Original Research Article

QTc INTERVAL: AN EARLY MARKER OF CARDIOVASCULAR RISK IN RURAL HYPERTENSIVE ADULTS

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ABSTRACT

Background: Hypertension is a major contributor to global cardiovascular morbidity and mortality. Left ventricular hypertrophy, a complication of hypertension, increases the risk of fatal arrhythmias and sudden cardiac death. Corrected QT interval (QTc) on electrocardiogram (ECG) is a simple, cost-effective marker for detecting ventricular repolarization abnormalities. The aim of study was to evaluate the difference in QTc interval in normotensive and hypertensive individuals, and further to explore the correlation of QTc interval with systolic BP (SBP) and diastolic BP (DBP).

Materials and Methods: A total of 50 hypertensive cases and 50 normotensive controls in the age group 35–45 years were included in the study. Blood pressure (BP) was recorded thrice with 2 min interval, and the average was considered for analysis. A standard 12-lead ECG was recorded, and QT and RR interval was measured. QTc interval in seconds was calculated using Bazett's formula. Unpaired-Samples t-test and Pearson's correlation were used to analyze the data.

Results: QTc interval was significantly longer in the hypertensive group when compared to normotensives. It was also significantly longer in hypertensive females when compared with hypertensive males. However, there was no significant difference among normotensive males and females. Further, QTc interval was positively and significantly correlated with both SBP and DBP.

Conclusion: QTc interval being a cheaper, non-invasive ECG parameter may be used in detecting ventricular repolarization defects in hypertension and should not be neglected especially in developing countries like India. This would help in risk stratification and prognosis of hypertensive patients and prevention of fatal arrhythmias and sudden cardiac death.

Keywords: Corrected QT Interval; Systolic Blood Pressure; Diastolic Blood Pressure; Hypertensive; Normotensive.

INTRODUCTION

Hypertension is a major global health burden, affecting over 1.28 billion adults worldwide and contributing significantly to cardiovascular morbidity and mortality.[1] In India, the prevalence of hypertension is increasing rapidly, with recent estimates indicating that nearly one-third of adults are hypertensive.[2] Persistent elevation of blood pressure is associated with structural and functional cardiac changes, including left ventricular hypertrophy, myocardial fibrosis, and coronary microvascular dysfunction.[3] These changes predispose individuals to electrical instability, arrhythmias, and sudden cardiac death.

The electrocardiographic QT interval reflects the total time required for ventricular depolarization and repolarization. When corrected for heart rate (QTc), it serves as an established marker of ventricular repolarization abnormalities. A prolonged QTc interval is associated with an increased risk of life-threatening arrhythmias, such as torsades de pointes, and with higher rates of all-cause and cardiovascular mortality.[4,5] The Framingham Heart Study demonstrated that prolonged QTc is an independent predictor of mortality, even in apparently healthy individuals.[6]

Hypertension may influence QTc duration through multiple mechanisms. Left ventricular hypertrophy, a common sequela of long-standing hypertension, has been independently linked to QTc prolongation.[7] Enhanced sympathetic activity, impaired coronary perfusion, and myocardial ischemia in hypertensive subjects further contribute to repolarization abnormalities.[8] In the Losartan Intervention For Endpoint (LIFE) trial, hypertensive patients with left ventricular hypertrophy showed longer QTc intervals, which correlated with increased cardiovascular events.[9]

Several studies across populations have evaluated the relationship between hypertension and QTc interval, but results remain inconsistent. A study in the Chinese population reported significantly higher QTc values among hypertensives compared to normotensives,[10] whereas some European cohorts found only modest differences.[11] Indian studies on this subject are scarce, despite the growing prevalence of hypertension and the unique cardiovascular risk profile of the Indian population.[12]

Given these observations, there is a strong rationale to explore the QTc interval in hypertensive patients within the Indian context. Early detection of QTc prolongation may help identify individuals at elevated risk of arrhythmias and sudden cardiac death, thereby enabling timely preventive interventions.

Research Question

1. What is the difference in corrected QT interval among normotensive and hypertensive individuals?

Aims & Objectives

Aims: To study is the difference in QTc interval in normotensive and hypertensive individuals in the age group of 20 years and above, as reported in Pravara Rural Hospital Loni.

Objectives:

1. To investigate whether there is a statistically significant difference in the QTc interval among hypertensive and normotensive subjects in rural area.
2. To explore whether there is a statistically significant difference in QTc interval among hypertensive males and hypertensive females and normotensive males and normotensive females.

3. To study the distribution of cardiovascular risk factors with respect to normal and prolonged Qtc.
4. To find any correlation with selected anthropometric parameters.

