THE RIGHT OBLIQUE TRANSTHORACIC ELECTROCARDIOGRAM

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Using the capillary electrometer, Waller (1887) placed the electrodes directly on the chest wall, and Lewis (1910) favoured transthoracic leads for his study of the mechanism of atrial action. In 1924 Ackermann proposed three chest leads for routine use; he paired an electrode in the 2nd right intercostal space at the sternal border with one over the apex beat in his lead A, with one in the 5th right intercostal space in his lead B, and with one at the inferior angle of the left scapula in his lead C. He described the pattern for tracings obtained from these leads in three cases, but not for diseased states. Following their experience with experimentally induced cardiac infarction in animals, Wolferth and Wood (1932) turned to investigate cardiac infarction in man by means of transthoracic leads. They placed one electrode on the front of the chest to the left of the mid-line at the cardiac level, and the other electrode opposite it at the back of the chest. They found that this newer lead, which they named IV, might show striking deviations of the S-T segment from the isoelectric line when there was no evidence of coronary occlusion in the three conventional limb leads. Weinstein (1934) stated that when both electrodes were applied to different sites on the chest, changes in the so-called silent areas of the myocardium could be detected more readily, and he experimented with seven such leads in a number of patients. Whitten (1937) tested the value of several transthoracic and arm-to-thorax leads in the detection of infarction involving that portion of the left ventricle supplied by the left coronary artery, and decided that the axillary lead, with the electrodes placed in the mid-axilla on either side at the cardiac level, gave the most satisfactory results. In the so-called heart triangle of Nehb (1938), the electrodes are connected as for the standard limb leads by placing the right arm electrode in the second intercostal space at the right sternal border, the left arm electrode near the inferior angle of the left scapula at a site corresponding with the projection of the cardiac apex on the posterior chest wall, and the left leg electrode at the apex in front. In such an arrangement the dorsal lead (D) corresponds with lead I, the anterior lead (A) with lead II, and the inferior lead (J) with lead III. He found that lead D was specially valuable in the detection of posterior cardiac infarction.

The more comprehensive electrocardiogram came into being in 1938 when Barnes *et al.* recommended that an electrode on either the left leg or from a common terminal leading from the right arm, left arm, and left leg, should be paired with one placed consecutively at six stations on the chest. In making their recommendations these authorities in cardiology added, "it would be unfortunate if our attempt to standardize precordial leads should discourage the investigation of leads of any kind whatsoever". Experience with these leads, but using the right arm rather than the left leg to hold the indifferent electrode, proved them reliable in uncovering a lesion in most parts of the left ventricle except for small faults situated postero-laterally. With this in mind two other leads were recommended for routine use. Thus, Evans and Hunter (1943) paired the right arm electrode with an electrode at station 7 in the posterior axillary line at the same level as stations 4, 5, and 6. This newer lead CR7 clearly differentiated between the deformed T wave in leads II and III

in right ventricular preponderance and that resulting from postero-lateral infarction. This lead also proved vastly more convenient than the œsophageal lead intended to explore an injury at the back of the heart as recommended by Nyboer (1941). The other lead which proved effective in uncovering the early postero-lateral lesion was IIIR (lead III recorded during deep inspiration), and depression of the S-T segment in this lead has often appeared as the only cardiographic sign of early cardiac infarction in this situation (Evans, 1951).

In the present investigation three transthoracic leads have been tested for their value in discovering a small injury at the side and back of the heart which may not be portrayed obviously in leads now in customary use. In each the indifferent electrode was placed in the 4th intercostal space at the right sternal border, while the exploring electrode was placed successively at station 7, station 8 ($1\frac{1}{2}$ in. (3.8 cm.) beyond 7), and at the inferior angle of the left scapula (Fig. 1). The disposition of this last lead resembles Ackermann's C lead and Nehb's D (dorsal) lead except that the indifferent electrode is placed two intercostal spaces lower down. In that these two last leads seldom equalled and never surpassed the first of these three transthoracic leads in the exploration of a left ventricular lesion, they are not the subject of further discussion.

The only transthoracic lead to be appraised here, therefore, is the one where the paired electrodes are placed on the chest at stations 1 and 7. To this arrangement the name *right oblique lead* has been given.

