The Vector U Loop of Ventricular Premature Beats

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There have been no reports on the U vector loop or arc of ventricular premature beats. Recently a systematic study was carried out on the vectorcardiogram of ventricular premature beats. The QRS and T vector loop of the ventricular premature beats will be reported elsewhere. Since the U vector loop could not be studied in all these cases because of technical difficulties, and since it needs a description rather independent from the QRS and T loops it is described here as a different paper.

Materials and Methods

The U vector loop of ventricular premature beats was studied in 32 cases. They were composed of 12 cases of apparently normal subjects, 7 cases of hypertension, 4 cases of coronary insufficiency, 2 cases of myocardial infarction, 4 cases of valvular heart diseases, and 3 cases of other heart diseases. Vectorcardiograms were taken in all cases by the method proposed by Frank and the three corrected orthogonal lead electrocardiograms, which are components of the vectorcardiograms, were recorded by a tape recorder at the same time, employing the P.W.M. method. These were reproduced later as vectorcardiograms for studies.

In the reproduction for the study of the U loop, the monitor electrocardiograms of our dissecting apparatus were separated from the beginning of the T wave to the end of the U wave, and the corresponding part of the vector loop was photographed, usually in the magnification of 1 mV. either to 2.4 inches or, more often, to 4.8 inches. This part of the vector loop will be called the T-U vector loop in this paper. In most cases a few other dissections were made, such as from some point of the T loop to the end of the U loop or to the beginning of the following P loop, and were recorded.

Results

Among the examined subjects, 12 cases were apparently normal and did not have any other heart diseases than ventricular premature beats according to routine clinical and laboratory examinations including electrocardiograms and vectorcardiograms. The U vector loop of normal beats of these cases...
seemed to be quite the same with that of normal healthy subjects without ventricular premature beats and could be regarded as a control. The features of the normal U vector loop were previously reported elsewhere, but since our vectorcardiography has been improved to have a higher sensitivity, more details could be elicited this time.

In our previous study on the normal U vector loop the beam-spot was observed apparently to stay at the T-U junction for a moment. But a presumption was stated in the report that such apparent pause at the T-U junction might be due to a return movement at the beginning of the U loop and that the tip of this return movement might correspond to the peak of the U

![Vector Diagram](image)

Fig. 1. The T-U vector loop, i.e. the vector loop from the beginning of the T loop to the end of the U loop, of normal beats and ventricular premature beats from apparently normal subjects.

Four cases at the bottom (cases 26, 39, 43 and 54) showed frequent ventricular premature beats. In this respect they can be excluded from the group of apparently normal subjects. The configuration of the U vector loop of the normal beat could not be delineated in case 26, because ventricular premature beats appeared in bigeminy and distorted U loops of preceding normal beats.

S: Sagittal plane; F: Frontal plane; H: Horizontal plane.
Fig. 2. An example of the vectorcardiograms of a normal beat (A) and a ventricular premature beat (B) from an apparently normal subject.

a. The whole vector loops.

S: Sagittal plane; F: Frontal plane; H: Horizontal plane

In all other vectorcardiograms the planes were shown in this order, i.e. the frontal plane, at top; the sagittal plane, lower left; the horizontal plane, lower right.

b. The T-U vector loop. Only this portion was electrically dissected out.

c. A portion of (b), recorded with a greater sensitivity in order to show the U loop in greater detail.

wave (the white arrow in Fig. 1 C of Ref. 3). In this study all such presumptions were found to be true. Namely, from the T-U junction a small return movement occurred, and made another turn, the tip of which corresponds to the peak of the U wave, frequently making a small circle (Fig. 1, 2 A). After this turn a small, slightly curved club-like vector arc was inscribed almost in the direction of continuance of the terminal limb of the T loop, as was described previously.3)

In contrast to the U vector loop of normal beats, that of ventricular premature beats from apparently normal subjects showed a much smaller return movement and inscribed a small circle less frequently. The small circle seemed to have been, as it were, pulled and unfolded. It was usually inscribed roughly in the direction of the terminal limb of the T loop like normal beats, but resembled a thicker club (Fig. 1, 2B, 3).
The U vector of ventricular premature beats from patients of various heart diseases was similar with that of ventricular premature beats from apparently normal subjects in many respects. One difference was that a marked bend was frequently observed at the T-U junction (Fig. 4, 5). This difference becomes clearer, if 4 cases (cases 26, 39, 43 and 54 in Fig. 1), who were apparently normal but showed frequent ventricular premature beats, were regarded as abnormal cases and excluded from the apparently normal group, which is probably justified, because occurrence of frequent premature beats itself may be due to some heart disease.
Fig. 4. The T-U vector loop of normal beats and ventricular premature beats from patients of various heart diseases. The configuration of the U vector loop of the normal beat could not be delineated in cases 5, 17, 33 and 63, since the U wave merged with the following P wave because of sinus tachycardia.

