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Serum Electrolyte Abnormalities on ECG in patients With and without Alcohol Use Disorders-A Cross sectional Comparative study

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Abstract:
Background *The burden of death and disease produced by alcohol is significant. Alcohol can cause ECG changes before the manifestations of cardiac disorders. It causes various electrolyte abnormalities. This study was undertaken with a hope of early detection of cardiovascular disease among Alcohol Use disorder (AUD) patients and preventing its complications. The basic significance of this study is it helps in counseling and convincing the patient to stop alcohol. Present study is aimed to assess the impact of duration of alcohol use and serum electrolyte abnormalities on ECG*
Materials and Methods*: A comparative study involving fifty AUD patients and fifty non-AUD patients satisfying the inclusion and exclusion criteria from the Psychiatry OPD and De-addiction centre till the calculated sample size was attained. After taking an informed consent and bio data, history of duration of alcoholism was recorded in a proforma. ECG was taken and the parameters were noted. Three ml of blood was collected from study subjects and serum electrolyte estimation was done in fully automated analyzer. Data was entered into excel sheet analyzed using SPSS version 21 software.*
Results*: There was no significant relation between duration of alcohol use and ECG changes. Serum sodium level showed a positive relation with P wave morphology, serum calcium level showed positive relation with QTc and serum magnesium showed a positive association with ST segment changes*
Conclusion: *A regular monitoring of AUD patients with ECG and other haematological parameters helps in early detection of cardiovascular disease so that remedial measures can be adopted early and can reduce the associated mortality and morbidity in the long term.*
Key Word*: Serum electrolytes, Alcohol Use Disorder, Electrocardiogram, Duration of alcohol use.*

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I. Introduction

Alcohol has been implicated in the burden of multiple diseases predominantly diabetes mellitus, cardiovascular disorders, GIT problems, epilepsy and other neuro-psychiatric disorders. It is also responsible for the major fraction of injuries due to accidents.

Alcohol use disorder (AUD) is a common disorder characterized by withdrawal, tolerance, craving, failure to fulfill major role at work, having persistent social or interpersonal problems, use in those situations in which it is physically hazardous etc.

DSM – 5 criteria: In May 2013, the American Psychiatric Association has issued 5th edition of the Diagnostic and Statistical Manual of Mental Disorders[2] (DSM–5).

DSM – 5 criteria combined the two DSM–4 disorders, alcohol abuse and alcohol dependence, into a single disorder called Alcohol Use Disorder (AUD) with mild, moderate, and severe sub-classifications.

The presence of 2 of these symptoms indicates an Alcohol Use Disorder (AUD).

The severity of the AUD is defined as:

Mild: The presence of 2 to 3 symptoms.

Moderate: The presence of 4 to 5 symptoms.

Severe: The presence of 6 or more symptoms

The prevalence of alcohol dependence among males in Thiruvananthapuram district is 38.4% [1] .It has been observed that prolongation of QT interval and non-specific ST and T changes are frequent in ECG of patients with chronic alcoholic use disorder. Most of the ST-T changes in chronic alcoholic use may be a manifestation of associated electrolyte abnormalities[10]Abnormalities of potassium[3] calcium [4] magnesium[6] are usually observed in patients with chronic alcohol use and these may lead to ECG changes. Alcohol impair the contractile function

of heart by interfering with the calcium uptake and binding by sarcoplasmic reticulum. Prolongation of QT interval may be due to the abnormality in serum calcium level[5]

Alcohol abuse is a pattern of drinking which cause damage to the physical, mental and social wellbeing of the patients and also to those around them. It is having a strong relation with hypertension and the prevalence is 50150% higher in heavy alcohol uses.[16]This is usually a transient hypertension and becomes normal, few days after withdrawal. The interaction between various electrolytes has been described to have a role in the generation of hypertension[7]

Therefore a regular monitoring of AUD patients with ECG along with other haematological parameters could be a step in early detection of cardiovascular disease so that remedial measures can be adopted, ultimately reducing the associated mortality and morbidity in the long term.

Primary objective

- To study the association of duration of alcohol use and ECG changes.
- To assess the serum electrolytes (serum sodium, potassium, calcium, magnesium) level and its association with ECG changes in patients having Alcohol Use Disorder.

