ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 *2009. No. 4(92)*
ELEKTRONIKA IR ELEKTROTECHNIKA

MEDICINE TECHNOLOGY
T115
MEDICINOS TECHNOLOGIJA

Ventricular Repolarisation Indices in Relation with Coronary Artery Lesions

J. Venclovienė
Vytautas Magnus University
Vileikos str. 8, LT-3035 Kaunas, Lithuania, e–mail: *j.vencloviene@gmf.vdu.lt*
Z. Bertašienė, S. Kaminskienė, G. Jaruševičius
[1]Institute of Cardiology, Kaunas University of Medicine
Sukileliu Ave. 17, LT-3007 Kaunas, Lithuania, e–mail: zbertasiene@yahoo.com
I. Blužaitė
Division of Cardiology, Department of Internal Medicine, Kantonsspital St.Gallen
CH-9007 St.Gallen, Switzerland, e–mail: ina.bluzaite@kssg.ch

Introduction

Non-invasive detection of coronary artery disease (CAD) is a prime goal for diagnostics in clinical cardiology. A suspicion and recognition of coronary artery (CA) stenosis from resting electrocardiogram (ECG) in cases of non–acute ischaemia has been limited until now. It is very important to diagnose significant CA lesions, especially located in proximal segments of CA, because these patients are more likely to develop acute myocardial infarction or sudden cardiac death. Different ECG indices were found to be informative to diagnose CAD during exercise test [1; 2], whereas resting ECG traditionally has limited diagnostic value in diagnosis of CAD. Despite some controversial results, several studies showed that increased QT dispersion (QTd) is a significant predictor of cardiovascular mortality [3; 4]. It was suggested that increased corrected QT dispersion at rest could be related to the extent and severity of coronary artery stenosis in patients with stable angina [5]. In our earlier research we have found that vectorcardiographic and electrocardiographic indices such as αQRS-T, QTcmax, Tarea and QRS duration could be beneficial for detecting CA stenosis at its early stages [6].

The purpose of this study was to investigate the potential for using of ECG variables to diagnose and discriminate proximal and distal CA lesions.

Patients and methods

293 patients (208 male and 85 female) with stable angina pectoris were investigated. All patients underwent coronary angiography. It was considered that stenosis of CA lumen ≥50 % is hemodinamically significant, stenosis of CA lumen ≤ 30% hemodinamically insignificant. Proximal CA stenosis was defined as follows:

- Stenosis in S_1 or S_2 ≥50 % (right coronary artery),
- Stenosis in one more segments of left descendent coronary artery ($S_5 – S_7$) ≥50 %,
- Stenosis in S_{11} (ramus circumflex of left coronary artery) ≥50 %.

Distal coronary artery stenosis was defined as follows:

- Stenosis in S_3 or S_4 ≥50 % (right coronary artery),
- Stenosis in S_9 or S_{10} (left descendent coronary artery) ≥50 %,
- Stenosis in S_{12}, S_{13}, S_{14} or S_{15} (ramus circumflex of left coronary artery)≥50 %.

Digital ECG was recorded for all patients (discretisation parameters 12 bit, 2kHz, recoding interval of 10s, 12 standard leads). Later on these ECGs were processed by computer software, created at the Institute of Cardiology, KMU.

To assess the relation of ECG variables and CA stenosis, we measured and calculated different resting ECG indices: QT, JT, QRS duration, their the minimal (min) and maximal (max) values; QT and JT dispersion (QTd, JTd); QT and JT dispersion in chest leads; αQTS-T, T loop morphology indices: T loop area and T loop index (ratio of T loop area and T loop length). The methods of measuring of those variables are presented in our previous publications [6]

Statistical analysis was performed using SPSS 13.0 and STATISTICA 6.0 softwares. Continuous data were expressed as mean ± standard error. Unpaired t-test, U-test, one-way ANOVA and Kruskal-Walis test were used to assess the influence of number of stenotic CA segments in proximal and distal area on ECG variables. The significance level used 0,05.

