CHANGES IN THE CHEST LEAD ELECTROCARDIOGRAM IN CORONARY THROMBOSIS

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This investigation was undertaken in order to show the sequence of changes and the variations occurring in the fourth lead of the electrocardiogram in cases of coronary thrombosis giving the T_1 or T_3 type of tracing. Particular attention was paid to the earliest abnormalities to occur and the last to disappear. Sixty-four clinical examples of coronary thrombosis were studied in which electrocardiographic abnormality confirming the diagnosis was present. No cases in which the tracings were doubtful or unconfirmatory were included. Twenty-four were acute cases examined electrocardiographically within a few hours to four days of the attack (eight within twelve hours). The criteria of abnormality in the standard leads were RS-T changes and T wave inversion occurring in the acute group over a period of a few days or weeks.

The chest lead used was that known as lead IV F. In this the right arm electrode is attached to the left leg and the left arm electrode is in contact with the outer edge of the apex beat. A normal tracing consists of an upright P wave, an upward initial wave R of good amplitude, a downward wave S, and an upward T wave. The S-T segment is either iso-electric or slightly elevated. Significant abnormalities in this chest lead electrocardiogram are R waves of less than 3 mm., elevation of more than 2 mm., and depression of more than 1 mm. of the RS-T segment, and inverted, diphasic, or very high-voltage T waves. The evidence for the pathological significance of these abnormalities has been given in a recent paper by Bourne and Courtenay Evans (1938).

ANALYSIS OF CASES

The cases were divided into two groups, according to whether the tracing was of the T_1 or T_3 type. A small third group consists of two cases with changes only in lead IV, and a single case of an anomalous type is placed in group four. These groups were subdivided so as to analyse the early changes in the acute cases, and the later changes in all cases.

GROUP I. CHANGES IN LEAD IV F IN THE T_1 TYPE OF ELECTROCARDIOGRAM. This group comprises 40 cases, 14 of which were seen in the acute stage. A. *Early Stage*.—The initial deflection R_4 was absent in six, small in one, and

normal in seven of the 14 cases. Electrocardiograms were taken within eight hours of the thrombosis in three cases and the initial positive deflection was already absent ; in one of these a tracing showed an absent R wave two hours after the occlusion. In three cases, four lead electrocardiograms had been taken before the coronary thrombosis occurred, and gave a normal R wave ; after the thrombosis, in one case, a tracing taken on the fourth day showed an absent R wave ; the R wave was not altered in the other two cases either

FIG. 1.—Serial T₁ type electrocardiograms from a case of anterior infarction, taken (A) 7 hours, (B) 4th day, (C) 5th day, (D) 11th day after coronary thrombosis. Note RS-T elevation and later inversion of T in leads I and IV ; monophasic negative initial deflection in lead IV (i.e. absent R₄).

in the acute stage or later. No significant changes have been noted in the S wave, but splintering was present once.

The RS-T segment was elevated in eleven cases, the average elevation being 3 mm. and the extremes 1 to 8 mm. It was depressed in three cases, the average depression being 1 mm. Humping with an upward convexity and slurring of the RS-T segment occurred in eight, but was absent in six. This humping showed any time after the fourth day, and sometimes remained for several weeks, but was not as a rule a permanent change.

The T wave was upright in eight cases, but in seven of them it became

inverted later. In the other six, the T wave was inverted in the first tracing taken after the thrombosis. Inversion of the T wave was never seen earlier than the third day, and appeared most commonly on the fourth day.

In limb leads, RS-T elevation occurred in seven cases in lead I. In three cases, RS-T elevation in lead I or in leads I and II was the only abnormal finding, when lead IV showed an absent R wave and gross RS-T elevation. In

FIG. 2.—Later curves from same case as FIG. 1, taken (E) 21st day, (F) 32nd day, (G) 136th day after coronary thrombosis. Note disappearance of RS-T elevation; persistence of T inversion in leads I and IV, and transitory T inversion in lead II; absent R_4 persists.

one of these, T_1 and T_4 did not invert until the fourteenth day. T_4 tends to invert slightly earlier than T_1 ; in one case T_4 inverted on the fifth and T_1 on the twenty-third day.

