Relationship Between QT Dispersion and a Heart Failure Survival Score

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Abstract

We assessed the relationship between QT dispersion and a heart failure survival score (HFSS). 12-lead ECGs were recorded to computer during 18 cardiac transplant assessment sessions on 17 patients. The HFSS was calculated for each subject from clinical data. QT intervals were measured manually and by an automatic technique. HFSS ranged from 6.27 to 9.80, with 5 assessments classified as low risk (HFSS $\geq$ 8.1), 7 classified as medium risk (7.2 < HFSS < 8.1) and 6 classified as high risk (HFSS $\leq$ 7.2). Dispersion measured manually ranged from 29 to 92 ms with mean (range) for the low, medium and high risk groups of 47 (29-59), 49 (35-61) and 60 (32-92) ms respectively. There were no significant differences between risk groups with manual measurement. Biphasic and ST offsets presented measurement difficulties for automated measurements.

1. Introduction

QT dispersion is considered an indicator of susceptibility to risk of sudden death due to arrhythmias [1]. Patients referred for cardiac transplant assessment are a highly vulnerable group and dispersion has been shown to be large in these subjects. Manual measurement of dispersion is difficult in this subject group due to the large numbers of immeasurable leads [2]. QT dispersion has been proposed as a marker of the risk of death for those awaiting heart transplantation [3]. The heart failure survival score (HFSS) is a validated multivariable index for predicting mortality in patients awaiting a heart transplant [4]. The index classifies patients into low, medium and high risk groups based on a range of clinical measurements.

Our aim was to see if there is a link between QT dispersion and the HFSS by comparing dispersion for groups of patients classified as low, medium and high risk on the transplant waiting list. We assessed manual and automated measurement of QT dispersion.

2. Method

2.1. Patients and data collection

The patient group comprised 17 subjects (1 female) mean age 52 years (range 44 to 64 years) referred to the Cardiothoracic Centre of Freeman Hospital for cardiac transplant assessment and placed on the transplant waiting list. One patient underwent assessments on two separate occasions providing 18 data records. 11 patients had ischaemic cardiomyopathy and the remainder dilated cardiomyopathy.

At each assessment a 12-lead ECG was recorded to computer at a sample rate of 500 Hz and amplitude resolution of 4.88 μV using an ECG amplifier (bandwidth 0.05 - 100 Hz, gain 1000) and AT-MIO-16E-10 (National Instruments Corporation) data acquisition card.

2.2. HFSS

The HFSS was calculated from clinical data routinely collected during assessment. The formula is [4,5]:

$$HFSS = \left| \sum_{i=1}^{7} c_i d_i \right|$$

where c_i are coefficients and d_i the clinical variables as specified in Table 1. Coronary artery disease (CAD), resting heart rate (HR) and left ventricular ejection fraction (LVEF) were the three variables found to have the greatest influence on the HFSS [4].

2.3. QT measurement

The QT intervals of 3 serial beats in each lead were measured. Leads with T amplitudes less than 100 μV and leads for which QT interval could not be measured manually were excluded from the analysis. Subjects with fewer than 4 measurable leads were excluded. Dispersion was calculated from the range of QT for each beat and the mean of the 3 beats was used in the analysis.

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2.3.1. Manual measurement

QT was measured manually using interactive QT measurement software which has been described previously [2]. Single leads were displayed on a computer screen at an equivalent paper speed of 70 mm/s and amplitude scale of 25 mm/mV. Q wave start and T wave end points were identified manually using a mouse to control a cross hair on the screen.

Table 1. Clinical variables and coefficients used for HFSS [4]

i	Coefficient (c)	Clinical variables (d)
1	+0.6931	coronary artery disease (yes = 1, no = 0)
2	+0.6083	intraventricular conduction delay (yes = 1, no = 0)
3	-0.0464	left ventricular ejection fraction (%)
4	+0.0216	heart rate (beats/min)
5	-0.0470	sodium concentration (mmol/l)
6	-0.0255	mean arterial blood pressure (mm Hg)
7	-0.0546	peak oxygen uptake (ml/min/kg)

2.3.2. Automatic measurement

Automatic measurement used a threshold on the QRS gradient to identify QRS start, and the intersection of the T wave downslope with the isoelectric baseline was used to detect T wave end points. Detected QRS and T wave end points were confirmed by visual inspection of these points as displayed by the detection software. Any end points measured from the wrong T wave slope were removed from the analysis.

