CHEST LEAD CR_7 IN CARDIAC INFARCTION

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The value of limb leads in the localization of early cardiac infarction is known, and there is general agreement that the T I type of electrocardiogram indicates anterior infarction, and the T III type, posterior infarction (Parkinson and Bedford, 1928; Wilson, Hill, and Johnston, 1934, 1935, & 1938). The recognition of the lesion at a later stage, however, has sometimes proved difficult although changes in the chest lead IVR sometimes confirm the presence of an anterior infarct when the limb leads are doubtful. No such help is yet available in posterior infarction, and the frequency with which T III is inverted in healthy subjects complicates the problem in diagnosis if the history and clinical findings are equivocal. We have, therefore, sought a chest lead that would implement the limb lead cardiogram in the diagnosis of posterior cardiac infarction. During our investigation, Nyboer (1941) published his paper describing an abnormal œsophageal cardiogram in cases of healed posterior infarction. Using the polarity now customary for chest leads, he found that with the œsophageal electrode at the level of the ventricle the T wave was often inverted. We confirmed this observation in several patients, but the discomfort caused by the test obviously detracts from its routine use. After testing several new chest leads we obtained the best results from one in which an electrode placed in the left posterior axillary line at the level of the inferior angle of the scapula was paired with one on the right arm. We suggest that this lead should be known as CR_7. This terminology is in keeping with the recommendations of the American Heart Association (1938) which applied the prefix C to all chest leads, and CR to those paired with the right arm; the chest stations were numbered 1 to 6 from right to left starting in the fourth intercostal space immediately beyond the right sternal border and ending in the left mid-axillary line. It follows naturally that the chest station in the posterior axillary line should bear the designation CR_7. An exploring electrode in this region was used by Wood *et al.* (1933) in their lead VI, but it was paired with one on the left leg and is not comparable with our CR_7.

We recorded the CR_7 cardiogram in 18 healthy subjects, in 32 patients with posterior cardiac infarction, in 12 with anterior infarction, and in 52 with some other form of heart disease. The changes observed in these four groups will now be described and compared with changes in the limb lead cardiogram, which was always a preliminary test.

CR_7 IN HEALTHY SUBJECTS

There were 18 cases whose clinical history and examination, which included cardioscopy, showed that they were healthy. They were chosen for the investigation because T III in their limb lead cardiogram was found to be inverted. Often this deformed T III was corrected by change of posture or respiration, but such effects do not concern us here. T I was always upright. In 13, T II was also upright, but in 4 it was low and in 1 it was flat. The T wave in CR_7 was invariably upright (Fig. 1).

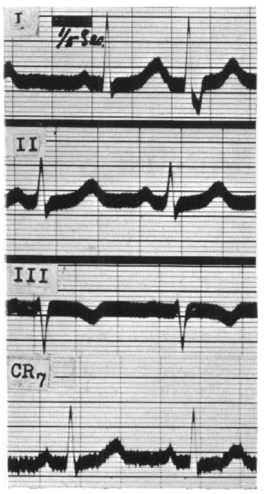


FIG. 1.

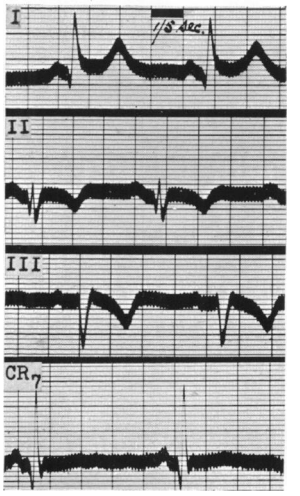


FIG. 2.

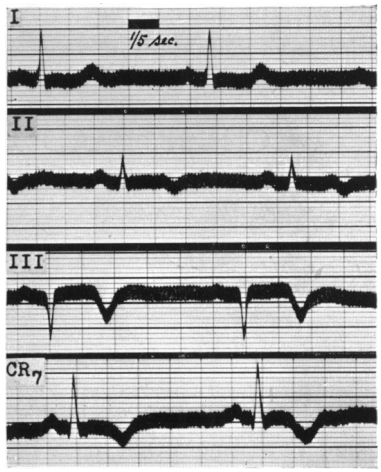


FIG. 3.