B. Later Stage.—In lead IV, the R wave was absent in six of the fourteen acute cases; three of these I was able to follow up and the R wave was still absent in two, 175 and 306 days after the thrombosis respectively. The other had a normal R wave after 137 days. Many tracings were taken at varying

intervals. Of the three others, two died in the acute stage and the third, still with an absent R, was lost sight of after 29 days.

Twenty-six other cases with the T_1 type of cardiogram were examined ten days to five years after the thrombosis. Twelve had an absent R wave, one an R deflection of 1 mm., and thirteen a normal deflection. Of the thirteen with an absent or very small R, one only showed recovery in later tracings, and in that case it followed cardio-omentopexy; the remainder were unchanged.

FIG. 3.—Serial T_1 type curves taken on (A) 1st day, (B) 5th day, (C) 29th day, and (D) 47th day after coronary thrombosis. Transient elevation of RS-T in leads I and IV; inversion of T_4 precedes inversion of T_1 . R_4 present throughout.

Most of these cases were repeatedly examined electrocardiographically for periods varying from five months to five years after the thrombosis.

Twenty-one of these forty cases with T_1 curves were followed up and seen on occasions five months to five years after coronary thrombosis. Analysis of lead IV showed notching of the QRS complex in three, W shaped QRS complexes in five, low-voltage QRS in one, and diphasic initial complex (QR) in three. The development of a diphasic initial complex (see Fig. 7 A) occurred a few months after the thrombosis in two cases, presenting at first an absent R wave and a large monophasic downward deflection. The S-T segment was

elevated in eight, iso-electric in eleven, and depressed in two. The T wave was inverted in twelve, diphasic in four, and normal in five. Three with diphasic T waves had formerly shown definite inversion. Of those with normal T waves, three were formerly inverted and return to normal occurred between the fourth and thirty-third week in one, between the eighth and twenty-fifth week in another, and between the fifteenth and thirtieth week in the other.

FIG. 4.— T_1 type curves in two cases of anterior infarction.

Case 1. (A) 6th day, showing earliest changes in lead IV only, i.e. Q-T elevation and absent R_4 . (B) 20th day, showing inversion of T_1 and T_4 with upright T_3 .
Case 2. (C) 39th day, showing inversion of T_1 and T_4 , with absent R_4 . (D) 291st day, T_1 inversion disappeared, but T_4 inversion persists.

In the limb leads T_1 remained inverted in nine, became diphasic in three, flat in four, and normal in five—inversion had been present in all. In the four cases which developed a flat T wave in lead I, T_4 remained abnormal; and in the five which changed to a normal T_1 , the T wave in lead IV remained abnormal in two.

GROUP II. CHANGES IN LEAD IV F IN THE T_3 TYPE OF ELECTROCARDIOGRAM.

A. Early Stage.—The initial wave R was normal in all of the eight cases; the QRS complex was W shaped in one. The RS-T wave was depressed in six

(average 3 mm., maximum 7 mm.) and iso-electric in two. The T wave was upright in seven, and diphasic in one. The diphasic T wave was transitory, lasting a few days, and returning to normal on the fourth day.

In the limb leads, the RS-T segment in leads II and III was elevated in seven on the third or fourth day. Two cases were examined electrocardiographically a few hours after the attack, one showed immediate RS-T elevation

FIG. 5.—Serial T_3 type curves from a case of posterior infarction, taken (A) 4 hours, (B) 4th day, (C) 32nd day, (D) 172nd day after coronary thrombosis. Note elevation of RS-T in leads II and III and depression of R-T in leads I and IV, followed by inversion of T_2 and T_3 .

in leads II and III; the other remained iso-electric in the first tracing and gave the characteristic elevation on the fourth day. T wave inversion usually started on the third or fourth day, but one did not show inversion until the eighth. Six eventually had inversion of T_2 and T_3 ; two who died within the first seven days had no inversion. Post-mortem, one of these showed infarction of the posterior surface of the ventricles; there was no autopsy in the other. A Q wave was present in lead II in four cases, and there was an abnormally large Q in lead III in five cases.

