

A Comparison of Commonly Used QT Correction Formulae: The Effect of Heart Rate on the QTc of Normal ECGs

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Abstract: The corrected QT interval (QTc) is widely used in pharmaceutical studies and clinical practice. Bazett's QT correction formula is still the most popular, despite Simonson's warning in 1961 that it could not be recommended. Other QTc formulae, e.g. Fridericia, Framingham, and Hodges, are also used. This study compares these four formulae using 10,303 normal ECGs recorded from four US hospitals. QT intervals were measured by the same computer program on ECGs confirmed by physicians. The distributions of QTc based on Fridericia, Framingham, and Hodges formulae were similar but Bazett's was significantly wider. The global group QTc-heart rate (HR) correlation coefficients were calculated as Bazett 0.33, Fridericia 0.24, Framingham 0.26, and Hodges 0.11, with the uncorrected QT-HR correlation being 0.82. Overall by far, Hodges QTc is significantly less correlated with HR compared to the others. Certain subgroup correlations of gender and low, mid, or high HR show that one individual formula can out-perform the others, whereby automated selection of QT correction formula based on the patient's HR and gender could be implemented as another option in products. The upper normal limits of corrected QTc were determined by excluding the top 2% from the global distribution charts as follows: Bazett 483 ms, Fridericia 460 ms, Framingham 457 ms, and Hodges 457 ms. Whether for males and/or females, the middle range of HR from 60 to 99 bpm has similar upper normal limits of QTc for all formulae except Bazett. Numerous references recommend 420 to 440 ms as the threshold for reporting prolonged QTc when using Bazett's formula. Based on this database, 30% of apparently normal ECGs would be reported as having abnormal QT intervals for the 440 ms threshold, or 10% if 460 ms is chosen, compared to <2% for the other formulae. It was also noted that QT has a linear trend with HR but not with RR. **Key words:** QT interval, QT correction formula, heart rate, Bazett, Hodges.

The QT interval varies with the heart rate (HR) as is well known: normally the faster the HR (or the

shorter the RR interval), the shorter the QT interval, and vice versa. For this reason, numerous clinical investigators have attempted to "correct" the QT interval to a value QTc which might be expected if the HR had been 60 beats per minute (bpm).

The corrected QT interval has clinical significance and is widely used in pharmaceutical studies and clinical practice. For example, it is affected by various clinical conditions, including electrolyte ab-

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0022-0736/04/370S-0030\$30.00/0

doi:10.1016/j.jelectrocard.2003.08.030

normalities, antiarrhythmic drug effects, myocardial ischemia or infarction with deep T wave inversion, bradyarrhythmias, hypothermia, myocarditis, etc (1,2).

There are numerous QT correction formulae that have been developed for research studies and clinical assessment with a variety of approaches being used in view of the complex relationship between QT interval and HR (or RR interval). Bazett's formula is still the most popular in clinical practice, research, and education (1–7) despite Simonson's warning in 1961 and many others since then that it should not be recommended (8–11). Other approaches used to adjust QT for HR, like the Fridericia, Framingham, and Hodges formulae, are also popular in the field (11–14). There is increasing research interest in QT correction for each individual's ECG (10,11). This approach is impractical for routine clinical ECG recording and is not considered further in this study. The hypothesis, therefore, is that the relationship between QT and HR can be mathematically or statistically described by a formula and applied to the general population. This assumption does not exclude the formula being HR and gender dependent.

Investigations eventually resulting in this paper originated from the situation that Burdick electrocardiographs only offered a single QTc calculation based on a "hardwired" formula. Some end users expected a QTc value based on either their most familiar or preferred formula, which might or might not be the same as that used by the manufacturer. Some customers even directly requested the company (Burdick) to provide options for QTc values calculated by several commonly-used QT correction methods so that they could have a choice based on their specific requirements.

Based on the review of a few commonly used QT correction formulae, this study was designed to 1) determine a default formula for our ECG products in expectation of a relatively better performance, 2) find out the upper normal limits for each QT correction formula and whether there might be any difference, and 3) investigate gender-specific performance when heart rates vary from low to high.

Materials and Methods

QT Correction Formulae

Four commonly used formulae were selected for the study, namely:

1. Two nonlinear formulae where the RR interval is in seconds:

Bazett (15,16)

$$QTcB = QT (HR/60)^{1/2} = QT (RR)^{-1/2}$$

Fridericia (17)

$$QTcFri = QT (HR/60)^{1/3} = QT (RR)^{-1/3}$$

2. A linear function of RR where the RR interval is in milliseconds

Framingham (18)

$$\begin{aligned} QTcFr &= QT + 154 (1 - 60/HR) \\ &= QT + 0.154 (1000 - RR) \end{aligned}$$

3. A linear function of HR where the RR interval is in seconds

Hodges (19)

$$\begin{aligned} QTcH &= QT + 1.75 (HR - 60) \\ &= QT + 105 (1/RR - 1) \end{aligned}$$

All 4 formulae are functions of two variables, namely the QT measurement value and HR or RR. They are presented here in a generalized form as follows:

$$QTcX = f(QT,HR) = G(QT,RR)$$

where X represents a specific author. This can be geometrically described by a 3-dimensional curved surface above the plane of HR and QT. The (bird's eye) two-dimensional views of the surfaces with pseudo-colors are used to compare the 4 formulae (Fig. 1).

