Two Extremes of Classically Normal Electrocardiograms, a Concave RS-T Elevation with a TU Fusion and a Gently-Sloped ST-T Segment with an Accentuated U Wave, Disclosed by Reaction Patterns in a Five-Minute Postural Test*

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Changes in the regulatory mechanism of the autonomic nervous system affect almost all organs including the cardiovascular system. The changes in the autonomic nervous system can be caused by an extremely abnormal mode of daily life such as a severely muscular (especially in athletes) or mentally-tense daily life on one hand and a recumbent, sedentary or mentally-relaxed daily life on the other hand. Previously, the author indicated the possibility of electrocardiographic differentiation of an overload (abuse) and an overprotection (disuse) of the autonomic nervous system¹. This paper deals with electrocardiographic manifestations of these two extremes of vegetative cardiovascular disturbances.

WHEN not only the ST segment and the T wave but also the U wave is taken into consideration, the classically normal precordial electrocardiograms can be divided into two extremes: one with a concave RS-T elevation and a TU fusion (QU shortening) and the other with a gently-sloped ST-T segment and an accentuated U wave (QU prolongation)¹. The former is found mostly in those who live a severely muscular (especially in athletes) or a mentally-tense daily life, and the latter mostly in those who live a recumbent, sedentary or mentally-relaxed daily life. These two extremes of electrocardiographic characteristics observed in vegetative cardiovascular disturbances might be related to the fact that a lower cardiac sympathetic resting tone and response level under standard sensory and mental stresses in emotionally placid individuals was manifested by a lower heart rate and

a longer ventricular isometric tension period, and both acute emotional arousal and prolonged emotional tensions as well as sensory annoyances were accompanied by an acceleration of the heart rate and shortening of the isometric period². Clinically, cardiologists know that not only the environment but also the symptoms and signs of patients with a concave RS-T elevation and a TU fusion were different from those of patients with a gently-sloped ST-T segment and an accentuated U wave^{1,3-14}. The former frequently complains of insomnia, precordial oppression, palpitation, headache, tightness in the throat and so on, and the latter frequently suffers from dizziness on standing, drowsiness, general malaise, headache, stiff shoulders and so on.

The so-called vegetative dysregulation has been the subject of numerous communications by many investigators and variously classified

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1,15-23. CHRISTIAN, KROFF and KURTH¹⁷ who employed the technique of factor analysis divided functional cardiovascular disease into two types: "die hypertone Regulationsstörung mit dynamisch-labiler Blutdruckregelung" and "die hypotone Regulationsstörung mit statisch-labiler Blutdruckregelung". In the former, factor I represents an increased sympathetic tone, factor II an anxiety state of patients and factor III a vegetative hyperreactivity, and in the latter, factor I represents asthenia in a constitutional sense, factor II a reduced drive and easy tiring with subjective symptoms of a reduced cardiovascular performance, factor III symptoms of the hyperventilation syndrome and factor IV an increased irritability.

According to GITTER²⁴, the purpose of the postural test (Stehversuch of Schellong) which was primarily devised for functional differentiation of cardiovascular disorders is to see the process of cardiovascular adaptation to a postural change from a switching phase (Umschaltphase) to a recovery phase (Erholungsphase). As to the physiologic mechanism of orthostatic regulation, CONDORELLI²⁵ emphasized not only the part of harmonic central regulation by the autonomic nervous system but also the essential role of a local tonus reaction of vessels in the lower extremities played in a normal orthostatic regulation.

Although many investigators published reports concerning the cardiovascular aspects of abnormalities of the autonomic nervous system^{2,8,10,14-33}, few of them referred to the electrocardiographic manifestations of these two extremes of the vegetative dysregulation. The present investigation was undertaken to substantiate the difference in the adaptability of the autonomic nervous system between subjects with a concave RS-T elevation and a TU fusion (QU shortening) and those with a gently-sloped ST-T segment and an accentuated U wave (QU prolongation).

MATERIALS AND METHODS

Normally, the blood pressures and heart rate return to a pre-standing level within a few minutes¹⁴. Therefore, differences in the blood pressures and heart rate between before and 5 minutes after standing sufficiently reflect the adaptability of the autono-

mic nervous system, a presence or an absence of a regression due to disuse or an exhaustion due to abuse of the autonomic nervous system.

