New formula for evaluation of the QT interval in patients with left bundle branch block

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BACKGROUND Left bundle branch block (LBBB) and QT prolongation both are associated with a worse prognosis. LBBB lengthens the QT interval. To date it is not known whether QT prolongation during LBBB differs in repolarization from QT prolongation during narrow QRS.

OBJECTIVE The purpose of the present proof-of-concept-study was to develop a formula that allows comparison of the adjusted QT interval during LBBB with reference values and thereby allows interpretation of the QT interval irrespective of QRS widening.

METHODS Sixty consecutive patients with sinus rhythm (SR) and narrow QRS underwent electrophysiologic study for ablation. In all patients, the intrinsic QRS ,QT, and JT times were measured during SR, and ventricular pacing from both the right ventricular apex (RVA) and the right ventricular outflow tract (RVOT) caused LBBB. We determined prolongation of the QT during as compared to SR (ΔQT). ΔQT was then divided by the QRS length during pacing QRS (QRSb). This describes the percentage of the QRS duration at LBBB, which must be subtracted from the measured QT (QTb) to determine the modified QT interval (QTm).

RESULTS The ratio of ΔQT to paced QRS was calculated as 48.3% (RVA) and 48.8% (RVOT) (mean 48.5%). The ratio intrinsic of JTi to paced JT was 1.0055 (RVA) and 1.0087 (RVOT). There was no significant difference in intrinsic JT vs paced JT ($P = .2$).

CONCLUSION Right ventricular pacing causes prolongation of the QT due to a paced LBBB without prolongation of the JT time. In our study, we showed that QT prolongation caused by LBBB constitutes 48.5% of the QRS width. This is the value that must be subtracted from the measured QT in LBBB in order to estimate the modified QT. Thus, the resulting formula for "modified QT" estimation in LBBB is QTm = QTb – 48.5% * (QRSb).

KEYWORDS QT formula; Left bundle branch block; QT interval; JT interval; QT prolongation; Long QT

ABBREVIATIONS **JTb** = paced JT interval; **JTi** = intrinsic JT interval; **LBBB** = left bundle branch block; **QRSb** = paced QRS interval; **ΔQT** = paced QT interval minus intrinsic QT interval; **QTb** = paced QT interval; **QTc** = corrected QT interval using the Bazett formula; **QTm** = modified QT interval; **RVA** = right ventricular apex; **RVOT** = right ventricular outflow tract; **SR** = sinus rhythm; **X** = quotient of ΔQT and QRSb

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Introduction

Various cardiovascular and noncardiovascular drugs prolong ventricular repolarization and thereby induce significant prolongation of the QT interval.[1] A prolonged QT interval increases the risk of arrhythmias, that is, polymorphic ventricular tachycardia of the torsades de pointes type, especially when an additional risk factor such as bradycardia or low potassium is present.[2]

Analysis of the QT interval in narrow QRS complex requires adjustments for heart rate, which is regularly used in the clinical setting.[3] In addition, modifications for gender have been suggested but are not used regularly.[4] The importance of the amount of QT lengthening for cardiovascular risk stratification has been demonstrated in large populations.[5,6]

The presence of left bundle branch block (LBBB) independently increases all-cause mortality in patients with dilated cardiomyopathy.[7] In addition, LBBB prolongs the QT interval and thereby impedes precise interpretation of the measured values. Retrospective analyses of patient cohorts comparing patients having LBBB with healthy individuals have suggested that the JT interval can be used for risk

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Table 1 Electrophysiologic characteristics

Procedure	No. of patients
Electrophysiologic study for evaluation of syncope	6
Idiopathic premature ventricular contractions	7
AV nodal reentrant tachycardia	23
Paroxysmal atrial fibrillation	14
Right atrial flutter	10
Total	60

stratification if the QT interval is significantly prolonged due to LBBB.[8] However, the influence of conduction prolongation due to LBBB on the QT interval measured on the surface has not yet been investigated in the same individuals.

The aim of the present electrophysiologic study was to develop a formula that allows estimating the adjusted QT interval during LBBB.