Further, the 3-D surface can also be viewed as a set of infinite spatial lines. If one particular line (or corrected QTc curve) is projected onto the HR-QTc plane, it is possible to compare all four 2-D HR-QTc curves in a plane as shown in Figure 2. When a QT measurement is obtained, the corrected QT value is a function of HR.

Study Population

The basic study population was collected from 4 US hospitals over 1 to 2 years, including 2 large teaching hospitals on the west coast and a southwestern state as well as 2 medium-sized community hospitals in the midwest and east central region. Twelve-lead ECGs were acquired by Burdick Eclipse carts, then transferred and stored in SCP format in each hospital's Pyramis database management systems. Prior to the 2003 HIPPA deadline, agreements were made with the hospitals to utilize backup tapes of their databases for our de-identified studies.

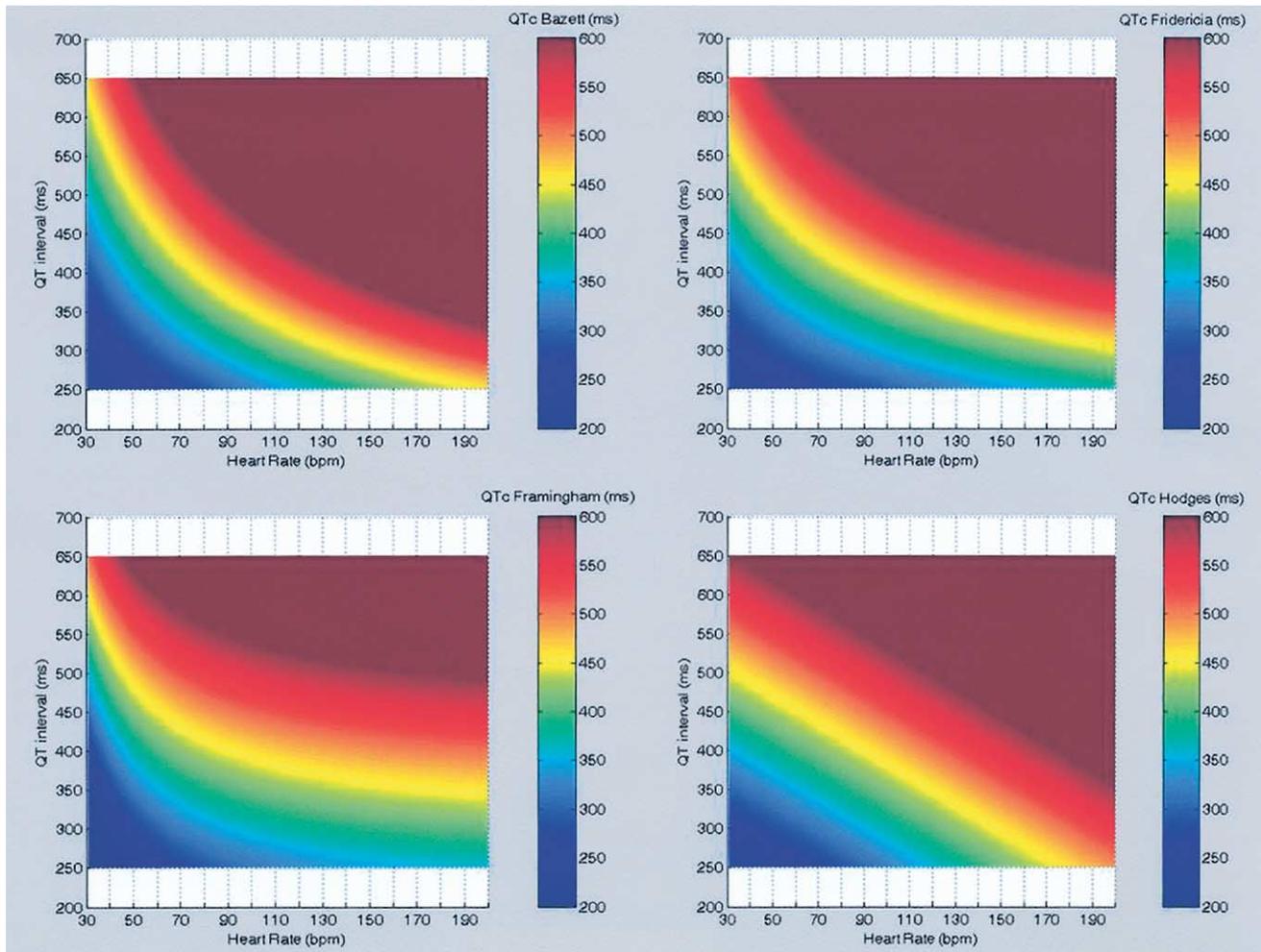


Fig. 1. The illustration shows the projection of a three-dimensional curved surface relating heart rate and QT interval versus corrected QT interval onto a two-dimensional plot. Drawing intersecting lines for QT and HR, the color gradient at the intersection point can be estimated as a value on the QTc gradient bar (color meter) at the right. The different colors are used to represent degrees of QT prolongation (red) or QT shortening (blue) in relation to the expected value (yellow). Note that the corrected QTc value can be read from the plots by finding the intersection of QT and HR for an individual ECG. If the colors are carefully prearranged, the color gradients can be used to estimate a rate correction of QT intervals, somewhat comparable to the traditional Nomogram method for QT (6).

