

UDC 615.12-008.3-085.825-085.3-073.7

QTC INTERVAL DURATION CLASS AND STIMULATION PARAMETERS IN PATIENCE DURING FIRST SIX MONTHS AFTER PACEMAKER

Maltseva M. S.

V. N. Karazin Kharkiv National University, Kharkiv, Ukraine

97 patients (55 men and 42 women) with implanted pacemakers (PM) in DDD/DDDR, VVI/VVIR and CRT modes were investigated. Pacing mode, location of the right ventricular (RV) and left ventricular (LV) electrode, percentage of the right atrium (RA), RV and LV stimulation, percentage of atrial flutter (AFL) and atrial fibrillation (AF), percentage of ventricular tachycardia (VT), base frequency of stimulation, RV and LV electrode impedance, RV and LV electrode stimulus amplitude and duration, RV electrode sensitivity, R-waves sensing, stimulated and detected AV-delay, interventricular delay, the minimum refractory period were evaluated in acute postoperative period (3-5 days) and six months after pacemaker implantation. Patients were divided into classes 1 (normal QTc (320-440 ms)) - 41 (42 %) of the patients) and class 2 (long QTc (> 440 ms)) - 56 (58 %) patients) of QTc interval duration. For data processing were used standard statistical procedures by Microsoft Excel. QTc interval prolongation is most often observed in patients with VVI/VVIR stimulation, normal QTc interval duration – in patients with CRT. The same part of normal and extended QTc interval duration is observed in patients with DDD/DDDR stimulation. Prolonged QTc interval duration is associated with more frequent RV electrode implantation in heart apex, higher percentage of AFL and AF, LV electrode impedance, RV and LV electrodes stimulus amplitude, detected and stimulated AV-delays, minimum refractory period in first six months after PM implantation. Patients with increased QTc interval duration after PM implantation require more intensive monitoring of stimulation parameters and enhancing medication.

KEY WORDS: cardiac pacing, stimulation parameters, electrocardiography, QTc interval

КЛАС ТРИВАЛОСТІ ІНТЕРВАЛУ QTC ТА ПАРАМЕТРИ СТИМУЛЯЦІЇ У ПАЦІЄНТІВ В ПЕРШІ ПІВРОКУ ПІСЛЯ ІМПЛАНТАЦІЇ ЕКС

Мальцева М. С.

Харківський національний університет імені В. Н. Каразіна, м. Харків, Україна

Обстежено 97 пацієнтів (55 чоловіків і 42 жінки) з імплантованими електрокардіостимуляторами (ЕКС) в режимах DDD/DDDR, VVI/VVIR і CRT. Оцінювали в гострому післяопераційному періоді (3-5 добу) і через півроку після імплантації ЕКС режим стимуляції, розташування правошлуночкового (ПШ) і лівошлуночкового (ЛШ) електрода, відсоток стимуляції правого передсердя (ПП), ПШ і ЛШ, відсоток тріпотіння передсердь (ТП) і фібриляції передсердь (ФП), відсоток шлуночкової тахікардії (ШТ), базова частота стимуляції, імпеданс ПШ і ЛШ електрода, амплітуда і тривалість стимулу ПШ і ЛШ електрода, чутливість ПШ електрода, сенсінг R-хвилі, стимульована і детектована AV-затримка, міжшлуночкова затримка, мінімальний рефрактерний період. Пацієнти були розділені на класи 1 (нормальної QTc (320-440 мс)) - 41 (42 %) пацієнтів) і 2 (подовженої QTc (> 440 мс)) - 56 (58 %) пацієнтів) тривалості інтервалу QTc. Для обробки даних використовувалися стандартні статистичні процедури за допомогою Microsoft Excel. Подовження тривалості інтервалу QTc найбільш часто спостерігалось у пацієнтів з VVI/VVIR ЕКС, нормальна тривалість інтервалу QTc - у пацієнтів з CRT. Однакова частота нормальної і подовженою тривалості інтервалу QTc спостерігалась у пацієнтів з DDD/DDDR ЕКС. Збільшення тривалості інтервалу QTc пов'язано з більш частою імплантацією ПШ електрода в верхівку серця, більшим відсотком ТП і ФП, імпедансом ЛШ електрода, амплітудою ПШ і ЛШ електродів, детектованою і стимульованою AV-затримками, мінімальним рефрактерним періодом в перші шість місяців після імплантації ЕКС. Пацієнти зі збільшенням тривалості інтервалу QTc після імплантації ЕКС вимагають більш інтенсивного моніторингу параметрів стимуляції та посилення медикаментозної терапії.

