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Conspicuous Q wave in lead III of the electrocardiogram

George Hal Demay
University of Nebraska Medical Center

THE CONSPICUOUS Q WAVE
IN LEAD III OF THE ELECTROCARDIOGRAM.

By

G. Hal DeMay

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INTRODUCTION

Electrocardiography is a laboratory procedure capable of furnishing two general types of information regarding the integrity of cardiac function and structure. The first is concerned with the mechanism of initiation and conduction of the electrical impulse responsible for the heart beat, and constitutes that phase of electrocardiography concerned with abnormalities of cardiac rate and rhythm. These abnormalities can often be recognized by clinical methods of examination. Certain cases, however, require electrocardiographic evidence for confirmation of the clinical impression, the evidence consisting of the established relationship between auricular and ventricular complexes. The second, and more important type of information is concerned with the form of the ventricular complex, and is indicative of significant myocardial lesions about which exact information cannot be obtained by clinical methods of examination.

In recording the standard leads of the electrocardiogram the electrodes are approximately equidistant from the heart, their electrical potentials of about equal magnitude and influencing the form of the electrocardiogram equally. The resulting complexes are consequently mixtures of electrical potential differences, and as such have no direct relationship to underlying cardiac events. The usefulness of these leads is therefore limited, their interpretation difficult, and often impossible without the assistance of the precordial lead, which records the electrical cardiac events in the portion of the heart muscle underneath the electrode. This type of ventricular complex may be interpreted on the basis of definite principles. Thus, in the case of precordial leads, deflection of leads from the right side of the chest represent potential variations of the right ventricle, and those from the left side of the chest similarly represent potential variations of the left ventricle. The form of the ventricular deflections of leads from the extremities will vary with the position of the heart, each variation depending upon which extremity receives the predominant potential of either ventricle.

These facts must be remembered when considering the significance of the individual deflections of the QRS complex.

THE METHOD OF PRODUCTION OF THE QRS COMPLEX.

As stated, the electrocardiogram depicts the origin of the impulse and its pattern of spread through the cardiac musculature. Functionally, the heart may be divided into two syncytial units; one shared in common by the auricles, the other by the ventricles. These two units are to be considered distinct from each other, joined only by a muscular bridge which penetrates the auriculo-ventricular junction separating the two. According to Katz (8) the heart contains two types of muscle fibers; one, the ordinary cardiac muscle, the other, the special cardiac muscular tissue which consists of (a) nodal muscle fibers, and (b) Purkinje muscle fibers. These two types of muscle fibers, however, are closely related in that the specialized muscular cells are virtually continuous with the ordinary auricular or ventricular muscular fibers.

There are two main accumulation of nodal tissue. The first, the sino-auricular node, is located in the right ventricle in the sulcus terminalis, at the point where the superior vena cava joins the auricle. It is approximately 25 millimeters in length, beginning subpericardially and ending endocardially. The second, the auriculo-ventricular node, lies in both the interauricular and interventricular septa. It is approximately 5 millimeters in length and is joined by transitional fibers with the ordinary auricular fibers. At its lower pole the auriculo-ventricular node becomes continuous with the common auriculo-ventricular bundle which is composed of Purkinje muscle fibers.(8)

The mass of the Purkinje muscle fibers comprises the complex contractile-conduction system of the ventricles, the His-Tawara system. This complex system is made up of the following units; (a) the common auriculo-ventricular bundle, or bundle of His, (b) the right and left bundle branches, and (c) the terminal arborization, or network.(8)

The common auriculo-ventricular bundle, being immediately continuous with the auriculo-ventricular node above, is about 10 millimeters in length and forms the single muscular bridge connecting the auricles with the ventricles. The auriculo-ventricular bundle divides at its lower end into the right and left bundle branches. The right bundle branch extends in the wall of the septum to the right anterior papillary muscle, reaches the surface inferior to this and branches into a fine network to give rise to the complex terminal arborization, just beneath the endocardium. The left bundle branch courses in the left side of the septum and branches extensively beneath the endocardium forming the terminal arborization of that side. Usually two rather large collections of this branch are given off to supply the anterior and posterior papillary muscles. (8)

The process of cardiac contraction has been divided theoretically into three parts: (a) the short phase of excitation comprising that preliminary stimulus which precedes and initiates the actual shortening, (b) the phase of contraction, or the actual shortening, and (c) the longer phase of relaxation. (15)