FIG. 1.—Diagrammatic representation of a transverse section of the chest at the level of the 5th thoracic vertebra to illustrate the disposition of the electrodes in four transthoracic leads. 1-A differs from the Ackermann and Nehb leads only in that the indifferent electrode (1) is in the 4th and not the 2nd intercostal space. The arrangement 1-7 represents the right oblique lead.

CODE OF EFFICIENCY

Before a new lead can lay claim to habitual usage, along with leads already accepted as standard, for routine recording, it must satisfy four criteria. First, it should never produce a curve of abnormal design in a subject known to be healthy. Secondly, the lead should never record a normal tracing in a patient in whom standard leads demonstrate a myocardial fault situated in an area which the lead has been elected as specially suitable to explore. Thirdly, the lead should frequently demonstrate a myocardial lesion more clearly than is done by conventional leads, and in this way it may be used to test the ability of certain lesser changes in the standard cardiogram to detect small myocardial faults. Fourthly, the lead may rarely by itself uncover a myocardial lesion through demonstrating a current of injury before an obvious deformity appears in any of the leads now regarded as conventional for routine clinical electrocardiography.

THE INVESTIGATION

The right oblique lead was recorded in 100 subjects made up of 60 patients with cardiac pain and cardiac infarction, and 40 adults who were regarded as healthy.

In the cardiac infarction series hypertension was excluded, and cardiac enlargement was usually absent, but if present it was moderate or less and was the direct result of the infarction. In the healthy series many had symptoms that were regarded as having no organic basis, while cardiovascular disease was deemed to be excluded following clinical examination, conventional electrocardiography, and cardioscopic examination.

In each of the 100 subjects, the seven bipolar leads, I, II, III, IIIR, CRI, CR4, and CR7 were recorded, and whenever the R wave in CRI was either absent or diminutive, lead CR2 was also taken.

TABLE

INCIDENCE OF ABNORMAL TRACING FROM RIGHT OBLIQUE LEAD IN 100 SUBJECTS, 60 OF WHOM WERE KNOWN TO HAVE CARDIAC INFARCTION AND 40 HAD BEEN CONSIDERED HEALTHY ADULTS

Site of infarct	Cardiographic pattern in conventional leads*	No. of cases	Right oblique lead		
			Normal	S-T depression	Lone T wave inversion
Anterior	T _I T ₄	5	3	2	0
Septal	Q ₁ Q ₂	3	1	2	0
Antero-lateral	S _{II} S _{III}	7	2	2	3
Lateral	T _I T ₇	17	0	13	4
Postero-lateral	T _{III} T ₇	13	0	9	4
Postero-medial	Q _T T _{III} T ₇	15	3	9	3
Presumed healthy series ..	Initially regarded as physiological	40	35	4	1

* Roman numerals indicate limb leads and Arabic figures refer to chest leads.

Allusion has already been made to the two transthoracic leads which, though recorded in every case, proved unreliable, so that only the right oblique transthoracic lead is to be matched with the conventional leads through testing their individual merits in the diagnosis of cardiac infarction.

THE FINDINGS

In the first place it was necessary to know the pattern which the right oblique lead writes in healthy subjects. Subsequently, the way in which the tracing differed from this normal standard was determined for infarction as it affected six separate segments of the left ventricle (see Table).

The Normal Series. This consisted of 40 subjects, 29 men and 11 women, whose ages varied between 16 and 66, mean age 44 years. Before they were accepted into the series it was conditional that the conventional electrocardiogram should be normal, and that no cardiovascular disease could be detected on clinical and radiological examination.

From the right oblique tracings obtained in them the design of the normal record was ascertained. Thus, the P wave was usually low; it was diphasic in 2 and inverted in 5. A Q wave was absent in 6; it measured 2 mm. or less in 26, and was 3 mm. or greater in 8, in 2 of whom it was 7 mm. deep. The S-T segment was not expected to be depressed below the isoelectric level, and though the amplitude of the T wave might be small, as happened in 12 subjects, it should never show inversion (Fig. 2). Whenever the T wave was low or even inverted in CR1 as a physiological finding, this innocent change did not affect the design of the right oblique cardiogram.