A total of 10,303 records (4,883 female and 5,420 male) exhibiting a computer interpretation of normal sinus rhythm, with some “except for rate” which includes bradycardia and tachycardia, and which were also confirmed as normal ECGs by the local physicians, were included in the study. ECGs exhibiting premature contractions or sinus arrhythmia were excluded as were those with AV and ventricular conduction defects. Patient demographics showed that there were no medication field entries. Both the computer interpretation and the local physician called only normal sinus rhythms with no other comments or abnormalities noted to find the truest set of normals. The study population

covered a wide range of adult ages with a mean of 49.00 ± 16.05 (MEAN \pm SD, where SD is the standard deviation) years and 100% of the population being in the range of 17 to 109 years old. The mean rate was 78.58 ± 16.87 bpm. 78.3% had normal sinus rhythm (60 to 99 bpm), 11.4% had sinus bradycardia (40 to 59 bpm) and 10.3% had sinus tachycardia (100 to 125 bpm).

QT and Other Measurements

The QT interval values used in this study are based on the measurements from the same Glasgow algo-

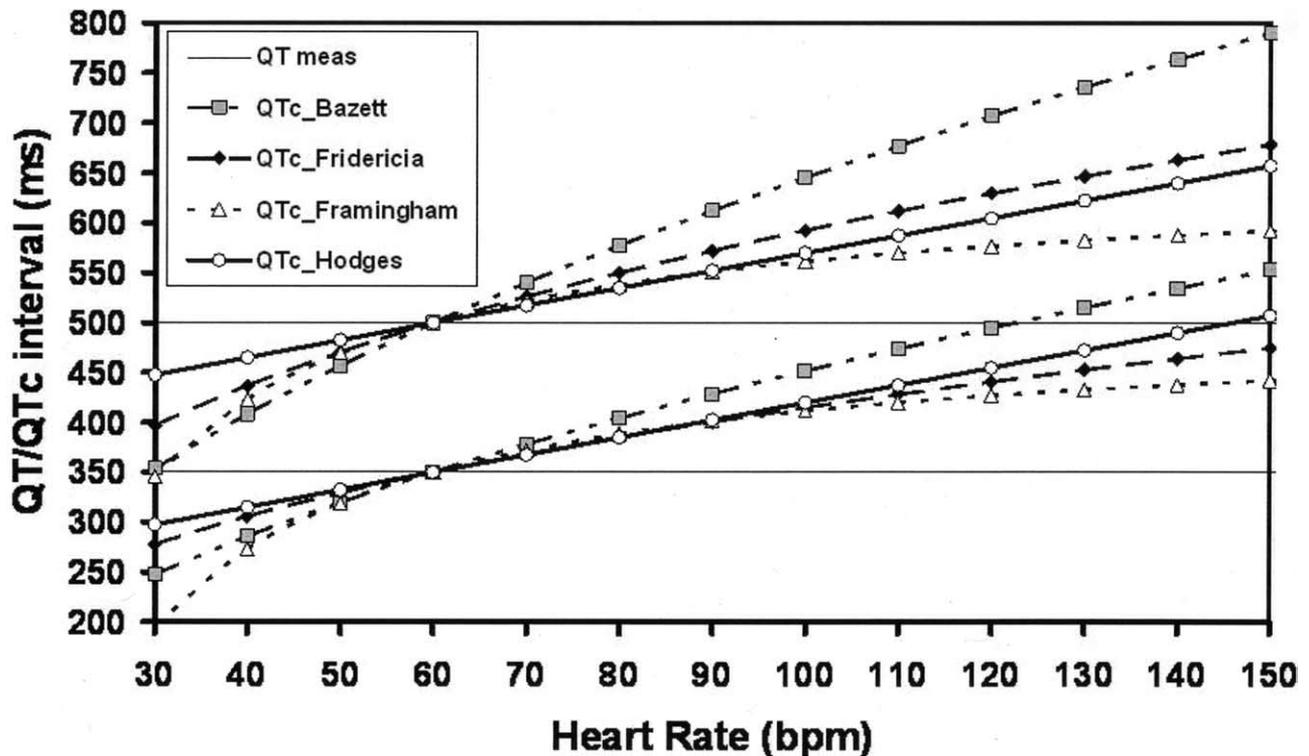


Fig. 2. A comparison of 4 different QTc formulae based on two values of QT, namely 350 ms and 500 ms. This clearly shows that the Bazett formula produces much higher values of QTc above 60 bpm compared to other formula and generally lower values below 60 bpm, with the exception of the Framingham formula.

