QT dispersion on ECG Holter monitoring and risk of ventricular arrhythmias in patients with dilated cardiomyopathy

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*ABSTRACT: **Background.** QT dispersion (QTd) is increased in patients with dilated cardiomyopathy. Increased QTd has been associated with the risk of sudden death. We studied: a) the relation between QTd on 12-lead ECG and QTd-ECG Holter; b) the relation between QTd apex (QTda) and QTd end (QTde) on ECG Holter and the risk of ventricular arrhythmias in patients with dilated cardiomyopathy.*

***Methods and Results.** 65 patients with dilated cardiomyopathy (33 idiopathic and 32 post-ischemic etiology; NYHA II-III) were studied. We divided the patients into: Group A -patients with not-sustained ventricular arrhythmias-; and Group B -patients without arrhythmias-. A significant direct correlation between QTd calculated from 12-lead ECG and from ECG Holter was found in all patients. QTda/24h was not significantly different in the two groups (Gr.A 59.9±7.8 msec vs Gr.B 53.6±8.4 msec p=ns) while QTde/24h was significantly higher in Group A (Gr.A 81.9±5.9 msec vs Gr.B 44.5±6.8 msec; p<0.005). In post-ischemic etiology (32 pts; 17 with arrhythmias) the correlation between QTde/24h and ventricular arrhythmias was confirmed (Gr.A 81.4±7.8 msec vs Gr.B 42.6±6.2 msec p<0.002).*

***Conclusions.** ECG Holter recordings can evaluate QTd as well as the QTd on 12-lead ECG.*
An increased QTde/24h seems to be correlated with the occurence of ventricular arrhythmias in patients with dilated cardiomyopathy and can then be a useful tool to select patients at high risk for sudden death. (Heart International 2006; 2: 33-8)

KEY WORDS: QTdispersion, ECG-Holter, Ventricular arrhythmias, Dilated cardiomyopathy, Sudden death

INTRODUCTION

The QT dispersion (QTd) is the difference between QT max and QT min on the surface ECG and corresponds to the time between the beginning of depolarization and the end of repolarization: it is a marker of inhomogeneity in ventricular refractoriness. QTd in normal subjects varies from 20 to 40 msec (1), but other authors have proposed 65 msec (2).

QTd prognostic value regarding the risk of life-threatening ventricular arrhythmias is not fully established in post-myocardial infarction patients (3). An increased QTd value has been associated with the risk of sudden death in patients with idiopathic dilated cardiomyopathy (4, 5). Other studies suggest that QTd seems to have poor prognostic value regarding arrhythmic mortality in advanced heart failure (6), and in nonischemic dilated cardiomyopathy (7).

Therefore QTd could be a prognostic marker of tachyarrhytmic events but it is still unclear whether this applies to patients with idiopathic dilated cardiomyopathy or after a myocardial infarction.

In dilated cardiomyopathy and coronary artery disease, repolarization is abnormal, thus the differences in measured QTd can be influenced by variations in projection of the T wave loop, in particular the end of the T wave. Several methods consider the apex of the T wave as a fiducial point of the ventricular repolarization (8), but it does not really represent the end of the repolarization of *all* the myocardial cells (9). It is, therefore, interesting to calculate both QTapex dispersion (QTd**a**) and QTend dispersion (QTd**e**) for a better evaluation of the arrhythmic risk in these patients.

Aim of the present study was to evaluate:
– the relation between QTd on 12-lead ECG and on Holter monitoring;
– the relation between QT dispersion on 24 hour Holter ECG and the occurence of ventricular arrhythmias in a population of patients with idiopathic or post-ischemic dilated cardiomyopathy.

MATERIALS AND METHODS

Study population: Sixty-five consecutive patients (48 men, 17 women; mean age 59±5 years; NYHA class II-III), 33 with idiopathic dilated cardiomyopathy (IDC) and 32 with post-ischemic dilated cardiomyopathy (PIDC), underwent: 12-lead ECG, 24-hour Holter recordings and transthoracic echocardiography (TTE). The study was performed with the subjects' consent.

Inclusion criteria: All patients were on sinus rhythm; absence of complete bundle branch block at 12-lead ECG was required. All patients were free from antiarrhythmic drugs. Ejection fraction at TTE less than 35% was considered cut-off for inclusion.

Control group: Forty-five normal subjects (31 men) with a mean age of 46±12 years, without any finding of cardiovascular disease at medical examination, with a normal 12-lead ECG and free from any drugs, underwent Holter recording (Tab. I).