КЛЮЧОВІ СЛОВА: електрокардіостимуляція, параметри стимуляції, електрокардіографія, інтервал QTc

КЛАСС ПРОДОЛЖИТЕЛЬНОСТИ ИНТЕРВАЛА QTc И ПАРАМЕТРЫ СТИМУЛЯЦИИ У ПАЦИЕНТОВ В ПЕРВЫЕ ПОЛГОДА ПОСЛЕ ИМПЛАНТАЦИИ ЭКС

Мальцева М. С.

Харьковский национальный университет имени В. Н. Каразина, г. Харьков, Украина

Обследованы 97 пациентов (55 мужчин и 42 женщины) с имплантированными электрокардиостимуляторами (ЭКС) в режимах DDD/DDDR, VVI/VVIR и CRT. Оценивали в остром послеоперационном периоде (3-5 сутки) и через полгода после имплантации ЭКС режим стимуляции, расположение правожелудочкового (ПЖ) и левожелудочкового (ЛЖ) электрода, процент стимуляции правого предсердия (ПП), ПЖ и ЛЖ, процент трепетания предсердий (ТП) и фибрилляции предсердий (ФП), процент желудочковой тахикардии (ЖТ), базовая частота стимуляции, импеданс ПЖ и ЛЖ электрода, амплитуда и длительность стимула ПЖ и ЛЖ электрода, чувствительность ПЖ электрода, сенсинг R-волны, стимулированная и детектированная AV-задержка, межжелудочковая задержка, минимальный рефрактерный период. Пациенты были разделены на классы 1 (нормальной QTc (320-440 мс)) - 41 (42 %) пациентов) и 2 (удлиненной QTc (> 440 мс)) - 56 (58 %) пациентов) продолжительности интервала QTc. Для обработки данных использовались стандартные статистические процедуры с помощью Microsoft Excel. Удлинение продолжительности интервала QTc наиболее часто наблюдалось у пациентов с VVI/VVIR ЭКС, нормальная продолжительность интервала QTc - у пациентов с CRT. Одинаковая частота нормальной и удлиненной продолжительности интервала QTc наблюдалась у пациентов с DDD/DDDR ЭКС. Увеличение продолжительности интервала QTc связано с более частой имплантацией ПЖ электрода в верхушку сердца, большим процентом ТП и ФП, импедансом ЛЖ электрода, амплитудой ПЖ и ЛЖ электродов, детектированными и стимулированными AV-задержками, минимальным рефрактерным периодом в первые шесть месяцев после имплантации ЭКС. Пациенты с увеличением продолжительности интервала QTc после имплантации ЭКС требуют более интенсивного мониторинга параметров стимуляции и усиления медикаментозной терапии.

КЛЮЧЕВЫЕ СЛОВА: электрокардиостимуляция, параметры стимуляции, электрокардиография, интервал QTc

INTRODUCTION

Cardiac pacing is one of the leading treatment methods for bradyarrhythmias and chronic heart failure (CHF) [1]. Stimulation parameters monitoring and correction allows control the paced rhythm and accompanying medical treatment [1-3].

Output of corrected QT interval duration (QTc) values beyond physiological scope is a poor prognostic sign, not only in patients with spontaneous rhythm, but also with the pacemaker (PM) [4, 5]. Despite this, stimulation parameters in QTc interval duration classes in patients with PM have not previously been studied.

OBJECTIVE

The purpose of the study is to estimate stimulation parameters in patients during first six months after pacemaker implantation in different modes in QTc interval duration classes.