3. Results

3.1. HFSS

The HFSS classified 6 patients as high risk, 7 patients as medium risk and 4 patients (5 assessments) as low risk. Figure 1 shows the HFSS for each assessment in low, medium and high risk groups. The percentage number of patients with CAD, and values of HR and LVEF are shown in Figure 2.

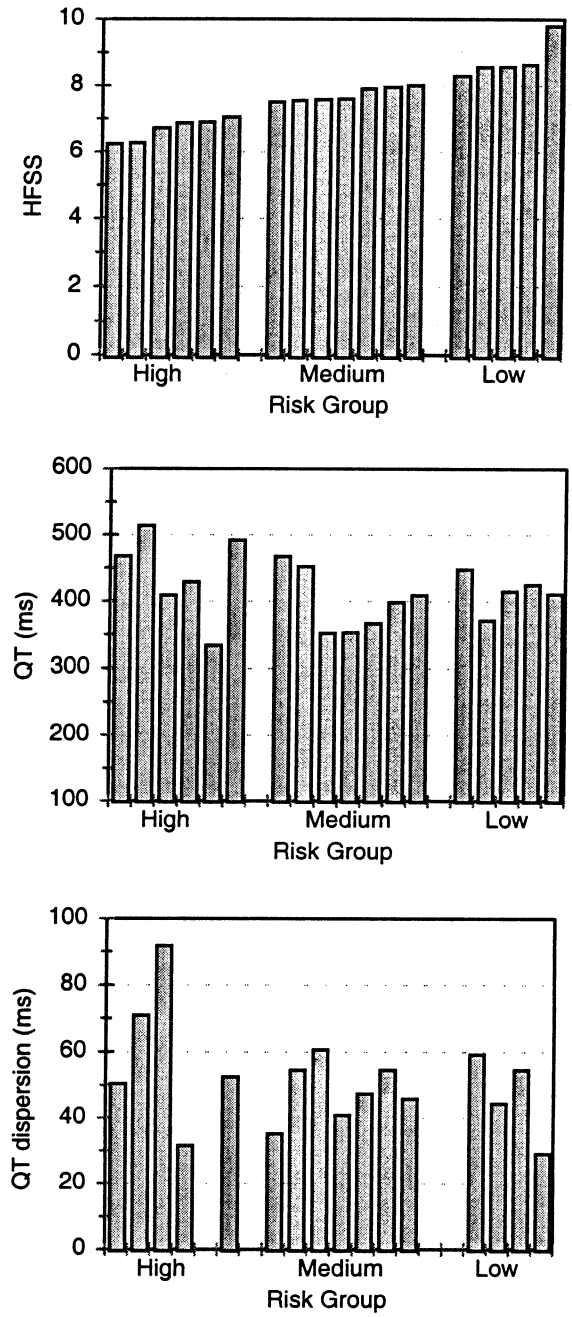

Figure 1. HFSS, QT and QT dispersion for each assessment separated into risk groups.

