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Transient Effect of Acute Mental Stress on Corrected QT Interval among Healthy Male Students

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ABSTRACT

Introduction
The time taken for depolarization and repolarization of the ventricles is represented by the QT interval. Psychological factors such as active mental stress may influence the action potentials developed in the heart and may alter QT interval of an individual. Therefore, our study was targeted to find the transient effect of acute mental stress on corrected QT interval among the healthy male students.

Methods
An experimental study was conducted among 55 male first year undergraduates, studying medical and dental courses in Nepal Medical College and Teaching Hospital (NMCTH). The study was executed in the Electrocardiography (ECG) lab of Department of Physiology of NMCTH from September 2022 – November 2022. ECG was obtained before and after the application of active/acute mental stress using standard mental arithmetic test (MAT) for 1 minute.

Results
In comparison to rest state, a statistically significant decreased RR interval and increased heart rate ($p<0.001$) was observed after MAT. A statistically significant decrease in QT interval [0.35±0.05 sec Vs 0.32±0.05 sec] ($p<0.001$) and QTc interval [0.41±0.05 sec Vs 0.39±0.05 sec] ($p<0.001$) was observed after MAT. Nevertheless, there was no statistically significant change in QRS duration after the MAT ($p=0.16$).

Conclusion
Acute mental stress causes shortening of the QTc interval in young healthy males.

Keywords
Acute mental stress, mental arithmetic test, QT interval, QTc interval

INTRODUCTION

Ventricular depolarization and repolarization duration is taken as the time interval between Q wave and T wave.[1] The QT interval is mainly affected by the heart rate. Hence, a corrected QT (QTc) interval was calculated by Bazett's square root formula: QTc = QT/√RR to analyze the QT interval after heart rate correction.[2]

Autonomic nervous system also affects QT interval by directly influencing the cardiac myocytes or through heart rate modulation.[1,3] Therefore, prolonged QT interval may be indicative of an unbalanced autonomic activity on the heart and has been related to a lowered threshold for ventricular fibrillation and cardiac failure.[4] Acute mental stress alters the neural transmission to the heart and induce lethal arrhythmias causing sudden cardiac death.[5]

Studies have found increase in QT interval when physicians were exposed to sudden alarm calls or awakened with bad news while they were sleeping.[6,7] When different stress inducers were applied in participants to elicit acute mental stress, QT interval decreased.[8,9] In some studies, QTc duration was analyzed after inducing stress. One of such study[10] found prolongation of QTc intervals when acute mental stress (AMS) was applied in 30 young healthy males while another study found shortening of QTc on stressed automobile drivers in comparison to the unstressed participants.[11]

As contradictory results were obtained from previous studies about the effect of AMS on QT interval, the present study intended to explore changes in corrected QT interval after the application of acute mental stress among the healthy young male participants .

METHODS

An experimental study was conducted among 55 male undergraduate students of Nepal Medical College and Teaching Hospital (NMCTH) from September 2022 – November 2022 after receiving an ethical approval from NMCIRC. The sample size was estimated from Stata 15 licensed software for two sample paired means test assuming Mean QTc before application of stress of 0.39 seconds and 0.42 seconds after application of test, from published literature.[12] With standard deviation of 0.62 seconds, the level of significance (Alpha) was set at 5% and power was set as 80%. The minimum required sample size was calculated by the software as 36. We took all the sample that was available after meeting the inclusion and exclusion criteria and 55 participants were included in the study.

