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Quantitative Evaluation of Body Surface Potential Mapping of Heart Electrical Field in Ischaemic Heart Disease

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Summary

New possibilities of quantitative evaluation of body surface potential mapping were studied in 78 patients with ischaemic heart disease. Integral maps of the Q wave, QRS and ST-T intervals were plotted and isochronous maps of ventricular activation time and maps of asynchronous potential minima of the Q wave were determined. Minimum and maximum potential values and their time relations were evaluated in the maps. Left ventricular contraction abnormality detected by left ventricular angiography was determined by a point score and expressed as an index of asynergy. The number of coronary artery branches with significant narrowing was assessed and the extent of coronary artery damage was evaluated by an arbitrary defined index. Using quantitative parameters from the maps, multiple stepwise linear regression was performed. The relationship between map parameters and index of asynergy corresponded to multiple correlation coefficient $r=0.69$ ($p=0.01$) in the whole group of patients. In the group of patients with left ventricular contraction abnormality the relationship between these parameters was found to be $r=0.87$ ($p=0.01$). The relationship between map parameters and the number of coronary artery branches with significant stenosis was $r=0.60$ ($p=0.01$) in the group of patients with positive coronary angiography. In the same group of patients the relationship between map parameters and the index evaluating coronary artery damage was equal to $r=0.63$ ($p=0.01$). The data obtained from body surface integral maps enable to quantify cardiac ischaemic damage.

Key words

ECG – Body surface potential mapping – Ischaemic heart disease

Introduction

This study is a continuation of our previous work on the quantitative evaluation of body surface potential maps in patients with ischaemic heart disease (Málková *et al.* 1990). The significance of electrocardiological parameters thus obtained was compared with the results attained by other diagnostic methods.

Methods

Mapping was performed using PC-aided ECG diagnostic system CARDIAG. Standard 12-lead electrocardiograms, vectorcardiograms using Frank lead system and matrix of 80 electrocardiograms for mapping were recorded simultaneously in sitting patients (Málková *et al.* 1992).

Seventy-eight patients with ischaemic heart disease were investigated, 58 men and 20 women (mean age 51.3 years). Thirty-six patients underwent Q myocardial infarction, 18 of them were diagnosed as having had anterior and 18 posterior myocardial infarction. Twenty-three patients underwent non-Q myocardial infarction and 19 patients were treated for angina pectoris without previous myocardial infarction.

Twenty-nine patients were treated for hypertension, but none of them had left ventricular hypertrophy as assessed by 2D-echocardiography. Patients with atrioventricular or intraventricular conduction abnormalities were excluded.

Integral maps were evaluated with the aim to reduce measured data but to preserve their information content. Integral maps of the following intervals were calculated: Q wave, 30 ms and 40 ms from the onset of QRS, QRS, 35 ms and 80 ms from the J point, ST-T and Q-T (Fig. 1).

