THE Q-T INTERVAL IN RHEUMATIC DISEASE IN CHILDREN*

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Received December 1, 1949

The diagnosis and evaluation of cardiac involvement during the course of acute rheumatic fever has long been one of the difficult problems in medicine. Although acute rheumatic carditis is the most important manifestation of rheumatic fever, few criteria have been established for arriving at a decision as to when carditis is present and when it has finally come to an end. There are even fewer criteria for evaluating the extent of total cardiac damage that might result from an episode of acute carditis. It must be admitted that the current laboratory aids inclusive of the commonly accepted electrocardiographic criteria have been disappointing in determining the presence and measuring the extent of the inflammatory process in the heart muscle during the course of the acute rheumatic episode.

In recent months there has been a renewed interest regarding the value of the measurement of electrical systole (QT interval) in the diagnosis of rheumatic carditis. In a recent publication (Taran and Szilagyi, 1947) we have shown that the duration of the QT interval is abnormally prolonged in patients having acute rheumatic carditis. Furthermore, the abnormal prolongation of the QT interval in these patients was shown to be a function of the severity of the carditis and not that of the cardiac rate. The more severe the clinical carditis, the longer the electrical systole relative to diastole. It was suggested that this disturbance in the sequence of electrical events in the cardiac cycle was a characteristic of carditis and might be used as a valuable diagnostic criterion for the recognition of carditis in rheumatic patients. These findings have been corroborated by Abrahams (1949).

It is the purpose of this paper to present further evidence in support of this contention, and in addition to present evidence that a careful study of the changes in the duration of electrical systole may be helpful in evaluating the extent of cardiac damage resulting from acute rheumatic carditis in children.

MATERIAL AND METHOD OF STUDY

A group of one hundred and forty children, six to sixteen years of age were observed under controlled conditions at the St. Francis Sanatorium for Cardiac Children. One hundred and twenty-three were studied during a single period of residence at the sanatorium, the average period of observation per patient being about twelve months. The remaining seventeen patients of the group studied were observed during several periods of residence at the sanatorium and were followed for a total period of several years. The average period of observation of this group was about four years per patient.

All electrocardiographic readings were made by the same examiner using the method already described (Taran and Szilagyi, 1947). The cardiographer was not familiar with the clinical findings

* Read before the III Inter-American Cardiological Congress, June 16, 1948, Chicago, Illinois, U.S.A.

at the time of the electrocardiographic reading. The QT interval was corrected for cardiac rate according to Bazett's formula. All clinical observations were made by another examiner following rigidly the same criteria during the entire period of observation. The evaluation of progressive cardiac disability was based upon the clinical evidence of valvular damage, Roentgen measurements of cardiac size and clinical evaluation of the functional capacity according to the criteria of the New York Heart Association (1939). The diagnosis of rheumatic activity was based upon unequivocal and generally accepted laboratory and clinical criteria.

Since it is well known that the duration of the electrical systole (QT interval) may be modified by various types of medication, all patients receiving digitalis, mercupurin, salicylates, or quinidine were excluded from this study. Furthermore, since other conditions such as hypocalcæmia, acidosis, and pericardial effusion are known to modify the duration of the electrical systole, such cases were not included in this study. Patients showing crude disturbance in rhythm such as paroxysmal auricular fibrillation, flutter, and tachycardia and those showing high degrees of conduction disturbance were also not included in the present study.

RESULTS

Group 1. Children Observed During a Single Period of Residence at the Sanatorium (Fig. 1).

Of 123 children who were observed for an average period of twelve months, 33 had a normal, or slightly or moderately prolonged electrical systole at the time of admission but all of these showed a gradual and significant shortening of the electrical systole during residence at the sanatorium. The QT interval on discharge was significantly shorter than at the time of admission. Two-thirds of these 33 children showed unequivocal evidence of rheumatic carditis. On the other hand only one in every five showed palpable evidence of progressive heart disease at the end of the period of observation. None of the 33 showed severe cardiac damage or congestive failure, and none died.

The duration of the electrical systole of 39 children of the group of 123 did not change during the entire period of observation. It was of normal duration or slightly prolonged in 13; only one of these showed evidence of rheumatic activity and one showed progressive heart disease during the period of observation. The remaining 26 children had a moderately or markedly prolonged electrical systole: all except one of these showed unequivocal evidence of active carditis and 13 had evidence of progressive cardiac disability at the end of the period of observation; none had congestive failure and none died.

The remaining 51 children of the group of 123 showed a progressive prolongation of the electrical systole from the time of admission to discharge. At the time of admission 11 of these showed QT intervals of normal duration and no evidence of rheumatic activity; at the end of eleven months of observation all were mildly active and four of these developed evidence of progressive heart disease. Forty children had a prolonged electrical systole at the time of admission and a significantly longer electrical systole at the end of the period of observation; more than three-fourths of this group (31) showed evidence of progressive heart damage. Of greater significance is the observation that of the 20 children in this group who had a markedly prolonged QT interval on admission, all except one showed severe and progressive heart damage; two developed auricular fibrillation, three developed congestive failure, and four died.

