National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

Study of QT interval in pediatric age group

Anwesit Mohanty[1], Magna Manjareeka[2], Jayanti Mishra[2], Soumya Mishra[3], Jyotiprakash Mishra[4]

[1]Department of Medicine, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India, [2]Department of Physiology, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India, [3]Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education & Research (JIPMER), Puducherry, India, [4]Department of Pediatrics, Capital Hospital, Bhubaneswar, Odisha, India

Correspondence to: Magna Manjareeka, E-mail: dr.magna@gmail.com

Received: July 18, 2016; **Accepted:** August 02, 2016

ABSTRACT

Background: Changes in QT interval is one of the important electrocardiographic parameters which are reported in many clinical conditions not only in adults but also among the pediatric age group. Diseases with a high risk of sudden deaths in the pediatric age group have initiated the interests among the researchers to focus on electrocardiographic studies. **Aims and Objectives:** This pilot study was done to obtain the normal QT values for the various age groups and both the genders of pediatric subjects. **Materials and Methods:** A cross-sectional study was conducted which included 162 healthy children (93 males and 69 females) and electrocardiographic recordings were taken. Subjects with congenital or acquired cardiovascular diseases were excluded from the study. **Results:** All the participants were divided into three age groups of 1-5 years, 6-10 years, and 11-15 years. It was found that heart rate was inversely proportional to QT/QTc interval while RR interval was directly proportional to both QT and QTc interval. With age, heart rate decreases but other electrocardiograms parameters increase progressively. Although the heart rate is inversely correlated with QT/QTc interval, there is positive correlation of QT/QTc with RR interval. **Conclusion:** Electrocardiography should be started as a routine investigation in pediatric subjects for the diagnosis of congenital and acquired cardiac diseases and arrhythmias which can be evident from QT interval determination.

KEY WORDS: QT Interval; Pediatric; Electrocardiographic; Age Groups; QT/QTc

INTRODUCTION

The QT interval is one of the important parameters of electrocardiograms (ECG). Prolongation of its duration may predispose patients to arrhythmia and sudden cardiac death. It is an established fact that QT interval is inversely correlated with heart rate. In 1920, Dr. Bazett introduced the first QT correction formula.[1] The Bazett formula is most commonly used, while the Fridericia,[2] Framingham,[3] and Hodges et al.[4] formulae are less commonly used. A number of diseases with a high risk of sudden death in infants and children have brought researchers to focus on electrocardiography studies.

Access this article online	
Website: www.njppp.com	Quick Response code
DOI: 10.5455/njppp.2017.7.0720402082016	

Changes in the QT interval of the ECG have been mentioned in a variety of clinical conditions. In conditions such as hypertension, heart failure, hypokalemia, hypocalcemia, rheumatic carditis, diphtheria, quinidine toxicity, nephritis, and cretinism prolongation of QT interval is observed. The QT has been used as an aid in differentiating acute cardiac dilatation and failure from pericardial effusion with heart failure, being prolonged in the former condition.

Abnormal shortening of the QT interval has been reported in hyperparathyroidism and digitalis intoxication. Changes in the QT interval of the ECG have been mentioned in a

variety of clinical conditions. One of the disorders of the heart's electrical activity is long QT syndrome (LQTS). It can result in sudden, uncontrollable, dangerous arrhythmias in response to stress or exercise. Arrhythmias are problems with the rate or rhythm of the heartbeat. People who have LQTS also can have arrhythmias for no known reason. However, not everyone who has LQTS ought to have dangerous heart rhythms; but when they do occur, they can be fatal. The term "long QT" refers to an abnormal pattern seen on ECG.

In pediatric age, the LQTS is characterized by prolonged QT interval, syncope, and sudden cardiac death due to ventricular arrhythmia aggravated by emotion or exercise.[5,6] LQTS may be congenital or acquired.[7] Mostly they are asymptomatic and can be detected on ECG recordings. Since ECG is not done routinely in pediatric age group, LQTS is often missed out at initial stages. This leads to increase rates of sudden deaths caused by ventricular arrhythmia due to the progression of disease.