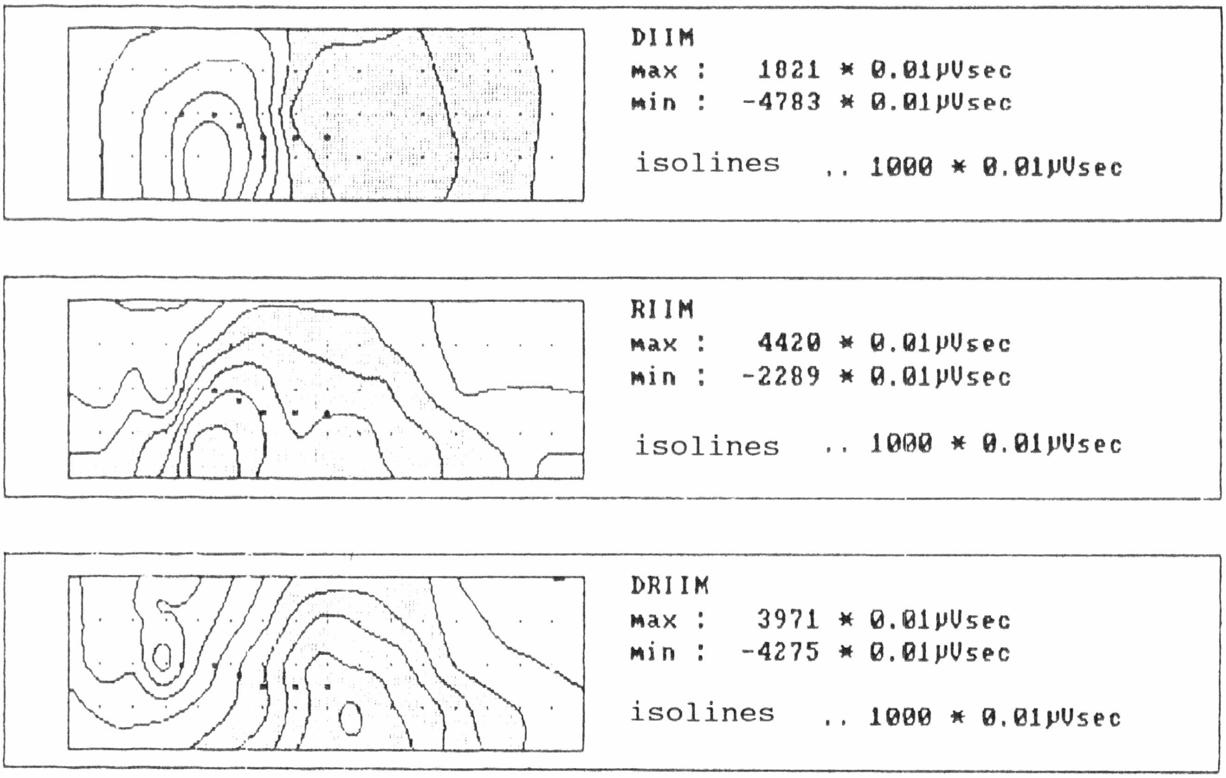

Fig. 1
Integral maps of a patient with old Q anterior myocardial infarction. Left part of the map represents the front part of the chest, the right part the posterior region of the chest. The area of positive potential values is shaded. Black points represent electrode positions. DIIM – QRS interval, RIIM – ST-T interval, DRIIM – Q-T interval.

Isochronous maps of ventricular activation time and of the Q wave and map of the Q wave asynchronous potential minima were determined (Stojan 1991). Minimum and maximum potential values and their incidence in time were evaluated in these maps (Fig. 2).

Left ventricular angiography and coronary angiography were performed in all patients. Regional wall motion of the left ventricle was evaluated by a point score using these parameters: extent of asynergy determined in 10 segments of the left ventricle, degree of asynergy evaluated by a 4 degree scale and index of asynergy expressed as a product of the extent and degree of asynergy (Málková A. *et al.* 1990, 1993). The number of coronary artery branches with marked stenosis or occlusion was determined by a currently used coronarographic procedure.

Furthermore, the extent of coronary artery disease was quantified using an arbitrary index. Stenosis less than 50 % of artery diameter was evaluated by half a point, stenosis equal to or more than 50 % by 1 point, stenosis equal to or more than 75 % by 2 points, 90 % stenosis by 3 points and a complete occlusion by 4 points. The total individual index was calculated by addition of points, for an individual coronary branch only the most marked stenosis was taken into account.

The relation of map parameters to parameters obtained by reference diagnostic methods was studied using multiple stepwise linear regression analysis.

Results

In all the investigated patients the relation between electrocardiologic parameters derived from maps and the index of asynergy detected by left ventricular angiography was evaluated by the multiple correlation coefficient which was equal to 0.69. In the group of patients with left ventricular wall motion abnormality this relationship had a coefficient equal to 0.87 and in the group of patients with old Q myocardial infarction the correlation coefficient was 0.79.

In the group of patients with old Q myocardial infarction a significant relationship between map parameters and the ejection fraction was also demonstrated (the correlation coefficient was equal to 0.70).

