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Study on T Wave Morphology and QT Interval in Diabetic Patients with or without Hypokalemia

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Abstract: *Diabetes Mellitus is often manifested with electrolyte disturbance of which hypokalemia is very common. It reflects clinically as changes in T wave morphology and QT interval in the electrocardiogram. Ninety subjects (45 diabetic and 45 non-diabetic) were studied after stratified randomised sampling. Their T wave height, T wave axis and QTc were studied in relation to their serum Potassium level. Patients with both Diabetes and hypokalemia had significant differences in ECG parameters when compared to those only with Diabetes, or only hypokalemia or none. In presence of diabetes and hypokalemia changes in T wave height and QTc become more prominent than in presence of diabetes alone.*

Keywords: *T wave, QT interval, Hypokalemia, Diabetes mellitus.*

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I. Introduction

Patients with severe hypoglycemia often present with electrolyte disturbances,with hypokalemia being most common type [1]. Hypokalemia associated with hypoglycemia may be associated with the increased risks of cardiovascular events in type 2 Diabetes mellitus during severe hypoglycemia. In fact, a decrease in serum potassium is a common observation in drug induced hypoglycemia. [2, 3].

Several experimental studies have observed relationships between hypokalemia and prolonged corrected QT (QTc) interval, which often leads to fatal cardiac arrhythmias and sudden death [4, 5]. Furthermore, a relationship between insulin induced hypoglycemia and hypokalemia during hypoglycemia in Diabetes has been noticed. Recently, one study suggested hypoglycemia causes increases in serum sodium and chloride levels and decreases in serum potassium levels [6]. Not only altered serum sodium and chloride levels during severe hypoglycemia in Diabetes occurs, whereas alterations of all electrolyte levels during severe hyperglycemia, such as Diabetic ketoacidosis (DKA) and a hyperglycemic hyperosmolar state, have been well established [7]. Incidences of hypokalemia during severe hypoglycemia in patients with type 2 diabetes appear to be a common finding.

II. Aims and Objectives:

This study aims to find out the changes in T-wave morphology and corrected QT interval in the Electrocardiogram of diabetic and non-diabetic individuals having hypokalemia as a common biochemical finding.

III. Materials and Methods

Study population : Consenting patients with T2DM attending or admitted in KPC Medical College and Hospital over a period of June 2016- May 2017
Sample size**:** 90 subjects (selected by stratified randomised sampling)
Age group **:** 40 to 60 years
Type of study **:** Cross sectional survey over a period of one year time
Site of study**:** Medicine wards and outpatient department (OPD) of medicine at KPC Medical College and Hospital.

Procedure followed for data collection**:** Each participant was explained about the study protocol, and informed consent of the adults were taken before recording their ECG and noting down the results of their blood parameters for blood glucose (Fasting blood glucose, Post prandial blood glucose), and electrolyte levels for Na+, and K+, the latter being measured within two hours of recording their ECG. An informed consent was signed by each of the participant who participated in the study.

Inclusion Criteria:
- Mentally alert and conscious subjects with full knowledge about the matter participated in the study.
- 45 subjects in the T2DM group were diagnosed at least two years back and were with or without ongoing treatment.
- 45 non diabetic participants were chosen as control some of whom had electrolyte disturbance.

Exclusion Criteria:
- Patients with other comorbidities like cancer, cirrhosis of liver, multi organ failure, chronic kidney disease (even if it was due to Diabetic Nephropathy) etc were excluded from the study.
- Those who were excluded from the study were those below 40 years of age and above 60 years of age.
- Pregnant women were not included in the study.

Source of finance:
The study was funded by researchers.

Plan of analysis*:*
Data were analyzed by using Microsoft Excel 2007 and SPSS-20. After analysis data were presented by tables and bar-diagrams.
The data obtained from current study were compared with similar studies available in literature.

Ethical consideration:
Extreme caution was taken to maintain confidentiality, and free voluntary consent was taken from the participants before the study.

An ECG was recorded for each patient and the T wave height, axis and QT interval was calculated. Corrected QT (QT_C) was calculated y using Bazetts formula: $QT_C=QT/\sqrt{RR}$.

