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Measurement of the QT interval

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Introduction

Ventricular repolarization is reflected by the T-wave of the surface electrocardiogram, the QT interval being the time taken for ventricular recovery.

QT measurement has assumed clinical importance as prolongation is associated with a variety of conditions including the Romano–Ward[1] and Jervell–Lange–Neilson[1] syndromes, drug toxicity[2] and an adverse prognosis following acute myocardial infarction.[3]. The QT interval is also modified by physiological factors, including heart rate[4–6] and catecholamine release[4–6]. The QT interval is commonly corrected (QTc) using one of a variety of formulae to normalize the measurement to a specific heart rate, usually 60 beats per minute[7].

Surprisingly little attention has been paid to the methods of QT measurement. Over how many cardiac cycles should it be measured? Should the cycles be consecutive or be chosen at random? Which ECG leads should be used? If in the context of acute myocardial infarction, is the QT in an ECG lead reflecting infarction different from those leads without changes of infarction?

In most electrocardiographic leads, the onset of the QRS complex is easily defined, but identifying the end of the T-wave may be less reliable particularly in the presence of low amplitude T-waves, bifid T-waves and U-waves.

Despite these problems and despite a lack of cellular electrophysiological correlates, the QT interval remains an accessible and potentially important electrocardiographic measurement. Re-evaluation of measurement methodology is essential to provide a standard for the many studies investigating the relevance and clinical association of QT interval abnormalities.

QT measurement criteria

Table 1 indicates current published recommendations regarding the choice of electrocardiographic leads for QT measurement[8–12] but not infrequently, measurement techniques are not detailed[13–16]. The mean of three consecutive measurements from standard lead II is used frequently in clinical practice. Schamroth[8] suggests that the QT should be measured in a lead with an initial Q-wave and cites aVL as particularly suitable, the U-wave in this lead usually being isoelectric. QT measurement in the ECG lead with the most distinctive T-wave is proposed by Friedberg[10] and Friedman[11]. They[10,11] and Blake[12] recommend that the relevant QT interval is the longest that can be measured, implying QT evaluation in multiple leads of the surface electrocardiogram.

Table 1 QT Measurement literature recommendations

Lead showing initial Q-wave	Schamroth 1982 [8]
Lead in which T is most distinct	Friedman 1977 [9] Friedberg 1966 [10]
AVL where U-wave is usually isoelectric	Schamroth 1982 [8] Hamer 1978 [1]
Lead in which QT is longest	Blake 1972 [12] Friedman 1977 [9] Friedberg 1966 [10]
No specification	Braunwald 1980 [13] Hurst 1982 [14] Chung 1980 [15] Goldman 1979 [16]

This report concerns an investigation of QT interval measurement in all 12 leads of the standard electrocardiogram.

QT measurement in 12 leads of the electrocardiogram

METHODS

A total of 101 electrocardiograms were recorded from 32 survivors of acute myocardial infarction who

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had been managed in Freeman Hospital, Newcastle upon Tyne. The patients were consecutive recruits to a double-blind randomized post-myocardial infarction study of oral sotalol[17]. This paper does not address differences between those patients who received active sotalol and those who did not.

ECG recordings at 50 mm paper speed were made on a three-channel ECG recorder prior to entry in the study, at one month, at three months and at six months after enrolment.

ECG data points were input by a digitizer and stored and processed by a PDP 11/34 computer. The points entered (Fig. 1) represented measurement of

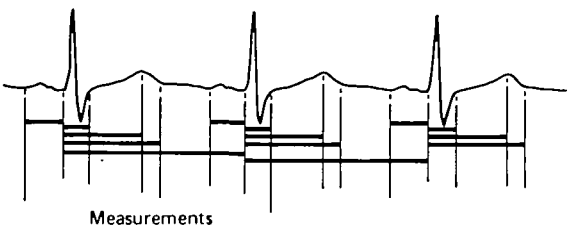

Figure 1 Diagram representing the 15 points digitized for each ECG lead. These points provided three PR measurements, three QRS measurements, three Q to apex T (QTa), three Q to end of T (QTe) and two cycle length measurements.

three PR intervals, three QRS duration intervals, three QT apex (QTa) intervals, three QT end (QTe) intervals and two cycle lengths. Each electrocardiographic lead was measured individually. ECG leads of inadequate technical quality for measurement were flagged and those leads showing changes of infarction were identified.