MATERIALS AND METHODS

Study Design: Analytical Cross Sectional Study
Study duration: Approximately 6 to 8 months
Study Setting:

* Patients admitted to Medicine ward and Family medicine, known cases of hypertension admitted to Pravara Rural Hospital
* Known cases of hypertension from constituent institutes of Pravara Institute of Medical Institute (DU).

Inclusion Criteria:

* Individuals with SBP >140 mm of Hg and/or DBP> 90 mm of Hg are considered as hypertensives (treated and nontreated individuals)
* The normotensive individuals included in study are considered with their SBP<140 mmHg and DBP<90 mmHg and will be never earlier diagnosed as hypertensive nor will be under any anti-hypertensive medications.
* All participants with the age group of 20 years and above to reduce the presence of cofounding factors and diseases.
* Men and women will be included in the study after taking consent from both.
* The hypertensive individuals and normotensive individuals will be age- and sex-matched.

Exclusion Criteria

* Subjects who are smokers, alcoholics, tobacco chewers, and diabetics, those with a history of myocardial infarction, pulmonary embolism, stroke, and peripheral vascular disease or suffering from any cardiac diseases are excluded from the study.
* Individuals who follow irregular anti-hypertensive treatment and hypertensive and normotensive individuals who use medications which will prolong QT interval will be also excluded from the present study

Sample Size: To determine the sample size, we can use the formula:

$$n = 2\frac{S^2(Z1 + Z2)^2}{(M1 - M2)^2}$$

(Source: Karthik M, Venkateswarlu V, Evaluation of corrected QT interval in hypertensive and normotensive subjects of Andhra Pradesh, India National Journal of Physiology, Pharmacy and Pharmacology Online 2019 | Vol 9 | Issue 6 page no 476 to 479 , Patrikar S. Text book of Community Medicine 1st Ed, 2009. Ed. Bhalwar R.D. of

Community medicine AFMC, Pune. Publ. WHO India Office, New Delhi)

Where:

n = sample size

M1 = Mean test intervention – 374. 70

M2 = Mean control intervention – 361.90

S1 = Standard deviation of M2 – 18.96

S = Pooled SD = 20.2116

AH – One sided = I, Two sided = 2

1-α – set level of confidence

Usual values 0.95, 0.99 – 0.95

1 – β – set level of power of test

Usual values 0.8,0.9

Z1 – Z value associated with alpha -> 1.64485

Z2 – Z value associated with beta -> 1.28155

n1 – minimum sample size 43

Steps in calculation.

Multiplier – 2

NUM – 3498.39

DENO – 163.84

n1 – 43

n1~45

Therefore, the sample size should be approximately 100.

Sampling Method: Convenient Sampling

Data Collection: Present study conducted after obtaining institutional ethical committee permission. Approval from Dean and Principals soughted before data collection. Present study conducted on hypertensive individuals (n=50) and normotensive individuals (n=50) who were randomly selected from the people visiting our institute hospital. The normotensive individuals were mainly the Institute's staff members and relatives of patients working and visiting Pravara Institute of Medical Sciences Deemed to be University (PIMS-DU). First year undergraduate's students list obtained from student section of respective college and sampling frame prepared. Simple random sampling method used to select participants for study.

Detail clinical history was gathered from all the participants and later anthropometric data collected. Study variables collected using following methods:

The Body weight and Height Measurement: The weight and height was measured by investigator himself to avoid possible observer's bias.

- Body weight of participant was measured in kilogram (kg) without any foot wear and with minimal clothing. Weight was measured with the participants standing motionless on weighing scale with feet 15 cm apart, and weight equally distributed on both legs .Weight was measured to the nearest 0.5 kg. Before taking the weight the indicator of weighing machine ensured to "Zero" mark each time.

- **Height:** It was measured by using stadiometer. Participant were asked to remove all his foot wear and head cap if any and asked to stand erect by keeping his back against the plain wall/pillor with his heel touching to wall/pillor and looking straight ahead.

1. Body Mass Index (BMI): B.M.I was calculated by using formula weight in Kilogram divided by height in meter squardivided by height in meter square.

BMI = weight in kg/(height meter height meter)^2

- For analysis purpose BMI classified as following manner.

Table: Body Mass Index (BMI)	
BMI value	**Grading**
≤ 18.50	Underweight
18.50 to 24.99	Normal
25.00 to 29.99	Pre-obese
30.00 to 34.99	Obese I
35.00 to 39.99	Obese II
≥ 40.00	Obese III

2. The Waist and Hip Circumference and Waist to Hip Ratio

- Waist circumference:-It was measured at the level of the midpoint between the inferior margin of the last rib and the crest of the ileum in the mid-axillary plane. It was measured on abdomen without clothing or over light clothing by asking participant to stand straight.