II. Material And Methods

This study was conducted in the Department of Psychiatry, Government Medical College, Thiruvananthapuram. The subjects participating in this study were chosen from AUD patients attending consecutively in the OPD of Psychiatry and De-Addiction center, Government Medical College, Thiruvananthapuram. Fifty AUD patients and fifty non AUD patients satisfying the inclusion and exclusion criteria were recruited till the sample size was attained. After taking an informed consent and bio data of each subject were recorded using a proforma. Under aseptic precautions, 3ml of blood was collected for examination.

Study design

Comparative Cross Sectional Study.

Study setting

OPD of Psychiatry and De-addiction centre, Government Medical College, Thiruvananthapuram.

Study population

Patients having Alcohol Use Disorder confining to DSM-5 criteria.

Comparative group

Other patients without Alcohol Use Disorder attending the OPD are selected as comparative group.

Study subjects

Exclusion criteria:

- Known case of diabetes mellitus, hypertension, coronary artery disease and other heart disease.
- Subjects on any long-term drugs that can cause ECG changes.
- Those who are not willing to give consent.

Sample size

Sample size is calculated using the formula:

$n = 2 \times \{ Z_{(1-\alpha/2)} + Z_{(1-\beta)} \}^2 \times \sigma^2$

Therefore a sample size of 50 was decided upon for each group

Sampling technique

Consecutive patients attending OPD of Psychiatry and de-addiction centre, Government Medical College, Thiruvananthapuram fulfilling study criteria is enrolled for the study.

Duration of study

1 year.

Study variables

- Duration of alcohol use.
- ECG parameters: Heart rate, P wave, PR intervals, QRS complex, ST segment, QTC interval, QT interval, T wave.

3. Serum electrolytes (sodium, potassium, calcium, magnesium).

Normal range: Sodium: 135-145 mmol/L[8]

: Potassium: 3.6-5 mmol/L[8]

: Calcium: 8.5-10.5 mg/dl[8]

: Magnesium: 1.82-2.43 mg/dl[8]

Data collection tool
Structured proforma was used to collect the clinical history and to confirm the diagnosis..

Recording of ECG
CARDIART 6108 T is the electrocardiograph machine used to record the ECG of both the cases and controls. Twelve lead ECG was recorded by using a standardised ECG machine.

Serum electrolytes (Na, K, Ca, Mg)
Serum sodium and potassium ions estimation done by Ion selective electrode method, serum magnesium estimation done using End point method and serum calcium estimation was done using Arzenazo III method in the Central lab, Department of Biochemistry, Government Medical College, Thiruvananthapuram.

Data collection technique
Ethical clearance was obtained. Patients coming to study settings before the administration of any drugs and confining to the inclusion and exclusion criteria was assessed for ECG changes. The purpose and Nature of the study was explained in detail. Informed consent was obtained. The information about the history was collected using a Proforma.

III. Procedure Methodology

Estimation of serum electrolyte
Under aseptic precautions 3ml of blood was collected for doing the serum electrolyte estimation. The blood was immediately centrifuged and serum was used for estimation of electrolytes. The estimation was done using fully automated analyser Beckmann Coulter AU 680.Caliberation of the machine for doing calcium and magnesium was done using system calibrator.

Statistical analysis

Analysis
- Data was entered in to Microsoft Excel data sheet.
- Quantitative variables were expressed as mean and standard deviation and qualitative variables were expressed as percentage.
- Statistical test of significance: Comparison of quantitative variables analysed using unpaired t test. Comparison of qualitative variables analysed using chi square test. Statistical test of significance for non-parametric variables include Mann-Whitney U test and Kruskal Wallis test.
- A P value of <0.05 was considered statistically significant and a P value <0.01 was considered very significant.
- Analysis of data done using appropriate statistical software SPSS version 21.