These observations suggest a close association between the abnormal prolongation of the electrical systole and the occurrence of progressive heart disease during the course of acute carditis. When the QT interval is abnormally prolonged and becomes longer during the course of rheumatic carditis, a high degree of associated cardiac damage may be expected. Furthermore, a marked prolongation of the QT interval that does not show a tendency to become shorter is frequently associated with evidence of progressive heart damage. Finally, patients who show a significant shortening of the abnormally prolonged electrical systole during the course of carditis usually present little evidence of progressive heart damage.

FIG. 1.—The figure is a graphic representation of the relation of the duration of the electrical systole to progressive heart disease observed during a single period of residence at the sanatorium. Each line represents a case; the arrow point represents the duration of the QTc at the end of the period of observation and the other end of the line represents the duration of the QTc at the beginning of the period of observation.

Group 2. Children Observed over Several Years Duration (Fig. 2).

The children of this group were observed carefully for a total of sixty-seven patient years. The periods of residence at the sanatorium were interrupted by short periods of home care, of follow-up at a clinic, or of admission to hospital.

Of this group of seventeen children, nine, who were observed over a total period of thirty-six patient years, showed no or minimal cardiac damage. All of these had definite rheumatic bouts but only a slight prolongation of the electrical systole at any time during the entire period of follow-up. In most cases the duration of electrical systole showed a tendency to decrease rather than increase. The remaining eight children who were observed over a total period of thirty-seven patient years showed moderate to severe progressive heart disease and all of these demonstrated moderate to marked prolongation of the electrical systole at any time during the period of observation with a distinct tendency for the QT interval to become longer from the beginning to the end of the period of observation.

In the children of Group 2, a high degree of correlation exists between the prolongation of the electrical systole and progressive cardiac disability. In addition, this group demonstrates that the time factor may also play a significant role in bringing about this close correlation. The longer the

FIG. 2.—This figure is a graphic representation of the relation of the duration of the electrical systole to progressive heart disease observed over several years duration. The broken ascending line represents the average duration of the QTc of each individual case. The lines crossing the ascending line represent the longest and shortest QTc for each period of residence at the sanatorium.

period during which the electrical systole remains prolonged, the more likely and the more severe the total cardiac damage.

This parallelism between the duration of the electrical systole and progressive cardiac disability becomes even more evident from a detailed study of individual cases (Fig. 3, 4, 5, and 6).

COMMENT

There has always been unanimous agreement among physiologists that a prolongation of systole relative to diastole is a manifestation of impairment of the functional integrity of the myocardium. Wiggers and Clough (1919) found consistently that prolongation of systole was significant of functional cardiac disorder. Katz (1929) suggested that the prolongation of systole in a diseased heart as compared with a normal heart would constitute a measuring rod for determining the functional integrity of the myocardium. Bazett (1920) was of the opinion that the duration of systole in a diseased heart may be used as a measure of active cardiac dilatation. Tung (1941) arrived at the same conclusion.

The evidence presented in this study would seem to concur completely with the above mentioned observations. One of the expressions of the disturbed cardiodynamics present in acute rheumatic heart disease is a prolongation of systole relative to diastole. The more extensive the carditis and, therefore, the greater the disturbance in the functional integrity of the myocardium, the longer is the

FIG. 5.—This figure illustrates the history of a patient who was observed for a period of five years. The patient had one attack of polyarthritis at nine years of age, a mild attack of carditis at ten years of age, and another attack of polyarthritis at twelve years of age followed by a mild carditis. Each of these attacks was of short duration.

Age is represented in years. The broken line represents the readings of the duration of the QTc at various intervals. The arrows point to the electrocardiograms represented on the chart. Functional classification in accordance with Nomenclature and Criteria for Diagnosis of Diseases of the Heart, New York Heart Association, 1939.

Cardiac size is represented as follows:

- N = normal size
- 1+ = slightly enlarged
- 2+ = moderately enlarged
- 3+ = markedly enlarged
- 4+ = marked enlargement in all diameters

Valvular damage is represented as follows:

- = mitral insufficiency
- = mitral stenosis
- △ = aortic insufficiency
- ▲ = aortic stenosis

electrical systole relative to diastole. The observations presented in this paper further indicate that there is a close correlation between the degree of prolongation of electrical systole and total cardiac damage. Finally, our observations suggest strongly that the longer the period during which the normal relationship of systole to diastole is disturbed, the greater the total cardiac disability resulting from rheumatic carditis. While this study does not postulate a cause and effect relationship between the prolongation of the electrical systole and progressive heart disease, the evidence clearly leads to this implication. Further exploration in this direction is now in progress.

FIG. 6.—This figure illustrates the history of a patient who was observed over a period of five years. The patient had protracted carditis fluctuating between moderate and severe during the entire period of observation.

SUMMARY AND CONCLUSIONS

One hundred and forty rheumatic boys and girls, six to sixteen years of age, were observed during a total period of almost one hundred and eighty patient-years.

The duration of the electrical systole (QT interval) was studied in these children in relation to progressive heart disability.

A close correlation existed between the duration of the QT interval and the extent of cardiac disability resulting from acute rheumatic carditis.

It was further observed that the longer the time during which the electrical systole remained abnormally prolonged, the more extensive the total cardiac damage.

It is postulated that this disturbance in the normal sequence of events in the cardiac cycle in acute rheumatic carditis in children may be used as a valuable aid in prognosticating the extent of cardiac damage resulting from carditis.

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