MATERIALS AND METHODS

97 patients aged 68 ± 10 (M \pm sd) (55 - female, 42 - male) were examined in the

department of ultrasound and instrumental diagnostics with miniinvasive interventions of GI «Zaycev V.T. Institute of General and Urgent Surgery of NAMS of Ukraine», among them - 21 patients have atrial fibrillation (AF). All patients were underwent permanent pacing therapy from 2006 to 2013 in modes: DDD (17 patients), DDR (28 patients), VVI (22 patients), VVIR (12 patients) and CRT (18 patients). RV pacing more than 50 % was observed in 35 (78 %) patients. Mainly atrial pacing (AP) (90 %) during DDD/DDDR pacing was observed in 8 patients (18 %) with sick sinus node syndrome (SSNS).

Patients aged less than 40 years, with concomitant stable angina III-IV functional class (FC), a single-chamber atrial pacing and dual chamber atrioventricular pacing with right ventricle (RV) stimulation less than 50 % were excluded from the study.

Pacing mode, location of the RV and left ventricular (LV) electrode, percentage of the right atrium (RA), RV and LV stimulation, percentage of atrial flutter (AFI) and atrial fibrillation (AF), percentage of ventricular tachycardia (VT), base frequency of stimulation, RV and LV electrode impedance,

RV and LV electrode stimulus amplitude and duration, RV electrode sensitivity, R-waves sensing, stimulated and detected AV-delay, interventricular delay, the minimum refractory period were evaluated in acute postoperative period (3-5 hours) and six months after.

To measure the duration of the QT interval and heart rate of the patients before and after pacemaker implantation (3-5 days after surgery) were recorded on a computer ECG electrocardiograph «Cardiolab +» (HAI-Medica). The stimulated QTc interval duration was measured after the removal of the stimulus artifact in three consecutive complexes of the Q wave to the beginning of the descending segment of the return of the T wave in leads to the contour II, V5, and V6 with choosing of a maximum value. The corrected QT interval duration (QTc) of the patients with spontaneous rhythm and pacing was calculated by the Bazett formula: $QTc = QT / (RR \wedge 0,5)$. For patients with AF, QTc was calculated using the formula $QTc = QT + 0,154 \times (1000 - RR)$ Fremingem study for patients with atrial fibrillation [6], the measurement accuracy - 0.5 ms.

The patients with pacemakers were divided into 3 classes of QTc interval duration of stimulated complexes (further classes): Class 1 - normal (in the physiological range of values)

- 320-439 ms, Class 2 - (qualified) an elongated QTc interval- > 440 ms, and Class 3 - (qualified) shortened QTc interval - < 320 ms [7].

There are a 41 (42 %) patients aged 66 ± 10 in class 1 (male - 20 female - 21) and 56 (58 %) patients aged 69 ± 9 in class 2 (male - 35 female - 21). In class 3, there was not a single patient. Values were estimated in QTc interval duration classes in acute postoperative period (3-5 hours) and six months after.

The data were processed after formation the Microsoft Excel and Statistica base. For statistical evaluation of the results, the parametric criteria (mean - M, standard deviation - sd) and nonparametric ones (absolute (n, number) and relative (percentage of (p, %) and the criterion χ^2) units) were used. The probability of differences between groups was determined using a non-parametric U - Mann-Whitney test. The expected result is determined by levels of reliability $p < 0.01$ and $p < 0.05$.

RESULTS AND DISCUSSION

The proportion of patients with a pacemaker in various stimulation modes in QTc interval duration classes is shown in Fig. 1.