The study was done in the ECG lab of the Department of Physiology. Written consent was taken from each participant after verbally explaining the aim of the study and their history was taken to meet the inclusion and exclusion criteria. Those who smoke daily or 3-5 sticks in a week, those who consume alcohol daily or more than 3 times in a week, those with history of cardiac disease or under any medication and those who take more than 3 cups of caffeine containing drinks were excluded. Female students were not included due to variation in QT interval occurring at different stages of menstrual cycle.[13]

Participants were informed that they should not have alcohol or caffeine and should not be involved in vigorous physical activities at least for 12 hours before they participate for the test. Participant were called from 2-4 pm and ECG was taken only during this period to avoid the diurnal variation in cardiac activity.[14] Participants were asked to sit down and relax for at least 5 min. Then they were instructed to lie down flat on one's back on the bed and again relax for next 5 minutes. ECG leads were placed and ECG was recorded using an Electrocardiograph (9620L Nihon Kohden Corporation, Tokyo Japan) at a paper speed of 25 mm/s with an amplification of 10 mm/mV. Active psychological stress or acute mental stress was given to the participant by asking them to solve the mental arithmetic test. Whenever participants have to actively undergo enduring situations or execute any performance in a challenging situation, it sets an active psychological stress in them. To induce similar stress in this study, mental arithmetic test was given to be solved in 1 minute to the participants.[10,15] Here, they had to perform a serial subtraction by 7 from 700 very swiftly giving correct answers.[15] In addition, the participants were told that their answers will be recorded and compared to the other participants so that their perceived stress level may increase and they are motivated to compete. A metronome sound at 90 beats/ minute was also kept near the participant to keep him alert about the time that also added an additional stress in the participant during the mental arithmetic test. At the end of 1 minute, second ECG reading was recorded. The QT interval was measured from the beginning of the Q wave to the end of the T wave from the obtained surface ECG of the participants once before and then after applying mental arithmetic test.[1]

Bazett's square root formula QTc= QT/√RR was then applied to calculate QTc interval.[2] The normal QTc interval should be <0.45 second for adult males and a greater value was denoted as QTc prolongation[2] while a value of QTc interval ≤0.33 seconds was considered as shortened QTc interval.[16]

The collected data was entered in Microsoft Excel 2007 worksheet and statistical analysis was done using EPI INFO version 7.2.4.0. and Stata 15 statistical software. Mean change in RR interval,

heart rate, QT and QTc interval and QRS duration was reported within 95% confidence limits. The mean difference in QT interval, QTc interval, RR interval and QRS duration before and after the application of active mental stress was obtained using Paired t test.

RESULTS

The study included 55 healthy young males of age ranging from 19-21 years. Table 1 shows the RR intervals at rest which was 0.75±0.14 seconds while it was 0.68±0.14 seconds after 1 minute mental arithmetic calculation. There was a significant decrease in RR interval (p<0.001) with the mean difference of 0.07 seconds. The heart rates (HR) at rest was 81.70±13.02 per minute while it was 91.41±17.51 per minute after 1 minute mental arithmetic test. There was a significant increase in heart rate (p<0.001) with the mean difference of 9.70 per minute.

QT interval was 0.35±0.05 seconds at rest while it was 0.32±0.05 seconds after 1 minute mental arithmetic test with the mean difference of 0.03 second (Table 1). There was a significant decrease in QT interval (p<0.001). QTc duration was 0.41±0.05 seconds before and 0.39±0.05 seconds after 1 minute mental arithmetic test. There was a statistically significant decrease in QTc interval (p<0.001) with the mean difference of 0.02 seconds. However, QRS intervals was 0.042±0.009 second at rest while it was 0.041±0.009 second after 1 minute mental arithmetic test that showed statistically significant decrease in QRS duration (p=0.16) with the mean difference of only 0.001 second (Table 1).

DISCUSSION

Many studies focused on QT interval variation in stressful conditions.[6-9] However, QT intervals are influenced by RR interval or heart rates and thus the corrected QT interval has been a parameter of interest to explore its changes on application of acute mental stress. Although few other similar studies have set its wings to explore QTc interval changes after acute mental stress,[10,11,12] present study also included changes in other parameters like RR interval, heart rate and QRS duration as well, after the application of acute mental stress. Mental arithmetic test was used as a stressor here.[1,12]

Present study noted significantly reduced RR interval and increased heart rate (p<0.001) after 1 minute mental arithmetic test (MAT). The results corroborates with the previous findings.[1,17] This highlights the fact that sympathetic stimulation due to acute mental stress caused increased firing rate of SA node and thereby increased the heart rate.[18] Hence, acute mental stress may be harmful for those who have a compromised cardiac function as in case of coronary artery disease which may increase the cardiac load and lead to states like myocardial infarction and cardiac failure.[19]

Present study noted a statistically decreased QT interval (p<0.001) after application of acute mental stress. Similar results were observed in studies done by Paavonen et al[17] Huang et al[8] and Halapanthi et al[9] when participants were exposed to acute mental stress.