The stimulus of excitation begins in the sino-auricular node and spreads radially through the auricular syncytium resulting in almost synchronous contraction of the auricles. The contraction of the auricles is comparatively slow and wave-like and gives rise to the P wave of the electrocardiogram. The excitation wave is then conducted by the transitional fibers from the ordinary auricular fibers to the auriculo-ventricular node, and thence to the auriculo-ventricular bundle of His, to activate ventricular contraction. The first part of the ventricle to be activated is the interventricular septum. Lewis (11) concluded that the inscription of Q and the beginning of the R wave, corresponded in time to the excitation of the septum, right papillary muscle, apices of the two ventricles, and the areas immediately adjoining. The activation process continues radially in the interventricular septum to and through the lateral walls of the ventricles. This activation of the mass of the ventricular walls, according to Lewis, results in the inscription of the prominent part of the R wave, and basilar excitation inscribes the remainder of the QRS complex. It should be noted that, because of the rapid rate at which the Purkinje fibers transmit the impulse (approximately 4000 millimeters per second), and because of the fine terminal network of the His-Tawara system, the whole ventricular syncytium enters into the contraction almost simultaneously, no one portion being activated more than 0.04 second before another. (1)

THE Q WAVE.

The possible relationship between abnormalities of the initial ventricular deflection of the electrocardiogram and coronary artery disease was first noted by Pardee (14) in 1920. At that time, this author published an original account of R-ST changes in a case of coronary occlusion and made note, also, of a conspicuous Q wave in Lead III of the electrocardiogram. Somewhat later Wilson (23) noted that a proportion of his electrocardiograms, exhibiting T inversion in Lead III, in cases of coronary artery disease, showed also large initial Q waves in the same lead. Parkinson and Bedford (17) also referred to this peculiarity and discussed the importance of widening and low voltage of the QRS complex as evidence of abnormal myocardial function consequent to coronary thrombosis. In their cases of coronary occlusion, Levine and Brown (10) corroborated the above observations and commented on the frequency of a large Q in Lead III. Notwithstanding these previous references, Pardee (16) in 1930, was the first to investigate, as an entity, the conspicuous Q wave as an abnormality indicative of coronary artery disease.

In his publication, at this time, Pardee discussed the frequent appearance of the deep Q wave in patients with the anginal syndrome, and proposed a criteria for the separation of significant from non-significant Q waves in Lead III of the electrocardiogram. This criteria is as follows:

(a) A downward initial deflection (Q) in Lead III, succeeded by a definite upward deflection (R), with no (S) following.

(b) An excursion of the Q wave in Lead III of more than 25 per cent of the greatest excursion of the QRS complex in any lead.

(c) Elimination of electrocardiograms with right axis deviation as Q_3 is a normal finding in such records.

(d) Exclusion of records with notching deformity of the QRS complex in any lead (the so-called W and M complexes).

THE INCIDENCE OF THE DEEP Q_3 WAVE IN INDIVIDUALS WITH NORMAL HEARTS.

If the deep Q_3 wave, as outlined by the criteria of Pardee, is to be considered an abnormal electrocardiographic sign, its incidence must be determined in individuals with normal cardiovascular systems. Obviously, if this criteria is of value, this incidence must be low, since it must not include Q_3 waves of small amplitude occuring normally in individuals without cardio-vascular disease. Pardee (16) who conducted the first such investigation recorded electrocardiograms on 277 individuals with apparently normal hearts and found only two Q waves which conformed to the above criteria, an incidence of 0.7 per cent. Edeiken and Wolferth, (5) in 1932, carried out a similar investigation on two groups of individuals also having apparently normal hearts. In the first group of 709 college students there was no significant Q_3 wave sufficient to satisfy Pardee's requirements. Nine of these tracings showed a Q_3 of sufficient depth but did not fulfill certain other stipulations by Pardee since all had either right axis deviation or a tendent right axis deviation. The second group included 117 college athletes. In this series only one significant Q_3 was found and this in an individual with Rheumatic heart disease, possessing both a systolic and diastolic murmur at the apex, and who erroneously had been classified among those with normal hearts. From these two groups reported by Edieken and Wolferth (5), it may be seen that "the finding of but one significant Q_3 among the electrocardiograms of 826 college students with presumably normal cardio-vascular systems reflects the rarity of this wave in the tracings of healthy adolescents and young adults. Furthermore, the fact that this one significant Q_3 lead to the discovery that its possessor had frank valvular disease......offers an illustration of the fact that this finding must not be passed over too readily". Ashman et al (2) recorded a slightly higher incidence when they found 3 tracings exhibiting a large Q wave in Lead III, among 150 patients without evidence of heart disease. Two of these waves were not typical, but fulfilled certain of the requirements of Pardee. In a study of the electrocardiograms of 178 individuals with apparently normal hearts and between 16 and 30 years of age, Kossmann et al (8) found no electrocardiogram which displayed a Q_3

that exceeded Pardee's criteria for the maximum normal size of this deflection. In a similar series, composed of two hundred men and women all with normal hearts and below the age period of significant arteriosclerotic disease, Shipley and Hallaran (18) found four records showing significant Q waves in Lead III, an incidence of only 2 per cent.