I. On the basis of the fundamental mechanism of the test, the author modified the procedures as follows: a) Have a patient in a recumbent position for 5 minutes, and then the blood pressures and pulse rate were measured. b) Passively have the patient stand close by the bed for 5 minutes with a manchet attached to the upper arm, and then the blood pressures and pulse rate were again measured. In every case, the test was carried out with an assistance of a nurse. This simplified postural test was carried out in the following four groups:

- Group A consisted of 36 patients with a concave RS-T elevation and a TU fusion (QU shortening) below the age of 50 (Fig. 1).
- Group B consisted of 42 patients with a gently-sloped ST-T segment and an accentuated U wave (QU prolongation) below the age of 50 (Fig. 2).
- Group C consisted of 19 patients with mild coronary insufficiency associated with eye-ground changes of Grade I to II of SCHEIE's classification (Fig. 3).
- Group D consisted of 13 healthy students of a nursing school aged 18 to 19 and 7 members of the Ground Self Defense Forces aged 18 to 32 whose ECGs were nearly an intermediate between the two extremes mentioned above (Fig. 4)

II. Reaction patterns were divided into the following four types:

- 1) Hypodynamic regulatory disturbance in which not only the systolic but also the diastolic blood pressure was lowered more than 6 mmHg.
- 2) Hypotonic regulatory disturbance in which only the systolic blood pressure was lowered more than 6 mmHg with a decrease in the pulse pressure.
- 3) Atherosclerotic regulatory disturbance in which the systolic blood pressure was elevated more than 6 mmHg, and the diastolic lowered more than 6 mmHg with an increase in the pulse pressure³⁵.
- 4) Normal orthostatic regulation in which neither the systolic nor the diastolic blood pressure was lowered more than 6 mmHg. Usually, the systolic blood pressure remained almost unaltered (slightly elevated or slightly lowered), and the diastolic tended to elevate with a slight to moderate decrease in the pulse pressure. Changes in the blood pressure less than 4 mmHg were considered to be within technical errors.

Therefore, a hypodynamic regulatory disturbance in patients with a concave RS-T elevation and a QU shortening corresponds to "die dynamisch labile Blutdruckregelung" of MECHELKE²¹, "die hypertone

Fig. 1. Concave RS-T elevations with QU shortenings (Group A).

Fig. 2. Gently-sloped ST-T segments with QU prolongations (Group B).

Regulationsstörung mit dynamisch-labiler Blutdruckregelung" of CHRISTIAN, KROPF and KURTH¹⁷ and to "die exogenen Vegetativen", "die bedingt Vegetativen" and "die Auseinandersetzung mit psychischen Stresssituationen" of KRAEMER¹⁶. While, a hypotonic regulatory disturbance in patients with a gently-sloped ST-T segment and a QU prolongation corresponds to "die statisch labile Blutdruckregelung" of MECHELKE²¹, "die hypotone

Regulationsstörung mit statisch-labiler Blutdruckregelung" of CHRISTIAN, KROPF and KURTH¹⁷ and to "vegetativer Verschwender" of KRAEMER¹⁶.

RESULTS

I. Changes in Blood Pressures and Heart Rate

The systolic blood pressure was lowered more than 20 mmHg in 19 per cent of group

Fig. 3. Mild coronary insufficiency (Group C).

Fig. 4. Intermediate patterns between group A and group B (group D).
(Normal electrocardiograms in a narrow sense)

A, 21 per cent of group B, 11 per cent of group C and 0 per cent in group D. A most marked fall was -76 mmHg in group A and -32 mmHg in group B. A syncope occurred in the former. The diastolic blood pressure was lowered more than 6 mmHg in 56 per cent of group A, in 31 per cent of group B, in 22 per cent of group C and in 7.2 per cent of

group D. An increase in the heart rate more than 20/min was observed in 17 per cent of group A, in 19 per cent of group B, in 11 per cent of group C and 0 per cent of group D. A most marked increase was $+45$ /min in group A and $+46$ /min in group B. A decrease in the pulse pressure more than 16 mmHg was observed in 17 per cent of group A, 17 per

Fig. 5. Percentage of reaction patterns in group A.

Fig. 6. Percentage of reaction patterns in group B.

Fig. 7. Percentage of reaction patterns in group C.

Fig. 8. Percentage of reaction patterns in group D.

cent of group B, in 17 per cent of group C and in 23 per cent of group D. The decrease in the pulse pressure in group D was mostly due to the elevation of the diastolic blood pressure.

II. Reaction Patterns in Each Group

1) In group A, a hypodynamic regulatory disturbance was observed in 56 per cent, a hypotonic regulatory disturbance in 11 per cent and a normal orthostatic regulation in 33 per cent. A syncope occurred in 2 cases which showed a hypodynamic regulatory disturbance (Fig. 5).

2) In group B, a hypodynamic regulatory disturbance was observed in 19 per cent, a

hypotonic regulatory disturbance in 55 per cent and a normal orthostatic regulation in 26 per cent (Fig. 6).

