Is there an "Adequate" Heart Rate Correction for QT?

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Introduction

- Length of the QT interval correlates with length of RR interval
- Therefore a correction should be applied
- BUT: corrections that don’t take out correlation = INAPPROPRIATE

\[ \text{QT}_{\text{end}} \text{ vs } \text{RR} \]

\[ \text{QT}_{\text{B}} \text{ vs } \text{RR} \]

Bazetts correction
Comparison of RR-Intervals between 5min und 10sec resting ECG recordings (Example I)
Comparison of RR-Intervals between 5min und 10sec resting ECG recordings (Example II)
There are MANY QT-RR models & correction formulas  
→ No one is uniformly best!

<table>
<thead>
<tr>
<th>Model</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>( QT_C = QT + \alpha \cdot (1 - RR) )</td>
</tr>
<tr>
<td>Hyperbolic</td>
<td>( QT_C = QT + \alpha \cdot (1 / RR - 1) )</td>
</tr>
<tr>
<td>Parabolic</td>
<td>( QT_C = QT / RR^\alpha )</td>
</tr>
<tr>
<td>Logarithmic</td>
<td>( QT_C = QT - \alpha \cdot \ln(RR) )</td>
</tr>
<tr>
<td>Logarithmic (shifted)</td>
<td>( QT_C = \ln(e^{QT} + \alpha \cdot (1 - RR)) )</td>
</tr>
<tr>
<td>Exponential</td>
<td>( QT_C = QT + \alpha \cdot (e^{RR} - 1) / e )</td>
</tr>
</tbody>
</table>

Malik M, et al. Relation between QT an RR intervalls is highly individula among healthy subjects[...]. Heart 2002, 87, 220-228
Corrections are not universal

**Solution**

- Individual correction parameters
  - More data necessary (e.g. baseline ECGs)
  - Increased demand of resources (workload, budget)

Reproducibility of QT-Interval Analysis

QT-Interval is stable over 2 days

Therefore QT-Interval measurements derived on day –1 (baseline before drug administration) may be used to determine individual correction parameters


Abbildung 3: Ergebnisse der QT-Analyse im 24-Stunden-Holter-EKG bei Patienten mit koronarer Herzerkrankung und stabiler Angina pectoris bei Aufzeichnung an 2 aufeinanderfolgenden Tagen unter einer Therapie mit 10 mg/d Bisoprolol oder 40 mg/d Nifedipin retard.
Individual Parameters

An example of parameters for the linear model

\[ QT = \beta + \alpha \cdot RR \]

Note: there seems to be a difference between men (●) and women (○).

Velislav N. Batchvarov, et. al. QT-RR relationship in healthy subjects exhibits substantial inter subject variability and high intra subject stability.
Circadian Cycle of QT-Interval by Gender

- Clear day-night cycle of QTc with a 5 to 10 msec difference
- Female QTc is consistently longer than males by approximately 25 msec
QT-Reporting Requested By Guideline ICH-E14

ICH-E14:

• „apply the most accurate correction available“
• QT, QTcB, QTcF, RR
• Summary statistics
  – Mean
  – Median
• Categorical
  – QTc>450, QTc>480, QTc>500
  – Change (\(\delta\)QTc) of more than 30ms, 60ms
Summary

• There is no universal QT-RR correction model

• Individual correction parameters improve correction performance in terms of consistently eliminating the RR influence

• The sympathovagal balance is a crucial issue
  – Can not be assessed by 10sec resting ECGs

• Longer ECG recording traces (>5 min) are needed for stable RR and QT interval estimation

• Modelling RR with QT should be preferred to correction
THE END – IS THIS A NORMAL ECG ???

NO!
This is Lyme’s Disease!

Thanks for your attention
Literature

Gastaldelli A, et. al. :“Insulin prolongs the QT interval in Humans“, Am J Physiol Regulatory Integrative Comp Physiol