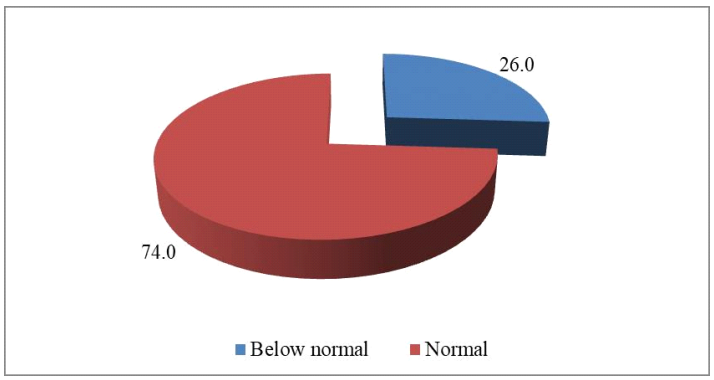
Ethical considerations
- Institutional Ethics Committee clearance was obtained.
- Informed consent obtained from the participants.
- Confidentiality was ensured and maintained throughout the study.
- No expenses were incurred from the patients.

IV. Results

This study was conducted with a view to compare the changes in ECG parameters associated with Alcohol Use Disorder patients with other non AUD patients attending study setting.

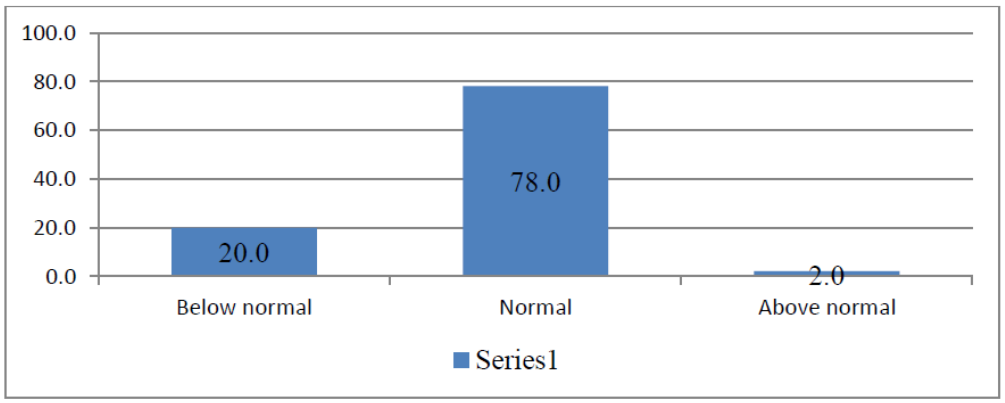
Serum electrolytes among patients with alcohol use disorder
Serum electrolyte was estimated in patients with alcohol use disorder. The association of ECG changes with the serum electrolytes was later compared. Also the changes in ECG parameters were compared with the duration of alcohol use.

- **Percentage distribution of the sample according to level of serum sodium (Fig. I)**



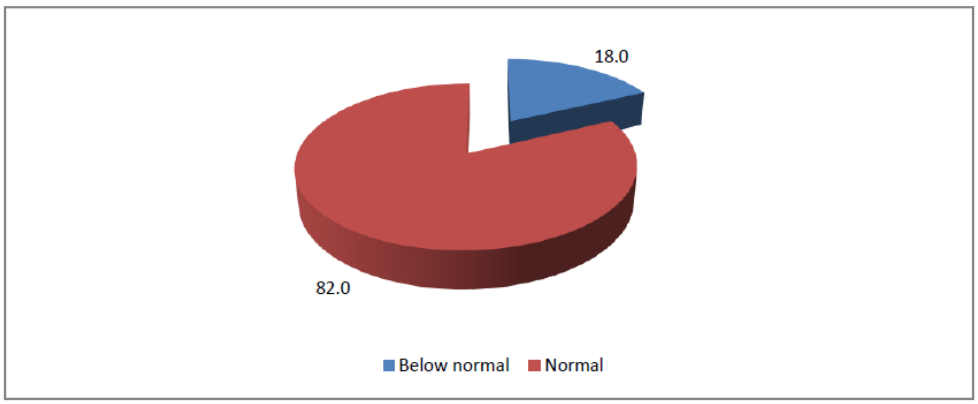
Among the patients assessed the mean serum sodium level was found to be 135.9(SD=2). 26% (N=13) of the subject had a value below normal and 74 % (N=37) of the subject had normal value.

