Morphologic Aspects of the Negativity of the U Wave and their Corresponding Electrocardiographic and Clinical Data

By D. Furbetta, M.D., F. Santucci, M.D., A. Bufalari, M.D., and P. Solinas, M.D.

The negative U wave has been studied in 200 electrocardiograms. Six different types of negativity of the U wave are recognized; a seventh type includes the alterations of the T-U segment. Electrocardiographic and clinical data are correlated with these changes. Two hypotheses to explain the varying morphology of the negative U wave are discussed.

UNTIL quite recently neither the genesis of the U wave nor its diagnostic significance has been carefully studied. The description of the U wave generally has been limited to a statement that it is positive (upright), negative (inverted), or diphasic. Only negative deflections have been considered of some clinical diagnostic importance.\(^1\)\(^-\)\(^6\)

In a previous paper,\(^7\) we thoroughly examined the morphology of the upright U wave. Additional experience justifies the statement that a positive U wave is of much less significance than the more complex negative U wave, the clinical and morphologic aspects of which are discussed in this paper.

MATERIAL AND METHODS

From our collection of 200 tracings with inverted U waves, 100 tracings were studied, both in the limb
and chest leads, or only in the latter. Only technically perfect tracings were included in order to eliminate artifacts that can lead to false interpretations. This selection is of importance, since negative U waves can be produced artificially. This has occurred once in our experience because of careless placing of the exploring chest electrode (fig. 1). We have found it useful and sometimes necessary to record 2 leads simultaneously because adequate evaluation requires comparison of findings in other more selective leads of the same electrocardiogram. The best paper speed to record clear waves seemed to be 40 mm/sec.

Observations

The morphology of the inverted U wave has been studied in comparison with the amplitude, duration, and location of the upright U wave elsewhere in the same electrocardiogram. The positive U wave will be referred to as the “basal” U wave. In the limb leads neither positive nor negative U waves change their fundamental morphology. Therefore, in 2 synchronously recorded limb leads, the points of maximal height and maximal depth of the positive and negative U waves occur simultaneously.

The inverted U wave has been most frequently described as a small deflection with

Fig. 2. The drawings illustrate the 6 morphologic types of negative U wave and a seventh one dealing with alterations of the T-U segment.

Fig. 3. Patient with tight mitral stenosis and tricuspid incompetence, right ventricular hypertrophy and strain. Negative U waves of the first type in every chest lead. U-wave duration was measured in lead I and aVL.
the descending limb shorter than the ascending limb. Our studies have shown that in the chest leads morphologic aspects of the inverted U wave are much more complex. We have schematically classified these variations into 7 patterns, which are described in figure 2.

We have also included in our study of the negative U wave the variations of the T-U tract (end of the T, beginning of the U) because of their close morphologic relationship and clinical and electrophysiologic significance, suggesting the possibility of a unitary genesis. The 7 types are characterized as follows.

1. The U wave is negative with varying amplitude. Compared with the “basal” positive U in another chest lead of the same electrocardiogram, its length does not show any variation. This type is characterized by a total inversion of the U wave (figs. 2–4).

2. The U wave is negative, but the inversion is present for only the initial one half or two thirds of its entire duration, as determined in the “basal” U wave of the same electrocardiogram. The final part of the wave is isoelectric (figs. 2, 5–7).

3. In this type the inversion is seen in the terminal one half or two thirds of the U wave, while the initial portion appears isoelectric (figs. 2 and 8).

4. The negativity occupies the central part of the wave, while the initial and final parts are isoelectric (figs. 2 and 9).

5. The U wave is diphasic “plus-minus” (figs. 2, 4, and 10).

6. The U wave is diphasic, but “minus-plus” (figs. 2, 5–7). In this type, as in the previous one, it is often possible to observe an equal development of the 2 components “minus” and “plus” of the diphasic wave.

7. This type includes the various morphologic anomalies of the T-U segment. It is most often depressed, but it may be elevated or sloped downward or upward (figs. 2, 7, and 11).

The modifications of the T-U segment are usually associated with anomalies of the U wave itself. More often elevation of the T-U is followed by the first, second, or sixth type of inverted U wave (fig. 7), while depression of the T-U is followed by an upright U, which becomes inverted subsequently.

Frequently different types of inverted waves are seen together. Usually a diphasic U wave of the sixth type in the right chest leads is associated with a negative wave of the second type in the left chest leads (figs. 4–7).

The incidence of the various types, the chest leads in which they appear, and the correlated electrocardiographic and clinical data are presented in table 1.
MORPHOLOGIC ASPECTS OF NEGATIVITY OF U WAVE

Fig. 5. Patient with mitral and aortic heart disease and left ventricular hypertrophy. Negative U wave of the second type in leads V5, V6, and of the sixth type in V4, and V5. Symmetric upright U wave in V6, V1. U-wave duration was determined in V2. Note the disappearance of the inverted U wave after administration of amyl nitrite.

DISCUSSION

Our investigation of the possible patterns of the inverted U wave and their electrocardiographic and clinical correlations permit conclusions that are of interest though their significance remains obscure.

In a small percentage of cases the negative U wave had the same characteristics as the corresponding positive one. In 66 per cent of
our electrocardiograms, the inverted U wave was of shorter duration than an upright U wave in other leads of the same electrocardiogram. In 21 per cent of the tracings it was diphasic with prevalence of the "minus-plus" type.

The most common types of precordial negative U wave were the second (negativity of the proximal portion) and the sixth ("minus-plus" diphiasm). They were usually seen in patients with arterial hypertension and aortic valvular disease and in electrocardiograms showing left ventricular hypertrophy and strain. The second and sixth types were also found in electrocardiograms with signs of coronary insufficiency.