rhythm used in Burdick Eclipse carts. All P-QRS-T fiducial points are detected from representative (average/median) beats. The termination of the T wave is basically determined by a two-order derivative algorithm (20) and newer T wave template logic (21). Because of a variation in the QT interval among the various leads, the algorithm reports a "true" longest QT interval, which is from the earliest QRS onset to the latest T offset in multiple leads excluding clear outliers. For this reason, the algorithm results could be slightly wider than that of a manual approach that mostly only measures a single lead.

To assess the measurement accuracy of the Glasgow 12-lead algorithm, a double blind test was conducted. Two product verification specialists measured QT intervals of 100 12-lead printouts based on a random selection of 10,303 ECGs. For hand measuring, one clear beat was chosen from one or a few channels and QT by 10-ms increments was visually measured with a magnifier.

It should be noted that the HR and RR measurements are based on the average time between beats during 10 seconds of recorded ECG data.

Data Processing

Steps of reviewing QT/QTc before and after applying the corrections to the patient data were developed.

Five QT/QTc data sets, each with 10,303 samples, including the original QT set, as well as Bazett, Fridericia, Framingham, and Hodges QTc sets, were counted for frequency of data points at 2-ms intervals separately and then graphed together so that the 5 data distributions were presented in a histogram.

The same 5 QT/QTc data sets with the corresponding HR and gender were arranged into data tables. In these data tables, all the correlation coefficients between QT/QTc and HR were calculated, including sorting the data for gender specific and heart rate range details.

Further, all 5 sets of QT/QTc with corresponding HR were XY plotted in a HR vs. QT graph. Linear regression lines were directly applied to the scatter plot and the corresponding slopes of the linear lines were found.

Finally, the upper and lower normal limits of QTc intervals for each formula were determined by

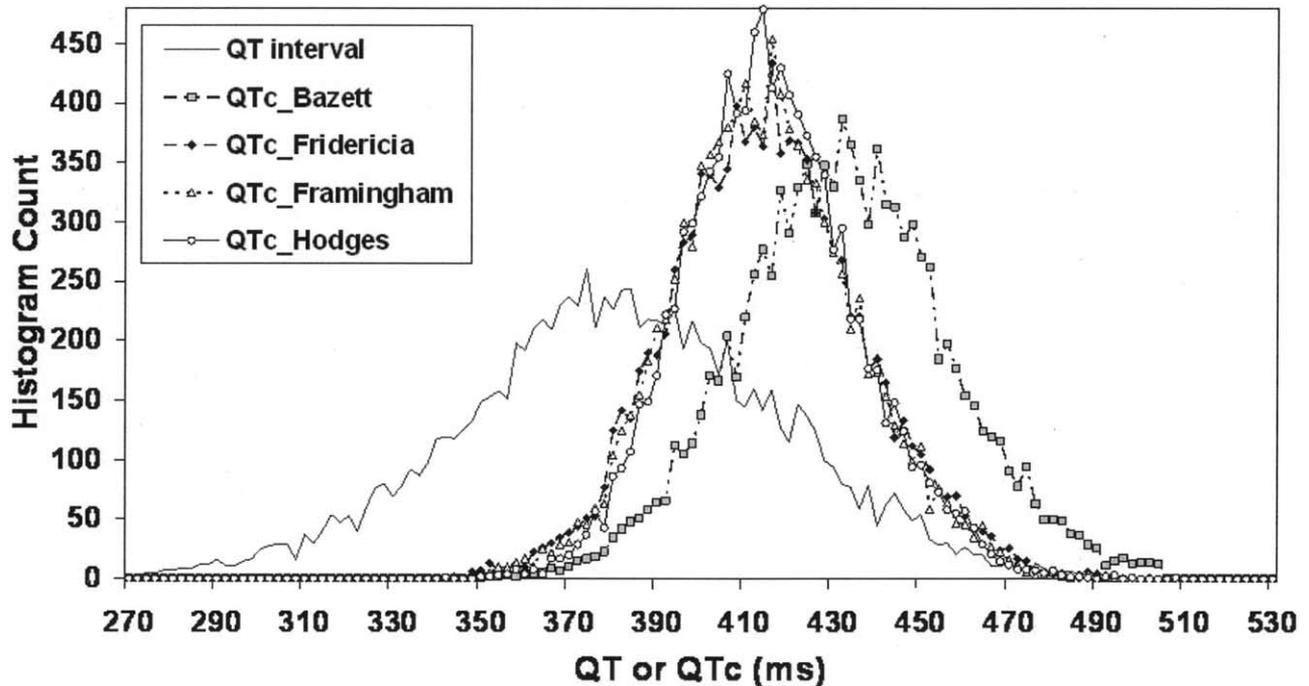


Fig. 3. Distribution of the uncorrected QT measures and the QTc values from four formulae based on all 10,303 data samples, presented as histograms.

excluding the top and bottom 2% of the data as sorted by gender and heart rate ranges.

