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Consequence of T Loop Morphology for Patients with Coronary Artery Stenosis

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Introduction

The inscription of the T wave on the body surface electrocardiogram (ECG) is generated by repolarization gradients at the myocardial level. A change in these gradients has an effect on T-wave morphology. Thus, repolarization gradients, arrhythmic vulnerability, and T-wave morphology are interrelated. Recently, novel T-wave morphology descriptors on the 12-lead ECG were shown to carry important prognostic information on arrhythmic susceptibility in patients with coronary artery disease [1, 2].

ST-T wave changes of electrocardiographic leads have long been recognized as predictors of future cardiac events, but they only imperfectly characterize T- loop morphology. Many researchers have been investigating the relationship between QT interval, T wave morphology variables and the extent of coronary artery lesions [3].

Methods

ECGs of high resolution (5 min. duration, 2 kHz, 12 bit, 12-lead) were recorded at rest. Noise was reduced using 21 point triangle moving average filter. Vectorcardiographic X, Y, Z orthogonal Frank leads were synthesized using Dower matrix. Vectorcardiographic 3D T loop was projected onto a vertical plane, and the projection was inscribed into a square. The square was divided into 20x20 subsquares. From the shape of the filled subsquares two parameters of T loop morphology were evaluated: T loop area and T loop index (ratio of T loop area and T loop length) [4]. The third parameter - the angle between the mean QRS and T vectors in frontal plane (αQRS-T) was derived from the lead I and III signals.

Eight leads of ECGs were recorded using computer analysis system – I, II, V1–V6, and another four leads – III, aVR, aVL and aVF are reconstituted from I and II leads. ECGs were filtered by means of high pass filters, eliminating drift of isoelectric line. At the next stage the recognition of P, Q, R, S, T waves was performed, durations and amplitudes of the waves were measured, then these parameters were averaged in a 10 s interval.

αQRS, αP, αT and αQRS-T angles describing projections of vectors in the frontal plane were determined from I and III leads, they were calculated using the formula:

where $\Delta y_i^{\mathrm{III}}$ – is the sum of QRS, P and T wave amplitudes from lead III, Δy_i^{I} – the corresponding sum obtained from lead I. 1.15 and 0.575 coefficients are

$$y_i = \operatorname{arctg}(1{,}15\frac{\Delta y_i^{\mathrm{III}}}{\Delta y_i^{\mathrm{I}}} + 0{,}575),$$

introduced in this formula because the leads I and III are not perpendicular to each other. The angles are measured not in the 0…360° interval, but 0…+180° and 0…-180° intervals, tgα value is negative in I and II quadrants and positive − in II and IV quadrants, therefore it was necessary to apply reduction formulae of these angles [5].

Results

196 patients (140 men and 56 women) with stable and unstable angina pectoris were investigated. They were classified in the groups based on the results of coronary angiography by the degree of artery lumen narrowing, number of damaged arteries, and location of the damaged arteries. T loop area and T loop index for the first group (stenosis of coronary artery lumen ≤30%) and the second patient group (stenosis of coronary artery lumen ≥50 %) as well as values of the αQRS-T angle are given in the table one. In comparison between these group T loop area and T

loop index were higher for the second group of patients (stenosis of coronary artery lumen ≥50 %).

Table 1. T loop morphology parameters for the groups I and II expressed as mean±SE

Parameters	I group (n=70)	II group (n=126)	p value
T loop area	183.2±7.3	204.9±5.6	0.021
T loop index	1.17±0.09	1.46±0,07	0.011
αQRS-T	29.3±3.4	36.4±2.9	0.132

αQRS – T – angle between QRS ir T vectors in frontal plane

The group II was further divided into three subgroups based on the number of damaged arteries (IIa-one, IIb-two, IIc-three). Significant differences were found only for T loop area and T loop index between the group I and subgroup IIa.

Table 2. T loop morphology parameters for the group I and subgroup IIa expressed as mean±SE

Parameters	I group (n=70)	IIa subgroup (n=51)	P value
T loop area	183.2±7.3	213±7.1	0.008
T loop index	1.17±0.09	1.46±0.1	0.031
αQRS-T	29.3±3.4	39.6±2.9	0.07

αQRS – T – angle between QRS ir T vectors in frontal plane

T loop morphology parameters did not differ between the group I and subgroup IIb (two vessel disease). T loop area and T loop index were higher for subgroup IIc (three vessel disease) comparing to the group I (T loop area accordingly 208.9±11.3 and 183.2±7.3; p=0.045, T loop index accordingly 1.63±0.1 and 1.17±0.09; p=0.005).