In myocardial infarction inverted U waves of the second type were usually found in association with patterns of the third stage or with residuals of old infarcts. In recent infarctions inverted U waves of the first type (negativity of the whole wave) or third type (negativity of the final portion) were more common.

In electrocardiograms with right ventricular hypertrophy due to mitral stenosis, inverted U waves were found only in the right chest leads, and their negativity was mainly of the first type (total wave inversion) or fourth type (negativity of the central portion).

The observation that precordial negative U waves in diseases affecting the right side of the heart differ, not only in their location, but also in their particular configuration, from those in left-sided heart disease might suggest that the left ventricle is responsible for the genesis of the initial portion of the U wave, while the terminal part depends on the right ventricle. Therefore, in left-sided heart disease, the negativity of the U wave in most of the cases occupied only the initial part of the wave. However, this hypothesis is not accepted by us.

Theoretically another possibility, which we endorse, is that the U wave is the summation of partial U waves, with origins from the right and the left ventricle. Hence in different pathologic conditions, 1 of the 2 components predominates, so that it causes a particular behavior of the resulting spatial vector and, consequently, in extreme cases, the negativity that we have described. According to this hypothesis, the various types of negative U waves do not depend for their origin on one or the other ventricle. They depend on the particular aspects of the spatial vector of U, resulting from the partial spatial vector of the unaffected ventricle and the preponderant spatial vector of the ventricle subjected to strain.
Fig. 7. Patient with mitral heart disease. T-U segment elevation combined with negative U wave of the sixth type in V₄ and of the second type in V₅ and V₆. U-wave duration was measured in V₃.

Finally, only the direction of the resultant spatial vector has electrobiologic and clinical significance; the various morphologic aspects of the negative U wave mean an abnormal and more obscure behavior of the instantaneous vectors in the development of the vector loop.

The T-U segment was present in most of the cases of inverted U wave and very often showed some deformities. Frequently it was elevated above the base line and followed by the negative U wave; it rarely appeared depressed without changes of the U wave.
It seems possible, therefore, that alterations in the T-U segment originate from the same electrophysiologic factors that produce abnormalities of the S-T segment.

**SUMMARY**

A careful examination of the morphology of the negative U wave led to the recognition of 7 different types. Modifications of the T-U segment were evaluated as equivalent to an inverted U wave.

After a correlation of the electrocardiographic and clinical data with the various types of negative U wave, 2 hypotheses were considered as explanations of the varying morphology. It is believed that the various
types of negative U waves represent the resultant spatial vector of the unaffected ventricle and the preponderant spatial vector of the ventricle subjected to strain.

**Summario in Interlingua**

Un caute examine del morphologia del negative unda U resultava in le differentiation de 7

Fig. 10. Anteroseptal myocardial infarction (third stage). Negative U wave of the fifth type in V₃ and V₄. U-wave duration was measured in V₁.

Fig. 11. Patient with hypertensive heart disease and angina pectoris and left ventricular hypertrophy. Depressed T-U segment seventh type in V₅ and V₆. T-U was determined in V₂.

typos. Modificationes del segmento T-U esseva evalutate como equivalentes de un invertite unda U.

Post correlation del datos electrocardiographic e clinic con le varie typos de negative
Table 1.—Distribution of Abnormal Morphologic Types among 100 Cases of Negative U Waves and T-U Segments in Precordial Leads

<table>
<thead>
<tr>
<th>Type Characteristics</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Electrocardiographic Pattern</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Right ventricular hypertrophy (V₁-V₃)</td>
<td>3</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>25</td>
<td></td>
<td></td>
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<tr>
<td>Right bundle-branch block (V₁-V₃)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left ventricular hypertrophy (V₄-V₆)</td>
<td>26</td>
<td>2</td>
<td>1</td>
<td>29</td>
<td></td>
<td></td>
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<tr>
<td>Left bundle-branch block &quot;strain&quot; (V₁-V₃)</td>
<td>3</td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
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<tr>
<td>Coronary insufficiency (V₅-V₆)</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td></td>
<td></td>
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<tr>
<td>Recent infarction (V₁-V₆)</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>11</td>
<td></td>
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<tr>
<td>Old infarction (V₁-V₆)</td>
<td>7</td>
<td>1</td>
<td></td>
<td>12</td>
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<tr>
<td>Isolated U-wave inversion (V₁-V₆)</td>
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| Clinical Data                                              |    |    |     |    |    |    |     |       |
| Arterial hypertension                                      | 3  | 20 | 9   | 32 |
| Arterial hypertension + angina pectoris                    | 14 | 1  | 5   | 2  | 22 |
| Arterial hypertension + old infarction                     | 5  | 1  | 6   |
| Arterial hypertension + aortic heart disease               | 4  |    |     |    |    |    |     |       |
| Angina pectoris                                            | 8  | 1  | 12  |
| Myocardial infarction                                      | 5  | 4  | 12  |
| Mitral heart disease (mitral stenosis and insufficiency)   | 3  | 1  | 5   |
| Mitral stenosis                                            | 3  |    |     |    |    |    |     |       |
| Aortic heart disease                                       | 2  |    | 4   |

| Incidence                                                  | 11%| 58%| 6%  | 2% | 2% | 19%| 2%  | 100%  |

* Each electrocardiographic pattern is followed by the leads in which the negative U waves or T-U segments occurred.

Undas U, due hypotheses esseva considerate como explicationes del variationes morfologic. Nos opina que le varie typos de negative undas U representa le resultant vector spatial del non-afficite ventriculo e le preponderante vector spatial del ventriculo subjicite al stress.

REFERENCES

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