Methods

Study patients and ECG analysis

Sixty consecutive patients with sinus rhythm (SR) and narrow QRS who underwent routine electrophysiologic study or ablation were included in the study (Table 1). The study conformed to the Guiding Principles of the Declaration of Helsinki. All electrophysiologic parameters were acquired during standard electrophysiologic examination. All patients provided informed consent to electrophysiologic study. In all patients, a diagnostic catheter was consecutively positioned in the right ventricular apex (RVA) and the right ventricular outflow tract (RVOT) to stimulate 10 ms below the SR cycle length, causing LBBB (Figure 1). The intrinsic QRS and QT time/JT time (QTi/JTi) were measured during SR and subsequent ventricular pacing. The QT interval was measured on the lead presenting the longest interval according to current recommendations,[4] usually V_2 or V_3. A tangent was used for accurate determination of the QT interval.[9]

Prolongation of the QT interval and QRS duration during ventricular pacing compared to SR (ΔQT [paced QT interval minus intrinsic QT interval] and QRSb [paced QRS interval]) were determined. Then ΔQT was divided by QRSb to obtain the percentage of the QRS duration at LBBB, which was subtracted from the measured QT interval, to determine the modified QT interval (QTm) (Figure 2).

Statistical analysis

Continuous data are presented as mean ± SD. Data were entered into a computerized database (Microsoft Excel, Microsoft Corp, Redmond, WA) and tested for normal distribution using the Shapiro-Wilk test. The Student *t* test was used to determine differences between groups. $P < .05$ (2-sided) was considered significant.

Results

In SR, mean QRS duration was 84 ± 10 ms with an intrinsic QT interval of 352 ± 31 ms. Stimulation from RVA increased QRS duration to 158 ± 18 ms and QT interval to 429 ± 33 ms ($P < .05$). Stimulation from RVOT increased QRS duration from 84 ± 11 ms to 158 ± 21 ms and QT interval from 350 ± 31 ms to 428 ± 37 ms ($P < .05$). Thus, ΔQT was 76 ± 16 ms (RVA) and 78 ms ± 19 (RVOT), respectively (P = NS).

The ratio of ΔQT/QRSb was calculated as 48.3% (RVA) and 48.8% (RVOT) (mean 48.5%). The correlation between ΔQT and QRSb was significant ($P < .001$, correlation coefficient 0.78 and 0.82).

The intrinsic JT interval was not significantly changed by stimulation from the RVA (268 ± 31 ms vs 269 ± 30 ms) or RVOT (266 ± 31 ms vs 268 ± 32 ms).

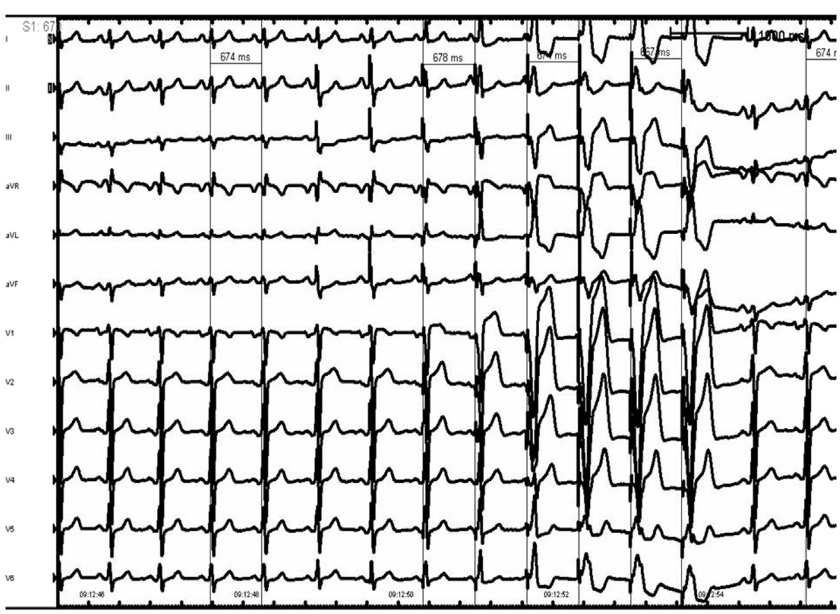

Figure 1 Twelve-lead ECG of the stimulation maneuver to induce left bundle branch block. Taking the basal cycle length (CL) into account as depicted on the *left* side of the ECG (674 ms), stimulation starts with a CL just above the basal CL with minimal decrements until LBBB is achieved.