- Hip circumference:-It was measured with tape, participant standing erect, both thigh and a foot touching each other and tape was placed at grater trochanter and maximum gluteal convexity.

- Waist and Hip Ratio:- The waist to hip ratio of ≥ 0.9 in men and ≥ 0.8 in females considered as indicative of central obesity

3. Blood pressure measurement and diagnosis criteria's: The hypertensive status was defined according Joint National Committee (2017) criteria and those individuals currently taking antihypertensive treatment.

Blood Pressure Categories

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

New guidelines of BP according to ACC & AHA (2017)

BP was recorded with digital BP apparatus (Diamond, Pune).BP was recorded thrice with three minutes interval and average will be considered as recorded BP.

Pre-Procedure: The first BP reading was taken after initials 5-10 min. rest and brief interrogation, so as to eliminate anxiety/fear factor. Then they were asked to sit calmly in a chair with feet on the flat floor and back supported. The second BP

reading has taken at end of the interview and average of two readings were recorded.

Procedure: The WHO recommended sitting position used for measurement of blood pressure. Participant asked to seat on chair by keeping right arm at heart level. Then he asked to roll up his sleeve. A cuffed bladder which encircled at least 80% of arm was used and blood pressure was recorded with digital BP apparatus

ECG recording and QT interval measurement: Twelvelead ECG was recorded in comfortable supine position. Lead-2 was used to measure the QT interval and RR interval. The resting supine subjects each had to undergo 12-lead standard ECG recording according to universal norms. Since the lead II had the most unambiguous T wave, QT interval and RR interval was determined from the lead II ECG strip (13).

After recording ECG all ECG record were analysed for heart rate,rhythm,waves (P,Q,R,S,T) and intervals (PR,QRS,ST,QT) in all leads.Heart rate more than 100 was considered as tachycardia and heart rate less than 60 beats per minute was considered as bradycardia.

The QT interval is different in different leads.This is mainly caused by varying projections on different lead vector.The QT interval was measured from the beginning of QRS complex to end of T wave in lead II,corrected QT (QTc) interval was calculated by using Bazett's formula ($QTc = QT/\sqrt{RR}$).

For heart rate <60 bpm, QT interval was not corrected using Bazett's formula. QTc was considered to be abnormally prolonged when it was >450 ms in males and >470 in females (14,15).

All collected data were systematically tabulated, and for each parameter, the mean and standard deviation (SD) were determined. . A p-value of less than 0.05 ($p < 0.05$) was considered statistically significant. Continuous data are represented as mean ± Standard deviation (SD). The statistical tests used are independent groups t-test and Pearson's correlation.

RESULTS

The anthropometric characteristics of the participants are summarized in [Table 1], with values expressed as mean ± SD. Both hypertensive and normotensive groups were comparable in terms of age and sex distribution.

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and the corrected QT (QTc) interval were found to be significantly higher among hypertensive individuals compared with normotensives. None of the participants exhibited abnormally prolonged QTc intervals (>450 ms in males and >470 ms in females) [Table 2].

Among hypertensive subjects, females showed a significantly greater QTc interval compared with hypertensive males. By contrast, no statistically significant differences in QTc interval were noted between male and female normotensive groups, nor between the overall male and female populations [Table 3].

Table 1

Parameter	Hypertensive Cases (n = 50)	Normotensive Controls (n = 50)	p-value
Age (years)	44.7 ± 6.7	40.0 ± 5.6	0.00023
Male, n	25	25	–
BMI (kg/m²)	30.6 ± 8.4	24.4 ± 5.5	0.00004
WHR	0.97 ± 0.12	0.84 ± 0.05	0.000001
Heart Rate from ECG (bpm)	88.5 ± 17.5	79.9 ± 13.3	0.0068
P < 0.05 = statistically significant. BMI: Body Mass Index; WHR: Waist–Hip Ratio; ECG: Electrocardiography.			

Table 2

Variable	Hypertensive Cases (n = 50)	Normotensive Controls (n = 50)	p-value
Systolic BP (mm Hg)	166 ± 24.7	119 ± 7.1	< 0.00001
Diastolic BP (mm Hg)	94 ± 8.9	78 ± 8.2	< 0.00001
QTc Interval (ms)	368 ± 17.6	334 ± 16.5	< 0.00001

P < 0.05 = statistically significant.

BP: Blood Pressure; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; QTc: Corrected QT interval.