FIG. 1.—Healthy subject, aged 22. T inverted in III and upright in CR_7.

FIG. 2.—Posterior cardiac infarction of four years' duration. Male, aged 68. T inverted in II and III, and low in CR_7. R–T segment raised in I.

FIG. 3.—Recent posterior cardiac infarction. Female, aged 54. T II and T III inverted. Inversion of T in CR_7 greater than in II.

TABLE I

T WAVE IN CR_7 COMPARED WITH T II AND T III IN POSTERIOR CARDIAC INFARCTION

Case No.	State of T wave in limb and chest leads			Change greater in T II or in T CR_7
	III	II	CR_7	
1	Inverted	Inverted	Upright	T II
2	,,	,,	Low	,,
3	,,	,,	,,	,,
4	,,	,,	,,	,,
5	,,	,,	,,	,,
6	,,	,,	,,	,,
7	,,	,,	,,	,,
8	,,	,,	,,	,,
9	,,	,,	,,	,,
10	,,	,,	,,	,,
11	,,	,,	,,	,,
12	,,	,,	,,	,,
13	,,	,,	Inverted	,,
14	,,	,,	,,	,,
15	,,	,,	,,	,,
16	,,	,,	,,	,,
17	,,	,,	,,	,,
18	,,	,,	,,	Comparable
19	,,	,,	,,	,,
20	,,	,,	,,	,,
21	,,	,,	,,	,,
22	,,	,,	,,	,,
23	,,	,,	,,	,,
24	,,	,,	,,	,,
25	,,	,,	Flat	T II
26	,,	,,	,,	,,
27	,,	,,	Inverted	T in CR_7
28	,,	,,	,,	,,
29	,,	,,	,,	,,
30	,,	,,	,,	,,
31	,,	Flat	Low	T II
32	,,	,,	,,	,,

CR_7 IN POSTERIOR CARDIAC INFARCTION

The CR_7 lead was recorded in 32 cases during different stages of recovery from posterior infarction, and changes in the T wave were compared with those found in leads II and III (Table I). The diagnosis of infarction was made from the clinical history and examination, and its localization determined from changes in successive cardiograms; in 2 cases a necropsy confirmed it. The T wave was always inverted in lead III. The findings in lead II were impressive, the T wave being inverted in 30 and flat in the remaining 2 cases. The series included patients examined many years after the initial infarction, but in none was T II upright. These findings show that recovery of the T II takes place much more slowly in posterior infarction than in anterior. Among the 32 cases, the T in CR_7 was only normal in 1, and that was taken two years after infarction. It was low in 13, flat in 2, and inverted in 16. In 21 patients the changes in the T wave were greater in lead II than in CR_7 (Fig. 2), in 7 they were comparable, while in 4 the changes in CR_7 were greater than in II (Fig. 3 and 4).

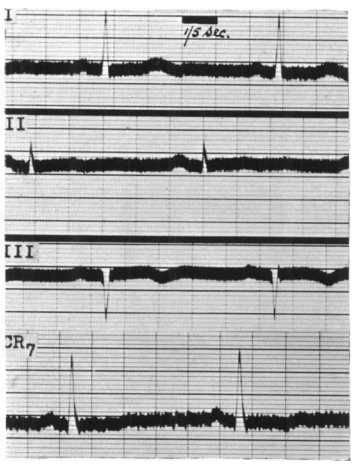


FIG. 4.

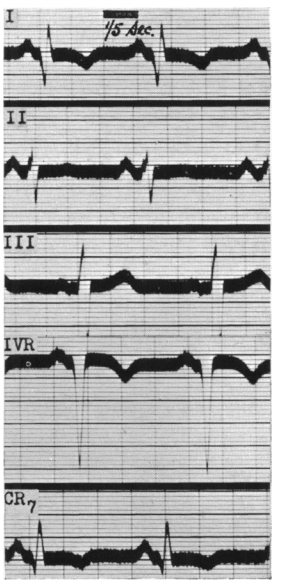


FIG. 5.