Results

Data Distribution

Figure 3 compares the uncorrected QT and the 4 QTc distributions. A corrected distribution in practical terms will be narrower than the original distribution. By simply applying a common approach, QT/QTc averages (MEAN) and the corresponding standard deviations were calculated for Table 1. The results show that 1) all 4 QTc distributions are narrower than the original QT distribution (smaller SD); 2) Bazett's is relatively wider (ie, has the biggest SD) and is an outlier (because of a relatively

different MEAN value) compared to all other formulae results; and 3) Hodges is the narrowest (ie, has the smallest SD).

Table 1 also shows that females have around 8 to 10 ms longer values than males for the average QT/QTc.

Measurement Accuracy

The Glasgow algorithm was evaluated independently by CSE (Common Standards for Quantitative Electrocardiography) (22). More details are in the Appendix.

The results of manual and computer measurements were compared. On average, the manual values were 3.2 ms longer with a standard deviation of 13.1 ms and maximum errors of -20 ms and $+33$ ms.

Table 1. The Calculations of Average QT/QTc and the Corresponding Standard Deviations (MEAN \pm SD, in ms) in the Current Study Populations Using 4 Different Formulae Discussed in the Text.

Gender	QT	QTcB	QTcFri	QTcFra	QTcH
Both (10,303)	379.98 \pm 36.41	427.27 \pm 25.44	410.43 \pm 23.39	410.42 \pm 22.04	411.25 \pm 20.97
Male (5,420)	375.91 \pm 36.71	422.63 \pm 25.39	405.94 \pm 22.82	406.07 \pm 21.47	407.48 \pm 20.42
Female (4,883)	384.50 \pm 35.53	432.43 \pm 24.49	415.42 \pm 22.99	415.25 \pm 21.65	415.43 \pm 20.77

Table 2. Correlation Coefficients Between HR and QT/QTc Values for 4 Different Formulae as Discussed in the Text.

Gender	HR	QT	QTcB	QTcFri	QTcFra	QTcH
Both (10,303)	All HR	0.82	0.33	0.24	0.26	0.11
	HR < 60	0.40	0.26	0.03	0.14	0.14
	HR 60 to 99	0.67	0.32	0.08	0.11	0.01
	HR > 99	0.54	0.13	0.29	0.35	0.02
Male (5,420)	All HR	0.83	0.37	0.22	0.23	0.07
	HR < 60	0.41	0.23	0.01	0.12	0.15
	HR 60 to 99	0.66	0.39	0.01	0.04	0.06
	HR > 99	0.54	0.11	0.28	0.34	0.01
Female (4,883)	All HR	0.82	0.29	0.26	0.30	0.15
	HR < 60	0.44	0.27	0.03	0.14	0.17
	HR 60 to 99	0.69	0.26	0.14	0.18	0.09
	HR > 99	0.53	0.13	0.28	0.34	0.04

Correlation Between QT/QTc and HR

A lack of correlation between HR and QTc is desired. Table 2 presents the correlation coefficients (absolute values) between QT/QTc and HR. The results show 1) globally, the QTc based on Hodges formula is significantly less correlated with HR compared to others; 2) considering HR as a factor, Fridericia QTc has the least correlation for HR <60 bpm, while Hodges is the better for HR ≥ 60; 3)

incorporating gender as another factor, for males Fridericia QTc has the least correlation with HR up to 99 bpm and Hodges is the best above this heart rate, while the situation is just the opposite for females; and 4) correlations between both Fridericia and Framingham QTc with HR are clearly higher than Bazett’s when HR is over 100 bpm for all situations.

Figure 4 shows a scatter plot of uncorrected HR versus QT and the corresponding regression line.

