Electrocardiographic Changes in Kwashiorkor and Marasmus

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PART II

In assessing T wave abnormalities we have relied to some extent on comparisons with the tracings during recovery. T wave changes occurred in all 48 cases and have been grouped as follows:

(1) *Electrolyte Pattern* (Hypopotassaemia).—Sagging ST segments with inverted T waves and probable U waves (Fig. 1a): four cases.*

(2) *"Cold Injury Pattern."*—Prolonged QRS duration, slow heart rate and low voltage of QRS

* One case went on to "Sharp T wave inversion" pattern and the other three showed various "recovery" patterns before returning to normal.

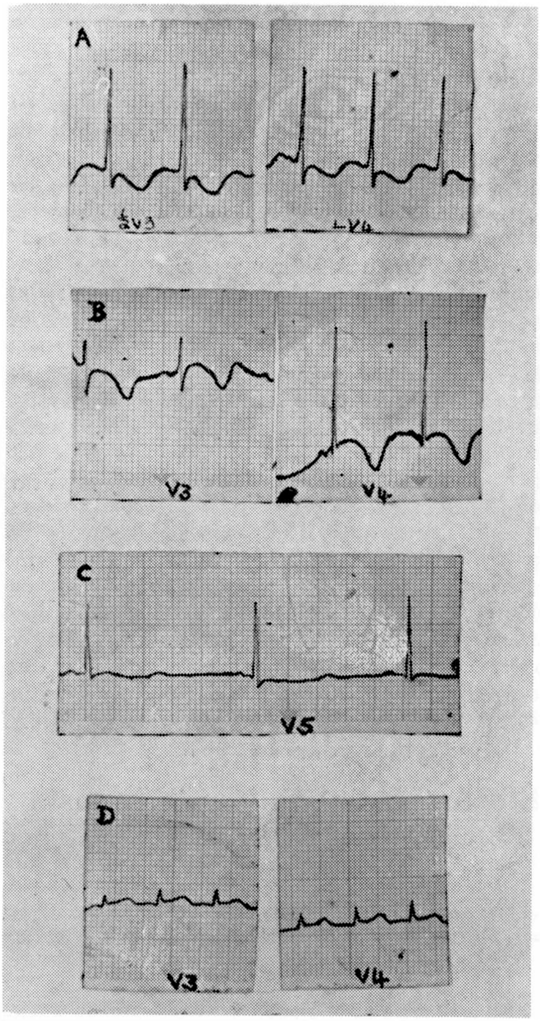

Fig. 1—A: Electrolyte pattern. B: Sharp T wave inversion pattern. C: Cold injury pattern. D: Low voltage pattern.

complexes and T waves (Fig. 1c): three cases. In the patients who survived the initial illness, sharp T wave inversion developed before T waves returned to upright.

(3) "*Sharp T Wave Inversion*" *Pattern*.—Sharp inversion of T waves across the precordium, maximal over the right ventricle and transitional zones (Fig. 1b): eight cases. Three cases with this pattern occurred *ab initio* and in the others it followed the "cold injury" pattern or low voltage T waves after three to seven days. In four cases followed up, T V4-V6 became upright with normal shape and voltage.

(4) *Low Voltage Pattern*.—Generally low voltage T waves associated with low voltage QRS complexes (Fig. 1d): one case. The voltage increased during recovery.

(5) *Low Voltage or Iso-Electric T Waves* over left ventricle associated with *T wave inversion* over right ventricle (Fig. 2): 20 cases. (Transitional zone T waves were sometimes diphasic.) In the 13 cases followed up, one showed sharp T wave inversion before return to normal pattern. In the others, T waves over the left ventricle in leads V4, 5, 6 or V5, 6 became upright and normal in shape and voltage. "Recovery" patterns, however, were seen in six cases in the early recovery phase. There was also a tendency for T waves in the transitional zone to become upright. T waves in leads V1-4 which remained inverted during recovery tended to become more negative. Convex elevation of the ST segment (Fig. 3) was common both initially and during recovery in those leads showing inverted T waves.