Results

112 (38%) patients did not have significant coronary artery disease. 181 (62%) patients had stenosis of CA lumen ≥50 %. 160 of them (88%) had significant stenosis in proximal segments and 104 (57.5%) - in distal segments. 7.2% (n=21) of patients had significant stenosis only in distal segments, 26.3% (n=77) – only in proximal segments, 28.3% (n=83) – in both (distal and proximal) segments. Among 104 patients, who had significant stenosis in distal segments, 60.6% (63) of patients had only one stenotic segment, 35.6% (n=37) – 2 stenotic segments, 3.8 % (n=4) - 3 stenotic segments. Among 160 patients, who had significant stenosis in proximal segments, 53.1% (85) of patients had one stenotic segment, 28.8% (n=46) – 2 stenotic segments, 18.1% (n=29)- 3 stenotic segments. Among 77 patients with significant stenosis only in proximal segments, 72.7% (n=56) patients had one stenotic segment, 18.2% (n=14) – 2 stenotic segments, 9.1% (n=7)- 3 stenotic segments.

To assess the capability of ECG to diagnose significant coronary artery stenosis in proximal and distal segments we calculated the mean values of ECG variables and compared them by unpaired t-test and U-test in all four groups of patients (I group-without significant stenosis, II group-stenosis only in distal segments, III group- stenosis only in proximal segments, IV group – stenosis in both proximal and distal segments). The means of variables when at least one p value was less than 0.2 are presented in the Table 1.

Table 1. The mean ± standard error values of ECG indices and their comparison between the groups of patients with stable angina pectoris (I group – without significant stenosis, II group – stenosis only in distal segments, III group – stenosis only in proximal segments, IV group – stenosis in both proximal and distal segments, p_{ij} – p value of t–test between i and j groups)

Index	I group n=112	II group n=21	III group n=77	IV group n=83	p_{12}	p_{13}	p_{14}	p_{23}	p_{24}	p_{34}
QTd	30.5±1.1	30.6±2.4	33.1±1.6	29.7±1.3	>0.5	0.295	>0.5	>0.5	>0.5	0.120
JTd	32.8±1.0	33.0±2.8	36.5±1.5	32.5±1.3	>0.5	0.042	>0.5	0.421	>0.5	0.033
QRSmin	69.1±0.9	73.1±1.8	67.9±1.1	70.5±1.0	0.040	>0.5	0.237	0.043	0.343	0.113
QTdapex	19.7±0.9	22.8±2.6	24.1±1.5	21.3±1.2	0.329	0.043	0.433	>0.5	>0.5	0.246
JTdapex	21.5±1.0	25.2±2.6	26.3±1.5	22.6±1.3	0.181	0.016	>0.5	>0.5	0.364	0.044
Age	56.8±1.0	61.5±2.4	58.9±1.1	62.0±1.0	0.106	0.239	0.001	0.365	>0.5	0.026
αQTS-T	25.1±2.4	30.8±8.8	35.6±3.5	38.8±4.5	>0.5	0.006	0.022	0.133	0.197	>0.5
Tarea	185±6.7	236±18.7	195±7.5	204±7.6	0.010	0.306	0.038	0.023	0.036	0.454
Tindex	1.19±0.1	1.71±0.3	1.31±0.1	1.49±0.1	0.033	0.291	0.037	0.103	0.321	0.241

The results from table 1 show that the mean value of JTd and JTd_{apex} in group III (patients with CA stenosis in proximal segments) is higher than in I group (patients without CA stenosis) and IV group (stenosis in both proximal and distal segments). Patients with lesions in proximal segments (III and IV groups) had significantly higher αQTS-T, QTd_{apex} and JTd_{apex} than comparing to the patients in I and II groups. Therefore dispersion of QT and JT is asociated with stenosis in proximal segments. Patients with lesions in distal segments (II and IV group) had bigger T-loop values than patients without stenosis in distal segments (I and III group). We can see that lesions in distal segments are more common in older patients. Means of QRSmin, Tarea ir Tindex had no significant differences between patients of I and III group (p>0,2), so higher values of means of T-loop variables we can associate with lesions in distal, but not in proximal segments. With lesions in proximal segments is associated only one T-loop variable- αQTS-T.

To asses ECG efficacy to diagnose multiple CA stenosis in proximal segments using one-way ANOVA we compared different means of QRS, QT interval, JT interval and T loop in association with the number of CA stenosis in proximal segments (Table 2). The results (significant difference between means – p<0.05) show that multiple (three CA) stenosis is associated with higher αQTS-T and with changes in JTd and JTd_{apex} dispersion. We see that in patients with three CA lesions means of JT and JT_{apex} dispersion are significantly lower.