LQTS is both under-diagnosed and over-diagnosed. Many patients are incorrectly diagnosed as having LQTS after presenting with syncope and demonstrating "borderline" QT prolongation (QTc ≥440 ms) in sentinel ECGs. Since the normal values of QT interval in pediatric age group would vary from adult values due to variation in cardiac functioning, there should be some standard values for evaluation of a normal range of QT intervals.[8]

The study of QT interval in pediatric age group could lead to important revelations. This study is therefore taken up to look into the QT interval in the pediatric age group and to determine the age and gender-related variations, as such studies are scantily documented in Odisha.

Some studies done in 2005, attempted at determining the normal ranges of all ECG parameters in children and adolescents.[9] Due to considerable variability of heart rate in children, it is difficult to judge whether a measured QT interval is normal or not. Whether to include age and sex in the determination of normal values of T interval was found to be debatable.

Some other studies observed that corrected QT (QTc) values calculated from the Bazett formula yielded the most consistent results across different ranges of heart rate and age.[10] Using statistical regression models, the Bazett method better fits the overall curvilinear trend in QT heart rate distribution than the other formulae. This study provides support for the use of the Bazett QT correction method over others in normal pediatric resting ECGs.

A study in 2009 was designed to detect any differences of the QTc intervals during sleep and being awake in healthy children of both genders and differences between the sexes, too.[10] The QTc interval as measured by the standard ECG differs to the 24 h recording measurement which is in average of 40-50 ms longer. The routine ECG seems to be a good screening method for the measurement of QTc intervals. However, there are very less reported studies available in this regard in this part of the country. This study was undertaken with the following objectives:

- To find and compare the mean QT interval of the subjects in all the age groups
- Compare the mean values of QT interval among the male and female children of the three study groups (age based)
- Compare the mean values of QT interval among the males and females (gender based)
- Determine the correlation between QT interval and QTc interval with respect to age, heart rate and RR interval.

MATERIALS AND METHODS

A cross-sectional study was conducted in the Department of Physiology, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, after taking approval of Institutional Ethics Committee during the period from May 2013 to June 2013. The sample size was estimated at 200 subjects using sample size estimation equation.

All the infants and children attending the pediatrics out-patient department of Kalinga Institute of Medical Sciences and students chosen randomly from each class (from nursery till class 10) of KIIT International School, during the 2 months of study, were considered as subjects. Written informed consent was given by parents or guardian after being briefed about the nature of the study. Subjects who are known cases of congenital or acquired cardiovascular diseases were excluded from the study.

Electrocardiograph recordings were obtained using a portable, battery operated 12-lead ECG recorder Allengers Pisces - A-103 (ver-2.4) at a paper speed of 25 mm/s (gain 10 mm/mV). Before the study, the electrocardiograph machine was tested for reliability, validity, and reproducibility on five apparently healthy subjects who underwent thorough cardiologic examination and evaluation. Electrocardiographs were performed with the subjects lying at supine position using adhesive electrodes.

ECG was projected on white paper and magnified at least 10 times its actual size. In this way, the difficulty often met in the determination of the start of the Q wave as well as the end of the T wave was lessened appreciably. Measurements were obtained to the nearest 0.005 s. As a rule, no <3 cardiac cycles were analyzed and from these measurements the average QT and the average cycle length, RR interval, was then derived. In instances showing abnormal ECG, subsequent readings were taken for cross-verification at 1 h intervals. All measurements were done on more than three cardiac cycles,

always including the shortest as well as the longest cycle lengths available.

Name, age, sex, heart rate, and ECG were recorded for all the subjects; from the electrocardiographic recordings, RR interval, QT interval and QTc interval were noted from lead II recordings of the subjects unless there was significant difference in the QT interval between this lead and either lead I or lead III due to an isoelectric Q wave in lead II.