Percentage distribution of the sample according to level of serum potassium (Fig 2)



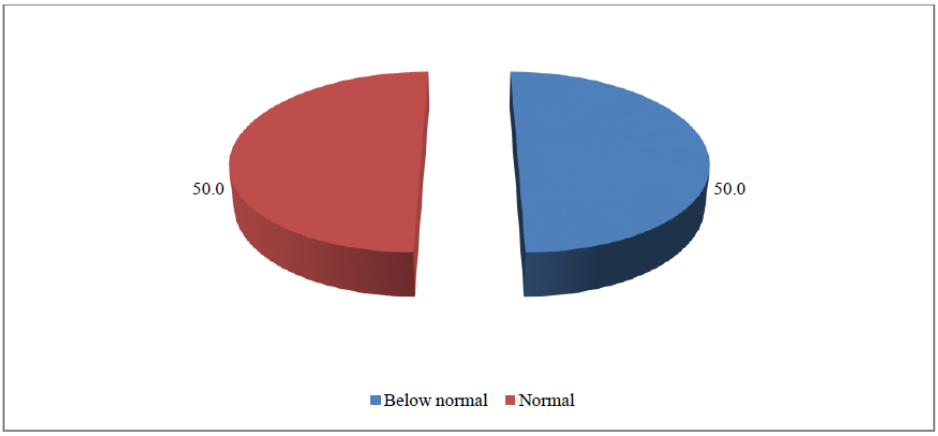
Among the study subjects the mean value of serum potassium obtained was 3.9(SD=0.5) .78% (N=39) of the subject had normal value .Only 20% (N=10) of the subject had values below normal. 2% (N=1) had values above normal.

- **Percentage distribution of the sample according to level of serum calcium (Fig 3)**



The mean value of serum calcium obtained in AUD patients was found to be 9.1(SD= 0.6). 82% (N=41) of them had normal value and 18 % (N=9) had a value lower than normal.

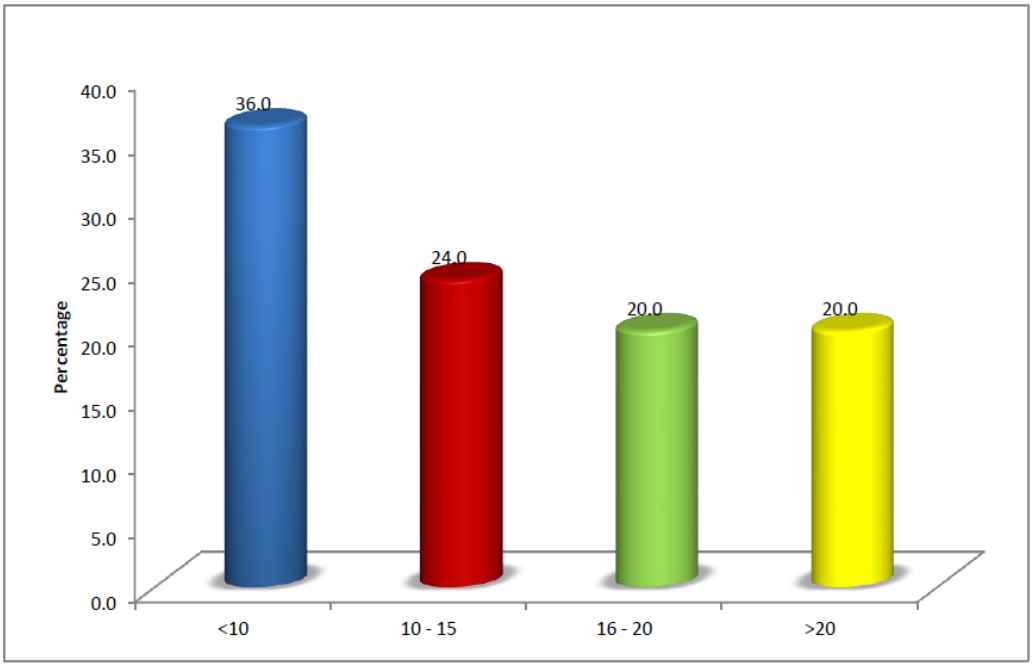
- **Percentage distribution of the sample according to level of serum Magnesium.(Fig 4)**



The mean value obtained among alcoholic patients was 1.8 (SD=0.3).The percentage distribution was 50:50, that is 50 % (N=25) of the patients had a value below normal and another 50% (N=25) had normal value.

