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Effect of Balloon Inflation-Induced Acute Ischemia on QT Dispersion during Percutaneous Transluminal Coronary Angioplasty

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Summary

Background: QT dispersion ($QTd = QT_{max} - QT_{min}$) measured as interlead variability of QT interval reflects the spatial inhomogeneity of ventricular repolarization times, and increased QTd may provide a substrate for malignant ventricular arrhythmias. Ischemia is associated with regional abnormalities of conduction and repolarization.

Hypothesis: This study aimed to investigate the effect of acute ischemia on QTd during successful percutaneous transluminal coronary angioplasty (PTCA).

Methods: Forty-three patients (10 women, 33 men, mean age 56 years) were enrolled in the study. Electrocardiogram (ECG) recordings were taken before PTCA and during balloon inflation period. QT maximum (QT_{max}), QT minimum (QT_{min}), and QTd ($QT_{max} - QT_{min}$) values were calculated from the surface ECG.

Results: There was no difference among QT_{max} values ($p = 0.6$). Mean QT_{min} during balloon inflation was lower than before PTCA (368 ± 45 vs. 380 ± 41 ms, $p = 0.002$). The difference between QTd values before and during balloon inflation was statistically important (65 ± 9 vs. 76 ± 10 ms, $p = 0.001$). This difference is caused by a decrease in QT_{min} during balloon inflation.

Conclusion: Acute reversible myocardial ischemia induced by balloon inflation causes an increase in QTd value, and this increment is the result of a decrease in QT_{min} interval. Therefore, QTd may be a marker of reversible myocardial ischemia.

Key words: percutaneous transluminal coronary angioplasty, acute ischemia, QT dispersion

Introduction

QT dispersion (QTd) measured as interlead variability of QT interval reflects the spatial inhomogeneity of ventricular repolarization times.[1–4] This inhomogeneity represents an important factor predisposing to ventricular arrhythmias.[5] The effects of acute ischemia and reperfusion on the homogeneity of ventricular repolarization have been studied extensively in animal models.[6, 7] Acute ischemia interferes with normal repolarization by changing action potential duration and conduction velocity[8] and can alter the QT interval and QTd.

In this study, we aimed to investigate the effect of acute ischemia on QTd during the balloon inflation period at percutaneous transluminal coronary angioplasty (PTCA).

Methods

Study Patients

Consecutive patients with clinically stable angina pectoris referred for elective PTCA were screened for inclusion in this study. Patients had symptomatic single-vessel coronary artery disease and no history of myocardial infarction (MI). Patients were excluded if they were taking drugs that modify the QT interval, had a congenital long QT syndrome, or had an intraventricular conduction delay or left ventricular hypertrophy. Patients undergoing atherectomy or stent implantation were also excluded.

Percutaneous transluminal coronary angioplasty was performed with standard approach. Nonionic contrast medium was used for all patients. Standard paper-based 12-lead electrocardiograms (ECGs) were recorded (all 12 leads simultaneously, Cardiotest EK53R, PPG Hellige, Freiburg, Germany) at a 50 mm/s paper speed before the first inflation (baseline) and then 60 s after intracoronary balloon inflation. Only recordings of the first inflation were used to avoid ischemic preconditioning. Patients without chest pain during the preprocedure (baseline) ECG were included in the study. Electrocardiograms were also excluded if the QT interval could not be measured accurately in at least six leads. QT intervals were measured

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manually from the onset of QRS to the end of the T wave, defined as a return to the T-P baseline. If U waves were present, the QT interval was measured to the nadir of the curve between the T and U waves. Four consecutive cycles in each of the 12 ECG leads were used to measure the QT interval, and then mean QT intervals were calculated. QT interval dispersion was defined as the difference between the maximal and minimal QT interval measurements occurring in any of the 12 leads on ECG. All ECG measurements were made by two experienced cardiologists who were blinded to the time they were obtained. Blinded inter- and intraobserver reproducibility of QT measurement was evaluated, and comparison revealed a Spearman correlation coefficient of 0.88 and 0.90, respectively ($p = 0.001$).

ST-Segment Changes

ST-segment deviation was measured at 60 ms after the J point. ST-segment elevation was considered significant when 1 mm ST-elevation occurred in two contiguous leads. ST-segment depression was considered significant when 1 mm ST depression occurred in two contiguous leads.

Statistical Analysis

For statistical analysis, the *t*-test and the Mann Whitney U test were used. Correlational analysis was performed by using the Spearmen rank correlation test. All data were presented as mean value ± standard deviation. A p value of < 0.05 was considered significant.

Results

Of the 62 patients screened for inclusion, 19 were excluded. The study group consisted of 43 patients (10 women and 33 men; mean age 56 ± 10, range 34–75 years). The coronary artery lesion involved the left anterior descending (LAD) coronary artery in 32 patients, the right coronary artery (RCA) in 5 patients, and the left circumflex artery (Cx) in 6 patients. During balloon inflation, ST-segment elevation in 4 patients, and ST-segment depression in 32 patients were seen, and 7 patients did not have ST-segment changes. No significant difference was found in heart rate values at baseline and during the balloon inflation period (68 ± 14 vs. 67 ± 15 beats/min, $p = 0.8$, Table I).

