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Body Surface Isochrone Maps of Peak R in Normal Adolescent Girls

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Summary

The aim of our study was to evaluate the adequacy of a new mapping device for obtaining a reliable set of normal maps characteristic for this approach. We studied body surface isochrone maps of peak R in four healthy adolescent girls using the mapping system CARDIAG 128.1 with 80 unipolar leads placed in a regular grid. The constructed maps were compared with published data using 10 criteria. None of the maps obtained could be regarded as normal. After evaluating the reasons for the "abnormality", we assume that they could be caused mostly by the processing of signals. This fact can be eliminated by improving the existing software.

Key words

Introduction

The peak of R wave represents the onset of the intrinsic deflection in precordial leads obtained by classical electrocardiography. It is considered to determine the arrival of the depolarization wavefront at the myocardial surface under the electrode and is also called the ventricular activation time.

In principle, this time instant can by measured at any point of the body. This fact is used in body surface mapping of the heart electric field when displaying time distribution of activation on the chest surface in the form of activation maps or peak R isochrone maps (Hayashi *et al.* 1981, Ikeda *et al.* 1985, 1987, 1988, Hanashima *et al.* 1988).

All types of body surface maps in healthy people have characteristic patterns of the displayed parameters that are not dependent on the mapping system employed. In spite of this, some differences are caused by each device because more possibilities are usually available for solving a given problem. It is therefore always necessary to have normal reference maps for every mapping system before starting to use it in clinical practice.

We studied body surface isochrone maps of peak R in healthy adolescent girls to evaluate the competence of a new mapping device for obtaining a reliable set of normal maps. As a criterion of normality we used the comparison with published data.

Methods

Four girls, 16 to 17 years of age, were examined. They were all considered to be healthy according to their negative medical history and normal electro- and vectorcardiographic findings.

The electric heart field was recorded using the mapping system CARDIAG 128.1 (Rydlo and Brabec 1991). Eighty unipolar electrocardiograms were registered in the supine position during normal expiration. Standard 12-lead electrocardiograms and Frank's X, Y, Z electrocardiograms were sampled simultaneously and were used for automatic determination of onset and offset of the QRS complex.

Isochrone maps were constructed in the following way. The onset of the QRS complex was taken as the zero time (t_0). The maximal voltage (U_{max}) which corresponds to the R wave peak was chosen for each lead and the time was designated as t_{max} (Fig. 1). Isochrone maps were displayed as the distribution of values

$$t_R = t_{max} - t_0$$

in a rectangular area representing the body surface, the left half reflecting the ventral surface of the chest and the right half the posterior surface (Figs 2 and 3).

Isochrone lines connect points on the map with equal activation time values t_R. When two R waves were present in a lead, the larger one was chosen for the measurement (Fig. 1). When there was no R wave in a lead, the area where the measurement point was located is called "no R-wave area" (NR area).

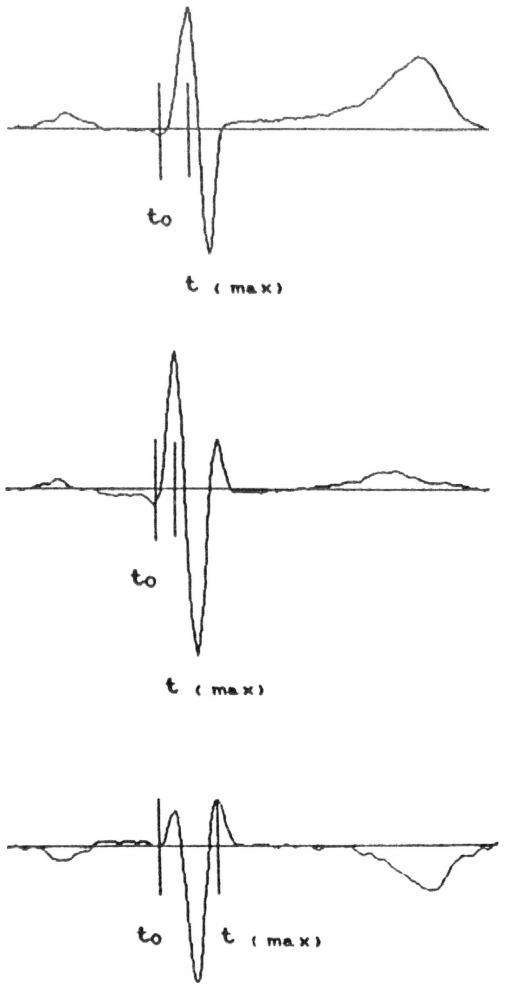

Fig. 1
Ventricular activation time in different ECG tracings.