T loop morphology parameters for the different location (LAD, CX and RCA) of a single damaged artery is given in the table 3. They did not differ between LAD, CX and RCA lesions

Table 3. T loop morphology parameter differences between LAD, CX and RCA lesions

Parameters	LAD lesions (n=37)	CX lesions (n=10)	RCA lesions (n=5)
T loop area	217.9±9.7	209.7±19.1	182.4±23.4
T loop index	1.48±0.1	1.49±0.2	1.27±0.3
αQRS-T	37.9±4.9	45.4±4.9	40±13.9

αQRS – T – angle between QRS ir T vectors in frontal plane

In the comparison of T loop morphology parameters for men and women, we found that T loop area and T loop index were higher for men (table 4).

Table 4. T loop parameter differences between men and women

Parameters	men (n=140)	women (n=56)	p value
T loop area	207.6±5.2	169.7±7.9	0.001
T loop index	1.51±0.06	0.97±0.08	0.001
αQRS-T	32.3±2.6	37.6±4.5	0.292

αQRS – T – angle between QRS ir T vectors in frontal plane

We didn′t find the relation between the age and T loop area. Exploring T loop area for men and women separately, it was found that both for men and for women T loop area increased with the age, the effect was more pronounced for women. T loop morphology parameters did not differ between the patients with stable and unstable angina.

To evaluate T loop morphology parameters for patients with and without ECG signs of left ventricular hypertrophy (LVH), it was found that only αQRS-T separated these patients: the value of αQRS-T was higher for patients with LVH (αQRS-T accordingly 42.6±4.0 and 26.4±2.2; p=0.001).

Studying the patients with and without myocardial mass index (MMI) increases, it was found that only αQRS-T separated these patients: the value of αQRS-T was higher for patients with MMI increases (table 5).

Table 5. T loop parameters differences between patients with increased MMI and not increased

Parameters	Increased MMI	MMI not increased	p value
T loop area	195.3±5.9	197.4±7.3	0.820
T loop index	1.32±0.07	1.39±0.08	0.570
αQRS-T	39.4±3.2	26.3±2.9	0.005

αQRS – T – angle between QRS ir T vectors in frontal plan

T loop morphology might reflect coronary artery stenosis: as the degree of coronary artery stenosis increases, T loop area and T loop index also increases: values of T loop area and T loop index were found to be higher in patients with coronary artery stenosis ≥ 50 % (accordingly p=0.021 and p=0.011), for one vessel (accordingly 0.008 and p=0.031), three (accordingly p=0.045 p=0.005) vessel diseases.

T loop area and T loop index were higher in men with coronary artery stenosis ≥ 50 % (accordingly p=0.001 and p=0.001).

The accuracy of T loop area and T loop index for prediction coronary artery stenosis were estimated using ROC curves (area under T loop area curve is 0.6; p=0.022, and area under T loop index curve is 0.608; p= 0.014) (fig. 1, 2). The accuracy of the test depends on how well the test separates the group. Accuracy is measured by the area under ROC curve. The ROC curve's position above the mean line demonstrates capability of the method to predict coronary artery lesions with some degree of precisios. An area of 1 represents a perfect test.

Conclusions

1. The values of T loop area and T loop index were found to be higher in patients with coronary artery stenosis ≥ 50 % (accordingly p=0.021 and p=0.011), for one vessel (accordingly 0.008 and p=0.031), three (accordingly p=0.045 and p=0.005) vessel disease.

2. The values of T loop area and T loop index were higher in men with coronary artery stenosis ≥ 50 % (accordingly p=0.001 and p=0.001).