Holter recordings were analyzed using Elatec System. The recordings were performed using three orthogonal bipolar leads (3-OL) X,Y and Z. The X lead (horizontal plane) was positioned at the 4th intercostal

space on the two mid-axillary lines; the Y lead (frontal plane) immediately under the right clavicle and on either the upper leg or left iliac crest; the Z lead (sagittal plane) at the 4th intercostal space (V2 position) and posteriorly on the left side of the vertebral column. Positive electrodes were respectively left, inferior and anterior. The ECGs were corrected for artifacts and templates adjusted if necessary. The Elatec Holter System (Ela Medical, France) (10) calculates the mean QT intervals over 30-second periods over 24 hours.

The software analyzes QT apex intervals determining the peak of the T wave: it fits a parabola through >20 microvolt samples of a window following the QRS complex. The end of the T wave is defined by the point of intersection of the maximal T wave deflection with the ECG baseline. Several Holter studies of ventricular repolarization mostly considered the Q to T apex interval because of problems in automatic identification of the end of the T wave (6, 9, 10). In this study we used a software to identify the end of the T wave in a simple way, after correcting for artifacts (Figs. 1, 2).

Using this software (11) we measured QT apex intervals (QT**a**: time between the onset of QRS and the apex of the T wave); QT end intervals (QT**e**: time between the onset of QRS and the end of the T wave); QTapex and QTend dispersion on Holter ECG (QTd**a**/24 h and QTd**e**/24h: mean value of all 2880 QTd measurements-one every 30 seconds- over 24 hours).

TABLE I

| | Study population | | |
	IDC	PIDC	NS
Number	33	32	45
Age (years)	56±9	57±4	46 ±12
LV EF (%)	24±7	25±8	–
LVDd (cm)	6.7±1.8	6.6±2.1	–
Anti-arrhythmic drugs	0	0	0

LV EF = Left Ventricular Ejection Fraction
LVDd = Left Ventricular Diastolic diameter
IDC = Idiopathic Dilated Cardiopathy
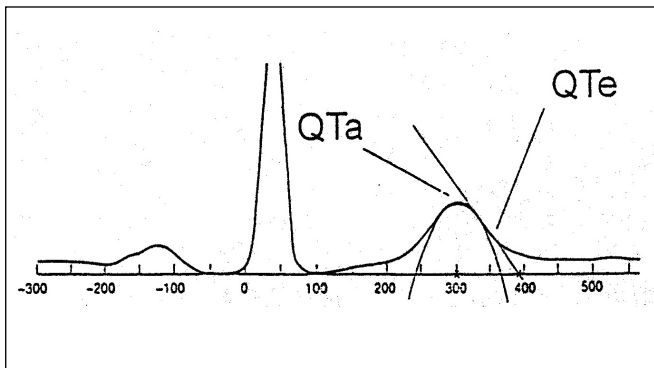PIDC= Post-Ischemic Dilated Cardiopathy
NS = Normal Subjects

Fig. 1 - *Determination of QT apex: the peak of the T wave is defined by a parabola through the samples following the QRS complex. Determination of QT end: the end of the T wave is the point of baseline-intersection of a tangent drawn to the maximum of the T wave deflection.*

Fig. 2 - *Determination of the peak and of the end of the T wave.*

We also calculated QTd**a** and QTd**e** on 12-lead ECG in all patients. QTd was measured manually on 12-lead ECG. All the values of QT and QTd were corrected for heart rate.

Statistical analysis

All data are expressed as mean ± standard deviation. The statistical analysis was performed with Student's t-test and the linear correlation co-efficient r. A two tailed p value <0.05 was considered statistically significant. To examine the predictors of ventricular arrhythmias we used a multivariate regression analysis.

RESULTS

In the control group no significant difference was found in QTd**e** and QTd**a** when calculated on 12-lead ECG and on Holter monitoring (QTd**e** on 12-lead ECG: 37.4±11.9 msec VS QTd**e** on Holter ECG: 43.4±19.4 msec p=ns); (QTd**a** on 12-lead ECG: 38.4±22.4 msec VS QTd**a** on Holter ECG: 41.3±17.6 msec p= ns).