All the subjects were divided into three different age groups of 1-5 years, 6-10 years, and 11-15 years. The mean values of ECG findings of all the subjects were compared among the three age-groups using one-way ANOVA applying *post-hoc* least significant difference test. Comparison among males and females was done using the Students' unpaired *t*-test. The correlation coefficient (Pearson's *r*-value) between QT/QTc intervals and age, heart rate and RR-interval was estimated.

All statistical analysis was performed using SPSS software version 16.0 (SPSS Inc., Chicago, IL, USA) and $P < 0.05$ was considered as statically significant.

RESULTS

A total of 162 subjects were included in this study. Neonates and infants could not be included as they were uncooperative during the ECG recording procedure. The subjects were divided into three different age groups of 1-5 years, 6-10 years, and 11-15 years. On applying ANOVA, the subjects grouped according to their age groups were compared for a significant difference in heart rates, RR interval, QT/QTc interval as shown in Table 1.

In Tables 2 and 3, the male and female subjects (respectively) were grouped into different age groups and ANOVA test was applied to analyze the various parameters taken into account in this study.

Using unpaired Student's t-test, all the male and female subjects included in the study were compared for a significant difference in the parameters considered for this study (Table 4).

Figure 1 shows the correlation between the QT intervals with age. There was a weak, but statistically significant correlation ($r = 0.283$, $P = 0.0001$). Similarly in Figure 2, correlation

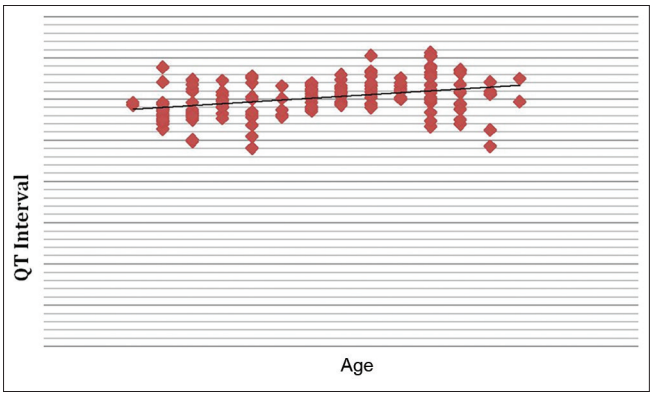

Figure 1: Correlation between QT interval and age

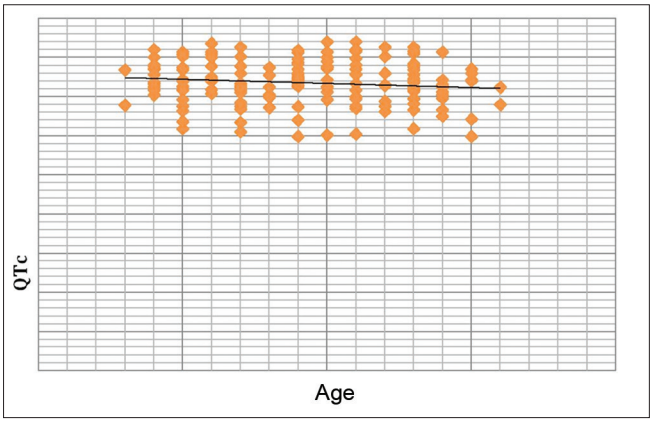

Figure 2: Correlation between corrected QT interval (QTc) and age

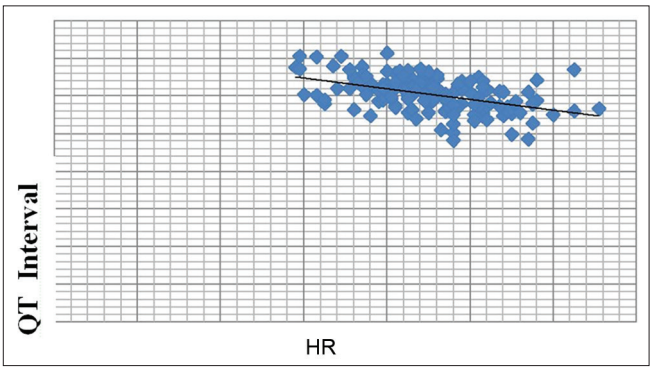

Figure 3: Correlation between QT interval and heart rate (HR)