3) In group C, a hypodynamic regulatory disturbance was observed in 11 per cent, a hypotonic regulatory disturbance in 44 per cent, an aortosclerotic regulatory disturbance in 11 per cent and a normal orthostatic regulation in 34 per cent (Fig. 7).

4) In group D, a hypodynamic regulatory disturbance was observed in 15 per cent, a hypotonic regulatory disturbance in 25 per cent and a normal orthostatic regulation in 60 per cent (Fig. 8).

DISCUSSION

The relationship of postural changes to an increase in sympathetic tone has been demonstrated, and various factors and mechanisms which participate or are integrated in the homeostatic regulation of the heart, vessels and circulating blood have been elucidated by many investigators^{25, 29-31, 34-41}. However, it is still difficult to determine which of these factors or mechanisms are responsible for an abnormal orthostatic regulation in a given case. Also in the present investigation, it is impossible to state whether or not the hypodynamic regulatory disturbance is caused primarily by a venodilatation or a failure of a vasoconstriction which subsequently leads to a lower ventricular filling pressure and to a lower cardiac output, and the hypotonic regulatory disturbance primarily by a decrease in the cardiac output due to a decreased ventricular inotropic response. What is responsible for the occurrence of these two types of regulatory disturbance may merely be a difference in the degree of abnormal adaptive responses of the autonomic nervous systems (vagal and sympathetic), hormones, pressor- or baro-receptors, vessels and circulating blood volume.

In the present investigation, a syncope occurred in 2 subjects with a marked hypodynamic regulatory disturbance in which, probably being due to a venodilatation or a failure of a vasoconstriction, not only the systolic but also the diastolic blood pressure was lowered. There are also many communications as to the mechanism of shock⁴²⁻⁴⁹. In regard to the orthostatic collapse, CONDORELLI³⁵, emphasizing an essential role of not only the arterial but also the venous system in the lower extremities, stated as follows: "Zur Auslösung des orthostatischen Kollapses müssen gleichzeitig zusammenwirken: 1. Die Aufhebung oder Erschöpfung des arteriellen und arteriölen Konstriktionsreflexes beim hydrostatischen Druck, wodurch die plötzliche Abwanderung einer erheblichen Menge des Kreislaufblutes in die kaudalen Gebiete ausgelöst wird: 2. die Aufhebung des Venentonusreflexes bei größerem hydrostatischen Druck, wodurch der Rückfluß zum Zentrum der in die abschüssigeren Gefäß-

gebiete abgeflossenen Masse verhindert wird".

It is well known that ECG shows diurnal changes, being sensitively affected by various psychologic and physiologic factors⁵⁰⁻⁵². However, as reported previously, a normalization of the concave RS-T elevation takes more than a few months, and the difference between the concave RS-T elevation with a QU shortening and the gently-sloped ST-T segment with a QU prolongation is far more than the diurnal difference. BERGES⁵³ who examined diurnal ECG changes concluded as follows: "Auch bei Gesunden sind im Laufe des Tages Größenänderungen sämtlicher Ekg-Parameter festzustellen . . . Das bedeutet, daß die Ekg-Tageschwankungen bei Gesunden mit der üblichen Auswerttechnik nur zu einem sehr kleinen Teil erfaßt werden . . ."

As to the role of psychic factors in the vegetative cardiovascular disorders, there are also many publications^{4-14, 22, 26, 53-58}, and some of them admitted the presence of a vegetative cardiovascular disturbance not associated with psychic troubles. As early as 1941, REINDELL and BAYER²³ clinically observed two types of vegetative cardiovascular disturbance; one which corresponds to the hypodynamic regulatory disturbance and the other which corresponds to the hypotonic regulatory disturbance. Namely, they stated "Neben diesen schweren psychischen Erschütterungen und voll bewußt erlebten Katastrophen, deren Auswirkung sich am Kreislauf schlagartig oder in kurzen Zeitabständen abspielt, ist es viel häufiger die jahrzehntelange unterminierende Wirkung an sich viel kleinerer psychischer Schäden, die einen großen Einfluß auf den Kreislauf haben können" and "Diese Regulationsstörungen können auftreten, ohne daß irgendwelche psychischen Einwirkungen vorliegen. Es scheint uns wesentlich nochmals darauf hinzuweisen, daß der Schwerpunkt für die Entstehung der Kreislaufstörungen hier nicht in der veränderten seelischen Reaktionslage, sondern in einer Fehlsteuerung des vegetativen Systems zu suchen sind."

