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Effect of coronary artery bypass grafting on QT interval dispersion

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Abstract

Introduction Coronary artery bypass grafting (CABG) improves prognosis in patients with coronary artery disease. An increase in QT interval dispersion (QTd) is a predictor of cardiac death. The aim of present study is to determine the changes in QTd in the early postoperative period following CABG.

Methods 63 patients with multivessel CAD undergo CABG. Standard 12 leads surface electrocardiogram is obtained on the day before operation, and on the first and fifth postoperative days. QTd is calculated by two different methods.

Results Complete coronary revascularization is performed. The mean QTd1 and QTd2 preoperatively are 86.03ms and 25.35ms, respectively. On the 1st postoperative day QTd1 and QTd2 decrease to 55.30ms, $p < 0.001$ and 17.04ms, $p < 0.001$, respectively, and on the 5th postoperative day - to 45.65ms, $p < 0.001$ and 14.78ms, $p < 0.001$, respectively.

Conclusions We find a statistically significant decrease in QTd in the immediate postoperative period in patients with CABG.

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INTRODUCTION

Coronary artery disease (CAD) accounts for a major part of morbidity and mortality in developed countries. With the increasing trend of life span, larger amount of patients with CAD will eventually be subjected to coronary artery bypass grafting (CABG).

Coronary revascularization has proved its capacity to improve the prognosis of patients. In a meta-analysis by Yusuf et al, 1994 comprising seven randomised trials and 2649 patients with stable coronary heart disease a strategy of initial CABG surgery has been compared with one of initial medical therapy [1]. The CABG group had significantly lower mortality than the medical treatment group at 5 years and at 10 years.

QT interval represents the time for both ventricular depolarization and repolarization, and therefore roughly estimates the duration of an average ventricular action potential. The dispersion of the QT interval (QTd) reflects the inhomogeneities of electrical activity in the different segments of the left ventricle. In the Rotterdam Study [2] including 5,812 adults > 55 years old followed up 4 years, it was demonstrated that subjects with QTcd (QTd corrected for heart rate) > 60 ms had a twofold risk for cardiac death or sudden death and a 40% increased mortality risk when compared to those subjects with a QTc dispersion < 30 ms. This finding was confirmed by another large study – the Caerphilly study, comprising 2512 patients, for whom it was proved that QTd is an independent predictor of cardiac death [3].

There is still no enough data about the changes in QTd after CABG. Therefore it remains to be tested if the changes in QTd in a given patient can be used by the physician as an additional determining prognosis factor.

AIM

The aim of the present study is to evaluate the immediate effect of coronary revascularization on QTd in patients undergoing CABG.

METHODS

STUDY GROUP

Our group consists of 63 patients with multivessel CAD, admitted to University Hospital "St. Marina", Varna in a period of three months (01.1.2007-31.03.2007). All patients undergo an elective CABG as part of their therapeutic work-up. Excluded are patients with valve replacement or repair procedures, patients with aortic surgery and patients who undergo an emergent operation.

ANAESTHESIA

A standardized anaesthetic protocol is used for all patients, including: morphine premedication; induction with midazolam, fenthanyl and pancuronium bromide; endotracheal intubation and mechanical ventilation by positive pressure; maintaining of anaesthesia with sevoflurane oxygen mixture, additional doses of fenthanyl and pancuronium bromide.

PERFUSION

All revascularization procedures are performed using extracorporeal circulation with standardized technique. During perfusion normothermia (36 ^{o} C) is maintained. Cardiac arrest is achieved with single application of cold crystalloid cardioplegia (St. Thomas II).

CORONARY REVASCULARIZATION

CABG is done with cross-clamping of the aorta on arrested heart. In all patients left anterior descending artery (LAD) is bypassed using left internal mammary artery (LIMA). Right coronary artery (RCA) is revascularized using vena saphena magna segment (v.s.m.). All significantly diseased obtuse marginal and diagonal branches are bypassed using v.s.m. and in 54 cases (85.7%) a 'jump' anastomosis is performed to the diagonal branch. Proximal anastomoses to the aorta are completed with partial clamping.