Generally, the heart rate is inversely proportional to the QT interval. Therefore, with shorter QT intervals there would be higher heart rates and with longer QT intervals there would be lower heart rates.[16] This might explain the results so obtained in our

Table 1. ECG parameters before and after acute mental stress induced by mental arithmetic test (n=55)

Parameters	Mean	Mean difference	SD	95% CI	t value	p value
RR intervals (sec)						
Before mental stress	0.75	0.07	0.14	0.71 - 0.79	5.91	<0.001
After mental stress	0.68		0.14	0.64 - 0.72		
Heart rate (beats per minute)						
Before mental stress	81.70	9.70	13.02	78.18 - 85.22	6.72	<0.001
After mental stress	91.41		17.51	86.67 - 96.14		
QT interval (sec)						
Before mental stress	0.35	0.03	0.05	0.34 - 0.37	8.98	<0.001
After mental stress	0.32		0.05	0.31 - 0.33		
QTc interval (sec)						
Before mental stress	0.41	0.02	0.05	0.39 - 0.42	4.04	<0.001
After mental stress	0.39		0.05	0.37 - 0.40		
QRS duration (sec)						
Before mental stress	0.042	0.001	0.009	0.039 - 0 .044	1.427	0.16
After mental stress	0.041		0.009	0.038 - 0.043		

sec : seconds; bpm : beats per minute

study that showed an increase in heart rate and a decrease in QT interval after application of acute mental stress. Sympathetic stimulation caused increased conductivity of action potential across the myocardium. This may highlight the shortening of QT intervals.

Significant decrease in QTc value ($p<0.001$) was observed in the present study, which was similar to the result of Karmakar et al[11] that noted decreased QTc intervals in stressed city drivers in comparison to that of unstressed control group. However, our result is contradicting to the results of some of the studies where QTc prolongation was observed after application of mental stress tests in healthy subjects.[1,10] When Gabor et al[1] performed a laboratory based study in 20 young healthy male volunteers, a statistically significant QTc prolongation ($p<0.001$) occurred at the onset of acute mental stress. However, it did not change significantly on the later phase of acute mental stress (AMS). The design of our study could not access these changes which might have missed the outcome of QTc prolongation at the onset of AMS. Anyway, AMS do alter QTc interval by altering the myocardial action potentials. Either there is QTc prolongation, representing increased ventricular repolarization time or shortening of QTc interval, depicting decreased ventricular repolarization time; both cases may induce severe ventricular arrhythmias[16] which again may implicate adverse/lethal conditions in a compromised heart. Thus, in patients with compromised heart conditions, on exposure to acute stressful stimuli, changes in QT interval may be an important index of its effects on their heart.

QT interval represents the ventricular depolarization and repolarization phases of ventricular action potential with QRS representing ventricular depolarization and the rest of the ECG waves representing the repolarization phase.[1] Our study observed no significant changes in QRS duration after application of acute mental stress ($p=0.16$) which has not been addressed in any other study. This clarifies that acute mental stress (AMS) primarily effects the repolarization phase of ventricular action potential.

CONCLUSION

Acute mental stress causes shortening of the QTc interval in healthy males. QTc duration shortened, but within the normal range. Since, the present study included only healthy subjects, the effects of mental stress on patients with underlying cardiac disease could not be explored. Further study including patients with different cardiac conditions should be done to elaborate on the effects of AMS on cardiac action potential which would highlight its role in aggravating the underlying cardiac disease.

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CONFLICT OF INTEREST

The author(s) declare that they do not have any conflicts of interest with respect to the research, authorship, and/or publication of this article.

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