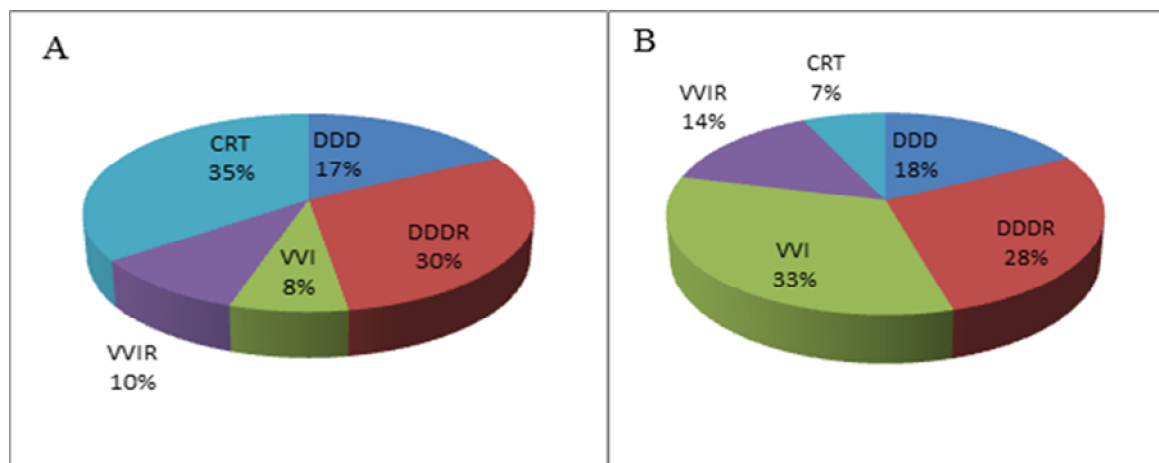


Fig. 1. Proportion of patients with a pacemaker in various stimulation modes: A - in the class 1 of QTc interval duration; B - in the class 2 of QTc interval duration.

The share of CRT in class 1 of QTc interval duration was five times greater than in class 2. Single-chamber VVI pacing mode more frequently observed in the class 2 of QTc interval duration, and much less in the class 1. The percentage of patients with DDD, DDDR,

VVIR pacemakers did not differ in both classes of QTc interval duration.

Stimulation parameters in patients during first six months after pacemaker implantation in QTc interval duration classes are presented in the table 1.

Table 1

Stimulation parameters in patients during first six months after pacemaker implantation in QTc interval duration classes

Stimulation parameters		QTc interval duration class			
		Class 1		Class 2	
		Acute postoperative period	After 6 months	Acute postoperative period	After 6 months
Location of RV electrode (%±p)	Apex	5 ± 3	-/-	12 ± 4*	-/-
	The upper third of IVS	29 ± 5*	-/-	17 ± 7	-/-
	The middle third of IVS	60 ± 6	-/-	56 ± 10	-/-
	The lower third of IVS	6 ± 3	-/-	15 ± 5*	-/-
Location of LV electrode (%±p)	Endocardial	17 ± 12	-/-	5 ± 4	-/-
	Epicardial	83 ± 12	-/-	95 ± 4	-/-
Percentage of stimulation (%±p)	RA	27 ± 12	32 ± 13	41 ± 9	44 ± 9
	RV	88 ± 14	76 ± 15	81 ± 7	90 ± 11
	LV	96 ± 4	97 ± 4	97 ± 5	98 ± 5
Percentage of AFI/AF (%±p)		1,6 ± 0,2	1,9 ± 0,5	2,0 ± 0,3*	3,4 ± 0,6*,**
Percentage of VT (%±p)		-	0,1 ± 0,05	0,2 ± 0,05	0,3 ± 0,1
Base frequency of stimulation (M±sd, 1/min)		71 ± 9	69±8	62±3	66±5
Impedance (M±sd, Om)	RV electrode	588 ± 26	608±28	592±21	636±34
	LV electrode	206 ± 42	228±41	271±32*	338±29*,**
Stimulus amplitude (M±sd, V)	RV electrode	0,4 ± 0,2	0,9±0,3**	1,3±0,3*	2±0,4*,**
	LV electrode	4,1 ± 0,4	3,7±0,4	5,1±0,8*	6±0,9*
Stimulus duration (M±sd, ms)	RV electrode	0,4 ± 0,1	0,4±0,1	0,4±0,1	0,4±0,2
	LV electrode	1,1 ± 0,1	1,2±0,1	1,5±0,2*	1,5±0,2
RV electrode sensitivity (M±sd, mV)		0,7 ± 0,2	0,8±0,2	1,2±0,4	0,9±0,3
R-wave sensing (M±sd, mV)		5,1 ± 1	6,7±0,5**	6,2±1,1	8,1±2**
Stimulated AV-delay (M±sd, ms)		134 ± 18	140±21	132±22	165±19*,**
Detected AV-delay (M±sd, ms)		106 ± 9	112±10	118±10	130±21*
Interventricular delay (M±sd, ms)		42 ± 7	48±6	43±10	49±11
Min refractory period (M±sd, ms)		251 ± 12	276±15**	306±24*	361±27*,**

Notes: * p < 0,05 – between values in classes; ** p < 0,05 – between values in different stages after PM implantation.