Table 1. The Incidence of the "Deep" Q_3 Wave in Individuals with Apparently Normal Hearts. (Employing Pardee's Criteria for a Significant Q Wave)

Investigator	No. of cases in series	No. of deep Q_3 waves	Per Cent
Pardee	277	2	0.7
Edeiken & Wolferth	826	1	0.12
Ashman et al	150	3	2.0
Kossmann et al	178	0	0.0
Shipley & Hallaran	200	4	2.0
Total	1631	10	0.61

Analysis of the findings of these various investigators, as shown in Table 1, readily reveals that, using the criteria outlined by Pardee, "deep" or significant Q_3 waves rarely occur in individuals with apparently normal hearts; that in no individual series did the incidence of significant Q_3 waves exceed 2 per cent; and that in the composite series of the electrocardiograms of 1631 individuals, all with apparently normal hearts, only 10 exhibited deep or significant Q_3 waves--an incidence of only 0.61 per cent.

THE INCIDENCE OF THE DEEP Q_3 WAVE IN INDIVIDUALS WITH ORGANIC HEART DISEASE.

It has been shown that the incidence of fortuitously occuring large Q_3 waves is very small,--only 0.61 per cent in the electrocardiograms of 1631 individuals with normal hearts. A similar study of the incidence of the deep Q_3 in patients with organic heart disease offers an interesting comparison, and tends further to designate this deflection as an abnormality associated with organic disease of the heart. Table 2 shows the incidence of the deep Q_3 in individuals with organic heart disease, as computed from the publications of various authors. Fenichel and Kugell (6) reported an incidence of 11.4 per cent in their series of 140 cases. Willius (21), in 263 cases, obtained an incidence of 8.4 per cent. Pardee (16), in 200 cases, and Ashman et al (2), in 2905 cases, found an incidence of 7 per cent and 4.9 per cent, respectively.

Analysis of the investigations of these authors reveals that, employing the criteria of Pardee, the incidence of the deep Q_3 wave in organic heart disease is notably higher than in normal hearts; that the incidence varied in the individual series from 4.9 per cent to 11.4 per cent; and that in the composite series of 3508 cases of organic heart disease there were 195 electrocardiograms exhibiting deep Q_3 waves, an incidence of 5.6 per cent. The latter figure compared with 0.61 per cent, the incidence of the deep Q_3 in normal hearts, is significant.

Table 2. The Incidence of the Deep Q_3 Wave in Individuals with Organic Heart Disease. (Pardee's Criteria)

Investigator	No. of cases in series.	No. of Deep Q-3 waves.	Per cent
Fenichel and Kugell	140	16	11.4
Willius	263	22	8.4
Pardee	200	14	7.0
Ashman et al	2905	143	4.9
Total	3508	195	5.6

FACTORS OTHER THAN HEART DISEASE WHICH MAY CAUSE A DEEP Q_3 WAVE.

Attention has been drawn to the surprisingly low incidence of deep Q waves occuring in individuals with normal hearts. It has been shown further that the incidence of the deep Q_3 is notably higher in those with organic heart disease. (Tables 1 and 2) Nevertheless, factors other than heart disease have been shown to produce significant Q waves. In 1925, Meek and Wilson (13), experimenting with dogs, found that traction on the heart to the left produced left axis deviation in the majority of cases, and also increased the incidence of the Q_3 wave from 45 to 68 per cent. Edieken and Wolferth (5) attempted to produce significant Q_3 waves in subjects with presumably normal hearts by taking tracings in various abnormal postural positions. Marked changes in the QRS complex resulted, but significant Q_3 waves were not produced. They found, however, that by transferring the electrode from the left leg to the left scapular region they could produce deep Q_3 waves. This maneuver essentially represented a deviation of the usual angle of the heart and consequently the ventricular septum in respect to Lead III. In view of the general belief that the ventricular septum is concerned with the production of the Q wave, they concluded that rotation of the septum may determine the presence or absence of a deep Q_3 wave. Ziskin (24) compared roentgenographically the position of the heart within the thoracic cavity of 20 individuals with apparently normal hearts with deep Q_3 waves to an equal number in a control group. He observed that: "a significant difference in the angle of inclination of the heart was noted between the roentgenograms of the Q wave series and those of the control series. The angle of inclination of the heart in the Q wave series varied from 20 to 40 degrees, the average for the entire group being 29.6 degrees.....In the control series the angle of inclination of the heart was 40 degrees or over in the majority of the cases, the average for the entire group being 42.9 degrees. There is a difference of over 13 degrees in the relative position of the heart between the Q wave series and the control series. The heart tends to lie in a more horizontal position in the chest cavity in the group showing large Q waves in Lead III".

