Differentiation of Neurogenic from Organic Complaints with the U Wave

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Statistical approach to differentiate neurogenic from organic cardiac complaints was made by classifying 513 patients according to their complaints and signs and by determining the percentage of U wave appearance in their precordial leads. When the significance of the U wave disappearance was statistically elucidated, a direct inquiry was made to discover the concrete contents of mental affliction in a patient who lacks the U wave in V4 and V5. The purpose of this inquiry was not only to treat the patient rationally but also to confirm the reliability of the statistical conclusions obtained.

There are not a few reports13-9 which indicated abnormalities in the ST segment and the T wave which simulate coronary insufficiency in patients under severe mental conflict or emotional tension, namely, in patients with anxiety neurosis or neurocirculatory asthenia. On account of this resemblance, these change in the ST segment and the T wave were ascribed to myocardial ischaemia by some10,11 but the ability of the autonomic nervous system by others12,13,14. Textbooks of electrocardiography deal with organic or structural heart diseases but not with neurogenic or functional cardiac disorders. Explanations made in these textbooks on the QRS complex and the T wave are in the terms of depolarization and repolarization, respectively, without convincing explanations on the genesis of the ST segment and the U wave. Einthoven’s interpretation15 of the U wave is as follows: Ein bedeutender Teil des Herzens kann schon in den Erschlaffungszustand übergegangen sein, so daß der Druck in den Kammerhöhlen so gut wie ganz verloren gegangen ist, während doch noch einige Fasern sich im Kontraktionszu-

stand befinden. Erst wenn diese letzten vollständig erschlafft sind, hat die U-Zacke ihr Ende erreicht. While, Hering17 ascribed the origin of the U wave to “die pulsatorische Dehning und die Aktion der Aorta”, and Hürthle18 to eigene aktive Kontraktilität der Aorta”. However, in 1931, Maekawa19,20,21 published a series of reports on the fundamental of the electrocardiogram. According to his fundamental experiments, the electrocardiogram of ventricular contraction consists of 2 components, a) the QRS complex and b) the ST segment and the upstroke of the T wave, and that of ventricular relaxation a) the downstroke of the T wave and b) the U wave. Namely, ventricular contraction reaches maximum at the summit of the T wave, and ventricular relaxation is completed at the end of the U wave. A diagrammatic representation of this principle is given in Fig. 1. Later, Hinden22, observing a correlation between hypertension not due to syphilis and the U wave, ascribed the origin of the U wave to an unaffected aorta, and W. Trendelenburg23 to “die Strömungsströmen des in die Aorta und Pulmonalis einströmenden Blutes” or to

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“die aktive Diastole der Kammern”. BLUMBERGER\textsuperscript{24} seems to have reached the same conclusion as HINDEN.

HOOGERWERF\textsuperscript{30,36} who took electrocardiogram from 260 Olympic champions in Amsterdam observed the U wave only in winners. Recently, however, SCHMID and ENGLAR\textsuperscript{37} who studied the U wave in sportsmen concluded as follows: Die Autoren betrachten daher die U-Welle nicht als charakteristische Erscheinung im Ekg von Sportlern und also auch als kein Anzeichen einer bestimmten Stufe des Trainingszustandes. Dies wurde auch durch das Vorkommen der U-Welle bei der Kontrollgruppe 86 dekompensierter Herzerkrankter bestätigt, wo sicherlich keine Stufe des Trainingszustandes vorliegt und wo die U-Welle in 72\% der Fälle beobachtet wurde.

An attempt was made in this paper to differentiate neurogenic from organic cardiac complaints with the U wave which reflects changes in the diastole due to changes in the counterpart of the systole, namely, the ST segment and the upstroke of the T wave, which has dexterously been demonstrated by MAEKAWA\textsuperscript{19,20,22}.

\section*{Materials and Method}

\subsection*{I. Classification of patients}

According to their chief complaints and objective signs, 513 ambulatory patients were divided into 3 groups.

\textbf{Group A}

Chief complaints:
- palpitation, precordial oppression or shortness of breath at rest or at night, insomnia, tightness in the throat, headache, weakness, dizziness, ringing in the ears or numbness.

Objective signs:
- casual blood pressure lower than 160 mmHg and pure heart sound.

\textbf{Group B}

Chief complaints:
- nausea, anorexia, vomiting, abdominal pain or discomfort, heart burn, flatulence, jaundice, loose bowels, constipation, cough or sputa.

Objective signs:
- casual blood pressure lower than 160 mmHg and pure heart sound.