RV electrode is more often located in upper and middle thirds of interventricular septum (IVS) in the class 1 and in lower third of IVS and heart apex in the class 2 of QTc interval duration (p < 0.05).

Percentage of RA, RV and LV stimulation in patients in classes 1 and 2 of QTc interval

duration in the acute postoperative period and six months after pacemaker implantation was the same.

Percentage of AFI and AF of all time of stimulation in acute postoperative period after pacemaker implantation was greater in the class 2 than in the class 1 of QTc interval

duration, six months after pacemaker implantation in class 1 it did not change, in the class 2 - increased ($p < 0,05$). The percentage of VT was similar in classes 1 and 2, the entire period of observation.

Base frequency of stimulation in both classes of the QTc interval duration at different stages after pacemaker implantation was the same.

RV electrode impedance did not differ in QTc interval duration classes both in acute postoperative period, and six months after pacemaker implantation. LV electrode impedance in acute postoperative period was higher in class 2 of QTc interval duration, in the semi-annual period of observation, it did not change in class 1 and increased in class 2 ($p < 0,05$). RV and LV electrodes stimulus amplitude in acute postoperative period was higher in class 2 of QTc interval duration, and six months after pacemaker implantation has increased only in class 2 for the RV electrode.

In classes 1 and 2 of QTc interval duration at different stages after pacemaker implantation stimulus duration of RV and LV electrodes, as well as the sensitivity of RV electrode did not differ.

R-wave sensing in QT interval duration classes was similar, increasing in equal measure to semi-annual period of observation after pacemaker implantation.

Detected and stimulated AV-delays in acute postoperative period after pacemaker implantation were similar in QTc interval duration classes, and six months after has increased only in class 2 ($p < 0,05$).

Interventricular delay was the same in classes 1 and 2 of QTc interval duration in acute postoperative period and six months after pacemaker implantation. Minimum refractory period in the acute postoperative period was higher in class 2 of QTc interval duration, to semi-annual period from it has increased, mostly in class 2.

More frequent CRT pacemaker implantation in patients with QTc interval prolongation in our study is consistent with the [8] and due to the fact that the extension of the complex QRS, like one of its parts, is an indication for CRT implantation. We have not been found data on relationship of QTc interval duration class with frequency of one- and dual-chamber devices implantation.

We, as well as [9], it was shown the connection of RV electrode implantation in

apex and QTc interval prolongation, but unlike [10], where it was shown also after RV electrode implantation in IVS, we had no a similar QTc interval prolongation. This is probably due to the greater proportion of patients in our research with position of the RV electrode in upper and middle thirds of IVS, where the conduction of excitation closest to the physiological.

Relationship of QTc interval prolongation and higher frequency of AFI and AF in patients with implanted pacemaker, was shown us, confirms the data [11].

Increased stimulated AV-delay in semi-annual period after pacemaker implantation in patients with baseline QTc interval duration prolongation, we received corresponds to [12], such a connection to the detected AV-delay were not previously investigated.

LV electrode location, percentage of RA, RV and LV stimulation, percentage of VT, base frequency of stimulation, impedance, amplitude and duration of RV and LV electrodes stimulus, RV electrode sensitivity, R-wave sensing, interventricular delay and minimum refractory period have not previously been studied in QTc interval duration classes.

Changes in stimulation parameters in patients during first six months after PM implantation are determined in generally, among other factors, by QTc interval duration class. There more often changes in patients with prolonged QTc interval duration indicate that they require more intensive PM monitoring and therapeutic management.

