a great number of records. The average values were as follows: 0.11 sec. in leads I and II, 0.13 sec. in lead III, and 0.10 sec. in lead IV.

*The form and amplitude of the T wave.* This varies with age. Burnett and Taylor (1936) in 167 healthy infants and children report well-defined T waves in leads I and II, and low voltage T waves in lead III in infants three weeks old. In children,  $T_1$  is higher than the adult standard of 5 mm.,  $T_2$  reaches an amplitude of 8 mm., while  $T_3$  is found to follow the adult type.

The authors describe also the susceptibility to external influences of T in childhood. In several records  $T_3$  becomes inverted when the child changes from the recumbent to the sitting position. This appears to be due to some shift to the right, since mediastinal structures are very flexible in childhood. In adults it has a greater stability than in childhood, but this varies with the sex. In women, the T wave, especially in lead III, is less stable and shows a greater variation than in males. The round form T was more frequent in leads I and II, while the pointed form was more frequent in lead IV (62 per cent.).

The characteristic feature of T in some leads is the immediate take off from the R-S base with the rapid ascending peak and the abrupt drop. This type was more frequently met with in lead IV. We feel that this should not be interpreted as an absence of the S-T segment, but as a fusion between S-T and the ascending part of T. The evidence pointing in this direction is the existence of an increased time duration for T when the S-T segment is abrupt or fused.

This association was found 21 times in lead IV, 6 times in lead I, and 3 times in lead II.

Inversion of T was found most often in lead III (46 per cent.). The view of Lewis, that when  $T_3$  is inverted, S or occasionally other deflections of QRS point in the opposite direction to T, is fully confirmed by our observations. Out of 23 records in which  $T_3$  was inverted:  $S_3$  was fused and upright in 12 records; upright in 2; and flat in 3 records; in the remaining 6  $S_3$  was downwards, with R inverted and Q upright in 4 records and with Q upright in 2 records.

As already stated the largest amplitude of T was found in lead IV, and an analysis of the deflection in all leads is reproduced in Table VI and in Fig. 4.

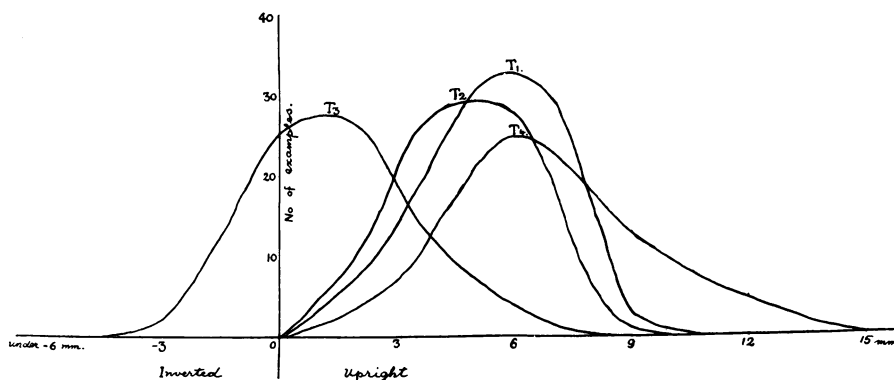


FIG. 4.—Frequency curves of the amplitude of T in the four leads.

The average values of the amplitude are also as given in the table. It is interesting to note that the average value for T in lead I had a slightly larger value than in lead II in our records. This suggests two explanations :

1. There is a slight preponderance of the right over the left heart, in accordance with Lewis's bicardiogram hypothesis with regard to the summation of the events in both ventricles.

2. In young women the anatomical position of the heart and the axis of the direction of the change of potential are such, that in lead I the potential recorded for the T wave is slightly larger in certain cases than that recorded for the T wave in lead II.

This may explain also the large proportion of inversion (46 per cent.) and

TABLE VI  
AMPLITUDE OF T IN 50 CASES (PERCENTAGES)

Range of amplitude in mm.	Lead I	Lead II	Lead III	Lead IV
-6 to -3	—	—	4	—
-3 to 0	—	—	50	—
0 to +3	28	42	38	14
+3 to +6	66	56	8	50
+6 to +9	6	2	—	26
+9 to +12	—	—	—	10
Average amplitude (mm.)	+3.23	+3.22	-0.74	+5.07

isoelectric T in lead III (30 per cent.). The S deflection shows also a larger average value in lead I than in lead II. In contrast with the T and S deflections the Q and R deflections show larger values for lead II than for lead I.