The body surface isochrone maps of the R wave in normal subjects display typical patterns and features (Ikeda *et al.* 1985, 1987). We summarized these into 10 points (Fig. 2) and used these criteria for the evaluation of "normality" of isochrone maps in selected subjects to judge the usefulness of the new mapping system. Following criteria A to J were used.

A: The activation began on the right upper anterior chest (the lowest t_R values). Isochrone lines extended from the right upper anterior chest to the left anterior chest leftwards and downwards. After reaching the left lateral chest they propagated to the back in a rightward and upward direction (the highest t_R values).

B: The 30 ms isochrone line crossed near the anterior midline at the 5th intercostal level.

C: The 40 ms isochrone line crossed the left axillary line at the 5th intercostal level.

D: The 50 ms isochrone line crossed near the posterior midline at the 5th intercostal level.

E: The difference between the activation time of neighbouring lead points did not exceed 20 ms except in the right axillary zone and upper back.

F: The NR area may appear on the upper right anterior chest or on the upper back.

G: The NR area did not appear on the right lower anterior chest, central sternal region, left anterior or left lateral chest, or lower back.

H: No more than 3 leads without R peaks were observed.

I: There was no activation time delay (more than 20 ms) near the NR area. The delay was considered to be significant when appearing in more than three leads with delayed activation close to the NR area.

J: Exclusively positive time values are displayed on the map (resulting from the definition of the maps).

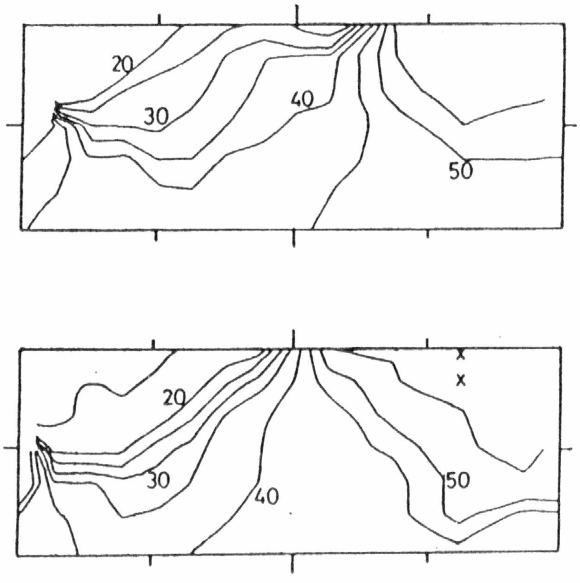

Fig. 2
Isochrone maps from normal subjects (modified after Ikeda *et al.* 1985). The rectangular areas represent the torso surface. Short vertical bars indicate the positions of the anterior median line, left axillary line and posterior median line, respectively. Short horizontal lines indicate the level of the 5th intercostal space. The numerals display the activation times (in milliseconds) and crosses indicate the no R-wave areas.