B. Association of duration of alcohol use and ECG changes

1 Percentage distribution of the sample according to duration of alcohol use (Fig: 5)



To find out the association between duration of alcohol and ECG changes in AUD patients were classified into four groups . Not statistically significant.(P value =0.364).

2. Association of heart rate with duration of alcohol use

There is no significant relation between duration of alcohol use and heart rate. Here the r value is 0.027 and P value is 0.854 that is the change in heart rate is independent of the duration of alcohol use.

- **Comparison of T Wave based on duration of alcohol use (Table II)**

T Wave	<=15		>15		^{2}	P
	Count	Percent	Count	Percent		
Normal	27	90.0	17	85.0	3.41	0.182
Tall wave	2	6.7	0	0.0		
Inverted T wave	1	3.3	3	15.0		

Not statistically significant. (P value =0.182).

C. Association of serum electrolytes with ECG changes among alcohol use disorder (AUD) patients

- **Potassium with ECG changes among AUD patients**

Table iii: Association of Potassium with ST segment among alcohol use disorder patients.

ST segment	Mean ± SD	Median	^{2}$	P
Normal	3.9 ± 0.5	3.8	0.37	0.831
Elevated	3.8 ± 0.3	4.0		
Depressed	3.6 ± 0.5	3.9		

$ Kruskal Wallis Test-The association was not statistically significant.

B. Potassium and T wave

Table iv: Association of Potassium with T wave among alcohol use disorder patients

T wave	Mean ± SD	Median	^{2}$	P
Normal	3.9 ± 0.5	3.8	0.77	0.681
Tall wave	3.8 ± 0.1	3.8		
Inverted T wave	3.9 ± 0.2	3.9		

$ Kruskal Wallis Test not significant

C.Potassium and QTc in AUD patients

There is no significant relation between the serum potassium and corrected QT interval. Here the r value is -0.109 and P value is 0.450.

2. Association of serum Calcium level and ECG changes

A. Calcium and QTc (Fig :5)

r = -0.358*, p = 0.011 *: - Significant at 0.05 level

It was observed that as the value of calcium decreases there is an increased duration of QTc interval.

3. Association of S. Magnesium with ECG changes in AUD patients.

Table v. Serum magnesium and ST segment in AUD patients

• ST segment	Mean ± SD	Median	^{2}$	P
Normal	1.9 ± 0.3	1.9	6.74*	0.034
Elevated	1.9 ± 0.2	2.0		
Depressed	1.3 ± 0.3	1.3		

B. Serum Magnesium and T wave

Table vi : Association of magnesium with T wave among Alcohol Use Disorder patients

T wave	Mean ± SD	Median	^{2}$	P
Normal	1.8 ± 0.3	1.9	4.73	0.094
Tall wave	2 ± 0.5	2.0		
Inverted T wave	1.6 ± 0.1	1.5		

$ KruskWallis Test not significant *: -

C. Serum magnesium with corrected QT interval

Not significant

4. Association of serum sodium with ecg changes

A. Serum sodium and morphology of P wave

Table vii : Comparison of level of serum sodium based on Morphology of P wave in lead II

Level of serum sodium	Normal		Abnormal		^{2}	p
	Count	Percent	Count	Percent		
Below normal	10	21.7	3	75.0	5.43*	0.020
Normal	36	78.3	1	25.0		

*: - Significant at 0.05 level

B. Serum sodium and T wave

Table viii : Comparison of level of serum sodium based on T Wave

Level of serum sodium	Normal		Tall wave		Inverted T wave		^{2}	P
	Count	Percent	Count	Percent	Count	Percent		
Below normal	12	27.3	1	50.0	0	0.0	2.04	0.360
Normal	32	72.7	1	50.0	4	100.0		

No significant relation

C. Serum sodium and QRS complex

r = 0.104, p = 0.470 not significant

V. Discussion

The present study was conducted in a view to compare the ECG parameters of the patients with alcohol use disorder to those who do not have this disorder. Alcohol use is a socio psycho economic burden to economically lower strata of people in Kerala as elsewhere. Alcohol use has got complex effects on cardiovascular functioning. One of the most important acute effect of alcohol on heart is the weakening of myocardium (negative inotropic effect).This can later lead to irregular and ineffective contractions of myocardium with very fast heart rate called as tachyarrhythmia [9.]