Any condition which will elevate the diaphragm and rotate the heart to the left will result at times in a large Q wave in Lead III. (5, 9, 13, 16, 24) Pardee (16) noted three patients in the latter part of pregnancy with deep Q waves in Lead III. Electrocardiograms repeated on two of these patients following delivery showed the disappearance of the significant Q waves. Edieken and Wolferth (5) examined the electrocardiograms of 25 women in the ninth month of pregnancy and found 3 cases exhibiting deep Q_3 waves. Electrocardiograms repeated on two of these, several months after delivery, also showed complete regression of the deep Q wave.

Other non-cardiac causes of this abnormality have been noted. Individuals with a hypersthenic type of chest, or those with abdominal distention elevating the diaphragm may at times exhibit deep Q_3 waves. (18, 24) Respiration affects the size of a Q_3 wave, causing it to become larger during expiration when the diaghragm is elevated, and smaller during inspiration. (16, 24) Krumbhaar and Jenks (9) reported the deep Q_3 as a common finding in the electrocardiograms of infants up to twelve months of age.

THE INCIDENCE OF HEART DISEASE IN ELECTROCARDIOGRAMS EXHIBITING DEEP Q_3 WAVES.

Pardee (16) in calling attention to electrocardiograms exhibiting large Q waves in Lead III, reported that 63 per cent of the 43 patients in his series had the anginal syndrome; furthermore 77 per cent fell into a group including angina, hypertension, and chronic, non-valvular heart disease. This observation prompted him to suggest the possible relationship between abnormalities of the initial ventricular deflection of the electrocardiogram and coronary artery disease. That a large Q_3 wave is frequently associated with coronary sclerosis and myocardial disease, may be seen from Table 3. Wallace (20) found that out of 108 cases exhibiting this deflection, 50 per cent gave a history of angina pectoris and that 87 per cent could be classified in the group including angina,

Table 3. The incidence of Various Types of Organic Heart Disease in Electrocardiograms Exhibiting a Large Q_3 Wave.

	No. cases in series	No. cases with angina	Per cent with angina	No. cases with hypertension	Per cent with hypertension	No. cases with arteriosclerosis	Per cent with arteriosclerosis	No. cases with angina, hypertension and chronic non-valvular heart disease.	Per cent with angina, hypertension and chronic non-valvular heart disease.	Per cent of cases with other types of heart disease.	Per cent of cases without cardiac signs or symptoms.
Pardee	43	27	63	2*	5	—	—	33	77	16	0
Wallace	108	54	50	14	13	22	20	94	87	3	10
Mazer and Reisinger	102	44	43	14	14	15	15	73	72	3	19
Willius	300	115	38	120	40	33	11	268	89	10	1
Strauss and Feldman	75	12	16	25	33	8	11	54	72	20	8
Edeiken and Wolferth	31	5	16	10	33	—	—	15	48	39	13
Ziskin	86	12	14	33	39	—	—	53	63	15	23

*Hypertension & Arterioslerosis classified together, hence this figure represents the sum total of the cases with hypertension and arteriosclerosis.

hypertension, or chronic, non-valvular heart disease. Mazer and Reisinger (12) in 102 cases, reported that 43 per cent of their series gave a history of angina, and that 72 per cent fell into the category including angina, hypertension, and chronic non-valvular heart disease. Willius (21) in 300 cases, and Strauss and Feldman (19), in 75 cases, reported the incidence of angina to be 38.3 and 16 per cent, respectively, while 89 and 72 per cent of these were classified in the group embracing angina, hypertension, and chronic, non-valvular heart disease. Edeiken and Wolferth (5), in 31 cases and Ziskin (24), in 86 cases, reported 16 and 14 per cent, respectively, gave a history of angina, and that 48 and 63 per cent could be grouped as having angina, hypertension, or chronic non-valvular heart disease.

THE SIGNIFICANCE OF THE DEEP Q_3 WAVE.

Regarding the material presented thus far concerning the conspicuous Q_3 wave, certain important features should be considered. Table 1 shows that the incidence of significant deep Q_3 waves in the electrocardiograms of individuals with normal cardio-vascular systems is negligible--only 0.61 per cent in 1631 instances. In Table 2 it is seen that the incidence of deep Q_3 waves in individuals with organic heart disease is notably higher, 5.6 per cent in 3508 cases. That the significant Q_3 wave is an abnormal deflection, usually associated with organic heart disease--rather than a normal deflection of the electrocardiogram, is indicated from a comparative study of these incidences. To conclude that the significant Q_3 wave (in view of its very low incidence in normal hearts) results only from organic heart disease would be erroneous, since factors other than heart disease have been shown to give rise to this deflection. These factors include any condition which will elevate the diaphragm and rotate the heart to the left, such as, pregnancy, abdominal distention, and hyperesthenic chests with a normally high diaphragm. In view of these considerations it would seem that, in any particular electrocardiogram, there is no more reason for regarding the large Q wave itself as indicative of organic heart disease than there is for regarding it as indicative of factors other than heart disease which also give rise to this deflection. Nevertheless, certain considerations tend to emphasize the significance of electrocardiograms in which the deep Q_3 is present.