Table 1: Comparison of various parameters between different the age groups

Variables	M±SEM			F	*P* value
	1-5 years (*n*=33)	6-10 years (*n*=66)	11-15 years (*n*=63)		
Age (in years)	4.36±0.114	8.15±0.175	12.75±0.165	820.59	0.0001**
HR (per min)	100.15±2.429	94.74±1.473	84.20±1.863	17.78	0.0001**
RR interval (in ms)	608.48±15.865	636.91±9.492	730.02±16.143	20.28	0.0001**
QT interval (in ms)	287.5±3.925	291.70±4.151	309.52±3.200	8.812	0.0001**
QTc (in ms)	342.79±4.311	355.38±5.050	369.23±3.718	9.137	0.0001**

M±SEM: Mean±standard error of mean, HR: Heart rate. **Highly statistically significant

Table 2: Comparison between males of different age groups

Variables	M±SEM			F	*P* value
	1-5 years (*n*=19)	6-10 years (*n*=39)	11-15 years (*n*=35)		
Age (in years)	4.26±0.12	8.26±0.232	12.94±0.222	306.64	0.0001**
HR (per min)	101.89±2.89	93.59±1.968	81.26±1.96	19.86	0.0001**
RR interval (in ms)	594.26±17.99	262.56±11.76	751.57±19.66	21.276	0.0001**
QT interval (in ms)	292.26±4.471	298.92±6.47	311.20±3.65	5.273	0.007**
QTc (in ms)	339.58±4.421	359.64±7.88	379.89±5.41	6.739	0.001**

M±SEM: Mean±Standard error of mean, HR: Heart rate. **Highly statistically significant

Table 3: Comparison between females of different age groups

Variables	M±SEM			F	*P* value
	1-5 years (*n*=14)	6-10 years (*n*=27)	11-15 years (*n*=28)		
Age (in years)	4.50±0.203	7.93±0.266	12.68±0.25	216.47	0.0001**
HR (per min)	97.79±4.208	96.41±2.21	87.36±3.29	3.45	0.038**
RR interval (in ms)	626.43±28.449	628.74±15.94	707.43±25.70	4.2	0.01**
QT interval (in ms)	281.07±6.80	295.70±3.97	307.54±5.37	5.341	0.007**
QTc (in ms)	323.50±6.80	356.67±4.48	373.36±4.63	6.829	0.001**

M±SEM: Mean±Standard error of mean, HR: Heart rate. **Statistically significant

Table 4: Comparison between male and female subjects

Variables	M±SEM		T	*P* value
	Males (*n*=93)	Females (*n*=69)		
Age (in years)	9.2±0.364	9.16±0.412	0.081	0.935**
Heart rate (per min)	90.65±1.49	93.01±1.85	−1.006	0.316**
RR interval (in ms)	673.93±11.55	660.20±14.08	0.759	0.449**
QT interval (in ms)	297.99±3.32	297.54±3.19	0.095	0.924**
QTc (in ms)	364.18±4.03	367.22±2.98	–	0.571**

M±SEM: Mean±Standard error of mean,**: Not statistically significant

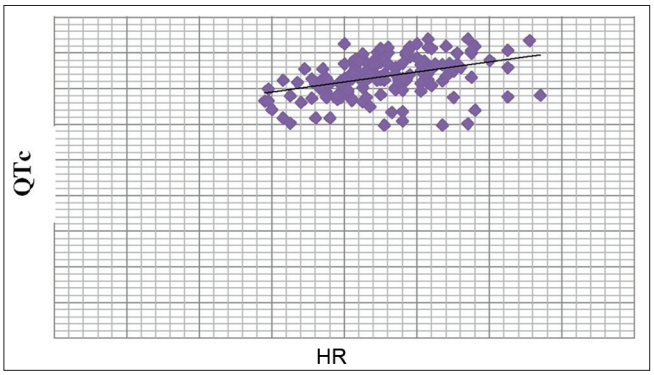

Figure 4: Correlation between corrected QT interval (QTc) and heart rate (HR)

between QTc and age was significantly weak ($r = 0.27$, $P = 0.0001$).