TABLE I Mean heart rate, QT_{max}, QT_{min}, and QT dispersion values

	Heart rate (beats/min)	QT_{max} (ms)	QT_{min} (ms)	QT dispersion (ms)
Before PTCA	68 ± 14	440 ± 38	380 ± 41	65 ± 9
During balloon inflation	67 ± 15	446 ± 20	368 ± 45	76 ± 10
p Value	0.8	0.6	0.002	0.001

Maximum QT values (QT_{max}) were 440 ± 38 ms before PTCA, 446 ± 20 ms during balloon inflation, and the difference was not significant ($p = 0.6$, Table I). Minimum QT values (QT_{min}) were found to be 380 ± 41 ms and 368 ± 45 ms, and difference between QT_{min} was significant ($p = 0.002$, Table I, Fig. 1). QT dispersion values were 65 ± 9 ms before PTCA and 76 ± 10 ms during balloon occlusion ($p = 0.001$, Table I, Fig. 2). There was no difference in QTd in patients developing ST-segment depression, ST-segment elevation, or in those without ST-segment changes (74 ± 11 ms; 76 ± 10 ms, and 75 ± 12, respectively; $p > 0.05$).

Discussion

The principal finding of our study is that QTd significantly increases during acute ischemia and that this increment is the result of a decrease in QT_{min} interval.

Percutaneous transluminal coronary angioplasty represents a suitable model of reversible acute ischemia and reperfusion since ECG recordings can be exactly timed with these events.[9,10] For determination of acute ischemia, several clinical and ECG parameters have been used.[9–15] The presence of QTd on the surface ECG is a marker of the dispersion of myocardial repolarization.[1,5,16,17] As is known, QTd is defined as

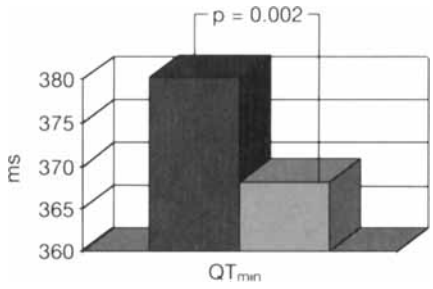

FIG. 1 Mean QT minimum values (before percutaneous transluminal coronary angioplasty and during balloon inflation). ■ = Before, ■ = during.

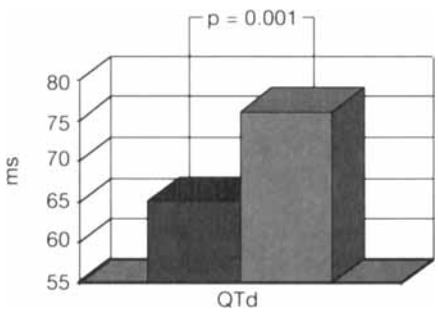

FIG. 2 Mean QT dispersion values (before percutaneous transluminal coronary angioplasty and during balloon inflation). ■ = Before, ■ = during.

the interlead difference between the longest and shortest QT interval on a standard ECG.[1, 16, 17] Increased QTd has also been shown to be a useful predictor of arrhythmia risk in patients with long QT syndrome, acute MI, cardiomyopathy, and heart failure.[17–21] Recent studies have also shown that QTd increases during stress test-induced ischemia in patients with coronary artery disease.[22, 23] In many studies, the effects of PTCA on QT_{max}, QT_{min}, and QTd were evaluated.[24–27] Pande *et al.*[9] and Tarabey *et al.*[27] found no significant change in QT_{max} interval in affecting leads during balloon inflation. However, the studies in patients with acute MI suggested that there was increased QT_{max} interval value during ischemia.[4, 28] During acute myocardial infarction, ischemia and many clinical factors, such as autonomic nervous system function, and hemodynamic factors affect the QT_{max}. This may explain the difference between QT_{max} in patients with acute MI and in those with acute ischemia during balloon inflation. In addition, we found no significant change in QT_{max} during balloon inflation-induced ischemia, and our finding is in agreement with Tarabey *et al.*[27] and Pande *et al.*[9] who observed no significant change in QT_{max} interval; hence, acute ischemia may not affect the QT_{max} interval.

Many studies showed QT_{min} was reduced by acute ischemia.[24, 25, 27] We found results very similar to these studies, that is, that QT_{min} during acute ischemia decreased. Our findings reported in this study also support the concept of increased QTd during acute ischemia and suggest that increased QTd is mainly caused by decreased QT_{min} interval. Also, in a similar manner, Tarabey *et al.*[27] and Michelucci *et al.*[24] found that shortening of QT_{min} in the affected leads was the main contributor to increased QTd during acute ischemia. In our study, increase in QTd was evident in all patients with or without ST-segment changes. In contrast to our study, Tarabey *et al.*[27] reported that increase in QTd was evident in patients with ST elevation but found no significant QTd change in patients with ST-segment depression. However, their results are conflicting because previous studies have shown QTd to increase during true positive stress test with ST-segment depression.[22, 23, 29, 30] Therefore, we suggest that QTd may increase in patients with ischemic ST-segment depression. Our findings are parallel with other studies that were performed in patients with induced ischemia.[22, 29, 30]

Because all of our patients had coronary artery disease, we found higher mean QTd before PTCA than those found in previous studies in normal populations,[31–33] a finding confirmed in other studies of patients with coronary artery disease.[5, 21, 32–34]

Our findings support the hypothesis that in acute ischemia induced during balloon inflation, some repolarization differences occur between normal and ischemic myocardium, and this may permit the development of a reentrant circuit permitting the development of ventricular tachycardia. Therefore, ischemia might result in an increase in QTd and in ventricular tachycardia or ventricular fibrillation.

It has been shown in a previous study that repeated balloon occlusions by ischemic preconditioning may cause reduction in QTd.[35] To avoid the effects of ischemic preconditioning, we did not use repeated balloon occlusion periods; measurements were taken only during the first balloon inflation period.

Conclusion

QT dispersion is increased by balloon inflation-induced acute ischemia, and this increment is due to a decrease in QT minimum value. Increased QT dispersion may be a simple and inexpensive marker of myocardial ischemia, and additional studies are necessary to define the clinical applicability of QT dispersion in the assessment of acute myocardial ischemia.

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