Table 2. The means of QRS, QT interval, JT interval and T loop morphology indices in association with the number of CA stenosis in proximal segments of patients with stable angina pectoris

Index	No lesions (n=112)	1 CA (n=56)	2 CA (n=14)	3 CA (n=7)	p
QTmax	412.0	417.16	413.6	427.0	>0.5
QTmin	381.5	384.7	376.1	397.9	0.47
QTd	30.5	32.4	37.4	29.1	0.22
QTmean	397.7	402.1	397.0	413.7	0.48
JTmax	329.9	333.7	336.4	347.0	0.46
JTmin	297.0	297.6	294.0	319.3	0.26
JTd	32.8	36.1	42.4	27.7	0.013
JTmean	313.4	317.2	315.8	334.4	0.26
QRSmax	94.85	95.2	92.9	91.9	0.83
QRSmin	69.1	68.8	64.8	66.9	0.56
QRSmean	84.0	84.56	80.9	79.4	0.29
QTd_{apex}	19.7	24.1	25.1	22.0	0.33
JTd_{apex}	21.5	26.8	28.4	18.3	0.027
Age	56.8	59.0	59.6	56.9	0.47
αQTS-T	25.1	34.9	32.8	46.4	0.035
Tarea	185.3	200.2	170.0	188.7	0.41
Tindex	1.19	1.36	1.09	1.22	>0.5

To find an explanation to this fact we analysed correlations between different indices of JT interval (JTd, JTd_{apex}), T wave (Tarea and Tindex) and indices of QRS (QRSmin, QRSmax, QRSmean) in 4 groups of patients: without CA stenosis, with stenosis in 1, 2 or 3 coronary arteries. Correlation coefficients were calculated in all patients of these groups without distal CA stenosis (Table 3, Fig. 1, Fig. 2).

Table 3. Correlation between JT dispersion and QRS interval and T–loop indices (significance: * - p<0.05, ** p<0.01) in patients with stable angina pectoris

Number of proximal stenosis	QRSmax	QRSmean	Tarea	Tindex
No distal stenosis				
0 (n=112): JTd	0.073	0.032	0.043	0.072
JTdapex	0.066	-0.013	-0.112	0.024
1 (n=56): JTd	0.477**	0.438**	0.161	0.131
JTdapex	0.332*	0.235*	0.079	0.096
2 (n=14): JTd	-0.009	-0.109	0.120	0.036
JTdapex	-0.144	-0.260	-0.333	-0.357
3 (n=7): JTd	-0.786*	-0.607	-0.82*	-0.96**
JTdapex	-0.536	-0.571	-0.77*	-0.82*
All patients				
0 (n=133): JTd	0.144*	0.099	0.076	0.115
JTdapex	0.124	0.036	-0.062	0.067
1 (n=85): JTd	0.353*	0.256*	0.250*	0.243*
JTdapex	0.349**	0.207*	0.154	0.205*
2 (n=46): JTd	0.020	-0.102	-0.142	-0.064
JTdapex	0.001	-0.190	-0.138	-0.016
3 (n=29): JTd	-0.159	-0.116	-0.52*	-0.45*
JTdapex	-0.022	-0.063	-0.272	-0.176

Results show that there is no correlation between JT dispersion and other indices in patients without CA stenosis – absolute value of correlation coefficient is lower than 0.1. No correlation is observed in patients with two CA stenosis as well. In patients with one proximal CA stenosis positive correlation exists between JTd and QRS indices (Table 3). When we analyze patients with 3 proximal CA stenosis, we find significant negative correlation between JT dispersion and T loop indices: there is a tendency decrease in JTd and JTdapex if T area increases (r < -0,75) (Fig 1). The analogue negative correlation is seen in patients with 3 proximal CA stenosis (r < -0,5) (Table 3). So we can expect that the patients with 3 proximal CA stenosis and bigger T loop area or Tindex will have lower JT dispersion.