Table 3 presents the slopes of the regression lines

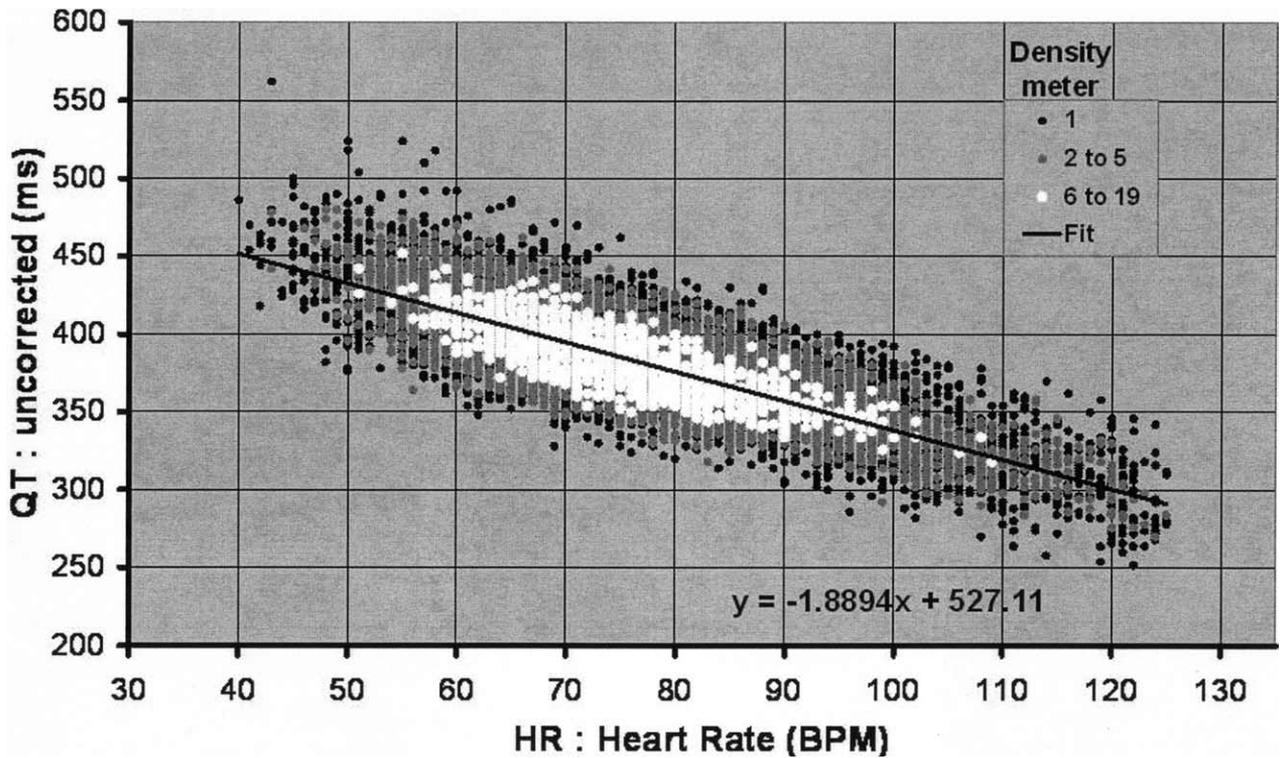


Fig. 4. Scatter plot of HR versus uncorrected QT and the corresponding regression line. Notice that QT values from this database have a linear trend with HR.

Table 3. Slopes of the Regression Lines Based on HR Versus QT/QTc Distributions for 4 Different Formulae as Discussed in the Text.

QT	QTcB	QTcFri	QTcFra	QTcH
-1.89	0.52	-0.35	-0.36	-0.14

based on QT/QTc vs. HR distributions for uncorrected QT and all 4 QTc formulae.

Normal Limits

Table 4 shows the normal limits for all 4 formulae. Whether for males and/or females, the middle HR groups of 60 to 99 bpm have similar upper normal limits for all formulae except Bazett, possibly because 78% of the observations were in this range of rates.

It was also noted that, with all formulae, females have 6 to 7ms longer QTc upper normal limits than males (Table 5).

Discussion

Accurate determination of the QT interval, especially the T-wave termination, is sometimes chal-

Table 4. Upper and Lower Limits of Normal QTc for 4 Formulae Discussed in the Text.

Gender	Upper normal limits (98%, in ms)				
	HR	QTcB	QTcFri	QTcFra	QTcH
Both (10,303)	All HR	483	460	457	457
	HR < 60	454	459	459	466
	HR 60 to 99	483	461	458	456
	HR > 99	492	445	436	451
Male (5,420)	All HR	480	457	454	454
	HR < 60	450	455	455	465
	HR 60 to 99	480	457	454	452
	HR > 99	490	445	436	450
Female (4,883)	All HR	486	463	461	460
	HR < 60	460	463	463	470
	HR 60 to 99	486	465	462	459
	HR > 99	492	448	434	452
Gender	Lower normal limits (2%, in ms)				
	HR	QTcB	QTcFri	QTcFra	QTcH
Both (10,303)	All HR	378	365	368	372
	HR < 60	363	372	367	375
	HR 60 to 99	382	370	374	372
	HR > 99	380	343	350	371
Male (5,420)	All HR	374	361	364	369
	HR < 60	361	368	363	369
	HR 60 to 99	379	368	372	369
	HR > 99	378	341	348	369
Female (4,883)	All HR	386	369	372	377
	HR < 60	372	381	377	386
	HR 60 to 99	388	374	378	376
	HR > 99	389	350	354	374

Table 5. Differences Between Upper Limits of Normal QTc (Female-Male) for Four Different QTc Formulae. Females Have 6 to 7 ms Longer QTc Than Males Globally, but the Differences are Slightly Larger at HR < 100 bpm and Significantly Smaller When HR > 100 bpm.