Among the 40 people, however, there were 5 in whom the transthoracic cardiogram departed from the design just accepted as the normal for the lead. The significance of the abnormalities which they showed instigated a more critical inspection of the conventional electrocardiogram, and the outcome of this review will be discussed later following an analysis of such blemishes in the right oblique cardiogram obtained from the 60 patients with cardiac infarction. These are considered for the separate sites of the infarction as determined by the tracings provided by the conventional leads.

Anterior Infarction (T_IT₄ pattern). There were only 5 patients in this group, 2 men and 3 women, and the mean age was 48 years. Changes in the conventional leads were confined to leads I and CR4. The number was kept small intentionally, for owing to the anterior disposition of the infarct it was not expected that the right oblique lead would prove helpful in discovering the lesion, nor did it. Thus, the tracing was normal in 3, while in the other 2 patients, though the S-T segment

FIG. 2.—The conventional electrocardiogram and the right oblique lead (RO) in 5 healthy subjects.

FIG. 3.—The Q wave is deep in CR1 in 2 patients with septal cardiac infarction. In the right oblique lead (RO) the S-T segment is depressed in one and the T wave is inverted in the other.

was depressed, the deformity was not as noticeable as the irregularities appearing in the conventional leads.

Similarly, in 7 patients with localized *antero-lateral infarction of $S_{II}S_{III}$ pattern* (5 men and 2 women) whose mean age was 56 years, and where the S wave was deep in leads II and III and absent in lead I, changes in the right oblique lead were inconstant. The tracing proved to be normal in 2, it showed depression of the S-T segment in 2, and inversion of the T wave in the remaining 3 patients.

Septal Infarction (Q_1Q_2 pattern). There were only 3 patients in this group, 2 men aged 70 and 47, and a woman aged 48 years. In each, the conventional electrocardiogram was within normal limits except for a deep Q wave in the chest leads CR1 and CR2. The right oblique cardiogram was normal once, and abnormal in two patients in whom it showed depression of the S-T segment in one and inversion of the T wave in the other (Fig. 3).

Lateral Infarction (T_1T_7 pattern). This group held 17 patients, 12 men and 5 women. Their ages varied from 36 to 69, and the mean age was 58 years. Abnormality in the conventional electrocardiogram affected leads I and CR7. In the right oblique tracing a Q wave was absent in 5 patients,

FIG. 4.—The T wave is low in lead I and is depressed or inverted in leads III, IIIr, and CR7 in 3 patients with lateral cardiac infarction. Such changes are more obvious in the right oblique lead (RO).

FIG. 5.—The T wave is inverted in leads III and IIIr and depressed in CR7 in 4 patients with postero-lateral cardiac infarction. More obvious S-T depression is present in the right oblique lead (RO).

2 mm. deep or less in 10, and 3 mm. or deeper in 2. In other ways the lead was never once normal, showing depression of the S-T segment in 13, and inversion of the T wave in the other 4. Such changes were usually more obvious in this transthoracic lead than in the conventional leads (Fig. 4).

Postero-lateral Infarction ($T_{III}T_7$ pattern). In this group where the abnormalities in the conventional electrocardiogram were confined to leads III and CR7, there were 13 patients, 11 men and 2 women. Their ages varied from 33 to 70, and the mean age was 55 years.

In the right oblique cardiogram the Q wave was absent in 2, 2 mm. or less in 6, and 3 mm. or deeper in 5 patients. Significant changes in the form of depression of the S-T segment appeared in 9, and inversion of the T wave in the other 4 patients. These abnormalities were usually more noticeable in the right oblique lead than in lead CR7 (Fig. 5).

Postero-medial Infarction ($T_{III}T_7$ pattern). In this group where the conventional electrocardiogram showed a deep Q wave and inversion of the T wave in lead III and usually in lead II as well, with depression of the T wave in CR7, there were 15 patients, 13 men and 2 women. Their ages varied from 39 to 67, and the mean age was 54 years.

FIG. 6.—A deep Q wave together with T wave inversion are changes in leads III and III R, in addition to lesser changes in leads II and CR7, in 4 patients with postero-medial cardiac infarction. S-T depression and T wave inversion are prominent changes in the right oblique lead (RO).

whether in fact they harboured a progressive myocardial lesion, for should its presence be confirmed, this newer transthoracic lead, now the subject of probation, would have provided the best evidence of it early in the illness.

