QRS Complex Isointegral Maps and Left Ventricular Dimensions

[1]K. Kozlíková, [1]J. Martinka, [2]J. Bulas, [2]J. Murín
[1] Institute of Medical Physics and Biophysics, Faculty of Medicine, Comenius University, Bratislava, Slovak Republic;
[2] First Internal Department, University Hospital and Faculty of Medicine, Comenius University, Bratislava, Slovak Republic.
E-mail: kozlikova@fmed.uniba.sk

Abstract. *In this study extrema of QRS complex isointegral maps (IIM) in relation to echocardiographic (ECHO) parameters were studied. We measured following diastolic heart dimensions: thickness of interventricular septum (IVSd,) left ventricular (LV) posterior wall (LVPWd), and LV internal diameter (LVIDd) on the group of 31 hypertensive patients with and without LV hypertrophy (age 52 ± 12 y, 12 women). We calculated relative wall thickness (RWT), LV mass (LVM) and LVM index (LVMI). The 24 – lead system after Barr was used to record and construct mean IIM QRS as well as IIM of QRS divided into thirds of equal length ($QRS_{1/3}$, $QRS_{2/3}$, $QRS_{3/3}$). We used regression analysis to compare maximum, minimum and peak-to-peak values of all IIMs with ECHO parameters. Only 14 of 72 regression analyses were significant ($p < 0.05$) with correlation coefficients $0.365 < |r| < 0.667$. There was no correlation between IIM $QRS_{1/3}$ and any ECHO parameter, between any electrocardiographic parameter and RWT. IIM QRS maximum correlated negatively with IVSd. Peak-to-peak values in IIM $QRS_{2/3}$ and IIM QRS correlated positively with LVIDd. Negative correlations were between minima of IIM $QRS_{2/3}$, IIM $QRS_{3/3}$ and IIM QRS and LVPWd, LVIDd, LVM and LVMI. Obtained results probably display different heart geometry and different heart - chest geometry.*

Keywords: electrocardiographic body surface mapping, isointegral maps, echocardiography, regression analysis, heart geometry

1. Introduction

Heart electrical activity measured on body surface should reflect both the heart dimensions – the heart geometry, and the electric function of the heart. It may be influenced by the geometry heart – chest as well. In our study we evaluated the relation between echocardiographically measured heart dimensions and extreme values of QRS isointegral maps.

2. Subject and Methods

We evaluated a group of 31 patients (12 women) with and without LV hypertrophy. All patients had clinically stated long-time hypertension (systolic blood pressure (BP) > 140 Torr and/or diastolic BP > 90 Torr). Echocardiographic examinations were done in M-mode. Chamber and wall dimensions were measured and LV mass *LVM* [g] was calculated according the Devereaux`s formula:

$$LVM = 1.04 \times \left[(IVSd + LVIDd + LVPWd)^3 - LVIDd^3 \right] - 13.6$$

where *IVSd* [cm] is the thickness of interventricular septum, *LVIDd* [cm] is LV internal diameter, and *LVPWd* [cm] is the thickness of LV posterior wall [1]. The left ventricular mass index *LVMI* [g/m^2] was calculated as well:

$$LVMI = \frac{LVM}{BSA}$$

The body surface area *BSA* was calculated after Mosteller [2].

Table 1 shows patients characteristics. Echocardiographic parameters involved normal values as well as increased chamber and wall dimensions. Sixteen patients out of 31 had LV hypertrophy according both the *LVM* and *LVMI* criterion and additional 2 only according the *LVMI* criterion [3].

Table 1: Characteristics of patients (n = 31)

Parameter	Mean ± standard deviation	Median	Range
Age [year]	52.3 ± 11.7	53.4	< 25.1; 71.9 >
BSA [m^2]	2.05 ± 0.24	2.04	< 1.59; 2.51 >
IVSd [cm]	1.22 ± 0.22	1.20	< 0.90; 1.90 >
LVPWd [cm]	1.14 ± 0.19	1.20	< 0.80; 1.60 >
LVIDd [cm]	5.02 ± 0.44	5.00	< 4.10; 6.20 >
RWT	0.45 ± 0.07	0.44	< 0.35; 0.63 >
LVM [g]	278.4 ± 82.7	269.9	<151.7 ; 522.3 >
LVMI [g/m^2]	135.3 ± 37.2 #	126.9	< 87.7 ; 267.1 >

Values were not distributed normally.

To measure the electric heart field and to construct maps we used the limited 24-lead system after Barr implanted in the portable mapping system ProCardio [4]. During each examination 1 - 3 records were registered, what lead to evaluation of 6 – 14 heartbeats. To process each heart beat a linear isoelectric baseline taken through T-P segment was used. The onset and offset of the QRS complex was established manually from the root mean square signal [5].