In 300 electrocardiograms exhibiting deep Q_3 waves, Willius (21) found that only three of the patients represented had normal hearts. Furthermore, in 198 of the records (66 per cent), the large Q_3 wave was the only significant electrocardiographic sign. From this observation, Willius concluded that the deep Q_3 is an abnormal deflection which may be viewed as an additional diagnostic sign and is significant even when occuring alone in an electrocardiogram otherwise unaltered.

Analysis of the investigations of various workers indicates that this electrocardiographic sign is more frequently associated with hypertension, uncomplicated by angina or coronary occlusion, than with the anginal syndrome. (24, 19, 21, 2) Nevertheless, that coronary artery disease may give rise to the deep Q_3 wave has been proved quite conclusively by the investigations of Fenichel and Kugell(6). These authors reported a series of 35 cases which came to autopsy. The hearts of 27 cases showed myocardial infarction or fibrosis and 17 of the electrocardiograms from this group exhibited deep Q waves in Lead III. Of the 17 cases with deep Q_3 waves, twelve showed left axis deviation and the infarction was located in the posterior portion of the septum. In three cases normal axis deviation was present and the infarction included the lower part of the septum anteriorly and posteriorly. The remaining two cases showed right axis deviation with infarction in the anterior and posterior portions of the septum. Of the eight cases which showed no myocardial damage at autopsy, none showed deep Q_3 waves in the electrocardiograms.

Another significant feature of the deep Q_3 wave is its relative permanency after other electrocardiographic signs have disappeared. This has been observed by Fenichel and Kugell (6), Wallace (20), and others (22, 4), in the case of coronary thrombosis. Fenichel and Kugell found that in their series of 35 necropsied cases of myocardial infarction or fibrosis a large Q_3 was present in 17 instances while negative T waves (in at least two leads) and displaced R-T segments were present in only 8 and 6 cases, respectively. These authors state that "the large Q-3 is especially important because it is the most frequent electrocardiographic sign during the chronic period of myocardial infarction. Sometimes it is the only graphic clue to the pathological condition present in the heart. During the acute period of myocardial infarction, the large Q-3 and other characteristic signs commonly occur together; but in the period subsequent to the acute coronary thrombosis the R-T segment inversion becomes absent or limited to either Lead I or Lead III". In view of the fact that the inscription of the Q wave corresponds in time to the activation of the ventricular septum and adjacent apices of the two ventricles, these authors concluded that damage to the septum with involvement of the minor conducting divisions supplying the apical regions, was responsible for the production of the large Q wave.

PARDEE'S CRITERIA FOR A SIGNIFICANT Q_3 WAVE.

A possible relationship between abnormalities of the initial ventricular deflections of the electrocardiogram and coronary artery disease was suggested by Pardee (16) who noted that large Q_3 waves were frequently associated with the anginal syndrome. As a result of his investigations Pardee concluded that a Q wave in Lead III was of diagnostic value when followed by an upward excursion (R) but no downward excursion (S), and was at least 25 per cent as large as the greatest QRS deflection in any lead. Pardee attached no significance to conspicuous Q waves in Lead III in the presence of right axis deviation or when there was notching deformity of the QRS in any lead (the so-called M and W complexes). Pardee found that 63 per cent of his group of curves which conformed to this criteria were associated with angina pectoris.

Since its proposal Pardee's criteria has been subjected to considerable investigation by various other authors. The findings of some of these observers are shown in Table 3 where it may be seen that incidence of the anginal syndrome in electrocardiograms which meet Pardee's requirements is as follows: Pardee 63 per cent (16), Wallace 50 per cent (20), Mazer and Reisinger 43 per cent (12), Willius 38 per cent (21), Strauss and Feldman 16 per cent (19), Edeiken and Wolferth 16 per cent (5), and Ziskin 14 per cent (24). The incidence of hypertension as shown in this table in electrocardiograms which meet Pardee's requirements is as follows: Pardee 47 per cent, Wallace 13 per cent, Mazer and Reisinger 14 per cent, Willius 40 per cent, Strauss and Feldman 33 per cent, Edeiken and

Wolferth 33 per cent, and Ziskin 39 per cent. Analysis of this data indicates that electrocardiograms with deep Q_3 waves which comply with the requirements established by Pardee are quite as often associated with hypertension, uncomplicated by angina, as with the anginal syndrome or coronary artery disease. Moreover, as shown in Table 3, a substantial number of the electrocardiograms are associated with arteriosclerosis and other types of heart disease, and even with normal hearts.