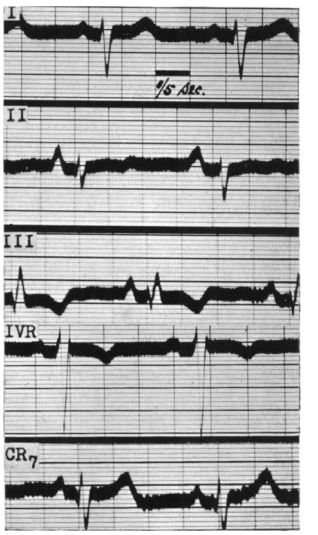


FIG. 6.

FIG. 4.—Posterior cardiac infarction, two months after cardiogram shown in Fig. 3. Slight inversion of T in II and CR_7 now comparable.

FIG. 5.—Anterior cardiac infarction. Male, aged 39. Inversion of T in CR_7 less than in I and IVR, but greater than in II.

FIG. 6.—Heart failure from emphysema. Female, aged 49. T inverted in III and slightly inverted in II, but upright in CR_7. T also inverted in CR_1 and IVR. (See also Fig. 8.)

CR_7 IN ANTERIOR CARDIAC INFARCTION

The CR_7 cardiogram was recorded in 12 patients with anterior infarction at various intervals after the attack, and the T wave compared with that in leads I, II, and IVR (Table II). The T wave was inverted in leads I and IVR in all cases; in lead II it was inverted in 7 and upright in 5, while in CR_7 it was inverted in 9 and upright in 3. In 3 cases where T was upright in lead II, it was inverted in CR_7, but was only once inverted in lead II when it was upright in CR_7. The degree of inversion of the T wave in CR_7 was next compared with that in IVR and I. It was never greater in CR_7 than in IVR and only once was it as great. The inversion of T in lead I was comparable with that in CR_7 in 5, greater than in CR_7 in 6, and less in only 1 case. Thus in anterior cardiac infarction inversion of the T was a commoner finding in CR_7 than in II, but less common and less prominent than in leads IVR and I (Fig. 5).

TABLE II

T WAVE IN CR_7 COMPARED WITH T IN LEADS I, II, AND IVR, IN ANTERIOR CARDIAC INFARCTION

Case No.	State of T wave in limb and chest leads			
	I	II	IVR	CR_7
1	Inverted	Inverted	Inverted	Inverted
2	,,	,,	,,	,,
3	,,	,,	,,	,,
4	,,	,,	,,	,,
5	,,	,,	,,	,,
6	,,	,,	,,	,,
7	,,	,,	,,	Upright
8	,,	Upright	,,	,,
9	,,	,,	,,	,,
10	,,	,,	,,	Inverted
11	,,	,,	,,	,,
12	,,	,,	,,	,,

CR_7 IN OTHER CONDITIONS

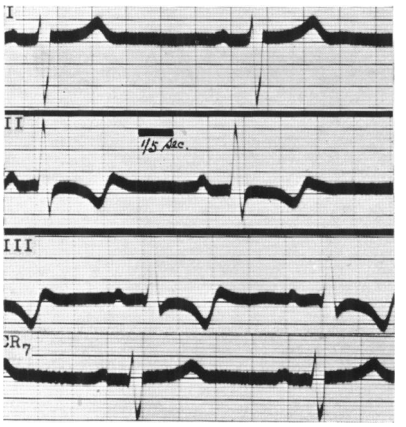
Congenital Heart Disease.—In three cases of pulmonary stenosis and in one with atrial septal defect the T wave was inverted in leads II and III, giving to the cardiogram the appearance of the curve characteristic of posterior cardiac infarction. In each instance the T in CR_7 was upright (Fig. 7 and Table III). Admittedly the clinical diagnosis of congenital heart disease was not here in doubt, but in older subjects with cardiographic irregularities from congenital heart disease, and especially in those with pain in the chest, the upright T in CR_7 serves to exclude the presence of cardiac infarction.