(6) *Low Voltage or Iso-Electric T Waves* over left ventricle associated with *upright T waves* over the right ventricle (Fig. 2): three cases. During recovery the T waves in leads V4, 5, 6 became upright and normal in shape and voltage, while T waves in leads V1, 2, 3 became inverted.

(7) *Minor T Wave Changes*.—Plateau T waves, i.e., symmetrical flat-topped low voltage T waves in leads V4, 5, 6 associated with inverted T waves in leads V1, 2, 3 (Fig. 3): 12 cases. During recovery the pattern remained essentially unchanged, but T waves in leads V4, 5, 6 became normal in shape and increased in voltage.

(8) *Upright T Waves Over Praecordium:* two cases. In one case followed up, T V4R to V3 became inverted on recovery.

(9) "*Recovery*" *Patterns*.—This term, coined by Smythe *et al.* (1962), refers to individual changes in T waves and ST segments, usually occurring in the early recovery phase. Apart from the group classified as "Minor T Wave Changes," in which the plateau T waves resembled the "recovery" T waves, these changes were not conspicuous in the initial E.C.G. and did not alter the basic patterns described above. "Recovery" patterns were common in the early recovery phase and were noted in 25 out of the 48 cases, being succeeded by normal patterns. However, minor abnormalities in the shape of T waves sometimes persisted for two months or more.

The "recovery" changes for reference are: plateau T waves, umbilicated T waves, notched T waves, M-shaped T waves, small rounded T waves and elevation of ST segments (Fig. 3).

In 32 patients who recovered and in whom adequate E.C.G.s were recorded in the first two weeks, 18 showed a marked improvement in voltage and shape of the T waves within one week and a further 14 at two weeks. T wave abnormalities tended to improve progressively up to one month or two months (where measured).

Correlation of E.C.G. Findings with Clinical Picture

In seven fatal cases the E.C.G. abnormalities were:

(1) Low voltage QRS with flat T waves going on to sharp T wave inversion with persisting low voltage of QRS at 14 days (death at 16 days).

(2) Flat T waves going on to T wave inversion 24 hours before death at eight days; the QRS voltage remained normal.

(3) "Cold injury" pattern shortly before death within 24 hours of admission.

(4) Flat T waves, low QRS voltage where death occurred within 48 hours of admission.

(5) Minor T wave changes (QRS voltage was normal) four days before death, which occurred on seventh day after admission.

(6) Upright T waves over the whole praecordium, with normal QRS voltage. E.C.G. was done within one hour of death, which occurred at three days.

(7) Sharp T wave inversion persisting up to time of death at 12 days. Low QRS voltage initially was becoming normal.

In the patients who were gravely ill on admission as judged clinically, including those who died, the E.C.G. changes were: "cold injury" pattern, 3 (3); sharp T wave inversion pattern, 5 (7); other T wave changes, 14 (34); short PR interval, 5 (8); short fixed PR interval, 3 (5); low voltage QRS apart from "cold injury" pattern, 14 (16); electrolyte pattern, 3 (4). Figures in brackets show the total number of cases demonstrating the changes referred to.

Discussion

Simonson *et al.* (1948), in a controlled study of E.C.G.s in semi-starvation in adults, showed decreased amplitude of P, QRS and T waves, sinus bradycardia, right axis deviation and prolongation of QT interval, but not of QTc. E.C.G. abnormalities in kwashiorkor have been described by several workers. Jansen and Le Roux (1950) showed a conspicuous decrease in amplitude of