Difference Female-Male	QTcB	QTcFri	QTcFra	QTcH
All HR	6	6	7	6
HR < 60	10	8	8	5
HR 60 to 99	6	8	8	7
HR > 99	2	3	2	2

lenging for both the trained eye and computer algorithms. For example, although there is no agreement on whether to include the U wave in the repolarization measurement (14), a few reference books suggest the U wave should not be included in the QT measurement (1,12). In fact, an automated algorithm measuring QT interval in subjects with abnormal ECGs may produce a false-positive long QTc calculation because distinguishing T termination in a TU wave is inaccurate with current techniques. If the ECG is normal, however, the automated measurements should be reasonably accurate (7).

Although all ECGs were confirmed as normal by local physicians, it is presumed that very few QT and HR were hand measured and edited, so most QT and RR values were directly generated by the automatic measurement program. Therefore, in this study, we examined accuracy and presented it in the results section.

One other study (10) exhibited a significant individual variability between QT and RR intervals among healthy subjects. Indeed, these authors claimed that any effort to find the “best” formula to apply to the general population was fruitless. The assertion seems partially not to deal with the fact that individual differences are very common for medical diagnostics and statistics, including accuracy measures which are employed to handle such differences. It is not surprising that there is inter-subject variability (sometimes of considerable magnitude) of QT vs. HR from person to person. It is of importance if these significant statistical characteristics exist when population samples become large. The scatter diagram in Figure 4 shows that, in our data base, the data clusters well along a regression line with $r = .82$. In addition to improving clinical practice, this study was aimed at determining better formula(e) in a statistical sense as the default setting for products, including proposing HR and gender dependent categorical corrections.

Presenting data in a HR vs. QT plane can help to

comprehend the QT/QTc and HR correlation visually (Fig. 4). After applying any QTc formula to the original QT data, it is expected that the slope of the regression line will be significantly lowered to come close to zero. Ideally, if the regression line can represent the data points well (a narrow QT distribution as discussed above) and has zero slope, the values in the Y direction should be statistically independent of the X direction, ie, corrected QT values would be uncorrelated to the HR. In other words, QTc values will not be influenced by any trend due to heart rate changes. Therefore, the criterion here is that the closer the slope is to zero, the less the correlation between HR and QTc will be. From Table 3, globally Bazett's formula has the largest (absolute) slope especially for data under 100 bpm while Hodges QT correction has a near zero slope in this formula group.

The results clearly do not support current usage of Bazett's correction for most situations (HR from 40 to 100 bpm). It is interesting that Bazett's formula has an upper normal limit at least 23-ms longer than that of the others. Numerous publications (1,2,5,6) recommend 420 to 440 ms as the threshold for reporting prolonged QT when using Bazett's formula. Based on this database, 30% of apparently normal ECGs would be reported by Bazett's as having abnormal QT intervals for the 440-ms threshold, or 10% if 460 ms is chosen, compared to <2% for the other formulae. Although "prolonged QT interval" from an interpretation program is a descriptive statement, it could be an issue in clinics if many more false positive reports of QT prolongation as suggested by ECG printouts are presented to physicians.

Globally, Hodges QTc correction remains the best choice with the smallest correlation coefficient (visually the narrowest distribution and near zero slope of the fit line). Based on this study, Hodges QTc formula should be selected as the default in products.

The key criterion, in respect of finding the "desired" formula, is the smallest correlation between HR and QTc. For a fun expansion of this study, a new QT correction formula with near zero correlation to HR could be developed based on this database. For example, by fine tuning the linear ($QTc = QT + \alpha(HR-60)$) and nonlinear ($QTcB = QT (HR/60)^\beta$) models, we obtained $\alpha = 1.867$ and $\beta = 0.4134$. After concluding the present study, it was found that a previous publication (23) showed that the latter result, based on the nonlinear model, is very close to the result $\beta = 0.42$ derived from a different database.

Figure 2 shows Bazett has more correction at

heart rates above 60 bpm than others, while Framingham has less correction above 100 bpm. Hodges has less correction at heart rates below 60 bpm than others, while Bazett has more correction with long QT and Framingham has more correction with short QT. This observation shows that the performances of the formulae are different as heart rate varies and seems to imply that some QT correction formula are good for sinus bradycardia while others are better for sinus rhythm or sinus tachycardia.

Automatic QTc formula selection logic based on the patient's HR and gender could be directly implemented as another option in products. Based on Table 2, for instance, if gender is unknown (not entered), the Fridericia formula could be used for HR <60 bpm (bradycardia) and Hodges for all other HR. For male patients, the Fridericia formula could be employed for HR <100 bpm and Hodges' correction for HR ≥ 100 bpm; and for females, Hodges' for HR <100 bpm and Fridericia's for HR ≥ 100 bpm. Correspondingly, the upper normal limits can be found in Table 4. This approach, however, needs further research and consideration before usage by the average physician. The reasons for automatic QTc formula selection for specific groups of population would need to be explained more comprehensively.