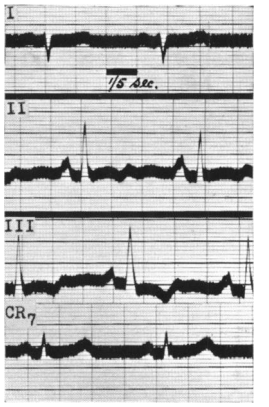
TABLE III

T WAVE IN CR_7 AND STANDARD LEADS, IN CONGENITAL HEART DISEASE, EMPHYSEMA, AND PERICARDIAL DISEASE

Case No.	Clinical condition	State of T wave in limb and chest leads			
		I	II	III	CR_7
1	Pulmonary stenosis	Upright	Inverted	Inverted	Upright
2	,, ,, ...	,,	,,	,,	,,
3	,, ,, ...	,,	,,	,,	,,
4	Atrial septal defect	,,	,,	,,	,,
5	Emphysema with heart failure ..	,,	,,	,,	,,
6	,, ,, ,, ..	,,	,,	,,	,,
7	Pericardial disease	,,	,,	,,	,,
8	,, ,, ...	,,	,,	,,	,,
9	,, ,, ...	,,	,,	,,	,,
10	,, ,, ...	,,	,,	,,	,,
11	,, ,, ...	Flat	,,	,,	Flat
12	,, ,, ...	,,	,,	,,	Inverted
13	,, ,, ...	Inverted	,,	,,	,,

Emphysema with Heart Failure.—In many patients with emphysema the cardiogram shows no distinctive changes, but when great enlargement of the heart is conjoined with failure, the limb lead tracing may resemble that found in posterior infarction (Fig. 6 and 8). We examined two such patients whose limb lead cardiograms showed inversion of T II and T III; in both the T in CR_7 was upright supplying evidence that the changes were the result of right heart failure and not posterior infarction. Incidentally, the same help in diagnosis was also given in our two patients by CR_1, which showed inversion of the T wave.





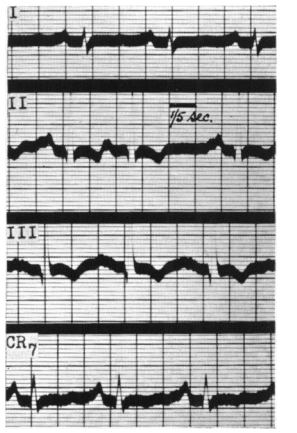


FIG. 7. FIG. 8. FIG. 9.

FIG. 7.—Congenital pulmonary stenosis. Female, aged 28. T inverted in II and III, but upright in CR_7. T also inverted in CR_1 and IVR.

FIG. 8.—Heart failure from emphysema. Male, aged 39. T inverted in II and III, but upright in CR_7. T also inverted in CR_1.

FIG. 9.—Pericardial disease. Male, aged 32. T inverted in II and III, low in I, and diphasic in CR_7.

Pericardial Disease.—The CR_7 cardiogram was recorded in 7 patients with pericardial disease in whom T II and T III were inverted (Table III); in 3 of these T I was upright when the T in CR_7 was also upright; in 3 the T I was low or flat, when the T in CR_7 was flat in two (Fig. 9) and inverted in the other; in one patient T I was inverted and so was the T in CR_7.

These changes appear to establish that when T II and T III inversion stands for pericardial disease, the T in CR_7 is upright when T I is upright, and inverted when T I is inverted.

Hypertension.—Among 12 cases of hypertension, T I was flat in 2 and inverted in 10. The T in CR_7 was inverted in every case. Changes in the T in other leads were varied, so that in lead II it was upright in 5, low in 2, and inverted in 5; in lead III it was upright in 9 and inverted in 3; in IVR it was upright in 7 and inverted in 5. When the degree of T wave inversion was specially considered in the different leads, in 6 cases it was greatest in CR_7 and I, in 4 cases in CR_7, and in 2 in IVR when the T in CR_7 showed the next most prominent inversion (Table IV).

It is known that the chest lead IVR cannot decide whether changes in the limb lead cardiogram stand for anterior cardiac infarction in a patient with prolonged hypertension. In these cases the T in IVR is sometimes inverted and sometimes upright, and on clinical grounds this change does not appear to depend on the presence or absence of cardiac infarction in addition to hypertension. The chest lead CR_7 does, however, help in the differential diagnosis of anterior infarction and such infarction conjoined with hypertension. Thus in a patient with hypertension when T is inverted in lead I and upright in IVR, the abnormal cardiogram is usually the direct result of the hypertension (Fig. 10). When the T in IVR is inverted, the degree of inversion in CR_7 should be examined; if the inversion is greater in IVR than in CR_7 (Fig. 11), the change is usually due to supervening cardiac infarction, but if the inversion is greater in CR_7 than in IVR, the change is likely to be the result of hypertension alone (Fig. 12).