Duration of alcohol use and electrocardiogram

In the present study the effect of duration of alcohol use on ECG parameters (heart rate, ST segment and T wave) was also done. Among the patients who had history of alcohol use of less than 15 years, 93% of them had normal ST segment and 90 % had normal T wave. 3.3 % had ST elevation and another 3.3 % had ST segment depression. 6.7% had tall T wave and 3.3 % had inverted T wave. While in patients with greater than 15 years of alcohol consumption 80% had normal ST segment, 10 % had elevated ST .wave. The heart rate was persistently elevated in both the age groups. However the findings are not statistically significant.

Sinus tachycardia and non -specific ST-T wave changes were common in patients with increased duration of alcohol use. Greater the duration of alcohol use greater will be the cardiovascular risk [10,11,12] .

Effect of serum calcium level on ECG changes

In the present study 18% of the subjects were having low serum calcium level. The mean value obtained was 9.1±0.6. Several studies have shown that hypocalcaemia is one of the common electrolyte abnormality found in patients with chronic alcohol use [13]. One of the reason for hypocalcaemia is that patients with alcohol use are having high values of calcium fractional excretion than normal. Ethanol also decreases the activity of Na^+-K^+ ATPase pump and decreases tubular absorption of Calcium [14.] Hypomagnesaemia along with suppressed secretion of parathyroid hormone results in further decreased calcium absorption in these patients [15,16.] Respiratory alkalosis in these patients results in parathyroid resistance leading to hypercalciuria which further leads to hypocalcaemia [17.]

The hypocalcaemia may contribute to the ECG changes in alcoholics. In the present study the relation of QTc prolongation with serum calcium was analysed and found out that QTc prolongation is associated with low serum calcium levels. This was similar to many other studies, [19,18] . Some studies have proved that severe hypocalcemia can be seen in chronic alcoholics and this causes QTc prolongation [20,21] QTc reflects impaired ventricular conduction [22] .

Effect of serum magnesium level on ECG changes

50% of our study population had hypomagnesaemia. One of the causes of hypomagnesaemia related to decreased magnesium intake is alcoholic dependence. Alcohol withdrawal syndrome causes redistribution of magnesium from extracellular to intracellular space. Proposed causes of increased magnesium entry into the cells were a) respiratory alkalosis b) excessive catecholamine release during alcohol withdrawal. Exogenous catecholamine also causes significant intracellular magnesium shift. Another reason is spurious that lipolysis in alcohol withdrawal causes mobilisation of FFA which binds magnesium and precipitate hypomagnesaemia. Gastro intestinal loss is another reason [23,24]

Another cause may be due to direct diuretic effect of ethanol [25]. Recently a study suggested nearly 21% of chronic alcoholics have hypomagnesaemia due to reversible tubular defect [26]. Transient hypoparathyroidism was reported as one of the cause for hypomagnesaemia during alcohol intoxication [16].

Clinical manifestation of magnesium depletion causes widening of QRS complex, prolongation of PR interval, inversion of T wave, U waves sensitivity to digitalis and digoxin and predisposition to various arrhythmias. Hypomagnesaemia is usually associated with hypophosphatemia, hypokalemia and hypocalcaemia. Significant ECG changes in our study were ST depression and T wave inversion. Statistically significant ST

depression is noted when magnesium is less than 1.3 mg/dl. T wave inversion was found when magnesium value is less than 1.6mg/dl. Corrected QT interval was prolonged but there was no statistically significant association with hypomagnesaemia.