Serum Sodium (Na^+) and Potassium (K^+) were estimated from freshly collected sample of blood using Ion Selective Electrode Analyser.

Out of 175 individuals who participated, 72 were found to be Diabetic and 103 were found to be non Diabetic. 45 individuals were selected from each of these groups by stratified randomised sampling. Individuals in each of these groups were further classified based on their serum Potassium level.

The subjects were divided into four groups:
- **Group 1**: Diabetic subjects with Hypokalemia (Serum potassium <3.5 mEq/L)
- **Group 2:** Diabetic subjects without Hypokalemia (Serum potassium = 3.5- 5.5 mEq/L)
- **Group 3:** Non-diabetic subjects with Hypokalemia (Serum potassium <3.5 mEq/L)
- **Group 4:** Non-diabetic subjects without Hypokalemia (Serum potassium = 3.5- 5.5 mEq/L)

For each group T wave height, axis and QT_C were tabulated and compared with the other groups using Student's T-test. A p-value of < 0.05 was considered to be statistically significant. Calculations were done using Microsoft Excel 2007 and SPSS 20.

IV. Observations and Results:

Table 1: Serum potassium levels, T-wave heights, T wave axis and corrected QT interval (QTc) of the subjects in different groups expressed as Mean (+/- SD)

GROUPS	GROUP 1 (n= 29)	GROUP 2 (n=16)	GROUP 3 (n=21)	GROUP 4 (n=24)
SERUM K+ (mEq/L)	3.39 (+/-1.20)	4.51 (+/- 0.53)	3.21 (+/-1.95)	4.23 (+/- 0.48)
T WAVE HEIGHT (mV)	6.2 (+/- 2.57)	6.8 (+/- 3.32)	5.7(+/- 2.38)	7.1 (+/-1.32)
T WAVE AXIS (DEG)	63 (+/- 6.52)	96 (+/- 7.91)	109 (+/- 4.65)	87 (+/-5.22)
QT_C	42 (+/- 5.82)	39 (+/- 4.28)	41 (+/- 5.39)	37 (+/-3.90)