\textbf{Group C}

Chief complaints:
- palpitation, shortness of breath or precordial oppression after exercise or muscular work, occipital headache, stiffness of shoulders, sleeplessness, dizziness, weakness or numbness.

Objective signs:
- casual blood pressure higher than 160 mmHg and/or distinct heart murmur.

Usually, patients in each group complained of more than 2 above-mentioned symptoms. The electrocardiogram was taken mostly on the 1st or 2nd consultation day with Sanborn's direct-writing electrocardiograph. As the control, electrocardiograms were taken from 20 healthy subjects. Electrocardiograms with a pulse rate of more than 85 per minute were not included in this survey.

\subsection*{II. Measurement of the U wave}

When 1 to 2 traces of the U wave followed 4 T waves or when the downstroke of the T wave fused stepwise into the U wave, it was scored as 0.5. When 4 T waves were followed with 4 distinct U waves lower than 0.5 mm or with the U wave with a height of 0.5 to 3.0 mm, it was scored as 1. A negative U wave, which usually follows a marked ST depression and T wave inversion, was scored as 0.

\section*{Results}

1) As shown in Fig. 2, the percentage of U wave appearance in healthy subjects was 97\% in V\textsubscript{4} and 75\% in V\textsubscript{5}.

2) In patients under 30 years of age, the percentage of U wave appearance in V\textsubscript{4} was

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46% in Group A, 80% in Group B and 93% in Group C, and that in V₅ 20% in Group A, 52% in Group B and 65% in Group C (Fig. 3).

3) The difference in the percentage of U wave appearance in V₄ between Group A and Group C was most marked in the 4th decade. The U wave appearance in V₄ was 28% in Group A, 93% in Group B and 97% in Group C, and that in V₅ 7% in Group A, 54% in Group B and 75% in Group C (Fig. 4).

4) In the 5th decade, the U wave appearance in V₄ was 36% in Group A, 89% in Group B and 92% in Group C, and that in V₅ 9% in Group A, 85% in Group B and 66% in Group C (Fig. 5).

5) The percentage of U wave appearance in V₄ in Group A tended to increase with advance in age. In the 6th decade, the U wave appearance in V₄ was 52% in Group A, 61% in Group B and 96% in Group C, and that in V₅ 13% in Group A, 43% in Group B and 78% in Group C (Fig. 6). Accordingly, V₅ was of more value than V₄ for the differentiation between neurogenic and organic cardiac complaints in this decade of life. Most patients with abdominal discomfort in Group B had fear of gastric cancer.

6) In patients over 60 years of age, classification of patients into 3 groups with chief complaints and objective signs was difficult. In Group A, typical neurogenic cardiac complaints due to mental conflict or emotional tension, which were most frequent in the 4th decade, were rare. In Group C, most patients showed a depressed ST segment and a flattened or inverted T wave with a disappearance or an inversion of the U wave. Thus, the U wave appearance in V₄ was 50% in Group A, 94% in Group B and 89% in Group C, and that in V₅ 42% in Group A, 75% in Group B and 67% in Group C (Fig. 7).
Fig. 4. Percentage of U Wave Appearance in Precordial Leads between 30 to 40 Years of Age.

Group A: 41 Cases
- Neurocirculatory Asthenia,
- Anxiety Neurosis,
- Lability of the Autonomic Nervous System.

Group B: 30 Cases
- Gastritis,
- Enterocolitis,
- Cholecystitis,
- Hepatitis,
- Bronchitis.

Group C: 36 Cases
- Congenital Heart Disease,
- Acquired Valvular Disease,
- Juvenile Hypertension,
- Renal Hypertension,
- Essential Hypertension.

Fig. 5. Percentage of U Wave Appearance in Precordial Leads between 40 to 50 Years of Age.

Group A: 22 Cases
- Neurocirculatory Asthenia,
- Anxiety Neurosis,
- Lability of the Autonomic Nervous System.

Group B: Cases
- Gastritis,
- Enterocolitis,
- Cholecystitis,
- Hepatitis,
- Bronchitis.

Group C: 32 Cases
- Congenital Heart Disease,
- Acquired Valvular Disease,
- Essential Hypertension.

Fig. 6. Percentage of U Wave Appearance in Precordial Leads between 50 to 60 Years of Age.

Group A: 69 Cases
- Neurocirculatory Asthenia,
- Anxiety Neurosis,
- Cerebral Arteriosclerosis,
- Lability of the Autonomic Nervous System.