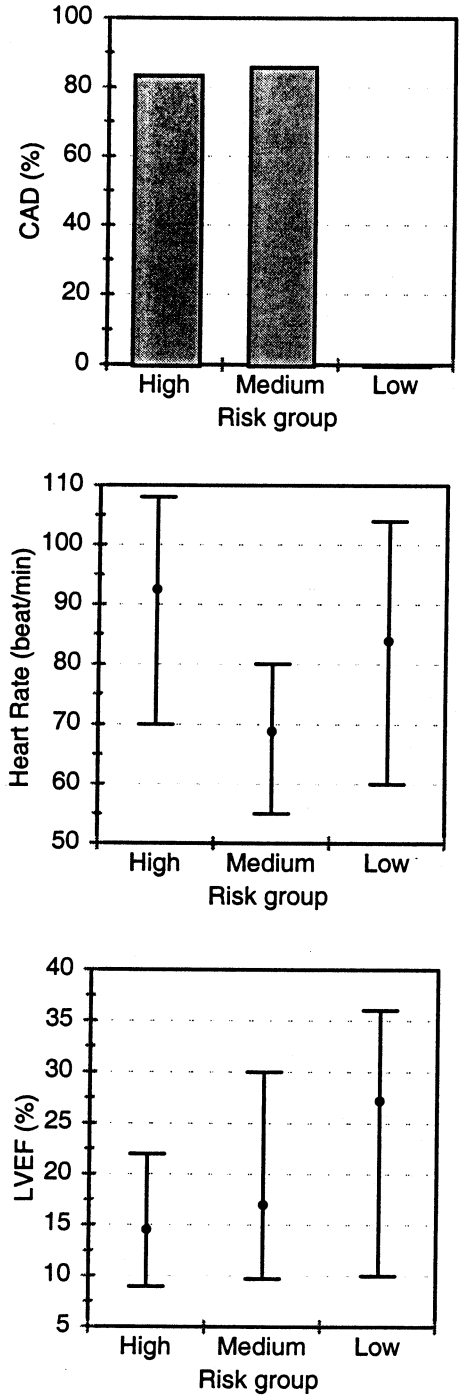

Figure 2. The three most important clinical variables of the HFSS for each risk group. The percentage of patients with CAD, and group mean and range of HR and LVEF are shown.

3.2. QT measurement

There were a large number of excluded leads with an average (range) of 7 (2-9) measurable leads in each subject. Two patients, one from the low risk and one from the high risk group, had fewer than 4 measurable leads and were excluded from the analysis. Figure 3 shows the number of leads analysed per subject in each of the risk groups. QT for each subject is shown in Figure 1.

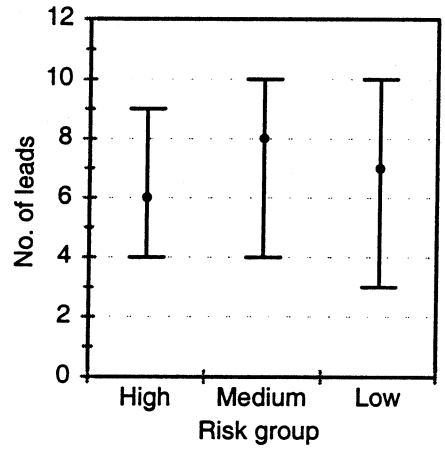

Figure 3. The number of measurable leads per subject in the different risk groups. Mean and range are shown.

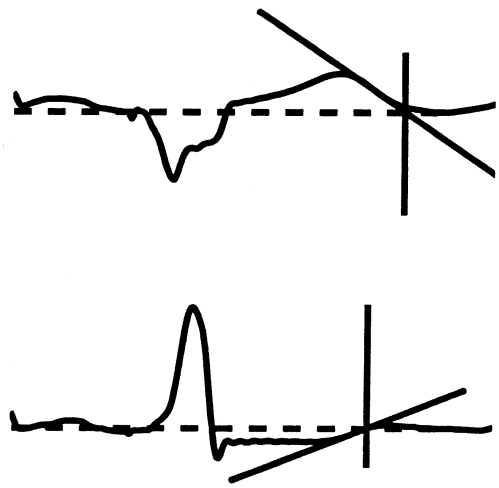

Figure 4. Automated QT measurement. ST depression gave short QT.

3.3. QT dispersion

3.3.1. Manual QT dispersion

Mean (range) QT dispersion measured manually for the high risk group was 60 (32 - 92) ms, for the medium risk group 49 (35 - 61) ms and for the low risk group 47 (29 - 59) ms (Figure 1). Differences between risk groups were not significant (Kruskal-Wallis $p > 0.05$).

3.3.2. Automatic QT dispersion

Difficulties in automatic measurement resulted from detection of T wave end points from the wrong T wave slope. This was particularly a problem in leads with ST depression, and this was found to influence the automated measurements (Figure 4). Such leads had short QT and were eliminated from the analysis. Further development of the algorithms for automatic measurement is necessary.

4. Discussion and conclusion

Manual measurement of QT dispersion has been shown to be difficult in patients listed for cardiac transplantation [2]. We have compared dispersion measurements with a validated risk index and found no significant difference in dispersion between risk groups when measured manually. The automated measurements also gave rise to measurement difficulties, mainly due to ST segment offsets and biphasic T waves, and further work will need to be carried out to fully assess the benefits of automated measurements in these patients. Preliminary results suggest that automated measurements will provide greater discriminating power compared with manual measurements in this patient group as has been demonstrated in other patient groups [6].

Acknowledgements

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