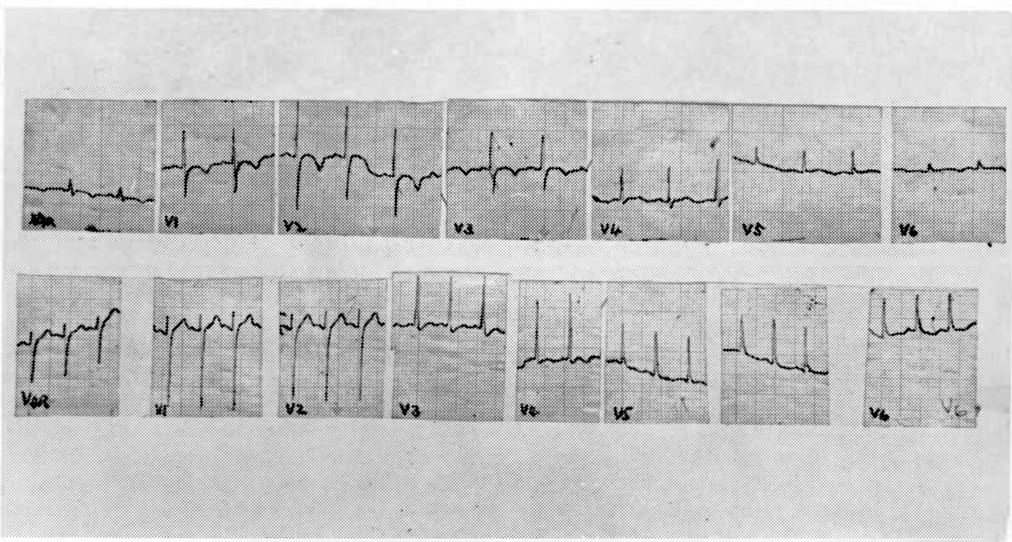

Fig. 2—Top row: flat and iso-electric T waves over left ventricle, right inverted. Bottom row: flat and iso-electric T waves over left ventricle, right upright.

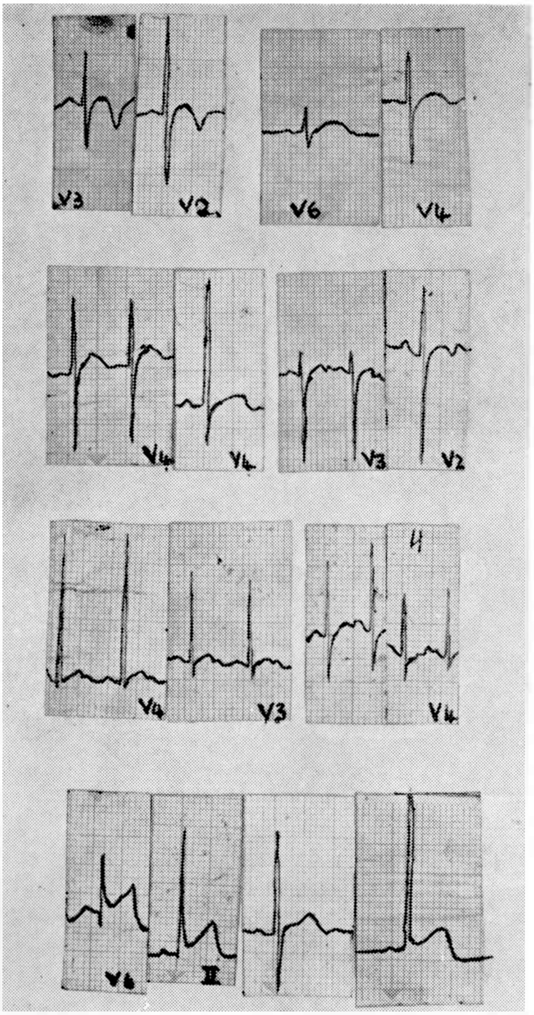

Fig. 3—Top row, left: Convex elevation of ST segments; right: plateau T waves. Second row, left: Umbilicated T waves; right: M-shaped T waves. Third row, left: notched T waves; right: small T waves. Bottom row: elevated ST segments.