Aortic Stenosis and Aortic Incompetence.—The changes in aortic stenosis (5 cases) and in aortic incompetence (3 cases) were comparable with those in prolonged hypertension. T in CR_7 was always inverted (Fig. 13), but in other leads it was variable; in lead I it was inverted in 6 and upright in 2; in lead II it was inverted in 5 and upright in 3; in lead III it was upright in 2, flat in 3, and inverted in 3; in IVR it was upright in 2 and inverted in 5, and it was not recorded in another case. When the degree of T wave inversion was compared in the different

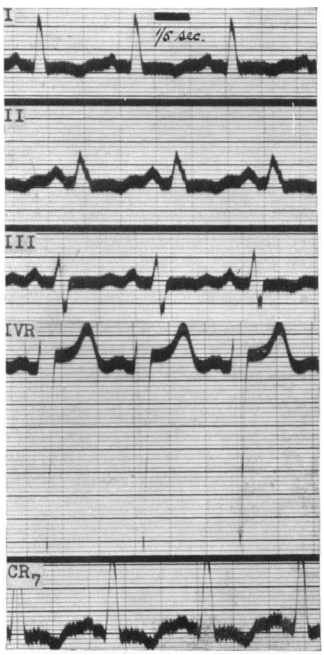


FIG. 10.

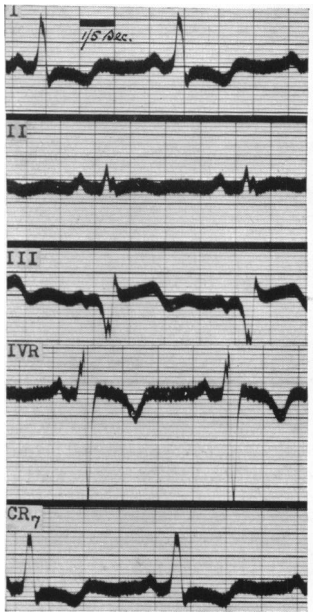


FIG. 11.

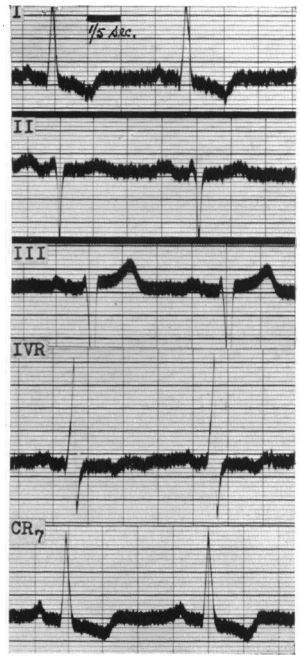


FIG. 12.

FIG. 10.—Hypertension. Male, aged 40. T upright in IVR. Inversion of T greater in CR_7 than in I and II.

FIG. 11.—Hypertension and cardiac infarction. Male, aged 62. T inverted in I and slightly inverted in II. Inversion of T in IVR greater than in CR_7.

FIG. 12.—Hypertension. Male, aged 70. Inversion of T in CR_7 greater than in IVR, and comparable with that in I.

leads it was found that 5 out of the 8 cases showed the greatest change in CR_7 and this finding is almost the same as in hypertension (Table IV).