QT INTERVAL DISPERSION

On the day before CABG, on the 1 st and on the 5 th day afterwards a standard 12 lead surface ECG is obtained. QT intervals are measured manually on a standard 12 lead surface ECG taken on the day before CABG, on the 1 st and 5 th postoperative days. QTd is calculated by two different ways: QTd1 – the difference between the maximal and minimal QT intervals (QTd1 = QTmax – QT min) and QTd2 – the standard deviation between the QT intervals in all 12 leads using the formula

Figure 1

$$SD = \sqrt{\frac{\sum_{i=1}^{N} (Xi - \overline{X})^2}{N-1}}$$

, where $\overline{X}$ is the mean value for the QT intervals in the 12 leads, Xi is the value of the QT interval in a given lead and N represents the number of leads – 12. All measurements are performed by 2 independent experts with long time experience on QT reference datasets [4] and a mean value for QTd1 and QTd2 is calculated. We have not performed a correction for heart rate with the help of the Bazett formula as it has been already proved that unlike the QT interval the dispersion of QT is rate-independent [5]

STATISTICAL METHODS

Continuous variables are presented as mean ± standard deviation (SD). Categorical variables are presented as percentages. The mean values of QTd on the day before CABG is compared with the mean values of QTd on the 1 st and 5 th postoperative day separately for QTd1 and QTd2 with nonparametric tests since the values are not normally distributed – the Wilcoxon signed-rank test is used. The number of cases that show a decrease, an increase or an unchanged QTd in each pair of comparable values is given. All analyses are performed with SPSS 13 for Windows.

RESULTS

The demographic and clinical characteristics of the patients are given in Table 1. Women are underrepresented in our study – only 11 (17.5%) patients of the studied population are female. The study group is of relatively low risk, with preoperative Euro Score of 2.38% (±0,5%).

Figure 2

Table 1: Demographic and clinical characteristics of the patients

Age	Mean (Standard deviation)	60.22 (± 8.13)
Body Mass Index (BMI)	Mean (Standard deviation)	31.4 (± 5.56)
Female	Number (%)	11 (17.5%)
Arterial hypertension	Number (%)	60 (93.8%)
Diabetes mellitus	Number (%)	34 (53.1%)
Angina pectoris	Number (%)	63 (100%)
Previous myocardial infarction	Number (%)	41 (64.1%)
LV systolic dysfunction (EF<50%)	Number (%)	19 (29.7%)
Preoperative Euro Score	Mean (Standard deviation)	2.38% (±0,5%)

All patients undergo an elective CABG with arterial revascularization (LIMA to LAD in all of the 63 patients (100%). The operative details are given in table 2. In a relatively few patients – 2 (3.2%) an IABP has been used.

Figure 3

Table 2: Operative details and perfusion times

CABG performed	Number (%)	63 (100%)
Number of by-pass performed	Mean (Standard deviation)	3.57 (± 0.82)
'Jump' anastomosis to diagonal	Number (%)	54 (85.71%)
LIMA to LAD	Number (%)	63 (100%)
Days spent in ICU	Mean (Standard deviation)	2.2 (± 1.3)
Crossclamp (minutes)[1]	Mean (Standard deviation)	51.84 (± 15.74)
Perfusion (minutes)[1]	Mean (Standard deviation)	91.26 (± 29.84)
Reperfusion (minutes)[1]	Mean (Standard deviation)	37.36 (± 16.26)
Intraaortic balloon pump	Number (%)	2 (3.2%)

The mean values and standard deviations of QTd preoperatively (labeled 'A'), on the 1st ('B') and on the 5th ('C') postoperative days are presented in table 3 separately for QTd1 and QTd2.

Figure 4

Table 3: Mean values, standard deviations, minimal and maximal values for QTd. QTd1A and QTd2A Â– QTd measured preoperatively with both methods- QTd1 (the difference between the maximal and the minimal QT intervals) and QTd2 (the standard deviation between the QT intervals in all 12 leads); QTd1B and QTd2B Â– QTd measured on the 1 postoperative day with both methods; QTd1C and QTd2C - QTd measured on the 5 postoperative day with both methods. (QTd Â–QT interval dispersion)

	N	Mean	Std. Deviation	Minimum	Maximum
QTd1A	63	86.03	46.53	28	260
QTd1B	63	55.30	23.45	16	156
QTd1C	63	45.65	16.03	20	92
QTd2A	63	25.35	15.26	9.4	94.4
QTd2B	63	17.04	7.40	3.8	51.1
QTd2C	63	14.78	5.21	6.9	32.4

The mean QTd values are compared with Wilcoxon signed-rank test (a nonparametric alternative to a paired samples t-test) since the values are not normally distributed. Four pairs of comparisons are performed: the preoperative value for QTd is compared with that on the 1st and on the 5th postoperative day separately for QTd1 and QTd2 (QTd1A with QTd1B and QTd1C; QTd2A with QTd2B and QTd2C).

When QTd is measured as the difference between the maximal and minimal QT intervals – QTd1, if we compare the preoperative QTd with the QTd on the 1st postoperative day separately for each patient the results are as follows: QTd decreases postoperatively for 51 patients, increases for 8 patients and does not change for 4 patients. Then if we look at the comparison between the preoperative QTd with that on the 5th postoperative day the results are even more positive: a decrease in QTd postoperatively is observed in 56 cases, an increase – in 6 cases and equal values in 1 case.