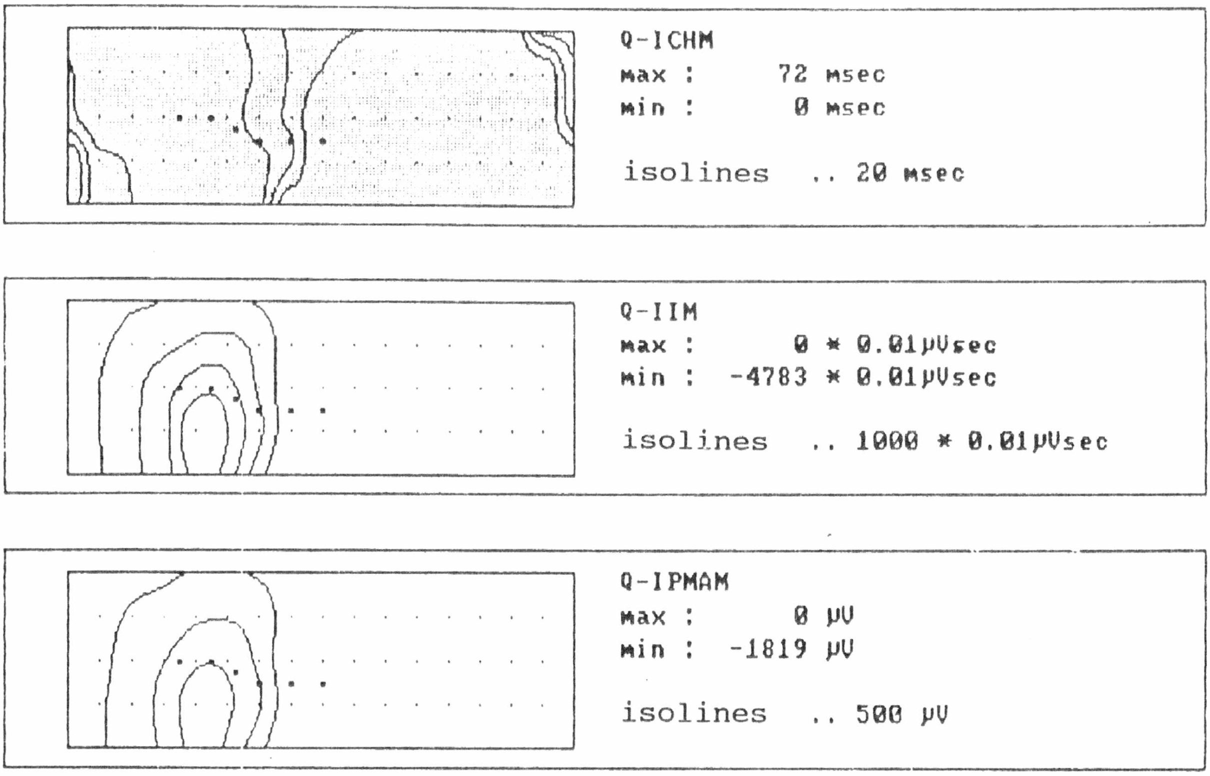

Fig. 2
Maps of the same patient as in Fig. 1. Q-ICHM – isochronous map of the Q wave, where isolines connect points with the same Q wave duration. Q-IIM – integral map of the Q wave. Q-IPMAM – map of the Q wave asynchronous potential minima, where isolines connect points of the same potential minima irrespective of time.

Only a loose relationship of map parameters to the number of markedly damaged coronary arteries was found in all the investigated subjects (the multiple correlation coefficient was equal to 0.54). In the group of patients with positive coronary angiography finding the correlation coefficient was 0.60.

In the whole group of investigated persons the vague relation of map parameters to the extent of coronary artery disease, expressed by the above described index, was determined (correlation coefficient equal to 0.49). This value is probably influenced by data of patients without appreciable coronary stenosis. In the group of persons with positive coronary angiography findings the correlation coefficient was 0.63 whereas it was 0.66 in the group of patients with old Q myocardial infarction and marked coronary stenosis. All these multiple correlation coefficients were statistically significant for $p = 0.01$.

For evaluation of the relationship between map parameters and features of regional wall motion abnormality the following values were found to be most important: the minimum potential value in the integral map of the Q wave and the maximum potential value in the integral map of the ST-T interval.

The most important parameters for estimating the significance of coronary artery damage were following: time when the minimum potential value occurred during ventricular depolarization and the maximum potential value from the integral map of the 80 ms interval from the J point.

Discussion

These results correspond to observations of other authors. Zachar *et al.* (1989) found a similar correlation between index Q-QS in maps and wall motion abnormality detected by 2D-echocardiography in patients with old myocardial infarction. They also described marked relationship of this index to ejection fraction.

Yúng-Zu Tseng *et al.* (1990) used as a diagnostic criterion the finding that in maps of patients with the abnormality of left ventricular wall motion the absolute value of the potential minimum exceeds the absolute value of the potential maximum in the earlier phase of the QRS complex than it appears in healthy subjects.

Sridharan *et al.* (1989) studied departure maps in relation to the gravity of coronary artery disease. They succeeded in discriminating the damage of individual coronary artery branches.

References

MÁLKOVÁ A., VALOVÁ D., DRŠKA Z., VALOVÁ D.: Body surface potential mapping in diagnostics of ischemic heart disease. In: *Electrocardiology 1989*. A. ANTALOCZY (ed.), Elsevier, Amsterdam, 1990, pp. 149–152.

MÁLKOVÁ A., POLÁNKOVÁ M., DRŠKA Z., VALOVÁ D.: BSPD processing by mapping system Cardiag 128.1. In: *Electrocardiology 1991*. J. JAGIELSKI (ed.), World Sci. Publ. Co. Pts Ltd, Singapore, 1992, pp. 119–122.

MÁLKOVÁ A. POLÁNKOVÁ M., DRŠKA Z., VALOVÁ D., JEBAVÝ, P., NIEDERLE P., KALLMÜNZER B.: Electrocardiologic patterns of LV wall motion abnormality in IHD. In: *Electrocardiology 1992*. F. DE PADUA (ed.), World Sci. Publ. Co. Pts Ltd, London, 1993, in press.

SRIDHARAN M.R., HORAN L.G., HAND R.CH., ORANDER P.C., KILLAM A.W., FLOWERS N.C.: Use of body surface maps to identify vessel site of coronary occlusion. *J. Electrocardiol.* 22 (Suppl.): 72–80, 1989.

STOJAN M.: Principles of analysis of the cardiac electrical field for clinical purposes. (in Czech), ZPA Čakovice, Prague 1991. pp. 487.

YÚNG-ZU TCHENG, CHUEN-DEN TSENG, HUEY-MING LO, FU-TIEN CHIANG, KWAN-LIE HSU, TEH-LU WU: The value of body surface potential maps in detecting abnormal ventricular wall motion. *J. Electrocardiol.* 23: 127–136, 1990.

ZACHAR A., DUGOVIČOVÁ K., DOSTÁLOVÁ K., TUREK M., PRACHAR K., BANKO J., GVOZDJÁK J.: Precordial 35-lead mapping for evaluation of left ventricle function in patients after myocardial infarction. (in Slovak), *Bratisl. lék. listy* 90: 256–262, 1989.

Reprint Requests

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