Results

The following results relate to QTe measurements.

TECHNICAL QUALITY

Overall

Of the 1212 ECG leads, 486 were unsuitable for QTe measurement and in five of the 101 electrocardiograms, none of the 12 leads was of adequate quality.

QTe and site of infarction

Of ECGs reflecting inferior myocardial infarction, 73% (38 of 52) had six or less ECG leads unsuitable for QTe measurement compared with 66% of patients with anterior myocardial infarction (27 of 41) who had seven or more unusable leads. This difference is statistically significant ($P < 0{\cdot}02$) (Fig. 2).

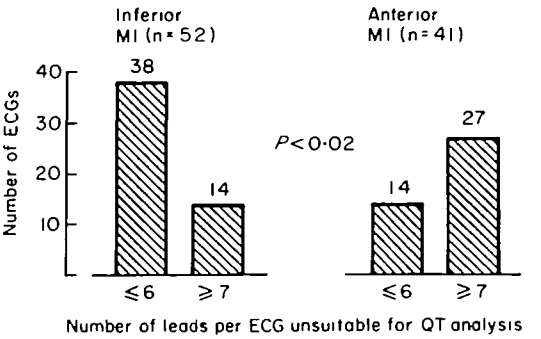

Figure 2 Comparison of number of leads per ECG unsuitable for QT analysis related to inferior and anterior myocardial infarction.

MAXIMUM MEASURABLE QTe (QTe_{max})

In 60 of the 101 electrocardiograms, QTe measurement in lead II was impossible. In seven of the 41 remaining ECGs (17%) QTe_{max} was in lead II. The lead most frequently containing QTe_{max} was V4 (23%) (Fig. 3). QTe_{max} was in V leads 2, 3 or 4 in 58% of ECGs whilst QTe_{max} was contained in any V lead in 70% of ECGs.

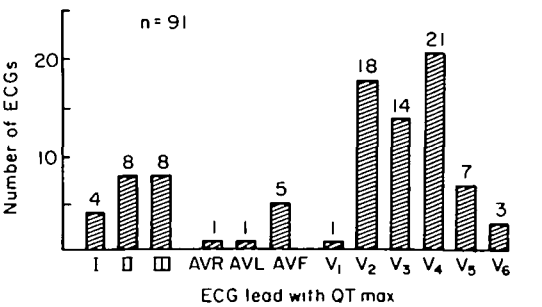

Figure 3 The frequency with which any ECG lead showed the QT maximum is depicted in this figure. It can be seen that in the majority of cases that the QT maximum lay between V_2 and V_4 with V_4 representing the peak frequency of QT maximum.

QTe_{max} AND SITE OF MYOCARDIAL INFARCTION

In 29 of 36 (81%) ECGs with anterior infarction and 35 of 47 (74%) with inferior infarction, QTe_{max} occurred in leads I, aVL, or V_{1-4} (P = NS). Thus no relationship between QTe_{max} and ECG site or myocardial infarction was found.

Conclusions

Standardization of QT interval measurement is long overdue. Even the simplest aspects such as choice of lead for measurement have been inadequately investigated. This study shows that in many ECG leads, the end of the T-wave is poorly defined. If, as would seem reasonable, the QTe_{max} is the relevant measurement, then the QT must be estimated in multiple leads. Standard lead II, a lead frequently used in clinical practice proved very unreliable for QT measurement and when measurement was possible only rarely did this lead reflect QTe_{max}.

We had considered it possible that the site of myocardial infarction would influence QTe measurement but QTe_{max} was found to be independent of this aspect.

Our results indicate that QTe measurements should be performed in all 12 electrocardiographic leads to define the QTe_{max}. If through constraints of time or ECG data availability, as for instance in electrocardiographic monitoring or 24 h ECG recording, only a single lead is available for analysis, then this should be a central V lead (V_2–V_4) rather than a standard limb lead.

These preliminary observations related to QTe measurement methodology form a basis for further investigations which should include the relevance of QTa to QTe measurements and the applicability and value of rate related correction formulae.

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