With the second method used – QTd measured as the standard deviation for all 12 leads QT intervals, the results are similar. The comparison between the preoperative QTd and the QTd on the 1st postoperative day shows us that QTd decreases in 50 patients and increases in 13 patients. When the preoperative QTd is compared with the QTd on the 5th postoperative day than a decrease in the QTd is observed in 56 cases and an increase in 7 cases.

The significance values from the Wilcoxon signed-rank test for all four pairs of comparisons are small (< 0.001) which indicates that QTd postoperatively is significantly decreased compared with QTd preoperatively.

The values for QTd preoperatively and on the 1st and 5th postoperative day for each patient are presented graphically in fig. 1 for QTd1 and in fig. 2 for QTd2. From the graphics it is clearly seen that there is a uniform tendency for the preoperative QTd ('') to decrease on the 1st ('') and on the 5th ('◊') postoperative day.

Figure 5

Figure 1: Individual values for QTd1 measured preoperatively Â'?Â', on the 1 Â'?Â' and on the 5 Â'?Â' postoperative day. (QTd 1Â–QT interval dispersion Â– measured by the difference between the maximal and the minimal QT intervals)

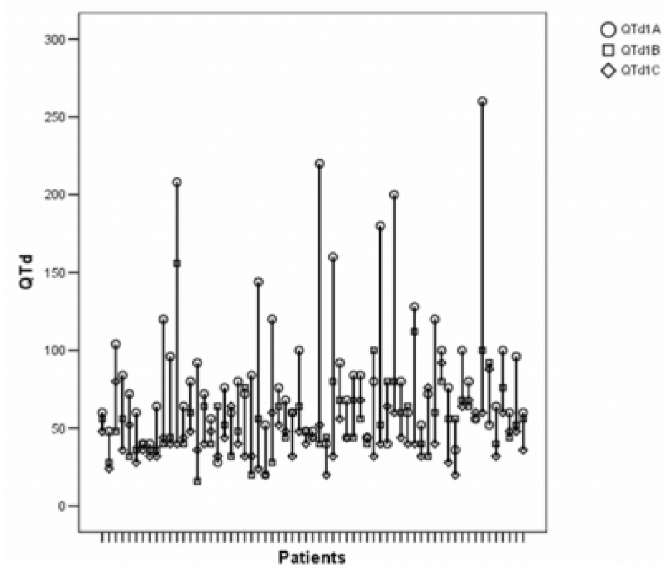


Figure 6

Figure 2: Individual values for QTd2 measured preoperatively Â‘?Â’, on the 1 Â‘?Â’ and on the 5 Â‘?Â’ postoperative day. (QTd2 Â–QT interval dispersion Â– measured by the standard deviation between the QT intervals in all 12 leads)

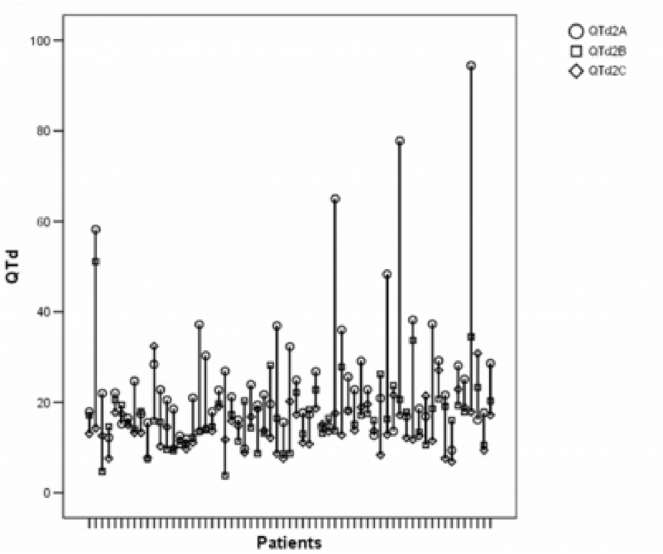
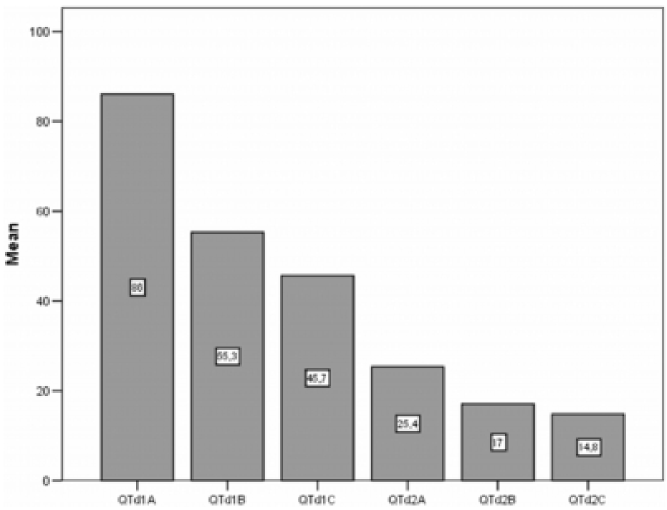