In the study population no significant difference was found between QTd**e** calculated from 12-lead ECG (mean values 65.4±8 msec) and from Holter recordings (62.4±20.4 msec). QTd**a** values showed a greater difference (mean values 73.5±9.9 msec vs 56.3±7.5 msec).
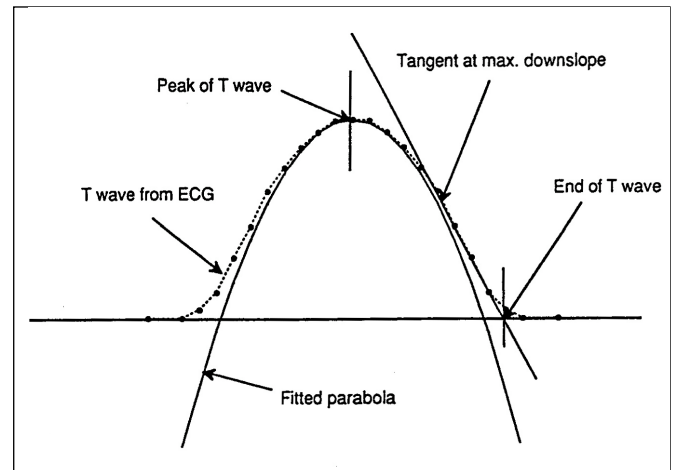
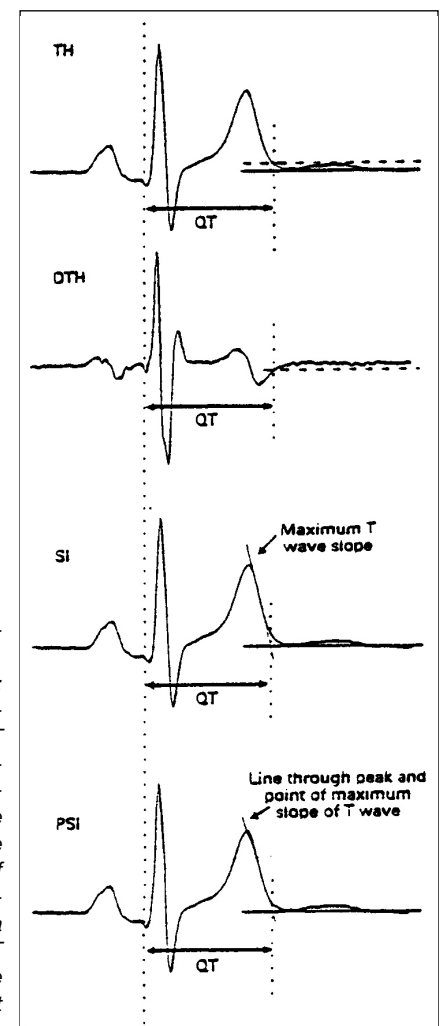In the second part of the study we divided the 65 pa-

Fig. 3 - *Main automatic QT measurement. From top to bottom: threshold method applied to the original T wave (TH) or to its differential (DHT); tangent method to the steepest point of the descending limb of the T wave (SI); tangent method with a line through the T wave peak and the maximum slope point (PSI).*

TABLE II

	PIDC + IDC (65 pts)	NS (45 pts)
QTde 12-lead ECG	65.4±8 msec* 3	7.4±11.9 msec°
QTde ECG Holter	62.4±20.4 msec*	43.4±19.4 msec°
QTda 12-lead ECG	73.5±9.9 msec #	38.4±22.4 msec •
QTda ECG Holter	56.3±7.5 msec #	41.3±17.6 msec •

* p=ns °p=ns • p=ns # p <0.05
PIDC = Post-Ischemic Dilated Cardiopathy
IDC = Idiopathic Dilated Cardiopathy
NS = Normal Subjects
ns= not significant

TABLE III

PIDC+IDC patients (65 pts)		
	Group A (31 pts)	Group B (34 pts)
QTda/24h	59.9±7.8 msec*	53.6±8.4 msec*

* p=ns r= 0.89

PIDC+IDC patients (65 pts)		
	Group A (31 pts)	Group B (34 pts)
QTde/24h	81.9±5.9 msec #	44.5±6.8 msec #

# p<0.005 r= 0.45

PIDC = Post-Ischemic Dilated Cardiopathy
IDC = Idiopathic Dilated Cardiopathy
Group A = patients with ventricular arrhythmias
Group B = patients without venticular arrhythmias
ns= not significant

TABLE IV

PIDC+IDC patients (65 pts)		
	Group A (31 pts)	Group B (34 pts)
QTda/12lead ECG	75.1±3.2*	72.1±2.9*

* p=ns r=0.83

PIDC+IDC patients (65 pts)		
	Group A (31 pts)	Group B (34 pts)
QTde/12 lead ECG	78.6±4.1 #	62.6±5.3#

p= <0.05 r= 0.52

PIDC = Post-Ischemic Dilated Cardiopathy
IDC = Idiopathic Dilated Cardiopathy
Group A = patients with ventricular arrhythmias
Group B = patients without venticular arrhythmias
ns= not significant

TABLE V

PIDC patients (32 pts)		
	Group A (17 pts)	Group B (15 pts)
QTda/24h	59.8±4.6*	56.7±3.2*

* p=ns r=0.93

PIDC patients (32 pts)		
	Group A (17 pts)	Group B (15 pts)
QTde/24h	81.4±7.8 msec #	42.6±6.2 msec #

# p<0.002 r= 0.49

PIDC = Post-ischemic Dilated Cardiopathy
Group A = patients with ventricular arrhythmias
Group B = patients without ventricular arrhythmias
ns= not significant

tients into 2 groups: a) those with not-sustained ventricular arrhythmias on Holter recordings (Group A: 31 patients, 48%); b) those without ventricular arrhythmias (Group B: 34 patients, 52%).