CASE REPORTS

Case 1. A naval officer, aged 40 years, had recently complained of epigastric pain which spread into the chest and which was relieved by taking a meal or a draught of bicarbonate of soda. The pain was unrelated to exercise so that he played golf habitually, carrying his own clubs in competitions and experiencing no discomfort. The pain had never awakened him from sleep. Clinical examination discovered no abnormal signs. A barium meal excluded gastro-duodenal ulceration, and radiological investigation of the gall-bladder during excretion of a dye showed that the viscus was functioning normally. It caused no surprise to find a normal conventional electrocardiogram, but the right oblique tracing showed inversion of the T wave without depression of the S-T segment.

In the right oblique cardiogram the Q wave was absent twice; it measured 2 mm. or less in 5, and was 3 mm. or deeper in 8 patients. Significant changes were absent from the tracing in 3 instances, but were prominent in the other 12 patients, appearing as depression of the S-T segment in 9, and as inversion of the T wave in 3 (Fig. 6).

Reliability of the Right Oblique Cardiographic Lead. In accordance with definition, admission into the series of subjects presumed to be healthy depended ultimately on the absence of clinical and radiological signs of cardiovascular disease, and on having a normal 7-lead conventional electrocardiogram. Initially, 40 of the 100 subjects were considered to comply with these criteria. Not all of them were free from symptoms. In 10 there were none and their examination had been a routine affair; 7 had trivial palpitation, and in 6 others there had been faintness. A history of chest pain was obtained in as many as 17, but in only 3 of these did it suggest that the pain might have its source in coronary arterial disease. It is from among these 17 cases that the 5 examples of an abnormal right oblique cardiogram were drawn. In 3 of them (Cases 1, 2, and 3) the pain did not resemble cardiac pain, but in 2 the pain in regard to its situation, distribution, and character tallied with the description of true cardiac pain.

When the conventional electrocardiogram was inspected more closely in these 5, in only one could the tracing be accepted as wholly without blemish. In the other 4, since the changes were slight and equivocal, they were retained in the series as test cases. There now follows a brief clinical history of each of these patients whose progress had been watched over a period of 12 years or more with the object of discovering

FIG. 7.—Inversion of the T wave in the right oblique lead (RO) was the only abnormality in (A) recorded in Case 1 when he was subject to chest pain. The tracing (B) taken 16 years later is normal and the patient had remained symptom-free in the intervening period. This mutable electrocardiogram has been accepted as evidence of coronary arterio-spasm rather than cardiac infarction.

When invited to attend after an interval of 16 years, he was found to be free from symptoms, while clinical and radiological examination again discovered no abnormal signs. The conventional electrocardiogram at this attendance was again normal, but the right oblique tracing on this occasion was also normal (Fig. 7).

From comparison of the two records the conclusion is drawn that the right oblique lead at the patient's first attendance discovered a blemish that was not detected by the conventional leads, and that the injury was of a temporary nature in the shape of ischaemia from coronary arterial spasm, for it left behind it no scar as from cardiac infarction.

Case 2. A man of 32 years had been conscious of his heart beat during the last two of his five years' detention as a prisoner of war. He also complained of indefinite pain in the left chest which has no relation either to deep in-breathing or to physical exercise. Clinical examination found an innocent sound in late systole. The conventional electrocardiogram was normal except for depression in the early part of the S-T segment in IIIr; in that his symptom was so unlike cardiac pain and the cardiographic sign was equivocal, the patient was included in the healthy series as a test case. The right oblique lead showed obvious depression of the S-T segment.

He has been seen at intervals over 12 years on account of periodic pain in the chest which has been interpreted as "rheumatism", and at no time has it resembled cardiac pain. In one respect the conventional cardiogram has deteriorated, namely that the amplitude of the T wave in lead I has lessened so that in this patient the abnormal right oblique tracing has confirmed the significance of the small initial change in IIIr which was regarded as equivocal when he was first seen.