*Duration of T.* No relation was found between the amplitude of the T deflection and the duration. In Table VII below is reproduced the analysis of the T wave duration.

*S-T Duration.* The S-T segment and T wave added together form the S-T duration—the second part of the ventricular deflection. The range of values found in our records was 0.16–0.36 sec., the minimum being found in 3 records in lead III, and the maximum in 6 records in lead I, 3 records in lead II, 2 records in lead IV and 1 record in lead III. The average values were : lead I, 0.28 sec. ; lead II, 0.27 sec. ; lead III, 0.25 sec. ; and in lead IV, 0.28 sec.

TABLE VII  
DURATION OF T IN 50 CASES (PERCENTAGES)

Range of duration in seconds	Lead I	Lead II	Lead III *	Lead IV
0.04–0.08	—	—	6	—
0.08–0.12	6	—	28	—
0.12–0.16	36	26	28	14
0.16–0.20	40	68	6	60
0.20–0.24	16	6	4	22
0.24–0.28	2	—	—	2
Mean value (seconds)	0.16	0.16	0.12	0.17

\* T was isoelectric in 14 records in lead III, and in one record in lead IV, and therefore not measured.

The values found by us in 50 normal records are in general smaller than those given for adults in most books on electrocardiograms.

#### SUMMARY

An analysis of 50 normal electrocardiograms has been given. The form, amplitude, and duration of each deflection have been studied in the light of classical and recent investigations. The three standard leads and lead IV R, drawn according to the calculated mean values, are reproduced in Fig. 5. The

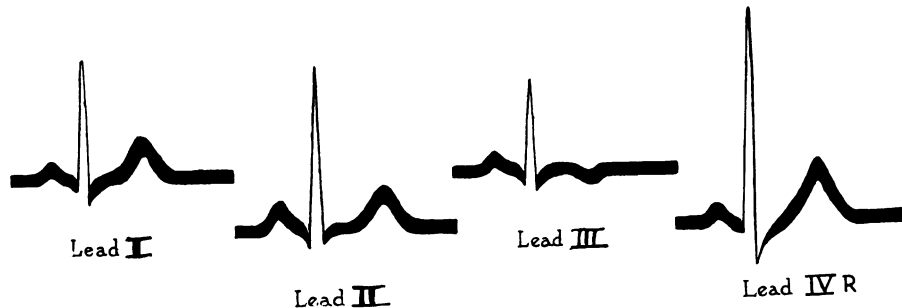


FIG. 5.—Standard four lead electrocardiogram drawn according to the mean values obtained in this series.

main part of the paper has been devoted to a detailed record and discussion of actual measurements of each component of the electrocardiogram.

In young women, each wave varies slightly from the values found by others for men and children ; both the voltage and duration appear to be intermediate, having in general lower values than in men and higher values than in children.

The classification of the components of the QRS deflection according to form has been a matter of some difficulty owing to the various views expressed by different authors. In describing Q and S it was found necessary to use the words inverted and fused, but we do not consider that the correct interpretation has yet been finally settled.

The form of R wave which we describe as diphasic is also a debated point. The other forms of R wave, however, were measured in accordance with the generally accepted view.

The S-T segment and S-T duration are studied separately in this paper. It was, however, difficult to ascertain the duration of the former on account of the frequency of the abrupt form which occurred mainly in lead IV.

The amplitude of T in lead I is a noticeable exception to our general conclusion that amplitudes have lower values in young women than in men. We regard as significant the frequent inversion of T in lead III.

Special attention has been paid to the findings in lead IV, and they have been compared with the other three leads.

Since we wrote this paper we have read the article by Chamberlain and Duncan Hay in this journal (1939). They made a study of 302 normal subjects, mainly in the third and fourth decades, and summarized the results in age groups covering seven decades. In general their values are similar to ours. We consider that the differences are accounted for by the fact that they investigated both sexes and a wider range of ages. In contrast with the 29 per cent. of inversion of T in lead III found by Chamberlain and Hay, we found 46 per cent. in our series of young women in their third decade.

We wish to express our grateful thanks to Professor Winifred Cullis, head of the Department of Physiology, and to Miss Marion Morris of the Department of Physics at the London School of Medicine for Women, for their help and advice.

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