In Figures 3 and 4, the QT/QTc interval was correlated with heart rate to find inverse, but strong correlation which was statistically significant (QT-heart rate: $r = -0.534$, $P = 0.0001$) (QTc-heart rate: $r = -0.567$, $P = 0.0001$).

There was statistically significant positive correlation between the QT/QTc and RR intervals as seen from Figures 5 and 6. Pearson's coefficient, $r = 0.514$ ($P = 0.0001$) for QT-RR interval and $r = 0.527$ ($P = 0.0001$) for QTc-RR intervals.

DISCUSSION

This study was done to evaluate the common QT interval correction methods in a set of normal pediatric resting ECGs spanning a wide age range. The Bazett method yields more consistent readings across a wide range of ages and heart rate. The heart rate decreases with increasing age. By the age of 15 years, it reaches nearly 84 beats/min. The ECG parameters such as QT/QTc and RR intervals increase progressively with advancing age. Similar trends were seen in males and females. However, there was no significant difference between males and females in the various parameters taken in the study.

From our study, we obtained the normal QT values for the various age groups of pediatric subjects. In age group of 1-5 years, the normal range of QT interval was 283-291 ms,

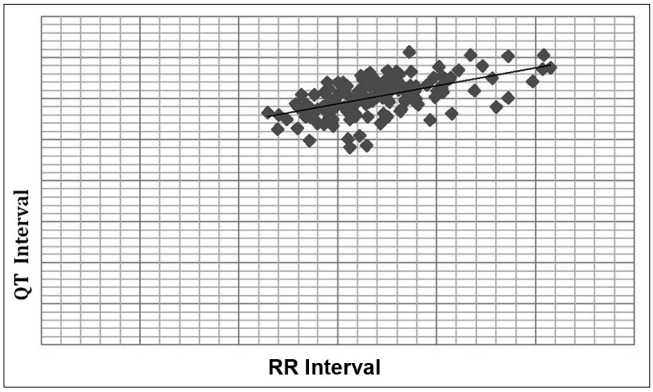

Figure 5: Correlation between QT interval and RR interval

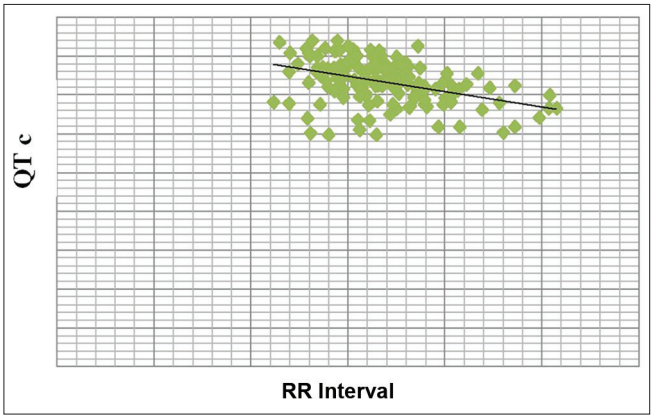

Figure 6: Correlation between corrected QT interval (QTc) and RR interval

while in 6-10 years age group, the normal range was 287-296 ms and in 11-15 years age group, the normal range was 306-313 ms. There are similarities between our findings and other reported investigations. In previous studies, the mean QTc was around 410 ms throughout childhood with an upper limit of normal of 450 ms.[11,12] However, these values were lower than the values obtained by a study done in 2007 in the USA.[13]

The QT interval reflects the duration of depolarization and repolarization and almost always given as a value corrected for heart rate (QTc). The correction is generally made by applying Bazett's formula, the validity of which has been questioned in adults. But in the case of pediatric age group, this is considered simple and reliable method of estimation.[10] However, QTc has no diagnostic importance in LQTS, neither has any independent prognostic importance in the arrhythmogenic progression of LQTS. The QTc prolonging drugs need monitoring of the QTc interval during the management of LQTS.[14] Thus, focusing on the QT interval could help in the diagnosis of many diseases in pediatric age and would drastically reduce the morbidity and mortality in children.