FIG. 8.—The conventional cardiogram in (A) is normal except for slight depression of the early part of the S-T segment in IIIr, but the T wave in the right oblique lead (RO) is inverted; the tracing was recorded when the patient (Case 3) was experiencing indefinite chest pain. When seen 15 years later, he was free from symptoms, but S-T depression was now present in leads II and CR7 of his conventional electrocardiograms (B) additional to the changes in lead IIIr and the right oblique lead (RO).

Case 3. A man of 47 years had complained of vague indigestion and flatulence for six weeks. A discomfort in the left chest was unrelated to exercise and to meals, and disappeared following reassurance that nothing serious ailed him. Clinical examination found no abnormal signs. The conventional electrocardiogram appeared to be normal except for depression of the early part of the S-T segment in lead IIIR. When the right oblique lead showed obvious depression of the S-T, the small abnormality in IIIR gained in its significance, but the patient was admitted into the healthy series for observation.

When recalled for examination 15 years later, the patient, now 62 years old, reported that he had kept well and that pain in the chest had not recurred. Once again clinical examination found no abnormal signs, and the heart was seen to be natural in shape and in size at cardioscopy. On this occasion, however, the T wave in lead I of the conventional electrocardiogram was significantly lower and the S-T segment was depressed in leads II and IIIR, while in the right oblique lead the same depression was prominent as on the previous occasion (Fig. 8).

Case 4. A man aged 49 years had been awakened by pain in the centre of the chest six weeks before; in every respect it resembled cardiac pain, but it did not recur subsequently in this form though he continued to suffer from indigestion as in the past.

Clinical examination found no abnormal signs. Casual inspection of the conventional electrocardiogram accepted it as normal and that is why the patient was admitted into the healthy series. When the right oblique lead showed depression of the S-T segment, the conventional tracing was examined more closely and it was then noticed that a Q wave, absent in lead III, was present in IIIR, a deformity which in the past has been shown to be evidence of a localized myocardial injury (Evans, 1951).

When the patient was recalled for examination 15 years later he reported that he had remained well except for his customary indigestion when the pain was usually confined to the abdomen. Clinical and radiological examination again discovered no abnormal signs. On this occasion the conventional electrocardiogram showed depression of both the T waves and S-T segments in certain leads, while the Q wave was present in IIIR as before, and the S-T was again depressed in the right oblique cardiogram (Fig. 9).

In this instance, therefore, an obvious deformity in the transthoracic lead led to a critical re-examination of the conventional cardiogram and to the finding in it of a lesser though significant deformity. Subsequently, it was joined by other signs which gave proof of the presence of cardiac infarction as the cause of the abnormal cardiographic signs.

Case 5. A man aged 51 years had complained for 4 days of pain in the centre of his chest and which spread into both arms. Clinically it was considered to be cardiac pain. There were no abnormal physical signs. It caused some surprise to find a near-normal conventional electrocardiogram, but the S-T segment was raised a little in leads I and II, and showed plane depression in IIIR. The significance of these signs was emphasized when obvious S-T depression was found in the right oblique lead. After an interval of three

FIG. 9.—A Q wave, absent in III and appearing in IIIR, is the only abnormality in the conventional electrocardiogram shown in (A) which was recorded in Case 4 following an attack of chest pain regarded as cardiac pain. The T wave in the right oblique lead (RO), however, was inverted. When re-examined 15 years later, significant electrocardiographic changes from extension of coronary arterial disease in the form of S-T depression in lead II, CR4, and CR7 had been added (B), while the same obvious inversion of the T wave was present in the right oblique lead (RO).

FIG. 10.—Depression of the last phase of the S-T segment in lead IIIr was the only blemish in the conventional electrocardiogram (A) recorded in Case 5 with chest pain which was considered to be cardiac pain. The T wave, however, was deeply inverted in the right oblique lead (RO). After an interval of three months, changes became apparent in leads II, III, IIIr, and CR7 (B), and these had improved when examined 16 years later (C), when the same deep inversion of the T wave had persisted in the right oblique lead (RO), and the patient continued to suffer from recurrent attacks of cardiac pain.

is true that in the 51 patients with cardiac infarction in whom the right oblique tracing was abnormal, the 7-lead cardiogram (leads I, II, III, IIIr, CR1, CR4, and CR7) had also furnished the diagnosis, and its peculiar merit in these cases rested with its ability in so many of them, to display the deformity more obviously than did the conventional leads.