QRS complexes and usually some abnormality of the T waves, the latter being of low amplitude, iso-electric or diphasic. Bradycardia was not conspicuous. Gopalan *et al.* (1955) mentioned prolonged QTc as the commonest and most persistent abnormality, other changes being a marked reduction in amplitude of QRS complexes and T waves. Bradycardia occurred in four out of 31 cases. Smythe *et al.* (1962) also found prolongation of QTc, lowered QRS voltage and T wave changes. The E.C.G. patterns were described as ionic, low voltage and flat T, sharp T wave inversion, recovery patterns and a small miscellaneous group, including "cold injury" pattern. Bradycardia was not encountered in their series in the absence of the "cold injury" type pattern; sinus tachycardia, however, occurred frequently. Cronje and Pretorius (1963) found the main abnormalities in acute kwashiorkor to be low voltage, a shortened PR interval, a QTc interval that was either abnormally shortened or abnormally prolonged, and inverted T waves in the tracings obtained from the left chest leads. No mention is made of bradycardia. Caddell (1965) mentions a fixed short PR interval and inverted or flat TV5 and TV6 as being the most significant abnormalities in kwashiorkor.

Our findings are, in general, in agreement with those of the other workers. The salient abnormalities in the initial E.C.G.s in our series were lowered voltage of QRS complexes (18 out of 48 cases) and a variety of T wave changes, the patterns of which have been described in detail above (48 out of the 48 cases). The commonest T wave abnormalities were flat or iso-electric T waves over the left ventricle, usually associated with inverted T waves over the right (20 cases), but occasionally with upright T waves in the right praecordial leads (three cases). Plateau T waves over the left ventricle were the next commonest abnormality (12 cases). A short PR interval occurred in eight cases, but in only five did this abnormality persist. This incidence is not in accord with the emphasis placed on this particular abnormality by Cronje and Pretorius (1963) and Caddell (1965).

Profound metabolic disturbances occur in kwashiorkor. In a recent review Dean (1965) described the changes in protein, carbohydrate, lipid and mineral metabolism. Sodium and water retention, mainly extracellular, potassium deficiency, especially in patients with diarrhoea, and the occurrence and significance of magnesium deficiency are cited. The E.C.G. abnormalities no doubt reflect the metabolic disturbances and have been variously ascribed to protein deficiency (Gopalan *et al.*, 1955; Schyns and Demayer, 1957), to hypopotassaemia for the electrolyte pattern (Smythe *et al.*, 1962), and to magnesium deficiency (Caddell, 1965). However, the causes of the E.C.G. changes are probably multiple; for instance, Caddell (1965) draws attention to the striking improvement in the E.C.G. which may follow transfusion with blood or plasma and which could hardly be attributed to the mineral constituents. The absence of a charcteristic pattern in fatal cases in our series, or that of Cronje and Pretorius (1963), is further suggestive evidence against a single uniform causation.

We found it difficult, as did Cronje and Pretorius (1963), to correlate the E.C.G. findings with the severity of the illness as judged clinically. The "cold injury" pattern, the "sharp T wave" inversion pattern and a shortened PR interval tended to occur in the more severely ill children. Otherwise, lowered voltage of QRS complexes was most consistently associated with severe illness. Of the four patients showing the "electrolyte" pattern, all had diarrhoea and two were clinically dehydrated. The other T wave changes occurred with about equal frequency in the severely ill and moderately ill patients. No specific pattern was noted in the fatal cases.

We agree with Caddell (1965) that "the E.C.G. is a sensitive indicator of the clinical status" in that all our recovering patients showed corresponding improvement in the E.C.G.; the electrocardiogram is obviously a most important research tool. Nevertheless, until further work is able to correlate more accurately the E.C.G. and biochemical changes, the E.C.G. will be of limited value in the clinical management of kwashiorkor. On the other hand, if such correlation could be demonstrated, then the E.C.G. would provide vital information to the clinician working in areas where facilities for detailed biochemical investigations are limited.

SUMMARY

The E.C.G. abnormalities occurring in a series of 48 cases of kwashiorkor (44) and marasmus (4) are described. Abnormalities were noted in all tracings, the most significant being lowered voltage of QRS complexes, various T wave changes and a shortened PR interval in some. No specific pattern was noted in the fatal cases; in the severely ill patients the "cold injury" pattern, the "sharp T wave inversion" pattern, a short PR interval and lowered voltage of QRS complexes occurred most commonly. The literature on E.C.G. changes in kwashiorkor is reviewed briefly and the possible causes and significance of the abnormalities are discussed.

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