It is evident from this analysis that Pardee's criteria is inadequate to differentiate coronary thrombosis from hypertension, and other intra and extra-cardiac conditions. It is therefore obvious that if abnormalities of the initial ventricular deflection, resulting from coronary artery disease, are to assume a significant diagnostic value they must be more satisfactorily defined.

CRITERIA GOVERNING THE INITIAL VENTRICULAR DEFLECTIONS IN DIAGNOSIS OF CORONARY ARTERY DISEASE.

Parkinson and Bedford (17), in 1928, described the successive changes in the RS-T segment following coronary occlusion, and divided these serial changes into two groups. In the first group, there is an elevation of the R-T segment in Lead I and a depression of the S-T segment in Lead III which occurs during the first few days following the onset of symptoms. Such displacement of the S-T segment is followed by the gradual development of a sharply negative T wave in Lead I, and sharply positive T in Lead III. In the second group, exactly opposite changes occur; depression of the S-T segment in Lead I and elevation of the R-T segment in Lead III, developing early, are followed later by gradual development of a sharply positive T in Lead I and a marked negative T in Lead III. These authors referred to electrocardiograms characterized by the changes described in the first group as the T_1 type, and those characterized by the changes described in the second group as the T_3 type. A knowledge of the T_1 and T_3 types of electrocardiograms is essential for the further discussion of a criteria for a deep Q wave in the diagnosis of coronary occlusion.

In 1933, Wilson et al (22), studied the electrocardiograms obtained in a series of 66 cases of myocardial infarction, and described two distinct types of abnormal QRS deflections frequently encountered. The first of these they found most frequently associated with infarction of the anterior wall of the left ventricle, and was characterized by the "presence of a conspicuous and, in most instances, rather broad Q in Lead I; the absence of Q in Leads II and III; the small amplitude of the largest of the initial deflections in Lead I; and the presence of a conspicuous S in Leads II and III". The second was found most frequently in infarction of the posterior wall of the left ventricle and was characterized by the presence of a conspicuous Q in Leads II and III; the absence of Q in Lead I; and relatively small amplitude of the initial ventricular deflections in Lead II. These two types of abnormal initial ventricular deflections were referred to as curves of the Q_1 and Q_3 types, respectively. Wilson and his coworkers (22) concluded from their studies that initial ventricular deflections of the Q_1 or Q_3 types, without certain characteristic changes in the final ventricular deflection, should not be considered diagnostic, but merely suggestive of coronary occlusion. When, however, curves of the Q_1 or Q_3 types were associated with the changes in the final ventricular deflections, as described by Parkinson and Bedford (17), that is, when Q_1 T_1 or Q_3 T_3 patterns were present, diagnosis of coronary occlusion is justified.

The work of Durant (4) has done much to confirm the conclusions of Wilson et al. Durant selected 96 electrocardiograms which conformed to standards of Pardee and, in addition, displayed Q waves in Lead II of at least 1 millimeter in amplitude. This author considered it necessary to omit two of Pardee's requirements in the selection of his electrocardiograms, first, that the Q_3 be followed by an upward excursion (R) but no downward excursion (S) and, second, the elimination of curves with slight notching of the downstroke of Q_3 (the W type of QRS complex). The basis for these omissions was the discovery that certain cases of definite coronary occlusion with conspicuous Q_3 waves failed to conform to these requirements. Of the 96 electrocardiograms, selected according to the above modifications of Pardee's criteria, corresponding case histories revealed 31 cases of coronary occlusion, and 29 cases of angina pectoris. The electrocardiograms were then classified accordingly as they fulfilled the following criteria: (A) that of Pardee with the exceptions mentioned (B) that constructed as follows: "(1) an initial downward deflection in Lead III having an amplitude at least ½ as great as the largest Q-R-S deflection in any lead, (2) an initial downward deflection in Lead II at least ¼ as large as R2, and (3) left axis deviation or a normal electrical axis." (C) criteria identical with B, and in addition, T wave inversion in Leads II and III, but not in Lead I. Table 4 shows the results of the classification of Durant's series of electrocardiograms according to these three sets of criteria.

Criteria A as shown in this table is the one, as described previously, by which the electrocardiograms were selected, and includes among 96 curves exhibiting large Q_3 waves, 60 cases of coronary disease and 36 cases without evidence of coronary disease. When criteria B was employed, clear evidence of angina pectoris or coronary occlusion was obtained in 81.8 per cent of the 44 cases which conformed to its requirements; 8 cases showed no evidence of coronary disease. When inversion of the T wave was added to the requirements enumerated for criteria B (Table 4, C) the number of cases conforming to the criteria (Criteria C) was reduced to 22, and all of these had definite coronary artery disease.