Chart 1: Comparison of mean T wave heights (in mV) in different groups

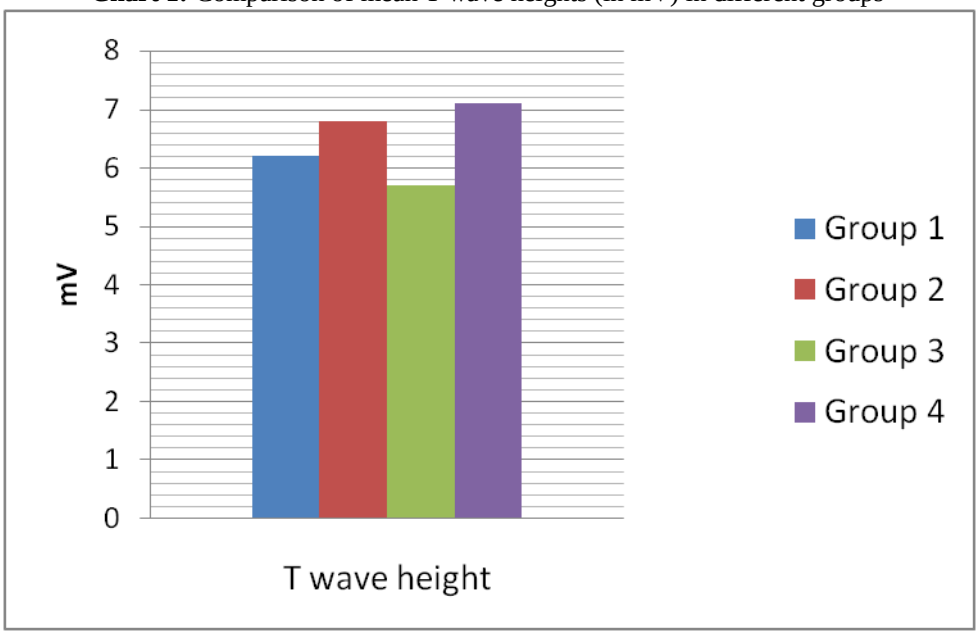
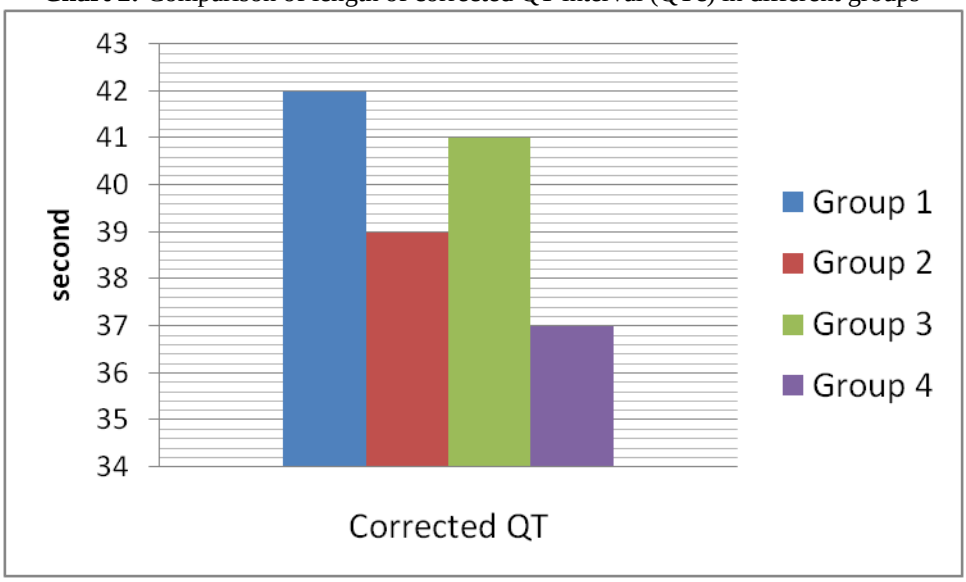


Chart 2: Comparison of length of corrected QT interval (QTc) in different groups



V. Discussion

Electrolyte disturbances are not uncommon in patients with T2DM. Patients with severe hypoglycemia often present with hypokalaemia. There has been demonstrated effect of drug induced hypoglycemia on serum electrolyte levels, with associated increase in Sodium and Chloride levels [4,5,6]. Hyperglycemic complications like Diabetic Ketoacidosis and Hyperglycemic hyperosmolar states have been found to alter serum levels of several electrolytes including serum Potassium [7]. Hypokalaemia often manifests with abnormal electrocardiographic findings including changes in QT segment and T waves and may present clinically as fatal cardiac arrhythmia and sudden death [2,3].

Previous epidemiological studies have shown that severe hypoglycemia could lead to arrhythmias, cardiovascular events, dementia, and death [8, 9]. It is well accepted that the prolongation of QTc related to ventricular arrhythmias and sudden death is induced by severe hypoglycemia in patients with both type 1 and type 2 diabetes [10]. Although hypoglycemia itself without hypokalemia might cause the prolongation of QTc interval in patients with type 2 diabetes [11], hypoglycemia with hypokalemia could enhance the prolongation of the QTc interval. Moreover, hypokalemia-associated with hypoglycemia is known to be associated with hyperinsulinemia and the increased secretion of catecholamines [12, 13] causing significant changes in ECG. Therefore it is speculated that hypokalemia might be associated with relative hyperinsulinemia and hypothermia

during severe hypoglycemia. This study aims to observe the changes in T wave height, T wave axis and corrected QT interval [QTc] in Diabetic patients with hypokalemia as compared to Diabetic patients without hypokalemia.

In our study, there was significant difference of means between Group 1 and the remaining groups for the values of T wave Height and QT_C ($P < 0.05$). The difference of means was also significant ($P < 0.05$) between Group 1 and Group 3. However, the difference of means of T wave heights was not significant between groups 2 and 4 ($P > 0.05$).

VI. Conclusion

In presence of Diabetes and Hypokalaemia the change in T wave height and QT_C become prominent unlike in presence of Diabetes alone.

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