It is in the 5 patients where the conventional leads were once regarded as normal in the presence of an abnormal right oblique lead that the justice of the claim of this transthoracic tracing for inclusion in the routine investigation of chest pain has to be weighed. It has been seen that in only 1 of the 5 patients did the right oblique lead provide evidence of coronary arterial disease by itself, and in this instance it was considered to be arterial spasm and not occlusion. In the remaining

months the abnormal signs in the right oblique lead were joined by extended signs in the conventional cardiogram which gave proof of cardiac infarction (Fig. 10).

When recalled 15 years later he was still subject to cardiac pain when exerting himself unduly, which would subside quickly when he stood still. Clinical examination again failed to discover any abnormal signs. The conventional electrocardiogram, though less deformed than previously, continued to provide evidence of cardiac infarction of limited distribution, while the right oblique tracing showed the same depression of the S-T segment. In this patient, therefore, the transthoracic cardiogram again showed more obvious changes than did the conventional electrocardiogram, as at the start they were unequivocal only in the right oblique lead.

THE PLACE OF THE RIGHT OBLIQUE LEAD IN ROUTINE ELECTROCARDIOGRAPHY

The investigation has confirmed the ability of this transthoracic lead to detect a lesion of the lateral portion of the left ventricle. Thus, not only did the lead produce an abnormal tracing in each of 30 patients with cardiac infarction limited to this area, it also showed the same abnormal curve in 5 among 7 patients with antero-lateral infarction and in 12 of 15 patients in whom the myocardial injury was disposed postero-medially (see Table). The absence of changes in this probationary lead in 9 of the 60 patients with cardiac infarction caused no surprise in that the lesion in these instances was situated too anteriorly in 6 and too posteriorly in 3, areas outside the domain which the lead was expected to explore.

The question to be posed next is whether it is necessary to add yet another lead to those already in customary use. Certainly, this newer transthoracic lead has demonstrated its proficiency in the search of a lesion in what has sometimes been regarded as the *silent area* of the heart. It

FIG. 11.—An interval of two days separated the recording of (A) and (B) in a patient with cardiac pain. In (C), recorded 3½ years later, the conventional cardiogram had recovered except for changes in IIIR, but T wave inversion in the right oblique lead (RO) was an obvious deformity.

FIG. 12.—S-T depression in IIIR and T-U depression in CR4 were the only changes in the conventional electrocardiogram in a patient with cardiac pain, but there was obvious inversion of the T wave in the right oblique lead (RO). The patient died from extension of cardiac infarction 13 days later.

4, however, this newer lead was obviously abnormal when the conventional leads at one time showed minimal changes which were regarded as equivocal especially in the two instances where the character of the pain bore no resemblance to cardiac pain.

In the first place, therefore, the transthoracic right oblique lead has established its claim to be recorded whenever the significance of changes in the limb lead III is in doubt, and when they might not have been resolved unequivocally by the addition of leads IIIR and CR7 (Fig. 11 and 12); indeed experience with this right oblique lead has emphasized the absolute need to include these two leads in routine electrocardiography. Thus, the CR7 tracing was abnormal not only in each of 45 patients in whom the infarct was laterally or posteriorly placed in the left ventricle, but also in the 3 patients in whom the infarct was situated too posteriorly for the transthoracic lead to discover. An abnormality in lead CR7 was often only poorly depicted in station 6, while in some instances it was absent in this position. On account of the lower voltage obtaining in V leads, V7 can never be a substitute for CR7. Leatham (1950) found that the mean height of the T wave in CR7 in 100 healthy subjects was 3.3 mm. compared with 1.5 mm. in V7. Moreover, the amplitude of the T wave in V7 was less than 2 mm. in as many as 57 of the patients and less than 1 mm. in 7, while it was isoelectric once, and actually inverted once.

SUMMARY AND CONCLUSIONS

The value of three transthoracic electrocardiographic leads in the investigation of cardiac pain was adjudged following their recording alongside a conventional 7-lead tracing in 60 patients with cardiac infarction and in 40 supposedly healthy subjects, 5 of whom were subsequently shown to have coronary arterial disease.