IIMs of the whole QRS complex (IIM QRS) and its thirds of equal duration – the initial (IIM $QRS_{1/3}$), the middle (IIM $QRS_{2/3}$), and the terminal third (IIM $QRS_{3/3}$) were constructed. We assumed that the initial third of QRS complex displays mainly the activation of septum, the middle third activation of the apical part of ventricles and the terminal third activation of the free ventricular walls and their basal parts. Mean IIMs were calculated from each examination and following map extrema were evaluated: maximum, minimum and peak-to-peak value (maximum – minimum). They were compared with echocardiographic parameters by means of linear regression analysis. Significant difference of correlation coefficients against zero was tested using t-test.

3. Results

Table 2 shows group extreme values of isointegral maps and Table 3 shows results of regression analysis. Only 14 out of 72 comparisons were significant. There was no correlation between IIM $QRS_{1/3}$ and any echocardiographic parameter, neither between any map and RWT. Most correlation of echocardiographic parameters was with maps' minima (11). Peak-to-peak values correlated twice and maximum once. The only correlation of IVSd with maps was surprisingly negative (Figure 1). Best correlation was obtained between IIM QRS minimum and LVIDd (Figure 2).

Table 2: Values of isointegral map extrema in patients (n = 31)

Map	Maximum [mV.ms]	Minimum [mV.ms]	Peak-to-peak [mV.ms]
IIM $QRS_{1/3}$	8.8 ± 4.1 (7.9) < 3.5; 21.1>	- 2.9 ± 1.4 # (- 2.6) < - 7.6; - 1.2>	11.7 ± 5.0 (10.7) < 5.0; 26.3>
IIM $QRS_{2/3}$	32.0 ± 13.4 (34.1) < 10.6; 55.9>	- 24.4 ± 11.9 (- 23.1) <- 58.2; -8.2>	56.3 ± 20.3 (51.6) < 23.1; 106.0>
IIM $QRS_{3/3}$	7.3 ± 8.0 # (4.8) < 2.6; 43.4>	- 12.5 ± 7.8 # (- 12.1) < - 46.3; - 1.2>	19.8 ± 13.0 # (16.6) < 4.7; 67.6>
IIM QRS	34.6 ± 17.7 # (32.6) < 9.3; 94.1>	- 28.8 ± 16.2 # (- 26.7) < - 92.5; - 10.1>	63.4 ± 26.9 (59.6) < 22.0; 139.2>

Values are given in form of mean ± standard deviation, median in parentheses, range is given below them in form of closed interval

Values were not distributed normally.

Table 3: Significant correlations between echocardiographic parameters and map extrema

Map	Regression formula	Correlation coefficient	Significance
IIM $QRS_{2/3}$	MIN = – 23.0 × LVPWd + 1.7	- 0.365	$p < 0.05$
	MIN = – 17.6 × LVIDd + 63.9	- 0.653	$p < 0.001$
	MIN = – 0.07 × LVM – 5.72	- 0.465	$p < 0.01$
	MIN = – 0.16 × LVMI – 3.16	- 0.491	$p < 0.01$
	PEAK = 19.8 × LVIDd + 33.8	0.431	$p < 0.05$
IIM $QRS_{3/3}$	MIN = – 9.48 × LVIDd + 35.1	- 0.540	$p < 0.01$
	MIN = – 0.05 × LVM – 0.19	- 0.486	$p < 0.01$
	MIN = – 0.11 × LVMI – 1.69	- 0.504	$p < 0.01$
IIM QRS	MAX = – 29.4 × IVSd + 70.6	- 0.368	$p < 0.05$
	MIN = – 36.2 × LVPWd + 12.3	- 0.423	$p < 0.05$
	MIN = – 24.4 × LVIDd + 93.8	- 0.667	$p < 0.001$
	MIN = – 0.10 × LVM – 1.09	- 0.508	$p < 0.01$
	MIN = – 0.24 × LVMI + 4.05	- 0.559	$p < 0.01$
	PEAK = 23.9 × LVIDd – 56.6	0.393	$p < 0.05$

