Evaluation of QT Correction Formulas Based on Electrocardiograms from Population Studies

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QT/QTc Interval

Heidelberg, 17.-18.11.2005
Evaluation of QT Correction Formulas

Background

- **Cardiac arrhythmias** cause up to 50% of sudden cardiac death.
- Little knowledge about the specific conditions that trigger the situation any one individual
- Development of severe cardiac rhythm disturbances and cardiac mortality is associated with a prolonged QT interval
ECG-Signatures: Definition

QRS:
Excitation

QT:
Excitation + Repolarization
QT interval and correction for heart rate

QT/QTc Interval
QT correction according to Bazett

\[ QTc = QT \times \left( \frac{60}{\text{heart rate}} \right)^{1/2} \quad [\text{ms}] \]

\[ RR = \left( \frac{60}{\text{heart rate}} \right) \times 1000 \quad [\text{ms}] \]

\[ QTc = QT \times \left( \frac{RR}{1000} \right)^{1/2} \quad [\text{ms}] \]
QT correction formulae

Bazett: \[ QT_c = QT \times RR^{1/2} \]

Fridericia: \[ QT_c = QT \times RR^{1/3} \]

Framingham: \[ QT_c = QT + 0.154 \times (1000 - RR) \]

Nomogram: \[ QT_c = QT + 0.116 \times (1000 - RR) \text{ if } RR > 1000 \]
\[ QT_c = QT + 0.156 \times (1000 - RR) \text{ if } 600 < RR < 1000 \]
\[ QT_c = QT + 0.384 \times (1000 - RR) \text{ if } RR < 600 \]
Towards Optimisation of QT Correction for Heart Rate

Objective

- To identify the best fit of QT-RR relation considering four known QT correction formulae using computerized ECG measurement derived from
  - a population-based survey and
  - a population-based follow-up
### Time table of the Monica Project Augsburg.

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Survey and follow-up ECG data used for QT and QTc interval evaluation

GSF – MONICA/KORA Study Group
Population-based studies in Southern Germany

Study region
- City of Augsburg and two surrounding rural districts
- Population register covers about 530,000 persons

GSF – MONICA/KORA Study Group
Monica Augsburg Surveys: ECG examination and data collection

- Twelve lead resting ECG
- 1st record: Survey 1984/85
- 2nd record: Follow-up 1987/88
- N = 3299

Computerized ECG Analysis
Advantages

- Expert knowledge
- Reproducibility of the analysis
- Electronic storage of measurement and interpretation for
- Statistical analysis

→ Valid Phenotyping
QT distribution (N=3299)

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Heart rate distribution (N=3299)

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<table>
<thead>
<tr>
<th>Variable</th>
<th>m (ms)</th>
<th>s (ms)</th>
<th>$R_{sd}^2$</th>
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<tbody>
<tr>
<td>QT</td>
<td>383.6</td>
<td>26.5</td>
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<tr>
<td>QTc (Bazett)</td>
<td>401.8</td>
<td>21.4</td>
<td>0.35</td>
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<tr>
<td>QTc (Cubic Root)</td>
<td>395.4</td>
<td>18.5</td>
<td>0.49</td>
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<tr>
<td>QTc (Framingham)</td>
<td>395.8</td>
<td>18.2</td>
<td>0.53</td>
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<tr>
<td>QTc (Nomogram)</td>
<td>397.1</td>
<td>17.9</td>
<td>0.54</td>
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</table>
The benefit of different QT correction formulae

✓ Inter-individual differences
  → Survey data (1st ECGs)

? Intra-individual differences of QT intervals
  →→ Follow-up data (1st vs. 2nd ECGs)
Follow-up: QT changes vs. RR changes (N=3)

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QT and QTc intervals: 1st vs. 2nd measurement (N=3299)

Best fit?

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Distributions of QT and QTc Differences: 2\textsuperscript{nd} - 1\textsuperscript{st} measurement

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<table>
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<tr>
<th>2\textsuperscript{nd} – 1\textsuperscript{st} measurement of variable</th>
<th>m (ms)</th>
<th>s (ms)</th>
<th>$R_{ic}^2$</th>
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<td>QTc (Bazett)</td>
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<td>0.36</td>
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<tr>
<td>QTc (Cubic Root)</td>
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<td>13.8</td>
<td>0.57</td>
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<tr>
<td>QTc (Framingham)</td>
<td>0.4</td>
<td>13.9</td>
<td>0.56</td>
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<tr>
<td>QTc (Nomogram)</td>
<td>0.6</td>
<td>13.6</td>
<td>0.58</td>
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Summary and Conclusion

• Correction of the QT- Interval for heart rate reduces the variance of the QT interval
  - cross-sectionally on a population-based scale
  - individually (follow-up)

• The QT correction formulas according to the Nomogram method, according to the Framingham study and also according to Fridericia are significantly superior to Bazett’s formula.

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References (1)

Bazett HC. An analysis of time relations of the electrocardiogram. *Heart* 1920;7: 353- 70


Karjalainen J, Viitasalo M, Mänttäri M, Manninen V. Relation between QT intervals and heart rates from 40 to 120 beats/min in rest electrocardiograms of men and a simple method to adjust QT interval values. JACC 1994, 23(7): 1547-53

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References (2): GSF publications based on investigations of the QT interval (2004-2005)


Towards Optimisation of QT Correction for Heart Rate

References (3)


Evaluation of QT Correction Formulas

Vielen Dank!

QT/QTe Herbstworkshop, Heidelberg, 17.-18.11.2005
Siegfried Perz