S, F and H are the same as in Fig. 1.

In the vectorcardiograms of ventricular premature beats in the remaining 8 cases of apparently normal subjects the T vector and the U vector were concordant in 7 cases and discordant in 1 case, whereas in those of 20 cases of various cardiac patients they were concordant in 9 cases (Fig. 6) and discordant in 11 cases (Fig. 5). (Note: The T vector and the U vector were called discordant in cases where the angle between both vectors were more than 90 degrees in more than one plane, they were called concordant in other cases).

The T-U junction vector, i.e., the vector from the null point to the junction of the T loop and the U loop, of the ventricular premature beats in apparently normal subjects was directed usually anteriorly (Fig. 7). In contrast to this, that of cardiac patients was directed in almost all directions. This occurred from 2 reasons: first because there was a marked bend at the T-U junction, as mentioned above, and secondly because the direction of the T loop was abnormal, although the U loop was inscribed in the continuation of the terminal limb of the T vector loop.

The U vector, namely the vector from the null point to a point on the vector loop which corresponds to the peak of the U wave, can now be fairly accurately defined and measured in normal cases. But the U loop of ventricular premature beats cannot be defined as accurately because of its above-men-
An example of a ventricular premature beat from a patient of anterior myocardial infarction.

Figure arrangement and abbreviations are the same with Fig. 3.

Figure 5. An example of a ventricular premature beat from a patient of anterior myocardial infarction. In many such ventricular beats the same vector with the T-U junction vector could be regarded as the U vector. In any event, overall results of the U vector did not differ greatly from the T-U junction vector (Fig. 8).

For various reasons it may be interesting to know whether there is any difference in the vector U loop of ventricular premature beats due to the phase of the preceding beat in which they occur. However, no significant differences were noticed either in shape or magnitude of the U loop. For instance, in cardiac patients the U loop discordant with the T loop was found in 7 of 12 cases of ventricular premature beats appearing before the preceding U waves, in 5 of 9 cases of ventricular premature beats appearing during the preceding U
waves, and in 1 of 4 cases of ventricular premature beats appearing after the preceding U waves. In 8 apparently normal subjects the discordant U loop was rarely observed in which ever phase ventricular beats appeared as mentioned above, although the discordant U loop happened to be found in 1 case when the ventricular premature beat appeared after the preceding U wave.

**Discussion**

The T wave change of ventricular premature beats in apparently normal cases is regarded usually as the secondary change to the QRS wave change.
Fig. 7. Distribution of the T-U junction vectors of ventricular premature beats from apparently normal subjects (a) and from patients of various heart diseases (b).

Closed circles in (a) denote the T-U junction vectors from subjects of frequent ventricular premature beats. Therefore they can be excluded from the group of apparently normal subjects. See text.

S, F and H are the same as in Fig. 1.

Fig. 8. Distribution of the U vectors of ventricular premature beats from apparently normal subjects (a) and from patients of various heart disease (b).

Closed circles and S, F, H denote the same with Fig. 7.

If the U wave can be treated similarly, the U loop change of ventricular premature beats in apparently normal cases can be regarded as a secondary change to the QRS loop change. According to the above-mentioned results, then, a bend at the T-U junction seemed to be some primary change. This is consistent with our previous results on the U loop of left ventricular hypertrophy³ and of myocardial infarction,⁴ where a marked bend at the T-U junction was observed characteristically frequently and was supposed to be due to pressure load or
to myocardial destruction.

Not only in the vectorcardiographic U loop but also in the electrocardiographic U wave no sufficient informations seem to have been given as for its polarity changes in ventricular premature beats. In the electrocardiogram of ventricular premature beats Papp\(^5\) described that, if ventricular premature beats were accompanied by a U wave, this was often upright; but where the S component was upright, U might be inverted. Surawicz, Kemp and Bellet\(^6\) found that in 2 cases among 10 patients showing ventricular premature beats these showed negative T waves with positive U waves in certain leads. Our results in this report provide informations on this from the vectorcardiographical point of view.

**Summary**

(1) The U vector loop of ventricular premature beats was studied in 32 cases. Vectorcardiograms were taken by Frank’s method.

(2) In contrast to the U vector loop of normal beats of healthy subjects, which showed a small return movement from the T-U junction and frequently a small circle at the tip of the U vector, the U vector loop of ventricular premature beats showed a much smaller return movement and rarely a small circle.

(3) The U vector loop of ventricular premature beats from apparently normal subjects was inscribed usually in the direction of the terminal limb of the T loop, but that from cardiac patients extended in various directions, often by having a marked bend at the T-U junction.

**References**