Group B: 27 Cases
- Gastritis,
- Enterocolitis,
- Cholecystitis,
- Hepatitis,
- Bronchitis.

Group C: 31 Cases
- Essential Hypertension,
- Cardiac Valvular Disease,
- Pulmonary Emphysema.

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After the significance of the U wave disappearance in $V_4$ and $V_5$ was thus statistically clarified, the author was enabled to draw the concrete contents of mental conflict or emotional tension out of nearly 9 of 10 patients. The characteristics of the contents of the stress thus drawn out were that the stress has continued for more than 1 month by the time of the first consultation and that there is no prospect of its resolution or there are unconquerable difficulties for its resolution. For example, the complaints originate in anxiety, depression or resentment brought on by socioeconomic or emotional stress such as degradation, strife, competitive activities with deadlines, family friction, disruption of family life or financial collapse.

The presence of a distinct U wave in $V_4$ and $V_5$ in patients with various many-sided complaints usually indicated the presence of lability of the autonomic nervous system, talkative character of a certain disease with shorter than 1 month duration.

The U wave in patients with organic cardiac complaints tended to increase in height up to 3.0 mm in precordial leads when the ST segment was normal or only slightly depressed without T wave inversion. When the ST segment was markedly depressed, and the T wave markedly flattened, diphasic or completely inverted, the U wave also tended to be flattened or inverted.

The percentage of the U wave appearance in $V_4$ and $V_5$ in patients with diabetes mellitus without cardiac and/or renal complications and in patients with hyperthyroidism without cardiac failure was low. However, on account of the lack of the number of cases, the statistical conclusion was withheld in this paper.

**DISCUSSION**

I. Etiologic aspect

As in philosophy, there are 2 ways of approach to the recognition of a human being in the province of medical science, if roughly divided; one is to recognize a man as merely substance and life and contemplative faculty as the production of materials in unknown ways, and the other is to recognize a human being as a substantial union of spirit and substance. Electronic and psychosomatic medicines may represent these 2 ways of approach.

Claude Bernard\(^{(3)}\) is of the opinion that experiments on the sensory organs and cerebral functions must be made in men because human beings are superior to animals with the ability which is missing in animals and because animals do not inform us of what they perceive. Emphasizing the importance of psychology of neurosis in medicine, Kretschmer\(^{(9)}\) stated as follows: Denn die

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Fig. 8. Control, T. O. 32 Years Old, a Laboratorian. Casual Blood Pressure: 124/76 mmHg.

Fig. 9. Control, Y. K. 28 Years Old, a Doctor. Casual Blood Pressure: 120/80 mmHg.
Fig. 10. Control, H. N. ♀ 31 Years Old, an Office Girl. Casual Blood Pressure: 110/70 mmHg.

Fig. 11. Group A, K. K. ♀ 17 Years Old, a High School Girl. Casual Blood Pressure: 124/82 mmHg. She has been a vice-monitor of the class for the past 2 months and is now under a term examination.

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Fig. 12. Group A, Y. I. 28 Years Old, an Engineer. Casual Blood Pressure: 124/60 mmHg. He was engaged to a girl in his home town, but he fell in love with an older woman in his boarding.

Fig. 13. Group A, M. N. 36 Years Old, a Taximan. Casual Blood pressure: 128/84 mmHg. He sleeps only 4 to 5 hours daily, but his monthly income is not enough to make his livelihood. His wife is chronically invalid.

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Fig. 14. Group A, Y. O.  52 Years Old, a Fisherman. Casual Blood Pressure: 130/84 mmHg. After the World War II his wife and 2 children have still been detained by force in a Russian camp.

Fig. 15. Group A, Y. T.  47 Years Old, a Dayworker. Casual Blood Pressure: 130/84 mmHg. He lives with his father-in-law with whom he always quarrels about the right of property.

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Fig. 16. Group A, D. T. 55 Years Old, a Bill Collector. Casual Blood Pressure: 136/80 mmHg. He obtained his present job about 4 months ago in the town to which he had been strange. He walks all day long to find a house without success.

Fig. 17. Group C, O. M. 34 Years Old. Bronchial Asthma. Casual Blood Pressure: 120/80 mmHg.

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Fig. 18. Group C, T. N. 23 Years Old. Congenital Heart Disease. Casual Blood Pressure: 128/80 mmHg.

Fig. 19. Group C, T. E. 41 Years Old. Compensated Mitral Insufficiency without Digitalis Administration. Casual Blood Pressure: 160/98 mmHg.

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Fig. 20. Group C, H. Y. 67 Years Old. Essential Hypertension Casual Blood Pressure:
230/120 mmHg.