One of the limitations of this study was that we should have done 24-h Holter monitoring to look for diurnal variations of QT interval in children. Furthermore, the sample size could have been increased to study a large population to get a better range of QT interval. However, we can call this as a pilot study and further studies can be taken up in future for estimating normal values for a large population. Further studies can be undertaken for determining QT interval normal values after making necessary adjustments for heart rate and RR interval.

CONCLUSION

Electrocardiography should be started as a routine investigation in pediatric subjects for the diagnosis of congenital and acquired cardiac diseases and arrhythmias which can be evident from QT interval determination. The normal ranges of QT interval obtained in different pediatric age groups in this study can be used as standards for evaluation in pediatric department.

ACKNOWLEDGMENTS

Authors are extremely thankful to the supporting staffs of KIIT International School, all the study participants and other colleagues who have cooperated and helped us for the completion of the project. We heartily thank ICMR for considering our project work in the STS program.

REFERENCES

1. Bazett HC. An analysis of the time relations of electrocardiograms. Heart. 1920;7:353-70.
2. Fridericia LS. Die Systolendaeur im elektrokardiogram beinormalen menchen und bei heizkranken. Acta Med Scand. 1920;53:469-86.
3. Sagie A, Larson MG, Goldberg RJ, Bengtson JR, Levy D. An improved method for adjusting the QT interval for heart rate (the Framingham heart study). Am J Cardiol. 1992;70(7):797-801.
4. Hodges M, Salerno D, Erlien D. Bazett's QT correction reviewed-evidence that a linear QT correction for heart is better. J Am Coll Cardiol. 1983;1(2):694.
5. Park MK, Troxler RG. Syncope. In: Park MK, Troxler RG, editors. Pediatric Cardiology for Practitioners. 4th ed. St. Louis, Missouri: Mosby Inc.; 2002. p. 449-59.
6. Guntheroth WG. Long QT syndrome in children. Circulation. 1993;87(6):2058-9.
7. Chiang CE, Roden DM. The long QT syndromes: Genetic basis and clinical implications. J Am Coll Cardiol. 2000;36(1):1-12.
8. Goldenberg I, Moss AJ, Zareba W. QT interval: How to measure it and what is "normal". J Cardiovasc Electrophysiol. 2006;17(3):333-6.
9. Dickinson DF. The normal ECG in childhood and adolescence. Heart. 2005;91(12):1626-30.
10. Krasemann T, Strompen C, Blumenberg J, Gehrmann J, Burkhardtsmaier G, Vogt J. Changes of the corrected QT interval in healthy boys and girls over day and night. Eur Heart J. 2009;30(2):202-8.
11. Davignon A, Rautaharju P, Boisselle E, Soumis F, Megelas M,

Choquette A. Normal ECG standards for infants and children. Pediatr Cardiol. 1979;1(2):123-31.
12. Rijnbeek PR, Witsenburg M, Schrama E, Hess J, Kors JA. New normal limits for the paediatric electrocardiogram. Eur Heart J. 2001;22(8):702-11.
13. Qiu H, Bird GL, Qu L, Vetter VL, White PS. Evaluation of QT interval correction methods in normal pediatric resting ECGS. Comput Cardiol. 2007;34:431-4.
14. Elming H, Brendorp B, Køber L, Sahebzadah N, Torp-Petersen C. QTc interval in the assessment of cardiac risk. Card Electrophysiol Rev. 2002;6(3):289-94.

How to cite this article: Mohanty A, Manjareeka M, Mishra J, Mishra S, Mishra J. Study of QT interval in pediatric age group. Natl J Physiol Pharm Pharmacol 2017;7(1):74-79.

Source of Support: Nil, **Conflict of Interest:** None declared.