Figure 3 shows the mean values and the 95% confidence intervals (CI) for QTd1 and QTd2 preoperatively and on the 1 st and 5 th postoperative day. There is a gradual decrease for the mean QTd from the preoperative value, compared to the value on the 1 st postoperative day and to the value on the 5 th postoperative day separately for QTd1 and QTd2.

Figure 7

Figure 3: Mean values and 95% CI for QTd1 and QTd2. QTd1A and QTd2A Â– QTd measured preoperatively with both methods - QTd1 (the difference between the maximal and the minimal QT intervals) and QTd2 (the standard deviation between the QT intervals in all 12 leads); QTd1B and QTd2B Â– QTd measured on the 1 postoperative day with both methods; QTd1C and QTd2C - QTd measured on the 5 postoperative day with both methods.



DISCUSSION

Operative revascularization in CAD patients improves the quality of life, decreases the frequency of untoward cardiovascular events and increases life-span. The dispersion of the QT interval decreases in situations where an intervention undertaken is known to improve survival, such as fibrinolysis or percutaneous revascularization in the setting of acute myocardial infarction [6, 7]. It is expected therefore that CABG will lead to a decrease in QTd. A controversy exists however regarding the effects of coronary revascularization on ventricular repolarization in different studies.

In a study from a Polish group of authors [8] QTd is assessed 6 months and 2 years after CABG in 64 patients. There is a significant reduction in QTd postoperatively compared with the baseline QTd before intervention.

A similar positive result (a reduction in the postoperative QTd) is reported also following CABG and aneurismectomy [9].

However on the very early stages after CABG (on the 1 st postoperative day) the QTd shows a significant increase according to a study by Cagli et al., 2006 comprising 53 patients [10].

Comparing this results a question arises: Is there a discrepancy between the study results or is it an expected finding to have an early postoperative increase in QTd, followed later on by improvement of this marker.

This was an incentive to us to evaluate the changes in QTd (in regard to its baseline value) in the early postoperative days, following a successful coronary revascularization.

Our results show a significant and consistent decrease in QTd when the preoperative values are compared with that on the 1 st and on the 5 th postoperative day, no matter which method is used for QTd measurement – the difference between the maximal and minimal QT intervals or the standard deviation for the 12 leads QT intervals.

These findings are not in concordance with the results from the study by Cagli et al., 2006, which shows a worsening of the markers of ventricular repolarization in the early postoperative period [10].

The decrease in the QTd that we find in the early postoperative days confirms the results of other studies that report a significant reduction in QTd later postoperatively [8].

Immediate decrease in QTd following CABG could be explained with completeness of coronary revascularization. Normothermic perfusion and myocardial protection protocol also influence the early changes in ventricular electrical activity. Out of question these contradictory results for early postoperative QTd could be a casual finding or result of the small study groups (ours as well as in previously performed studies [8, 10]). Nevertheless the results from these 63 patients have given us a very highly significant ($p < 0.001$) reduction in QTd postoperatively, which have answered our question that it is not an expected finding to have a postoperative increase in QTd.

It should be noted that the number of studies that investigate the effect of coronary revascularization on ventricular repolarization is relatively small – a search in Pubmed and Medline results in 7 studies regarding the QTd changes perioperatively. Further investigation in this field is needed. Our future task is to study larger group of patients which will enable us to assess the effect of different procedures such as mitral valvuloplasty, aneurismectomy etc on ventricular repolarization. We contemplate also to evaluate the effects of perioperative complications on QTd and the prognostic significance of QTd for late postoperative complications and overall prognosis.

CONCLUSION

Successful coronary revascularization in ischemic heart disease patients leads to a significant improvement in markers of ventricular repolarization, expressed as a decrease in the dispersion of the QT interval.

CLINICAL IMPLICATIONS

Our study suggests that CABG improves ventricular repolarization. Therefore a decrease in the QTd should be expected postoperatively compared with its baseline value. An increase in the dispersion of repolarization should point to a complicated perioperative course and should focus the attention of the physician on this patient in order to treat or prevent if possible these complications.

LIMITATIONS

This is a retrospective study and therefore a selection bias cannot be excluded. As already said future studies with larger group are needed to take account for other operative procedures and perioperative complications, which were not a subject of the present study.

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