Fig. 21. Group C, M. S. 67 Years Old. Essential Hypertension. Casual Blood Pressure:
170/100 mmHg.
Fig. 22. Group C, Y. N. 54 Years Old. Essential Hypertension. Casual Blood Pressure: 200/100 mmHg.

Fig. 23. Group C, H. O. 67 Years Old. Essential Hypertension. Casual Blood Pressure: 150/80 mmHg.

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Fig. 24. Group C, M. N. 82 Years Old. Combined Valvular Disease. Casual Blood Pressure: 190/80 mmHg.

Fig. 25. Group C, Y. W. 58 Years Old. Malignant Hypertension. Casual Blood Pressure: 250/150 mmHg.

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Psychologie der Neurose ist die Psychologie des menschlichen Herzens überhaupt. Ein Neurosenkenner ist an sich ein Menschenkenner. While, Fisher, who summarized a number of reports on psychological factors and heart disease concluded as follows: 1) Circulatory responses are produced by individually perceived stress which may influence the occurrence or course of heart disease. 2) Cardiac patients often report a history of gradual increase of life stress situations prior to heart disease. 3) Individuals with cardiovascular disease often present a history of working excessively under self-imposed and environmental pressure.

As is well known, psychologists have another way to approach this neurosis problem. Reindell and Bayer, introducing opinions of some psychologists, stated as follows: Eine gewisse Berechtigung für den Begriff "Organneurose" erscheint uns nur dann gegeben, wenn bei Verwendung dieses Ausdrucks das Somatische im Hintergrund steht und die überragende Bedeutung des abweichenden multiplen Verhaltens hervorgehoben werden soll (Jahreiss, Siebeck).

Der Begriff Neurose umfaßt die Entwicklung, in deren Verlauf ein Mensch unbewußt und oft unverschuldet aus seiner Gleichgewichtslage und seiner multiplen Gesundheit in eine schwere Störung der Gleichgewichtslage seiner Persönlichkeit hineingerät, die für ihn mit großen Leiden verbunden ist (Speer).

Discussing the significance of abnormalities in the reactivity of the autonomic nervous system, Reindell and Bayer further stated that "Nachprüfungen durch v. Bergmann, Katsch, und Westphal u.a. haben aber ergeben, daß es diese reinen Formen der vegetativen Störung mit Übergewicht des Vagus oder Sympathicus tonus gar nicht gibt . . . . Unter krankhaften Bedingungen kann man bei einer Unausgeglichenheit des vegetativen Nervensystems häufig Mischformen finden, wo gleichzeitig sympathische und parasympathische Symptome an verschiedenen Organ systemen überwiegen. So besteht bei manchen Basedowformen neben Tachykardie, Augensymptomen und Tremor als Ausdruck eines gesteigerten Sympathicus tonus Neigung zu vermehrter Darmperistaltik und Diarrhöen, die zweifellos als Symptom vermehrter vagischer Erregbarkeit aufzufassen sind". Indicating the complexity of the autonomic nervous system which is regulated not only by neural but also influenced by physicochemical, electrical, ionic, hormonal, enzymatic and catalytic factors, they also stated that "Damit wird es klar, wie falsch und nichtsagend es ist, wenn man Störung in diesem so schwierig zu durchschauenden vegetativen System, die sich oft nur an einem Organ äußern, als "Organneurosen" bezeichnet und damit "organisch" geradezu im Gegensatz zu "funktionell" setzt (v. Bergmann).

As to the possibility that functional disturbance may produce sustaining organic damage, Claude Bernard suggested that histopathological changes are not necessarily the primary cause of the disease but often the result of the disease, and this result may, of course, be the cause of further pathological symptoms. Reindell and Bayer are also of the opinion that "Es muß aber in jedem Fall damit gerechnet werden, daß bei längerem Bestehenbleiben solcher (funktionellen) Störungen, die Möglichkeit einer Dauerschädigung des Herzens gegeben ist".

Demonstrating arachnoiditis adhaesiva in patients with neurogenic angina pectoris Mekawa stated on the basis of the law of causality that "It is now necessary for us to bring cardiac neurosis from the site of spirit down to the site of material as Harvey did".