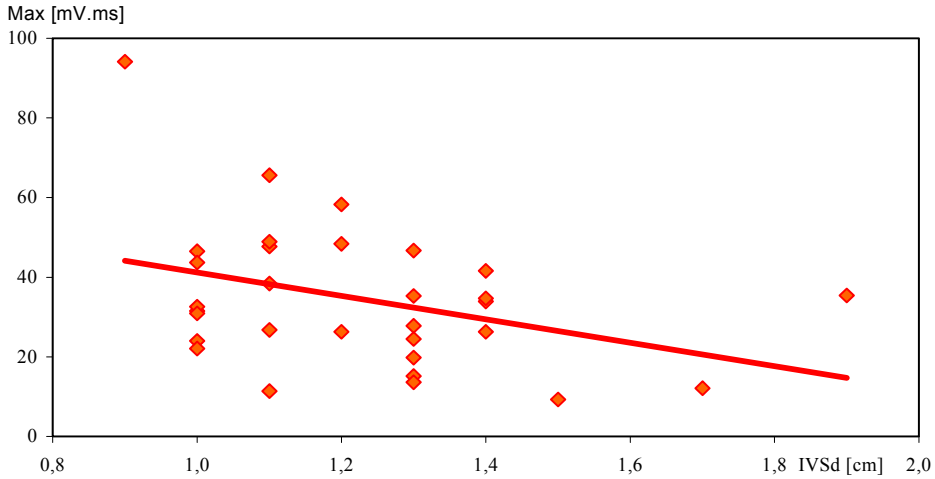

Figure 1: Negative correlation between IIM QRS maximum and IVSd.

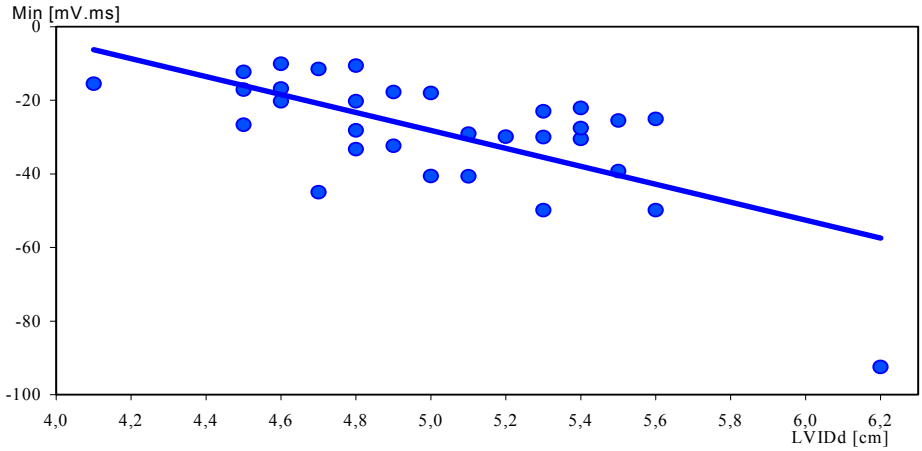

Figure 2: Best significant correlation (IIM QRS minimum and LVIDd)

4. Discussion and Conclusions

Thickness of interventricular septum negatively correlated only with maximum of IIM QRS. May this exceptional correlation be due to "large" distance of septum from chest surface or may it be caused by inhomogeneous localisation of hypertrophy?

There was no correlation of extreme values during the initial third of QRS complex with echocardiographic parameters. Is the initial ventricular activation too "weak" to be displayed on chest surface in correlation with heart dimensions, notably septum? Why there was no correlation of maximum with chamber size nor maximum with thickness of the free ventricular wall that is close to the chest wall?

Minima correlated with thickness of the free ventricular wall, with chamber size, left ventricular mass and its index during the middle and terminal third, as well as during the whole QRS complex. May it be due to projection of ventricular activation into "suitable" or "unsuitable" chest areas? Or is it due to next factors?

Answers to stated questions can be given only by next studies that will involve also the arrangement of extrema on the chest surface, include higher number of patients with homogeneous groups concerning the localisation of hypertrophy (septum, posterior wall, chamber). Also the influence of combined heart geometry, as well as the geometry heart - chest has to be considered.

References

1. Devereux RB, Detection of Left Ventricular Hypertrophy by M-Mode Echocardiography. Anatomic Validation, Standardization and Comparison to Other Methods. *Hypertension* 1987; 9(suppl. II): II19-II26
2. Mosteller RD, Simplified Calculation of Body Surface Area. *New England Journal of Medicine* 1987; 317(17): 1098
3. Bulas J, Murín J, Kozlíková K, Echocardiographic Characteristics of Left Ventricular Hypertrophy. *Kardiológia* 1998; 7(2): 92-98 (in Slovak)
4. Rosík V, Tyšler M, Turzová M, Portable Device for ECG Mapping. In: Frollo I, Plačková A, eds. Measurement'97. Proceedings, International Conference of Measurement. Bratislava: SAS, 1997: 367-370
5. Kozlíková K, Body Surface Integral Maps, Their Characteristics and Methods of Quantitative Analysis. *Bratislava Medical Journal* 1990; 91(11): 815-823 (in Slovak)