Seeling compared the electrocardiographic patterns of magnesium depletion appearing in alcoholic heart disease. Magnesium plays a significant role in maintaining myocardial integrity. Magnesium depletion leads to disruption of the myocardium at cellular level and mitochondria. Serum level of magnesium is not a reliable indicator of muscle magnesium. Hence ECG changes with serum magnesium gives a better idea about myocardial injury. Though ECG improvement after magnesium therapy is not done in our study, many study showed in improvement [28,29].

Tachycardia and other ECG changes resembling those of hypokalaemia or with only primary ST changes have been reported by Flink and collaboraters [30,31].

Effect of serum potassium level on ECG changes

Twenty percentages of our subjects were having potassium values below normal. Most common sign of chronic alcohol consumption include precipitous decrease in plasma concentration of Phosphate , Magnesium, Potassium and chloride within first 24 to 36 hours after admission[34].Fifty percentage of population with alcohol use disorder will develop hypokalemia[33,34] Similar to any other electrolyte abnormalities potassium deficit also occurs due to decreased intake and gastrointestinal loss. Another cause is that there will be increased urinary loss of potassium. If the patient is having clinical symptoms like vomiting and ketoacidosis, there will be increased loss of urinary potassium due to coupling of increased mineralocorticoid levels and increased delivery of sodium to distal nephron. Coexisting magnesium deficiency also increase the chance of hypokalemia[34]There is increased insulin secretion in these patients which leads to intracellular shift of potassium. Another proposed mechanism of hypokalaemia in alcoholics is the autonomic hyperactivity and development of respiratory alkalosis[35].

Normally at a value of 3.5 meq /L there will be ST segment depression and prominent U wave will be present immediately after T wave resulting in a falsely prolonged QT interval. At a value of 2.5 meq/L PR interval will be prolonged, ST segment is depressed and T wave is inverted. QT interval remains normal. The mean value of potassium in our study was 3.9±0.5 meq/L. There was no statistically significant relation between the serum potassium and ECG findings

Effect of serum sodium level on ECG changes

In the present study 26% of the subjects were having hyponatremia (N=50). Hyponatremia is common among alcoholics. In another study by Liami 17.3% of their subjects were having hyponatremia related to alcohol use and it is the third common electrolyte abnormality[37].

In patients with AUD there will be hypertriglyceridemia and there will be marked increase in the non-aqueous phase of plasma which results in pseudohyponatremia due to fall in sodium concentration when compared to total volume[38] Another cause for hyponatremia is hypovolemia which will stimulate ADH secretion resulting in increased water intake and water retention[39]. In those who had excess consumption of beer , there will be decreased excretion of free water due to decreased excretion of urinary solutes[40]. This results in dilutional hyponatremia. SIADH and Cerebral salt wasting syndrome which are alcohol induced are other reasons for hyponatremia[41,42]

In present study 23 % of patients with hyponatremia in alcoholics had abnormal P waves which were statistically significant. Hyponatremia is one of the dyselectrolemia which have the least ecg changes. Hyponatremia decreases phase zero of the action potential[43]. P wave alternans was reported in a case of hyponatremia. In that study they further concluded that fluctuating P wave morphology should raise suspicion about biochemical or other derangement[44]. Other ECG changes in the present study did not show any statistically significant correlation with hyponatremia.

VI. Conclusion

The present study reveals the effect of duration of alcohol use and the electrolyte derangement on the ECG changes in patients with and without AUD

There was no significant relation between duration of alcohol use and ECG changes though NSST changes are more in those with greater duration of alcohol use. Serum sodium level showed a positive relation with P wave morphology. Serum calcium level showed positive relation with QTc .Serum magnesium showed a positive association with ST segment changes. No significant relation was seen in Potassium with ST segment, T wave and QTc, Magnesium with T wave and QTc and Sodium with QRS and T wave.

From the above findings it is concluded that there are significant ECG changes in patients with Alcohol Use Disorder compared to comparative group. This could be due to the direct effect of ethanol on heart or due to

underlying electrolyte abnormality .This indicates that patients with AUD are at higher risk of cardiovascular disease. Earlier detection of ECG changes can prevent cardiovascular morbidity.

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There are no conflicts of interest for this study

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