From all discussions and statements cited above, it may well be stated that neurosis is the "Grenzgebiet" between or a joint sphere of internal medicine and psychology or neuropsychiatry and that full understanding of neurosis problem requires further studies from not only medical but also psychological and neuropsychiatric viewpoint. However, it is neither theory nor hypothesis but a scientifically proved physical fact that patients with neurogenic angina pectoris showed arachnoiditis adhaesiva at the upper thoracic level and that patients with neurogenic cardiac complaints showed the ST-T abnormalities and the U wave disappearance, whatever the first cause which is required by the law of causality may be. Not only from the scholastic but also from the materialistic point of view it may well be accepted that a regulator in the brain and a
regulated organ may affect each other and that a mediator between them may also influence them both and vice versa. It seems to this author not illogical to assume that there is a stage of functional-organic abnormality between functional disturbance and organic damage, namely, a stage of functionally produced organic change. Cardiac neurosis may be a manifestation of this functional-organic abnormality such as arachnoiditis adhesiva due possibly to sustaining stressful life.

What kind of electrical events are responsible for the ST-T deviation and the U wave disappearance is not the subject of this paper.

II. Diagnostic aspect

An experienced cardiologist can differentiate cardiac neurosis from organic cardiovascular disease easily even without the aid of the electrocardiogram. However, as pointed out by Reindell and Bayer with the following statement “Nach außen lassen sie oft eine ausgezeichnete Haltung erkennen. Man darf sich aber durch das Maß von Haltung, die Selbstbeherrschung und das Pflichtbewußtsein dieser Leute nicht täuschen lassen. Hinter diesem großen Maß von Haltung verbirgt sich oft eine schwere innere Qual (Schults)”, it is not always possible to draw out the concrete contents of mental conflict or emotional tension from patients with calm, self-composed attitude and reticence even with the aid of the electrocardiogram. However, when the electrocardiogram revealed a complete disappearance of the U wave in V4 and V5, the author had the patient take a recumbent position mostly with his eyes closed, and then told the patient straight-forwardly. “Your electrocardiogram has revealed the presence of mental conflict, emotional tension or dissatisfaction, and I think it may be the cause of your troublesome symptoms. What is it, may I ask? Then, most patients, astonished, confide in detail their affliction. If not, it is necessary to ask concretely a patient about various aspects of affairs of family, profession and acquaintance. It many sound too private a question, but a patient in a recumbent position with his eyes closed usually answers it without much hesitation. When a patient is accompanied by a family or colleague, the situation is different. A complete dissap-
accompanied by simultaneous objective improvement, namely, by a reappearance of the U wave in $V_4$ and $V_5$. For example, in a 21-year-old engineer who has led a stressful life imposed by construction works with deadlines, it took more than 1 month of hospitalization, namely, a release from his daily competitive activities, for the U wave in $V_4$ to reappear. This fact strongly suggests that cardiac or anxiety neurosis is not purely functional but functional-organic or organic in nature.

Administration of Bellergal together with a tranquilizer is usually sufficient to stabilize the autonomic nervous system. In a case of benign hypertension, reappearance of the U wave which was lost as a reflection of a marked ST depression can be accomplished by Persantin or Segontin administration together with gradual lowering of the blood pressure.

**Summary**

The percentage of U wave appearance in precordial leads was determined in a total of 513 ambulatory patients with neurogenic or organic cardiac complaints. The percentage of U wave appearance in $V_4$ in the 4th decade was 28% in a group of neurogenic cardiac complaints and 97% in that of organic cardiac complaints. The U wave appearance in $V_4$ tended to increase with advance in age, and $V_5$ became of more value than $V_4$ in the 6th decade, i.e., the percentage of U wave appearance in $V_5$ was 13% in a group of neurogenic cardiac complaints and 87% in that of organic cardiac complaints in this decade. A complete disappearance of the U wave in patients with neurogenic cardiac complaints tended to extend from the left to the right precordial leads up to $V_4$ with continuation of stressful life. The U wave in patients with organic cardiac complaints tended to increase in height up to 3.0 mm, unless ST depression was marked. Usually, a flattened or negative U wave followed a marked ST depression and a flattened or inverted T wave. The presence of a distinct U wave in $V_4$ and $V_5$ in patients with diverse, rambling complaints usually indicated the presence of the lability of the autonomic nervous system, talkative or hysterical character or a fear of a certain disease with shorter than 1 month duration.

The U wave disappearance in patients with neurogenic cardiac complaints was interpreted by the author that it is a reflection in the diastole of the ST–T deviation in the systole. The characteristics of the concrete contents of mental conflict or emotional tension discovered on the basis of the statistical conclusions obtained from patients with neurogenic cardiac complaints were that the stress had continued for more than 1 month before the 1st consultation and that there is no prospect of its resolution in the near future.

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