Earliest time of change in QT dispersion after stenting in patients with single vessel coronary artery disease

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Dispersion of the QT interval (QTd) is a measure of inhomogeneity of ventricular repolarization, and its prolongation may provide a suitable substrate for life-threatening ventricular arrhythmias. The present study was performed to determine the onset time of change in the corrected QT (QTc) interval and QTd in patients with stable angina and single vessel coronary artery disease. Electrocardiograms of 60 patients with successful stenting, obtained 1 h before and 1 h, 6 h, 12 h and 24 h after the procedure were analyzed. The QTc interval, QTc maximum, QTc minimum and QTd were measured. All electrocardiograms were scanned, and then underwent computer-based analysis. There was a significant reduction in the mean QTc interval as early as 12 h after the procedure

(from 474 ± 41 ms to 460 ± 31 ms; $P < 0.001$), which persisted to the 24 h follow-up. This was associated with a significant reduction in mean QT maximum (from 496 ± 31 ms to 418 ± 66 ms; $P < 0.001$) and a significant prolongation in mean QT minimum (from 403 ± 21 ms to 444 ± 12 ms; $P < 0.001$) at the same time intervals. Therefore, successful stenting of coronary arteries in patients with single vessel coronary artery disease and stable angina decreases QTd as early as 12 h after the procedure. This phenomenon may be the result of improved regional myocardial circulation, and reduced ischemia. A persistently low QTd in the following months may therefore have prognostic significance, and can be used as a noninvasive marker of stent patency. Further studies are necessary to define the clinical applicability of QTd in the assessment of long-term stent patency in such patients.

Key Words: Coronary artery disease; QT dispersion; QT interval; Stable angina

Dispersion of the QT interval (QTd) reflects the inhomogeneity of ventricular repolarization (1-3), and its prolongation can provide a substrate for inducing serious life-threatening ventricular arrhythmias and sudden death (4-6).

Although there are several reports concerning the effect of percutaneous transluminal coronary angioplasty (PTCA) on QTd in humans (7,8), few are available regarding the effect of stenting on QTd in patients with coronary artery disease (9). In addition, there are no data regarding the onset time of QTd changes after stenting. Therefore, we explored the latter in patients with single vessel coronary artery disease undergoing conventional stenting.

METHODS

Patients

The study group consisted of 60 consecutive patients having successful elective PTCA and conventional stenting for symptomatic (Canadian Cardiovascular Society class II stable angina pectoris [10]), one-vessel, major epicardial coronary artery disease.

All patients had severe, type A lesions in large, native coronary arteries suitable for stenting. Patients were excluded if they had a severely calcified lesion, were taking drugs that could modify the QT interval, had an intraventricular conduction delay, failed to have successful coronary artery PTCA and stenting, or had incomplete electrocardiographic (ECG) data.

Patients with anginal chest pain at the time of ECG recordings, and those who had complications such as recurrent ischemia, myocardial infarction or death within 24 h of the procedure were also excluded. All patients gave informed consent, and the study protocol was approved by the ethics committee of the institution.

Study protocol

Data regarding the patients' age, sex and medications were recorded. In addition, the dilated artery and severity of the lesion before and after stenting were determined for all participants.

ECG analysis

Standard 12-lead ECGs, at a paper speed of 25 mm/s, were obtained 1 h before stenting and 1 h, 6 h, 12 h and 24 h after the procedure. All ECGs were scanned by a Canon scanner (Canon USA, Inc), and computer-based analysis was performed by two independent physicians, who were blind to the timing of the ECGs and patients' data. The RR, QRS and QT intervals were measured in sinus rhythm, in each of the 12 leads, according to standard recommendations (11,12). The average of the QT intervals of three consecutive beats in each ECG lead was considered the final QT interval.

QTd was defined as the difference between the maximum and minimum QT intervals observed in any of the 12 leads on

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TABLE 1
Corrected QT interval (QTc) and QT dispersion measured in 60 patients with single vessel coronary artery disease 1 h before, and 1 h, 6 h, 12 h and 24 h after primary stenting

QTc interval	1 h before	1 h after	6 h after	12 h after	24 h after
Mean	474±41	474±38	474±38	460±31*	460±36
Mean dispersion	62±12	61±19	61±18	42±17*	42±17
Maximum dispersion	71±14	71±14	71±14	49±21*	49±12
Minimum dispersion	29±17	29±17	29±17	36±12*	36±18

Data presented as mean ± SD. All values measured in ms. *P<0.001

a standard ECG. QT intervals were then corrected for the heart rate using Bazett's formula:

$$QT_c = \frac{QT}{\sqrt{RR}}$$

Subsequently, the corrected QTd was calculated and analyzed. In addition, the minimum QTd (QT min) and the maximum QTd (QT max) were calculated as the difference between the minimum and maximum QTc interval before and after stenting, respectively.