TABLE IV

T WAVE IN CR_7 COMPARED WITH T IN STANDARD LEADS IN HYPERTENSION AND AORTIC DISEASE

Case No.	Clinical condition	State of T wave in limb and chest leads					Leads showing greatest inversion
		I	II	III	IVR	CR_7	
1	Hypertension	Flat	Inverted	Inverted	Inverted	Inverted	IVR
2	,, ...	,,	,,	,,	Upright	,,	CR_7
3	,, ...	Inverted	Upright	Upright	,,	,,	,,
4	,, ...	,,	,,	,,	Inverted	,,	,,
5	,, ...	,,	Inverted	,,	Upright	,,	CR_7 & I
6	,, ...	,	,,	Inverted	,,	,,	,,
7	,, ...	,,	Low	Upright	,,	,,	,,
8	,, ...	,,	,,	,,	Inverted	,,	IVR
9	,, ...	,,	Inverted	,,	Upright	,,	CR_7 & I
10	,, ...	,,	Upright	,,	Inverted	,,	,,
11	,, ...	,,	,,	,,	,,	,,	CR_7
12	,, ...	,,	,,	,,	Upright	,,	CR_7 & I
13	Aortic stenosis ..	,,	Inverted	Flat	Inverted	,,	II
14	,, ,, ...	,,	,,	Inverted	,,	,,	CR_7
15	,, ,, ...	,,	,,	Upright	Inverted	,,	,,
16	,, ,, ...	Upright	,,	Inverted	,,	,,	IVR & I
17	,, ,, ...	,,	Upright	Flat	Upright	,,	CR_7
18	Aortic incompetence ..	Inverted	,,	Upright	,,	,,	CR_7 & IVR
19	,, ,, ..	,,	,,	Flat	Inverted	,,	III
20	,, ,, ..	,,	Inverted	Inverted	,,	,,	CR_7

Bundle Branch Block.—In 5 cases of left bundle branch block the T wave was inverted in CR_7 (Fig. 14), and it was upright in 4 cases of right bundle branch block (Fig. 15). The T wave in the other leads (limb and IVR) was sometimes inverted and sometimes upright.

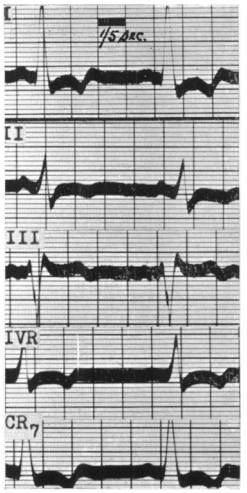


FIG. 13.

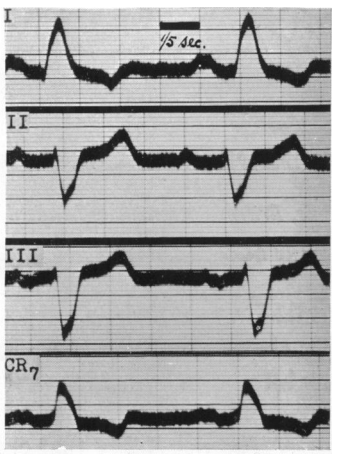


FIG. 14.

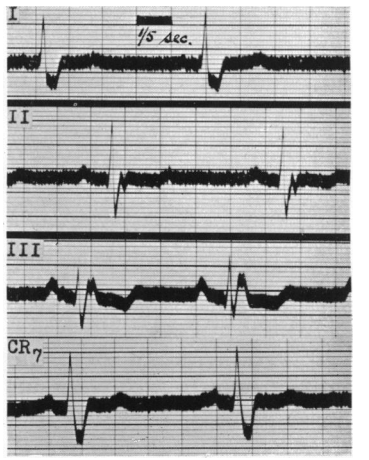


FIG. 15.

FIG. 13.—Aortic stenosis. Male, aged 65. T slightly inverted in II. Inversion of T in CR_7 greater than in IVR, and comparable with that in I.

FIG. 14.—Left bundle branch block. Male, aged 65. T inverted in CR_7.

FIG. 15.—Right bundle branch block. Male, aged 64. T upright in CR_7.

CONCLUSIONS

A new chest lead, CR_7, is described and has been tested in the differential diagnosis of cardiac infarction.

The lead proved to have a limited value in identifying posterior infarction, but it was seldom superior to the limb leads. Indeed our experience has emphasized the importance of T II in posterior infarction, for in 30 out of 32 patients it supplied the evidence necessary for the diagnosis. In contrast, T II in anterior infarction was less reliable, and T in CR_7 was often its superior, although inferior to T in IVR.

CR_7 had greatest value in distinguishing between the T II and T III inversion of posterior infarction and similar changes found in heart failure from emphysema, in pericardial disease, in congenital heart disease, and occasionally in healthy subjects. This new chest lead also helped in the diagnosis of hypertension and aortic valvular disease when complicated by anterior cardiac infarction.

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