B. Later Stage.—This is an analysis of eleven cases of coronary thrombosis with the T_3 type of electrocardiogram in which tracings were taken over four months or longer. In lead IV, the initial deflection R was normal in all cases. The RS-T segment was finally iso-electric in six, depressed in four, and elevated in one (formerly depressed). The T wave was finally upright in all eleven, and

FIG. 6.— T_3 type curve 10 months after coronary thrombosis, showing Q_3 with slight inversion of T_3 . Note abnormally large T_4 (18 mm.).

in only one was there ever an inversion (14th day). The T wave became of large amplitude in two (19 mm.), returning to normal size in one. Humping of the RS-T segment with a downward convexity was seen in one case only. In limb leads, the Q wave in lead III remained large in six. T_3 remained inverted in seven and T_2 in three cases.

GROUP III. EVIDENCE OF CORONARY THROMBOSIS IN LEAD IV ONLY.

A. Early Stage.—In two cases, evidence of a recent coronary thrombosis was seen only in lead IV, there being no changes in the limb leads. The electrocardiogram showed T_4 inversion with subsequent return to normal in one, and

T₄ inversion with humping of the RS-T complex in the other. The clinical evidence of coronary thrombosis was very strong.

FIG. 7.—(A) T₁ type curve, 157 days after coronary thrombosis, showing diphasic initial complex (QR) in lead IV (previous curves showed monophasic negative initial complex). Curves taken on (B) 25th and (C) 49th day after coronary thrombosis, showing transitory inversion of T₄ and humped R-T₄ as only change.

B. Later Stage.—Four other cases, examined some time after the thrombosis, gave the only changes in lead IV, three by T wave inversion and one by an abnormally small R wave.

GROUP IV. ANOMALOUS CURVES AFTER CORONARY THROMBOSIS.

One acute case, which came to autopsy, showed elevation of RS-T₄, absent R₄, elevation of RS-T₁, and later diphasic T₂ and T₃. Auricular fibrillation, auricular flutter, and normal rhythm were present at different times. Post-mortem, a large infarct of the anterior and posterior surfaces of the ventricles.

POST-MORTEM EVIDENCE AND THE CHEST LEAD ELECTROCARDIOGRAM

Wood and Wolferth (1933) found, in experimental infarction in dogs, that depression of the RS-T segment occurred in anterior and elevation in posterior lesions. Using the standard lead IV, as in our cases, these findings would be reversed. Wood, Bellet, MacMillan, and Wolferth (1933) described thirty-one cases of acute coronary thrombosis, nineteen of which had anterior and twelve posterior infarction. The former had changes in the initial wave and in T_4 ; confirmation of the site of infarction was made by autopsy. Wood and Wolferth (1934), writing about abnormally large T waves in præcordial leads, describe such a case where autopsy showed an infarct on the anterior surface of the left ventricle. Willcox and Lovibond (1937) describe lead IV in six cases verified by autopsy. In three with posterior infarction, the correct diagnosis had been made from the limb electrocardiograms which were of the T_3 type. Of these, two had a normal lead IV, and the other an absent initial R, with slight elevation of S- T_4 , but the post-mortem showed also patchy fibrosis of the anterior surface of the left ventricle. Of the other three, one had an apical infarction and the electrocardiogram showed a large T_4 ; another had an anterior and apical infarct and the tracing gave a T_1 type of curve with an abnormal R_4 and inverted T_4 ; the last case revealed an antero-posterior infarct and the tracing showed depression of R-T in leads I and II, elevation in leads III, and IV, and an absent R_4 . Master, Dack, Kalter, and Jaffe (1937) describe the cardiograms of fifty cases examined post-mortem. Fifteen of these had anterior infarction with an absent initial R_4 in eleven, small R_4 in two, and normal R_4 in two. Thirteen had posterior infarction with a normal R wave in nine, small in four, and absent in one; the latter also had an old partial occlusion of the left anterior descending coronary branch. In nineteen cases anterior and posterior infarctions were present; the R wave was absent in four, and small in one-half of the cases. Two cases had infarction of the lateral wall of the left ventricle and one case infarction of the septum; the QRS complex was normal in all three. Master only referred to the initial wave changes, not to the T waves.