Coronary angiography, angioplasty and stenting

Coronary angiography was performed using the Judkins technique from the right femoral artery. The American Heart Association and American College of Cardiology guidelines (13) were used for assessment of the coronary lesions in multiple views.

A 6 Fr guiding catheter was used for all patients, and a 0.014 in guide wire was used to pass through the lesions. Balloon dilation with a pressure of 8 atm was performed, and subsequently, the stent was deployed. Angiographic success was defined as a residual diameter stenosis of less than 30% after balloon implantation. Acetylsalicylic acid (325 mg/day) and ticlopidine (500 mg/day), or clopidogrel (75 mg/day) were given to all patients after the termination of the procedure. Cardioactive medications were not discontinued for stenting.

Statistical analysis

All descriptive data are reported as mean ± SD. A paired *t* test was used for comparison of the data at different time intervals. P<0.05 was considered significant.

RESULTS

Study patients

Sixty patients who had successful, uncomplicated PTCA, and stenting with adequate ECG data, satisfied the entry criteria for the present study. There were 31 men and 29 women (mean age ± SD 55±13 years), and none had a previous myocardial infarction.

Coronary anatomy

A coronary arterial lesion was identified in the left anterior descending artery in 44 patients (73.3%), in the right coronary artery in 11 patients (18.3%) and in the left circumflex artery in five patients (8.3%). No significant wall motion abnormality was detected by left ventricular angiography.

Figure 1 Mean ± SD corrected QT (QTc) interval dispersion measured in 60 patients with single vessel coronary artery disease 1 h before stenting, and 1 h, 6 h, 12 h and 24 h after the procedure. ns Nonsignificant

QTd in the entire group

The mean QTc interval and the QT min, QT max and mean dispersions 1 h before and during subsequent recordings up to 24 h are shown in Table 1. A significant reduction in QTc interval was noted as early as 12 h after the procedure, which persisted to the 24 h follow-up (P<0.001) (Figure 1). There was a significant reduction in the mean QT max (from 496±31 ms to 418±66 ms; P<0.001), and a significant prolongation in the mean QT min (from 403±21 ms to 444±12 ms; P<0.001).

DISCUSSION

Our findings included a significant reduction in QTc interval following a successful stenting, as early as 12 h after the procedure and persisting to the 24 h follow-up.

This reduction in the QT interval seemed to be partly due to an increase in the minimum QT interval, because the minimum QT interval measured before stenting was significantly shorter than the minimum QT interval measured 12 h after stenting. It has been shown that QTd increases during stress test-induced ischemia in patients with coronary artery disease (14) and during balloon inflation-induced acute ischemia at the time of PTCA (15,16). During acute ischemia, the action potential duration decreases (17). The lengthening of the minimum QT interval following successful stenting could indicate the recovery of the action potential duration in the previously ischemic zone of the myocardium in our patients. However, concomitant shortening of the maximum QT interval was also noted after stenting. Variable results have been seen in the degree of maximum QT changes during PTCA. Yunus et al (8) and Pande et al (18) found no significant change in the maximum precordial QT interval, while Nowinske et al (7) reported prolongation in seven patients and shortening in another two patients. Further studies are needed to explain the exact underlying reasons for these clinical observations.

Clinical implications

There are no reliable noninvasive markers of significant restenosis after stenting. Neither the patients' symptoms nor

the findings of exercise tolerance tests can always predict restenosis. Because increased QTd may act as a simple indicator of myocardial ischemia, it seems wise to have a baseline ECG as early as 12 h after any successful stenting for comparison with subsequent follow-up ECGs, and correlation with patients' symptoms.

The present study has certain limitations. The number of our patients was rather small. In addition, we did not have a control group with unsuccessful stenting, or follow-up angiograms to assess the stent patency in the participants. Thus, we could not assess the sensitivity, specificity and the predictive value of our findings. Therefore, the present study should be considered preliminary, and further larger, well-designed, long-term studies

should be performed to assess the predictive value of QTd on stent patency.

CONCLUSION

Successful stenting of coronary arteries in patients with single vessel disease and stable angina decreases QTd as early as 12 h after the procedure. This phenomenon may be the result of improved regional myocardial circulation and reduction in ischemia. A persistently low QTd in the following months may therefore have prognostic significance, and can be used as a noninvasive marker of stent patency. Further studies are necessary to define the clinical applicability of QTd in the assessment of long-term stent patency in such patients.

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