As to the fundamental of the treatment of vegetative cardiovascular disturbances, KRAEMER¹⁶ made the following statements: Sog. vegetative Störungen sind meistens keine

Fig. 9. Combined patterns of group A and group B.

krankhaften Zustände, sondern normale Regulationen . . . Mein Ausgangspunkt ist, daß die vegetative Dysregulation zunächst ein Ausgleichversuch ist und nichts Pathologisches, auf das man sich gleich mit therapeutischem Eifer stürzen müßte." CHRISTIAN, FINK-EITEL and HUBER¹⁹ who followed up 100 patients with vegetative cardiovascular disturbances for 10 years reported as follows : A change from a dynamic to a static unstable blood pressure regulation and vice versa was not observed. Only from a combined form of blood pressure regulation was there a change into either the dynamic or the static unstable blood pressure regulation in a few control cases. He obtained better therapeutic results by physical therapy, dieting, changes in the way of life, psychotherapy and autogenic training methods than by medications in most of the patients treated. The therapeutic success obtained by these procedures are, however, surpassed by therapeutic effects obtained by improvements in family life, social rise and success in professional life. In fact, an improvement by medication is temporary and that by a better conditioning of patient's daily life permanent. Moreover, an environmental improvement was accompanied by an ECG improvement in a course of a few to several months unless a continuation of functional ECG changes caused irreversible organic damages^{10,12,14}.

At the end of this discussion, it should be indicated that there are combined patterns (not an intermediate) of these two extremes of classically normal electrocardiograms, i.e., one with a concave RS-T elevation associated with an accentuated U wave (Fig. 9-a), and the other with a gently-sloped ST-T segment associated with a TU fusion or an isoelectric U wave (Fig. 9-b). The author is impressed that the former was usually observed in patients with actual neurosis associated with an intermittent or sustaining borderline hypertension and/or a lack of physical exercise, and the latter usually in those with vegetative asthenia who became so hypochondric or depressive as to be accompanied by insomnia, an increased irritability and occasionally by a borderline hypertension.

Closing this paper, the author does not hesitate to state that there are many problems left to be elucidated, i.e., how many percentage of asymptomatic active persons show one of these two extremes of classically normal electrocardiograms, and whether or not those with an intermediate pattern (a normal pattern in a narrow sense) are actually vegetatively asymptomatic and normally active.

SUMMARY

1) A five-minute postural test was carried out in 36 patients with a concave RS-T ele-

vation and a QU shortening (A), 42 patients with a gently-sloped ST-T segment and a QU prolongation (B), 18 patients with mild coronary insufficiency (C), and 20 control subjects with ECG which showed an intermediate pattern between the group A and group B (D).

2) The procedures of the five-minute postural test were as follows: a) have a patient in a recumbent position for 5 minute and then have the patient stand passively by the bed for 5 minute. The blood pressures and heart rate were measured at the end of lying and standing positions, respectively.

3) Reaction patterns were divided into 4 types: a) hypodynamic regulatory disturbance in which not only the systolic but also the diastolic blood pressure was lowered more than 6 mmHg. b) hypotonic regulatory disturbance in which only the systolic blood pressure was lowered more than 6 mmHg with a decrease in the pulse pressure. c) aortosclerotic regulatory disturbance in which the systolic blood pressure was elevated more than 6 mmHg, and the diastolic lowered more than 6 mmHg with an increase in the pulse pressure. and d) normal orthostatic regulation in which neither the systolic nor the diastolic blood pressure was lowered more than 6 mmHg.

4) In group A, hypodynamic regulatory disturbance was observed in 56 per cent, a normal orthostatic regulation in 33 per cent and a hypotonic regulatory disturbance in 11 per cent. A syncope occurred in 2 patients with a hypodynamic regulatory disturbance. In group B, a hypotonic regulatory disturbance occurred in 55 per cent, a normal orthostatic regulation in 26 per cent and a hypodynamic regulatory disturbance in 19 per cent. In group C, a hypotonic regulatory disturbance was observed in 44 per cent, a normal orthostatic regulation in 34 per cent, an aortosclerotic regulatory disturbance in 11 per cent and a hypodynamic regulatory disturbance in 11 per cent. In group D, a normal orthostatic regulation occurred in 60 per cent, a hypotonic regulatory disturbance in 25 per cent and a hypodynamic regulatory disturbance in 15 per cent. It is concluded that a concave RS-T elevation with a QU shortening which shows a hypodynamic regulatory disturbance is one

extreme, and a gently-sloped ST-T segment with a QU prolongation which shows a hypotonic regulatory disturbance the other extreme of classically normal electrocardiograms.

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