3. T loop morphology parameters did not differ significantly between LAD, CX and RCA artery lesions.

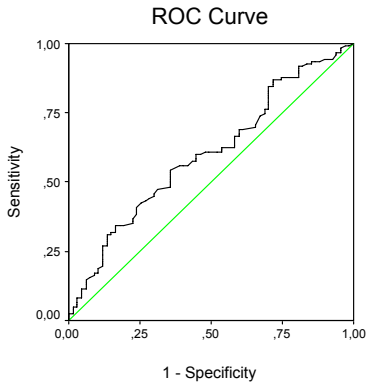

Fig. 1. T loop area ROC curve

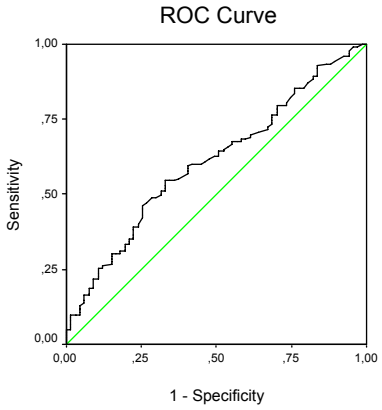

Fig. 2. T loop index ROC curve

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S. Kaminskienė, G. Urbonavičienė, G. Barauskienė, M. Tamošiūnaitė, I. Blužaitė. T kilpos morfologijos parametrų ryšys su vainikinių arterijų pažeidimais // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2004. – Nr. 3(52). – P. 56-58.

Aprašomas metodas, kuriuo pabandyta nustatyti T kilpos morfologijos parametrų ryšį su vainikinių arterijų susiaurėjimais. Įvertinti 196 ligonių T kilpos ploto, T kilpos indekso ir αQRS kampo skirtumai. 126 ligoniams koronarografijos metu buvo nustatyti vainikinių arterijų susiaurėjimai ≥ 50 proc. 70 ligonių vainikinių arterijų susiaurėjimų nebuvo nustatyta. Palyginti šių grupių ir pogrupių ligonių parametrai. T kilpos plotas ir T kilpos indeksas buvo didesnis tų ligonių, kuriems buvo nustatyti VA susiaurėjimai ≥ 50 proc. T kilpos ploto ir T kilpos indekso vertės buvo didesnės tų ligonių, kuriems nustatyti vienos ir trijų VA susiaurėjimai, taip pat šių parametrų vertės buvo didesnės vyrų, kuriems koronarografijos metu buvo nustatyti vainikinių arterijų susiaurėjimai ≥50 proc. Ligonių su skirtinga vainikinių arterijų pažeidimo lokalizacija T kilpos morfologijos parametrai nesiskyrė. Il. 2, bibl. 5 (anglų kalba; santraukos lietuvių, anglų ir rusų k.).

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The aim of this study was to determine if T loop morphology variables are related to coronary artery stenosis. We assessed T loop morphology parameters in 196 patients. In 126 patients coronary arteries stenoses ≥ 50% were determined. 70 patients normal coronary arteries were determined. T loop morphology might reflect coronary artery stenosis: as the degree of coronary artery stenosis increases, T loop area and T loop index also increases: values of T loop area and T loop index were found to be higher in patients with coronary artery stenosis ≥ 50 % (accordingly p=0.021 and p=0.011), for one vessel (accordingly 0.008 and p=0.031), three (accordingly p=0.045 p=0.005) vessel diseases.T loop area and T loop index were higher in men with coronary artery stenosis ≥ 50 % (accordingly p=0.001 and p=0.001). T loop morphology parameters did not differ significantly between damaged LAD, CX and RCA arteries. Ill.2, bibl. 5 (in English; summaries in Lithuanian, English and Russian).

С. Каминскене, Г. Урбонавичене, Г. Бараускене, М. Тамошюнайте, И. Блужайте. Значение морфологии Т петли для диагностики ишемической болезни сердца // Электроника и электротехника. – Каунас: Технология, 2004. –- № 3(52). – С. 56-58.

Описываются результаты определения корреляции между параметрами Т петли и степенью поражения коронарных артерий. В обследование были включены 196 больных. У 126 больных были установлены сужения коронарных артерий ≥ 50 %. У 70 больных сужений коронарных артерий не было установлено. Значения параметров Т петли были достоверно выше у больных, которым были установлены сужения коронарных артерий ≥ 50 %. У мужчин, которым были установлены сужения коронарных артерий ≥ 50 %, значения параметров Т петли были выше. Мы не нашли различий параметров Т петли у больных с различной локализацией поражений коронарных артерий (на английском языке; рефераты на литовском, английском и русском яз.).