Table 4. The means of QRS and T loop variables in patients with angina pectoris and different number of distal CA stenosis and without CA stenosis

Index	Without CA stenosis (n=112)	1 CA (n=17)	2-3 CA (n=4)	p
No proximal stenosis				
QRSmax	94.8	95.0	101.0	0.229
QRSmin	69.1	71.4	80.3	0.042
QRSmean	84.0	84.8	90.3	0.240
Tarea	185.3	229.3	260.3	0.015
Tindex	1.19	1.64	1.96	0.044
All patients				
	No stenosis (n=189)	1 CA (n=63)	2-3 CA (n=41)	p
QRSmax	94.7	93.9	96.0	0.434
QRSmin	68.6	70.0	72.4	0.048
QRSmean	83.8	83.7	85.9	0.213
Tarea	189.4	204.9	218.3	0.037
Tindex	1.24	1.49	1.59	0.023

The results of ECG capability to diagnose multiple coronary artery stenosis in distal segments using one way ANOVA are in Table 4. We compared the means of QRS, QT interval, JT interval and T loop in patients without coronary artery stenosis, with coronary artery stenosis in 1 coronary artery, 2-3 coronary arteries. Our results show that the more significant stenosis in distal segments, the higher means of minimal QRS duration, T area and T index exist. This tendency remains without taking into account proximal CA stenosis (Table 4).

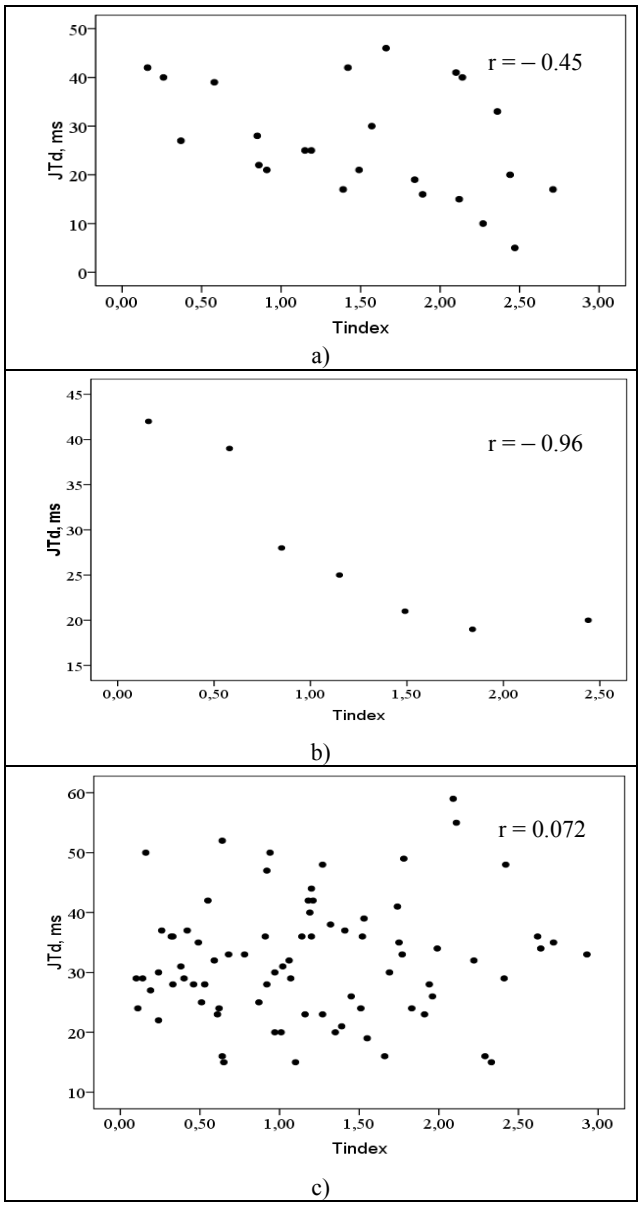

Fig. 1. Correlation between JT dispersion and Tindex in patients with stable angina pectoris: a – lesions in proximal segments of all three CA; b – lesions in proximal segments of all three CA and no distal lesions; c – without significant CA lesions)

The indices of QT and JT duration, JTd, JTdapex, QTd, QTdapex are not informative for multiple coronary artery stenosis in distal segments (p>0.5). There is a tendency of increasing QRSmax and QRSmean according the number of CA stenosis in distal segments, but the increase is insignificant.

Summarising the results of our investigation we can resume that T loop parameters –T loop area and T loop index - are associated with CA stenosis in distal segments: the more stenotic CA we have, the higher values of T loop variables we measure. Lesions in proximal segments don't

have influence on T area and T index, but correlations between JT dispersion and T loop and QRS variables depend on number of coronary arteries with proximal stenosis. JT dispersion (JT and JT apex dispersion) and αQTS-T are associated with CA stenosis when lesions are in proximal CA segments.