A couple of references (1,24) suggest a simple "rule of thumb"-the normal QT interval should be less than half the RR interval. Based on this database, 41% of apparently normal ECGs would be reported as having prolonged QT intervals.

Some references (8,12) indicate that QTc values slightly increase with age. Based on this database, such a slight trend can also be seen in the global population.

QT versus RR has similar results to QT versus HR from this database. However, it is interesting from QT/HR and QT/RR distributions that the uncorrected QT has a linear trend with HR over a broader normal HR range, but not with RR. While this linear reasoning sparks further debate, this observation is somehow different from another study (10) that is based on the QT-HR relation of individual subjects, probably partially due to the different HR ranges studied. QT intervals do not proportionately follow with RR interval changes and present an obvious nonlinear relation when RR intervals are short (<600 ms) and some nonlinearity as RR lengthens (>1100 ms). Therefore, results from this database do not support a linear RR formula like Framingham, especially when HR is higher. Further, one other study (25) presented a plot of QT and RR intervals during and after exercise, which

demonstrated a significant nonlinear relationship between QT and RR. It is worthy of note, however, that a linear trend can be observed if the data is re-plotted in the QT and HR plane. In that example, QT intervals altered rapidly for short RR intervals and significantly slowly for long RR intervals. The inverse ratio of HR to RR may compensate the observed non-linear RR vs. QT into a near linear relation.

Although the $MEAN \pm SD$ was employed to quantify the width of QT distributions, we selected the top and bottom 2% from the distributions instead of the $mean \pm 2*SD$ as the upper and lower normal limits. This approach is based on the fact that the characteristics of QT distributions are not clear. One group calculated (26) the upper limit of QT interval based on the $mean + 2 * SD$ while another suggested (23) that it is misleading because the assumption of Gaussian distribution of QT is not valid. In fact, Simonson (8) showed in 1961 that most ECG variables have a skewed distribution.

It would be better if there were a prolonged QT data set, eg, based on the known effect of a drug, so that a decision criterion could be developed based on the intersection of true positives and true negatives. It is promising that one other study (26) used patients receiving psychotropic drugs as a true positive data set although the authors realized that no evaluation was made of the degree of QT lengthening induced by drugs.

The HR histogram for the present study is nearly symmetric, with the peak around 70 to 75 bpm. It might have been optimal if patient data had been more widely distributed across different HR.

A few areas might warrant further research:

1. A different direction-some authors (26,27) prefer to diagnose prolonged QT without correction. A list of upper normal limits of measured QT based on HR was presented, an approach claimed to be the most reliable for estimating prolonged QT intervals.
2. A separate topic could be a comparison between data derived from a purely healthy group and that from normal ECGs recorded from hospital inpatients.

Finally, for the sake of being lighthearted, it may be relevant to ask why QT interval is corrected to 60 bpm. Indeed, this can probably be traced back to Bazett's original paper where he in turn refers to work by others where formulae relating to the duration of systole tend to involve $(cycle)^{1/2}$. This then naturally leads to 60 becoming involved in relation to the duration of a cycle.

Table 6. An Adaptation of the CSE Study for Mean Difference and Corresponding Standard Deviations (in ms) of QT Intervals Measured by Four Programs and Compared Against Human Referees as a Gold Standard

Computer Program	MEAN (ms)	SD (ms)
Glasgow	4.5	12.2
Competitor 1	0.9	12.2
Competitor 2	6.0	14.7
Competitor 3	4.6	12.3

Conclusion

The Bazett formula is the most commonly used because physicians pass on its use to their students without considering the literature pointing out that it is not the best formula to use. If Bazett continues to be used regularly, an educated user should more completely understand the implications. Manufacturers can encourage their customers not to use Bazett by providing an alternative formula as the default though the market may dictate that Bazett is provided as one of a number of formulae so that the customer can make an informed decision on which formula to use. This study concludes that the Hodges QTc formula most appropriately fits this database globally and should work well with other populations.

Appendix

The measurement accuracy of the Glasgow algorithm and other 12-lead programs was evaluated in an independent study run in 1987 as part of the CSE (Common Standards for Quantitative Electrocardiography) project (22). ECGs (218) representing a variety of diagnostic patterns were analyzed by 9 different algorithms that determined the key (global) measurements. These results were then compared to annotations by 5 referee cardiologists. Partial results from this study are shown in Table 6. Although the standard deviations (SD) are much more important for the comparison, the T-wave termination in the Glasgow program was adjusted a few years ago by moving the offset four milliseconds earlier (2 sample points for 500 samples per second data) as a result of the CSE study. Based on this adjustment, the current mean difference is actually nearer 0.5 ms.

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