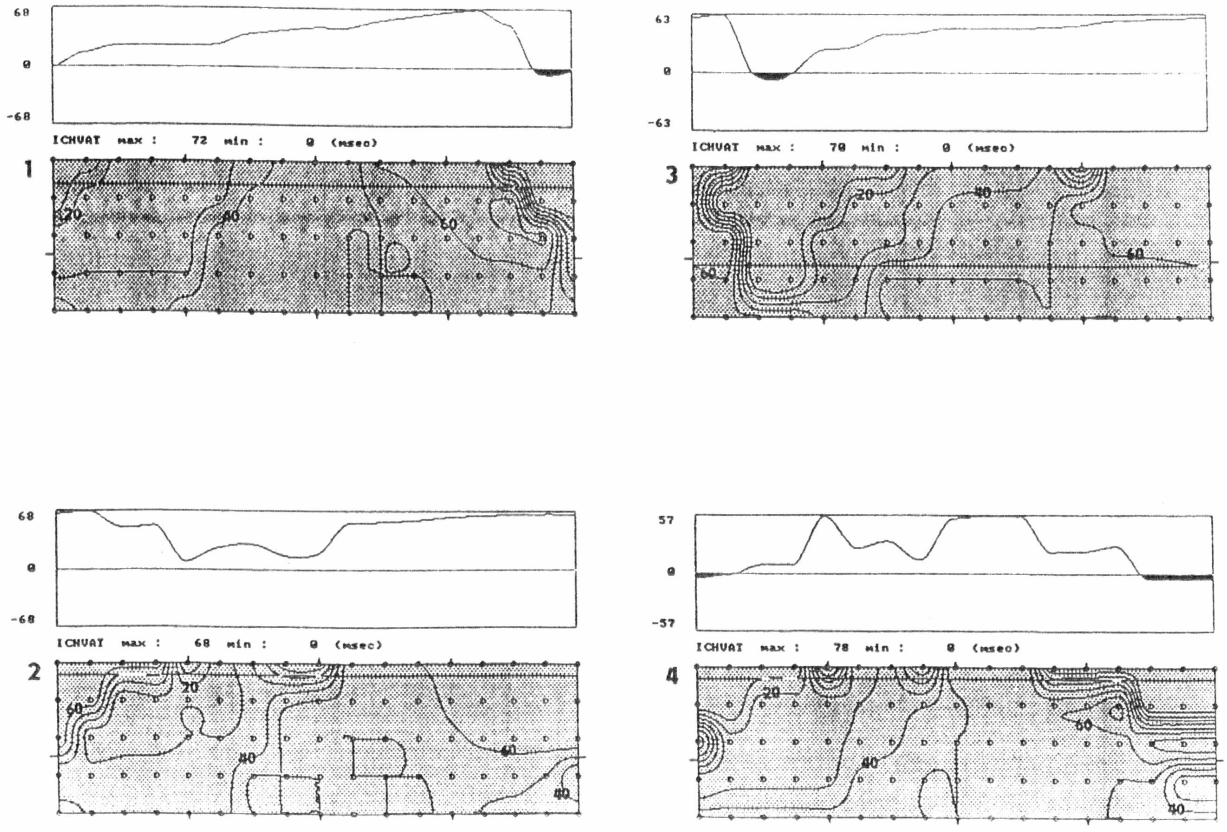

Fig. 3
Body surface R peak isochrone maps in normal adolescent girls as measured with the mapping system CARDIAG 128.1. A projection of isochrone line values corresponding to the position of a horizontal line drawn across the whole map is displayed above each map. Empty circles indicate the positions of electrodes.

Results

The use of above mentioned criteria A to J is summarized in Table 1. The presence of each feature is marked by a plus sign, its absence by a minus. The question mark denotes doubts in the unambiguous fulfillment of the studied criterion. The numbering of maps is the same both in Fig. 3 and Table 1. We regarded an isochrone map as normal when both the criterion J and at least further 5 arbitrary criteria A to I were fulfilled.

Table 1
Normality criteria of studied subjects

Map	Criterion									
	A	B	C	D	E	F	G	H	I	J
1	+	+	–	–	+	+	+	–	+	–
2	+	+	?	–	–	–	?	+	+	+
3	+	+	+	?	–	+	–	–	+	–
4	+	+	–	–	–	?	?	–	+	–

Discussion

Body surface isochrone maps are not very often used although they are very convenient for interpreting and reducing large amounts of data. The construction of this type of maps is based on the fact that the body surface potential at a given point is mainly determined by the epicardial potentials beneath it although it is also affected to some extent by potentials of other parts of the epicardium. However, body surface isochrone maps reflect the normal left ventricular activation sequence from the septum to the free wall and depict abnormalities which corresponded well with the asynergic site in patients with myocardial infarction. It is believed that they can be used clinically to determine the activation sequence of the myocardium (Ikeda *et al.* 1985).

Based on the results summarized in Table 1, we cannot consider the analyzed body surface isochrone maps in the four girls studied to be unambiguously "normal" although this conclusion would be expected according to the selection of the subjects. The following reasons may explain this.

The used criteria (except for J) were established using an 87-lead mapping system in adult men, 21 to 55 years old (Ikeda *at al.* 1985, Hanashima *et al.* 1988). As the lead systems were similar we assume that the greater differences may be due to the age of girls examined – the end of puberty. The dependence of isochrone R peak maps on the age and sex is not known yet.

The criteria E to J may be influenced by the quality of signal registration. This did not play a significant role in our study as the control of single recordings showed only a few measurement errors (failure of 0 to 4 leads out of 80). Unfortunately, this error can not be excluded when using lead systems with full grids.

Prevailingly the same criteria as mentioned earlier are influenced by the signal preprocessing and processing. Their contribution cannot be judged by ourselves as the used software algorithms are exactly known only to the manufacturer of the mapping system.

When studying the obtained maps we could see that there is a time shift of about 10 to 20 ms in activation times as compared with normal maps published previously. This might be due to incorrect setting of the QRS onset. After removing these shortcomings, a wider use of body surface isochrone maps in clinical practice may be expected because of their simple interpretation.

Acknowledgments

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Reprint Requests

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