Table 4.

	Criteria	Total cases	Coronary Disease: Coronary occlusion	Coronary Disease: Angina Pectoris	Coronary Disease: Total	No Evident Coronary Disease	Percentage Coronary Disease
A	Q-3 at least 25% of largest Q-R-S deflection Q-2 at least 1 mm. Left axis deviation or normal axis	96	31	29	60	36	62.5
B	Q-3 at least 50% of largest Q-R-S deflection Q-2 at least 25% of R2. Left axis deviation or normal axis	44	25	11	36	8	81.8
C	Same as under B, and in addition T wave inversion in Leads II and III, but not in Lead I	22	18	4	22	0	100.0

Table reproduced from article by Durant, T.M.: The Initial Ventricular Deflection of the Electrocardiogram in Coronary Disease, Am. J. Med Sci., 188, 225, 1934.

Analysis of criteria C of Durant reveals that it is essentially a more completely defined description of the Q_3 T_3 pattern described by Wilson and his coworkers. The data supplied by Durant indicates further that when this pattern is present, as defined by him, a diagnosis of coronary artery disease is practically certain. Moreover, in the absence of abnormalities of the final ventricular deflections, a fairly high degree of diagnostic accuracy lies in the QRS deflections alone as described in criteria B.

Certain other factors deserve attention in differentiating abnormalities of the initial ventricular deflections produced by coronary artery disease from those resulting from other causes. Several authors have pointed to the Q_2 wave as a factor which enhances the diagnostic value of the Q_3 in the diagnosis of coronary artery disease. (3, 6, 21, 20, 22) Notable is the work of Bayley (3) who investigated the relationship to coronary artery disease of electrocardiograms in which conspicuous Q waves were present in Leads II and III. The electrocardiograms in this series were selected on the basis of the following standards which constitute a criteria: (1) Q waves in Lead III of a duration equal to or greater than 0.04 seconds in five consecutive QRS complexes, and (2) Q waves in Lead II of at least 1 millimeter in amplitude. No electrocardiograms were included which showed one or more of the following characteristics: (1) right axis deviation, (2) QRS complexes of a duration of 0.11 seconds or more, (3) M or W shaped complexes in Lead III, and (4) Q_3 waves of a duration of 0.03 seconds or less. Bayley found that when this criteria was employed in the selection of electrocardiograms that 91 records conformed and that 82.4 per cent of these represented cases of either acute or subacute myocardial infarction or angina pectoris. In a control group, in which the criteria for selection was essentially the same except for the absence of a Q wave in Lead II of the electrocardiogram, Bayley found that only 38 cases, or 53 per cent, of the 72 patients represented had coronary artery disease. Bayley concluded from this investigation that the "presence of a Q_2 in addition to a Q_3 wave lends further support to the presumptive diagnosis of coronary disease".

Amplitude is another factor which has its affect upon the diagnostic value of this deflection in coronary artery disease. Pardee (16) stressed the significance of the depth of the Q_3 wave in relation to the greatest R in any lead. He found, in his series of 43 cases, all of which had Q_3 waves of at least 25 per cent of the greatest R in any lead, that 63 per cent had the anginal syndrome. When, however, the depth requirement for this wave was increased to 50 per cent, fewer curves conformed but the incidence of the anginal syndrome increased to 73 per cent. Ziskin (24) found that in his series when records appeared in which the Q was 50 per cent or more of the greatest R, 65 per cent had coronary disease. Only 14 per cent had angina, however, when the depth requirement for the Q-3 wave was only 25 per cent of the greatest R wave. From the observations of these two authors it can be seen that as the percentage of the ratio of the Q_3 to the greatest R increases, so does the incidence of coronary artery disease increase. Wallace (20) investigated the actual size of the Q_3 per se, irrespective of its ratio to the greatest R, in the diagnosis of coronary artery disease. He expressed the opinion that when the Q_3 reached an amplitude of 5 millimeters a serious case of heart disease was imminent. Nevertheless, he concluded that "cases of previous coronary thrombosis were about equally divided among different Q_3 sizes and ratios, and were unexpectedly seen with greater frequency in the records with smaller Q_3 waves".