CONCLUSIONS

1. QTc interval prolongation is most often observed in patients with VVI/VVIR stimulation, normal QTc interval duration – in patients with CRT. The same part of normal and extended QTc interval duration is observed in patients with DDD/DDDR stimulation.

2. Prolonged QTc interval duration is associated with more frequent RV electrode implantation in heart apex, higher percentage of AFI and AF, LV electrode impedance, RV and LV electrodes stimulus amplitude, detected and stimulated AV-delays, minimum refractory period in first six months after PM implantation.

3. Patients with increased QTc interval duration after PM implantation require more intensive monitoring of stimulation parameters and enhancing medication.

PROSPECTS FOR FUTURE STUDIES

It seems appropriate to investigate the relationship between QTc interval duration after right ventricular PM implantation and

changes in stimulation parameters after correction of drug therapy in the class of prolonged QTc interval duration in late postoperative period.

REFERENCES

1. 2012 ACCF/AHA/HRS Focused Update Incorporated Into the ACCF/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society // *Circulation*. – 2013. - № 127. – P. 283-352.
2. Krasnoperov P. V. Optimizatsiya atrioventrikulyarnoy zalezki u patsiyentov s dvukhkamernoy elektrokardiostimulyatsiyey pod kontrolem ekhokardiografii/ P. V. Krasnoperov, Y. A. Shneyder, S. R. Kuz'mina-Krutetskaya [et al.] // *VA* - 2011. – № 48. –P. 43-46.
3. Auricchio A. Long term clinical effect of hemodynamically optimized cardiac resynchronization therapy in patients with heart failure and ventricular conduction delay/ A. Auricchio, C. Stellbrink, S. Sack [et al.] // *J Am Coll Cardiol*. – 2009. - № 39. – P. 2026-2033.
4. Prochnau D. QRS duration and QTc interval are predictors of risk for ventricular arrhythmias during cardiac resynchronization therapy/ D. Prochnau, H. Kuehnert, H.R. Figulla [et al.] // *Acta Cardiol*. – 2011. – №. 66 (4). – P. 415-20.
5. Kulik V.L. Interval QT v kardiologicheskoy klinike / V. L. Kulik, N. I. Yabluchanskiy // *The Journal of Kharkiv V. N. Karazin` National University, Series «Medicine»*. – 2009. – № 879 (18). – P. 73-96.
6. Sagie A. An improved method for adjusting the QT interval for heart rate (the Framingham Heart Study) / A. Sagie, M. Larson, R. Goldberg [et al.] // *Am. J. Cardiol*. – 1992. – № 70. – P. 797–801.
7. Moss A. Long QT syndrome / A. Moss, J. Robinson // *Heart Dis. Stroke*. – 1992. – № 1. – P. 309–314.
8. Bhatia A. Biventricular pacing and QT interval prolongation / A. Bhatia, V. Nangia, J. Solis [et al.] // *J Cardiovasc Electrophysiol*. – 2007. - № 18 (6). – P. 623-627.
9. Saba S. Effect of Right Ventricular Versus Biventricular Pacing on Electrical Remodeling in the Normal Heart / S. Saba, H. Mehdi, M. A. Mathier [et al.] // *Circulation: Arrhythmia and Electrophysiology*. – 2010. - № 3. – P. 79-87.
10. Prochnau D. QRS duration and QTc interval are predictors of risk for ventricular arrhythmias during cardiac resynchronization therapy / D. Prochnau, H. Kuehnert, H.R. Figulla [et al.] // *Acta Cardiol*. – 2011. - № 66 (4). – P. 415-420.
11. Tayeh O. Potential pro-arrhythmic effect of cardiac resynchronization therapy / O. Tayeh, W. Farouk, A. Elazab [et al.] // *J Saudi Heart Assoc*. – 2013. - № 25 (3). – P. 181-189.
12. Ishikawa T. Optimal atrioventricular delay setting determined by QT sensor of implanted DDDR pacemaker / T. Ishikawa, T. Sugano, S. Sumita [et al.] // *Pacing Clin Electrophysiol*. – 2002. - № 25 (2). – P. 195-200.