Conclusions

1. T loop area and T loop index are associated with coronary artery stenosis in distal segments.

2. JTdispersion, JT apex dispersion and αQTS-T are associated with coronary artery stenosis when lesions are in proximal coronary artery segments.

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Received 2009 02 19

J. Venclovienė, Z. Bertašienė, S. Kaminskienė, G. Jaruševičius, I. Blužaitė. Ventricular Repolarisation Indices in Relation with Coronary Artery Lesions // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 4(92). – P. 111–114.

The aim of the study was to find rest electrocardiogram (ECG) indices which are valuable do detect patients with coronary artery (CA) lesions in proximal or distal CA segments. The study population consisted of 293 patients with stable angina pectoris. Stenosis of CA lumen ≥50 % was diagnozed in 62 % (181) of patients. The patients were divided into groups: without CA stenosis, proximal stenosis in 1, 2 or 3 CA, distal stenosis in 1,2, 3 CA, and rest ECG indices (minimal, maximal and mean QRS duration, JT and JT apex dispersion, T loop area and T loop index, αQTS-T) were measured. In our study T loop area and T loop index were associated with CA stenosis in distal segments. Ventricular repolarisation indices (JT and JT apex dispersion) and axis angle αQTS-T were associated with CA stenosis when lesions were in proximal CA segments. Ill. 1, bibl. 6 (in English; summaries in English, Russian and Lithuanian).

Й. Венцловиене, З. Берташене, С. Каминскене, Г. Ярушявичюс, И. Блужайте. Связь между параметрами реполярзации желудка сердца и изменениями артерий // Электроника и электротехника. – Каунас: Технология, 2009. – № 4(92). – С. 111–114.

Цель этой статьи – определить связь между повреждениями коронарных артерий (КА) в проксимальных и дистальных сегментах и параметрами спокойствия ЭКГ. В исследование были включены 293 больные с *angina pectoris*. Для 62% (181) из них был установлен стеноз, КА ≥ 50%. Пациенты были разделены на группы: без стеноза КА, со стенозами одной, двух и трех КА в проксимальных сегментах; со стенозами одной, двух или трех КА в дистальных сегментах. Использованы следующие параметры: миниманьная, максиманьная и средняя продолжительность QRS, JT и JTapex дисперсия, площадь и индекс Т петли, αQTS-T. По нашим данным, площадь и индекс Т петли информативны при повреждениях КА в дистальных сегментах. Реполяризацию отражающие параметры (JT и Jtapex дисперсия) и угол αQTS-T были информативны при повреждениях КА в проксимальных сегментах. Ил. 1, библ. 6 (на английском языке; рефераты на английском, русском и литовском яз.).

J. Venclovienė, Z. Bertašienė, S. Kaminskienė, G. Jaruševičius, I. Blužaitė. Skilvelių repoliarizacijos rodmenų ryšys su vainikinių kraujagyslių pakyčiais // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 4(92). – P. 111–114.

Darbo tikslas buvo nustatyti ramybės elektrokardiogramos (EKG) rodmenis, kurie padėtų aptikti vainikinių arterijų (VA) susiaurėjimus proksimaliniuose arba distaliniuose VA segmentuose. Tiriamųjų kontingentą sudarė 293 ligoniai, sergantys stabiliąja krūtinės angina. 181 pacientui (62 %) buvo diagnozuoti ≥50 % VA spindžio susiaurėjimai. Ligoniai buvo suskirstyti į grupes: be VA susiaurėjimų; su vienos, dviejų ar trijų VA proksimalinių segmentų susiaurėjimais; su vienos, dviejų ar trijų VA distalinių segmentų susiaurėjimais. Buvo apskaičiuoti įvairūs EKG rodmenys: minimali, maksimali ir vidutinė QRS trukmė, JT ir JTapex dispersija, T kilpos plotas ir T indeksas, αQTS-T. Mūsų duomenimis, T kilpos plotas ir T indeksas buvo susiję su vainikinių kraujagyslių distalinių segmentų susiaurėjimais. Skilvelių repoliarizaciją atspindintys rodmenys (JT ir JTapex dispersija) bei kampas αQTS-T buvo susiję su VA proksimalinių segmentų susiaurėjimais. Il. 1, bibl. 6 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).