From this review of the literature, an attempt has been made to determine a criteria which will differentiate the QRS changes due to coronary artery disease from similar changes due to other causes. It is probable that as yet no such absolute criteria has been proposed, however, criteria "C" of Durant approaches this end. This criteria is as follows: (1) an initial downward deflection in Lead III having an amplitude at least ½ as great as the largest QRS deflection in any lead, (2) an initial downward deflection in Lead II at least ¼ as large as R_2, (3) left axis deviation or a normal axis deviation, (4) T wave inversion in Leads II and III, but not in Lead I. Durant found that all of the electrocardiograms which conformed to this criteria represented definite cases of coronary artery disease. He found, moreover, that this criteria was highly diagnostic even in the absence of T wave inversion in Leads II and III. It is evident that, even though this criteria is highly diagnostic of coronary artery disease, very few electrocardiograms will conform to its strict standards. Hence there is a definite loss of specificity and probably many cases of coronary occlusion would be un-diagnosed if this criteria were employed.

SUMMARY AND CONCLUSIONS.

The method of production of the QRS complex has been reviewed.

The literature has been studied to determine the incidence of the deep Q_3 wave in the electrocardiograms of individuals with normal hearts, where Pardee's criteria was adhered to. Among 1631 electrocardiograms from individuals with normal cardiovascular systems only 10 significant Q_3 waves were found, an incidence of 0.61 per cent.

The literature was then studied to determine the incidence of the significant Q_3 wave in organic heart disease. Among electrocardiograms of 3508 individuals with organic heart disease, 195 significant Q_3 waves were found which conformed to the criteria of Pardee; an incidence of 5.6 per cent was determined. Comparison of the incidence of the deep Q_3 wave in the electrocardiograms of individuals with normal cardiovascular system to those of individuals with definite organic heart disease reveals that this deflection is an abnormality notably more frequent when pathological conditions of the heart exist.

To conclude that the deep Q_3, as determined by Pardee's criteria, is always indicative of cardiac disease would be erroneous since it has been shown that factors other than heart disease also produce this deflection. These factors include any condition which will elevate the diaphragm and rotate the heart to the left.

Pardee suggested the possible relationship of this abnormality to coronary artery disease, and found that 63 per cent of his series of 43 patients whose electrocardiograms showed conspicuous Q_3 waves had the anginal syndrome. This possible relationship was studied by review of the literature and it was found that 745 electrocardiograms, which were selected by the criteria of Pardee, were as often associated with hypertension, uncomplicated by angina, as with the anginal syndrome or coronary artery disease. Furthermore a large per cent of the records were associated with other types of heart disease, and even normal hearts. It was concluded from this analysis that Pardee's criteria was no more diagnostic of coronary artery disease, than of hypertension, and other intra and extra-cardiac conditions.

A discussion of the significance of the large Q_3 wave, as outlined by Pardee's criteria, is presented, and the following factors emphasized: (1) Willius' evidence in 300 electrocardiograms that only three of the patients represented had normal hearts; that in 198 of the records the conspicuous Q_3 wave was the only significant electrocardiographic sign, and from this, his conclusions that the deep Q_3 is an abnormality which may be considered as an additional diagnostic sign even when the electrocardiogram is otherwise unaltered. (2) Additional evidence by various investigators that indicated this abnormality was as often, if not more frequently, associated with hypertension than with any other type of organic disease of the heart, including coronary artery disease. (3) The fact that coronary artery disease does give rise to the deep Q_3 wave as described by Pardee was evident from the study of Fenichel and Kugel who found in 27 hearts which showed myocardial infarction at necropsy, 17 were associated with electrocardiograms exhibiting a deep Q_3 wave. In all 17, the infarction was located in the interventricular septum. (4) Another significant fact of value concerning the conspicuous Q_3 wave, was its relative permanency when other electrocardiographic signs had disappeared.

An attempt was made, through a review of the literature, to determine what criteria, if any, would at all times differentiate abnormalities of the initial ventricular deflections resulting from coronary artery disease from similar changes resulting from other causes. It was concluded that the criteria most applicable was criteria "C" of Durant. This was described as follows: (1) an initial downward deflection in Lead III having an amplitude at least $\frac{1}{2}$ as great as the largest QRS deflection in any lead, (2) an initial downward deflection in Lead II at least $\frac{1}{4}$ as large as R_2, (3) left axis or normal axis deviation, and (4) T wave inversion in Leads II and III but not in Lead I. It is believed that when electrocardiograms are present which conform to this criteria the diagnosis of coronary artery disease is practically certain. In the absence of T wave changes, moreover, this criteria is still highly diagnostic of coronary artery disease.

Finally, attention has been called to various other factors which, when present, enhance the value of the large Q_3 in the diagnosis of coronary artery disease. These include: (1) the presence of a Q wave in Lead II of at least 1 millimeter or more in amplitude, and (2) a large amplitude of the Q_3 wave per se. It has been shown that as the ratio of the Q_3 wave to the greatest R increases, so does the incidence of coronary artery disease increase, in those records which meet the requirements of this criteria.

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