In our series there were two autopsies. One of these showed recent infarction of the posterior surface of the left ventricle with sclerosis of the descending branch of the right coronary artery, but no arterial thrombosis. The tracing taken three days before death, on the fifth day, had elevation of the R-T segment in leads II and III, slight enlargement of Q_3 , and humping of S-T in lead III. Lead IV was normal. The other case had extensive recent infarction of the whole of the left aspect of the interventricular septum and of adjacent parts of the anterior and posterior surfaces of the left ventricle; the right coronary artery showed patchy areas of atheroma, and the left coronary at the commencement of the anterior descending branch was filled by adherent ante-mortem clot. The electrocardiogram as already described (Group IV) was anomalous.

Left Lateral Infarction.—Wood, Wolferth, and Bellet (1938) have described a type of electrocardiogram which they state is characteristic of left lateral

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infarction. They produce post-mortem evidence and suggest that usually the circumflex branch of the left-coronary artery is occluded. The characteristics of the tracing are depression of RS-T in leads I, II, and IV, with a diphasic or inverted T wave in lead I, and an inverted T wave in lead IV. Auricular fibrillation is a common association. Electrocardiographic features may subside very rapidly, and after healing of the infarct all the changes may disappear from the tracing.

Three of my acute cases from Group I, with a T_1 type of electrocardiogram, had depression of RS- T_4 , maximum 3 mm., and in two the RS-T segment in lead I was slightly depressed also. The R wave was present in all three. These are possible examples of left lateral infarction.

SUMMARY AND CONCLUSIONS

In the T_1 type of electrocardiogram after coronary thrombosis, the changes in lead IV occur in the following sequence. The initial wave R disappears immediately in half the cases, and elevation of the R-T segment, 3 mm. above the iso-electric level, occurs at the same time in three quarters of the cases. The T wave becomes inverted on the third or fourth day, synchronous with or slightly earlier than inversion of T_1 , and sometimes many days earlier. At the same, time, the R-T elevation diminishes and, in half the cases, changes any time after the fourth day into a humped upward convexity with broad slurring of the curved portion. Return of RS-T to normal, with disappearance of the humping, occurs after several weeks. T wave inversion disappears in half the cases between the third and sixth month, but in behalf the cases it persists. The initial wave R, when once absent, usually tends to remain absent ; the initial complex in these cases sometimes becomes diphasic (QR).

In the T_3 type of electrocardiogram, RS-T is depressed 3 mm. below the iso-electric level, returning to normal within a few days in two thirds of the cases. The initial R wave is present, the S wave is often small, and sometimes a W shaped complex is seen. Later, humping of the S-T segment with a downward convexity occurs in a few cases, but is not common. The T wave is upright and tends to increase in amplitude ; it may attain 13–19 mm. in the second or third weeks. As a rule the changes in lead IV, after the initial RS-T depression has passed, are slight and not very helpful in diagnosis.

Post-mortem evidence suggests that T_1 and T_4 inversion, and absent R_4 with elevation of RS-T in leads I, II, and IV indicate an anterior infarction, and that T_2 and T_3 inversion with depression of R- T_4 indicate a posterior infarct. Where absence of R_4 and T_4 inversion are associated with inversion of T_2 and T_3 , the evidence points to infarction of both anterior and posterior ventricular walls. The third type of occlusion, involving the left circumflex artery and causing left lateral infarction, shows RS-T depression in leads I, II, and IV, with inversion of T in leads I, II, and IV. These changes are often of a transitory nature and may be associated with auricular fibrillation.

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