Table 3

QTc Interval (ms)	Males	Females	p-value
Hypertensive cases (n = 50)	350 ± 17.5 (n = 25)	386 ± 19.5 (n = 25)	< 0.0001
Normotensive controls (n = 50)	336 ± 17.8 (n = 25)	332 ± 15.2 (n = 25)	0.23
Total (both groups)	343 ± 17.65 (n = 50)	359 ± 17.35 (n = 50)	< 0.0001

P < 0.05 = statistically significant.

QTc: Corrected QT interval.

DISCUSSION

The present study revealed a statistically significant difference for QTc interval among hypertensive cases and normotensives controls. QTc interval was significantly longer in hypertensive females than males, though there was no gender difference among normotensives.

Previous research has identified a prolonged QTc interval as a marker linked to increased morbidity and mortality in both hypertensive patients and individuals with normal blood pressure.[16] Even in cases where hypertension is controlled, complications such as left ventricular hypertrophy can persist, potentially leading to life-threatening arrhythmias and sudden cardiac death.[17] The findings of our study align with earlier research that observed significantly extended QTc intervals in hypertensive individuals compared to normotensive counterparts.[18] One such study also highlighted that both hypertension and left ventricular hypertrophy were associated with prolonged QTc intervals.[19]

A prolonged QTc has been strongly associated with ventricular arrhythmias, torsades de pointes, and higher rates of all-cause and cardiovascular mortality.[20–23]

Several population-based studies have investigated the relationship between hypertension and QTc interval. The Framingham Heart Study demonstrated QTc prolongation as an independent predictor of mortality.[24] In the Losartan Intervention For Endpoint Reduction in Hypertension (LIFE) trial, hypertensive patients with left ventricular hypertrophy exhibited longer QTc durations and increased cardiovascular risk.[25] Studies in Asian populations, such as those by Tan et al,[26] and Zhang et al,[27] reported significantly higher QTc values in hypertensive individuals compared with normotensives. Similar findings were observed in African and European cohorts,[28–31] However, some studies noted minimal or no differences,[32,33] highlighting the variability across populations.

Left ventricular hypertrophy (LVH), a common consequence of long-standing hypertension, is independently linked with QTc prolongation.[23,24] Okin et al,[36] reported that increased LV mass was associated with QTc dispersion and higher cardiovascular mortality. Sympathetic overactivity and impaired coronary perfusion in hypertensives further exacerbate repolarization abnormalities.[37,38]

A prolonged QTc is a powerful predictor of sudden cardiac death. Straus et al,[39] and Goldenberg et al,[40] demonstrated that prolonged QTc independently predicted mortality even after adjusting for confounders. Dekker et al,[41] in the Zutphen Study confirmed this association in elderly men, while other studies showed similar results in women and diabetic patients.[42–45]

Despite the growing burden of hypertension in India, studies evaluating QTc interval in hypertensive patients are limited. Singh et al,[46] observed a higher prevalence of QTc abnormalities in rural and urban Indian populations with hypertension. Gupta et al,[47] also reported a correlation between elevated blood pressure and prolonged QTc in a North Indian cohort. These findings underline the importance of studying QTc in Indian hypertensive subjects, given their unique risk profile influenced by genetics, diet, and lifestyle factors.[48–51]

The gender-related difference in QTc interval observed in our study is consistent with previous research, which has also shown significantly longer QTc intervals in hypertensive women compared to hypertensive men.[52] Conversely, several other investigations have demonstrated that even healthy females tend to have longer QTc intervals than healthy males.[53-55] Studies further revealed that castrated men exhibit prolonged QTc intervals, whereas virilized women display shortened ones.[53] In addition, men after puberty have been noted to show reduced QTc intervals.[54] These findings suggest that sex hormones are an important determinant of QTc interval differences between males and females. However, in contrast to these reports, our study found no statistically significant variation in QTc intervals between normotensive men and women, or between the total male and female groups. We therefore propose that the influence of sex hormones on QTc interval differences becomes more pronounced in the presence of hypertension, particularly among hypertensive males and females.

CONCLUSION

Our study demonstrates that hypertensive individuals exhibit significantly prolonged QTc intervals compared with normotensive controls. This easily obtainable ECG parameter deserves greater clinical attention, particularly in resource-limited settings such as India, where it has often been overlooked. Being a cost-effective, non-invasive tool readily accessible to primary care physicians, its importance cannot be underestimated. QTc measurement may serve as a practical approach for evaluating hypertensive patients and identifying those at higher risk. Early recognition of such changes could aid in preventing serious hypertension-related complications, including cardiac arrhythmias and sudden cardiac death. Therefore, QTc interval assessment holds potential value for screening, risk evaluation, management, and prognostication in patients with hypertension.

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