In two of the leads an electrode in the fourth intercostal space at the right border of the sternum was paired with an electrode at station 8 (1½ in. (3.8 cm.) beyond station 7) in the one, and at the angle of the left scapula in the other; the latter arrangement is the same as that adopted for the

Ackermann and Nehb leads except that the indifferent electrode in these instances is placed in the second rib space. Since the tracing obtained by these two leads was frequently normal in patients in whom the cardiac infarct was situated either laterally or posteriorly, they have no claim to be used in routine electrocardiography, nor in the occasional case that presents difficulty.

In the third transthoracic lead submitted to probation, the electrode in the fourth intercostal space at the right border of the sternum was paired with one in station 7 in the left posterior axillary line; this arrangement has been named the *right oblique lead*.

In the healthy series the P wave in this lead was usually low and sometimes inverted; a Q wave was usually present and it was often deep; the T wave was often low, but was never flat or inverted; the S-T segment was never depressed below the isoelectric line.

In 30 patients with lateral or postero-lateral cardiac infarction where the conventional leads demonstrated either a $T_I T_7$ or $T_{III} T_7$ pattern the right oblique cardiogram was abnormal in each, showing significant depression of the S-T segment in 22, and inversion of the T wave without S-T depression in 8 patients. In these cases the changes in the right oblique lead were always obvious and in the majority were more noticeable than in the conventional leads. In 15 other patients in whom the infarct was more anteriorly disposed the lead produced an abnormal tracing in 9, and in 12 among 15 patients where the infarct was situated postero-medially there was an abnormal tracing.

In 5 patients in particular, where consideration of their chest pain alongside their conventional electrocardiograms did not lead to an unequivocal diagnosis of coronary arterial disease, changes showing in the right oblique tracing removed the uncertainty in each. This lead proved superior to any other in uncovering a small lesion in the lateral wall of the left ventricle, so that whenever the significance of changes in leads III, IIIR, and CR7 of the conventional electrocardiograms is being questioned, recording the right oblique lead will place the diagnosis beyond doubt.

The right oblique transthoracic lead is likely to emerge as one of the most competent single leads in the investigation of patients with cardiac pain and cardiac infarction.

REFERENCES

- Ackermann, R. (1924). Über thorakale Ableitung des Elektrokardiogramms. *Dtsch. Arch. klin. med.*, **144**, 61.
 Barnes, A. R., Pardee, H. E. B., White, P. D., Wilson, F. N., and Wolferth, C. C. (1938). Standardization of precordial leads. *Amer. Heart J.*, **15**, 235.
 Evans, W. (1951). The effect of deep inbreathing on lead III of the electrocardiogram. *Brit. Heart J.*, **13**, 457.
 —, and Hunter, A. (1943). Chest lead CR₇ in cardiac infarction. *Brit. Heart J.*, **5**, 73.
 Leatham, A. (1950). The chest lead electrocardiogram in health. *Brit. Heart J.*, **12**, 213.
 Lewis, T. (1910). Auricular fibrillation and its relationship to clinical irregularity of the heart. *Heart*, **1**, 306.
 Nehb, W. (1938). Zur Standardisierung der Brustwandableitungen des Elektrokardiogramms. *Klin. Wsch.*, **17**, 1807.
 Nyboer, J. (1941). The normal and abnormal esophageal electrocardiogram, with particular reference to myocardial infarction. *Amer. Heart J.*, **22**, 469.
 Waller, A. D. (1887). A demonstration on man of electromotive changes accompanying the heart's beat. *J. Physiol. (Lond.)*, **8**, 229.
 Weinstein, J. (1934). Multi-plane chest electrocardiography. *Ann. intern. Med.*, **7**, 1503.
 Whitten, M. B. (1937). Midaxillary leads of the electrocardiogram in myocardial infarction. *Amer. Heart J.*, **13**, 701.
 Wolferth, C. C., and Wood, F. C. (1932). The electrocardiographic diagnosis of coronary occlusion by the use of chest leads. *Amer. J. med. Sci.*, **183**, 30.