We found that QTda/24h in group A was not significantly different from QTda/24h in group B (mean values: 59.9±7.8 msec vs 53.6±8.4 msec). On the other hand QTde/24h in group A was significantly higher than QTde/24h in group B (mean values: 81.9±5.9 msec vs 44.5±6.8msec p<0.005) (Tabs. III-IV).

When we considered the subgroup with post-ischemic dilated cardiomyopathy (PIDC; 32 patients), 17 patients were included in group A (53%) and 15 in group B (47%). In post-ischemic patients the correlation between QTde/24h and ventricular arrhythmias was confirmed (81.4±7.8 msec in patients with arrhythmias vs 42.6±6.2 msec in patients without arrhythmias p<0.002). We also confirmed the absence of correlation between QTda/24h and arrhythmias in post-ischemic patients (Tab. V).

By *multiple regression analysis* QTd**e**/24h on Holter monitoring and QTd**e** on 12-lead ECG were only weakly predictive of ventricular arrhythmias in the overall study group and in the two subgroups (cut off values: >60 msec for QTd**e**/24h, p=0.05; >65 msec for QTd**e** on 12-lead ECG, p=0.06), while the other parameters (QTd**a**/24h and QTd**a** on 12-lead ECG) were not predictive.

DISCUSSION

Our study suggests and confirms (4,5) that QTd evaluated by Holter recordings (indicating temporal variability in QT dispersion interval) can provide the same information as QTd evaluated by 12-lead ECG (indicating the spatial variability in QTd). So the 24-hour Holter monitoring offers the opportunity to evaluate the temporal variability rather than the previously well-studied spatial variability in QT interval dispersion. Moreover the Holter recordings have the advantage of speeding-up and making the calculation easier as compared to the 12-lead method (10-12).

Several Holter studies of ventricular repolarization mostly considered the Q to T apex interval because of problems in automatic identification of the end of the T wave (6, 9, 14). In our study we used a software that allowed us to identify the end of the T wave in a simple way.

Comparing Holter and 12-lead ECG the correlation was stronger with QTd**e** rather than QTd**a**. These results stress the importance of the end of the T wave for the evaluation of repolarization heterogeneities, in particular in patients with dilated cardiomyopathy: in this population the end of the T wave provides some more information about repolarization than in normal subjects, as confirmed by various authors (13-16).

When we evaluated the episodes of ventricular arrhythmias we found that an increased QTd**e**/24h was more strongly correlated with the evidence of arrhythmias on Holter ECG: this correlation was even stronger in post-ischemic patients in whom QTd is highly influenced by variations in projection of the T wave loop due to ischemia. On the other hand, we found no significant differences in QTd**a**/24h in patients with or without arrhythmias in general population and in post-ischemic group.

The late repolarization contained in the end of the T wave is important for identification of disorders of QT interval and T wave in pathological situations such as idiopathic dilated cardiomyopathy and myocardial ischemia as suggested by other authors (16, 17). Myocardial ischemia can prolong QT interval and QT dispersion: the heterogeneities of spatial repolarization are increased and the arrhytmic risk is higher (18, 19).

These preliminary data allow us to conclude that the QTd**e**/24h can give other important information about the inhomogeneity of myocardial repolarization also in patients with dilated cardiomyopathy and myocardial ischemia. In our opinion an increased QTd**e**/24h seems to be useful to evaluate the risk of ventricular arrhythmias in patients with dilated cardiomyopathy.

The main limitation of our study is the lack of prognostic information on the patients' follow up so that we did not provide an association between the outcome and the predictors of events: our principal aim was to compare QTd on Holter and ECG and to compare QTd**e** with QTd**a.** Moreover, normal subjects did not undergo complete cardiac evaluation to exclude occult disease.

CONCLUSIONS

Holter recordings can evaluate QTd (in particular QTd end) as well as the 12-lead ECGs and has the advantage of speeding-up and making the calculation easier.

QTd **end**/24h seems to be better than QTd **apex**/24h (and at least similar to QTd **end**/12–lead ECG) for the evaluation of disorders in ventricular repolarization and is more useful in identifying patients at higher risk of ventricular arrhythmias.

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