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ELECTROCARDIOGRAPHIC CHANGES RELATED TO POTASSIUM LEVEL IN END STAGE RENAL FAILURE

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ABSTRACT

Objectives: To evaluate electrocardiographic changes related to potassium level and it's severity in end stage renal disease patients. **Methods:** This is a prospective cross sectional study of emergency department patients with end stage renal disease on replacement therapy with hyperkalemia and ECG recorded at time of hyperkalemia, inclusion criteria were(potassium level >5.5 and age>18 years. We clssified hyperkalemia into mild(5.5-6mmol\L), moderate(6-7mmol\L), and asevere (>7mmol\L), for analyzing the relationship between potassium level and ECG changes. **Results:** A total of 125 cases were collected, of those 25 were excluded because they didn't meet the inclusion criteria, the sample consist of 100 patient {men 53% _women47%}Median age of patients was 53.5 years+/- 17.5. The number of normal ECG were 33, with 67abnormal ECG mainly showing hyperacute T wave(55) patients and prolonged PR interval(35) patients, QRS prolongation (16) patients, sine wave(5) patients, asystole(2) patients and atrial fibrillation(AF) in (6) patients. **Conclusion:** The ECG is a good tool of early hyperkalemia detection, correlating significantly to it's severity. Patients with end stage renal disease present electrocardiographic alterations similar to patients with hyperkalemia due to other causes.

KEYWORDS: To evaluate electrocardiographic changes related to potassium level and it's severity in end stage renal disease patients.

INTRODUCTION

In patients with renal failure, sudden death is a major reason for mortality and hyperkalemia with cardiac arrhythmia, is one of the main causes.[1],[2] In patients on hemodialysis (HD), hyperkalemia is known to be a consequence of tissue break down and decreased renal potassium excretion.[3] Typical electrocardiographic (ECG) manifestations include peaked T-waves in the precordial leads, and widening of the QRS-complex, both abnormalities of altered cardiac conduction. Flattening or absence of the P-wave, and a "sine-wave" appearance is associated with severe hyperkalemia.[4] Although, ECG is generally speculated as a reliable rapid method for detection of potentially lethal hyperkalemia, investigators have reported that even in the presence of profound hyperkalemia, there may be only minimal or non-specific ECG changes, or even no changes in ESRD patients, suggesting that one cannot entirely rely on the ECG features of hyperkalemia in renal failure.[5,6,7,8,9,10,11,12] The aim of this study is to evaluate the presence of expected ECG features in ESRD patients with hyperkalemia, and to determine whether any of the ECG parameters could predict the existence of hyperkalemia in this patients.

PATIENTS AND METHODS

This is a cross sectional descriptive, prospective study conducted at Emergency Department of Baghdad Teaching hospital, Medical City, from January 2011 till January 2012. A total of 100 cases were collected of the (53 male, 47 female) We included patients with ESRD on replacement therap(on haemodialysis), older than 18 years and with documented potassium level>5.5. Exclusion criteria include: patients with hyperkalemia not related to ESRD (trauma, burn), potassium level<5.5 and Lab. notation of a hemolysed sample.

Lab. specimens were obtained by Emergency department. nursing staff and then send to the hospital emergency lab. ECG were done by Emergency department nursing staff and the readings were done by the emergency physician.

Criteria for ECG changes was the presence of new peaked and symmetric T wave at time of hyperkalemia, presence of new atrioventricular(AV) delay, atrial fibrillation(AF), wide QRS complex, sine wave and asystole. clinical variables included chief complain, age, sex, ECG findings, old ECG records, lab. Results for potassium, blood urea, S.creatinine, glomerular filtration rate(GFR).

Secondary outcome including dysrythmia, admission, and death were also recorded. Prior studies of hyperkalemia have used specific cutoffs based on potassium elevation (15) In similar fashion we recorded potassium into categorical values into mild (5.5-6mmol\L), moderate (6-7mmol\L), sever (>7mmol\L), for analyzing the relationship between potassium level and ECG changes.

RESULTS

A total of 100 patients slightly of more men than women (53male,47 female), The median age of patients was 53.5 years+/- 17.5, ranging between(18 and 90).

Mean potassium level was 6.6 mmol\l. The male patients shows more severe hyperkalemia than female patients, no age association was defined in relation to hyperkalemia (p< 0.472) as shown in table-1. No difference was shown between haemodialysis (HD) patients and patients kept on conservative treatment regarding their relation to hyperkalemia.

The distribution of recorded serum potassium concentrations was significantly skewed toward the lower end of the range with a median potassium level of 6.6 meq/l. atrial fibrillation has been found in 6 patients represented as AF, with cardiac arrest represented as asystole documented in two cases.

The ECG were normal in 33patients, 31of those were in the mild group and only two in the moderate group with mean [k] level of 5.78 meq\L +\- 0.16 std. deviation. Our study showed 67 patients with abnormal ECG in relation to hyperkalemia with mean potassium level 6.66 meq\L +\- 0.54, signifying the high correlation between hyperkalemia and presence of ECG changes(P=0.0005). as shown in the table-2. On examination of the ECGs no difference was noted in the P-wave amplitude, although the small size of the P waves limited the precision of the assessment in this regard. From the 67abnormalECGs, 55 ECG showed peaked T wave of these 46 were in the moderate group with mean potassium concentration of 6.5 +\- 0.41 and (p value<0.0005) as it appear in table-4. Regarding AV delay(prolonged PR interval), 35 patients had it with majority(n=30) in the moderate group, with mean potassium concentration of 6.6 +\- 0.33. There was significant relation between hyperkalemia and AV delay represented by (p<0.0005) as shown in table-5. New QRS prolongation (QRS >120 ms) was noted in 16 ECGs at time of hyperkalemia with maximum QRS duration of 140 (range 130 to 140 ms). The majority (n = 11) of which were in the severe group.

There was significant association between presence of wide QRS and hyperkalemia as assessed by (p=0.0005) as shown in table-3.

Sine wave were present in 5 patients, all of them were in the severe group with significant relation to hyperkalemia (p<0.0005), and mean [k] concentration of 7.5 +\- 0.66.(table-6). Asystole appeared in 2 ECGs with significant relation to hyperkalemia (p=o.o45), and mean [k] concentration of 7.2 +\- 0.7. (Table-7). Atrial fibrillation appeared in 6 patients one in the mild group and the other in the moderate group with no significant relation to hyperkalemia (p=0.331), this may be due to the small number of patients with atrial fibrillation.

Patients disposition after diagnosing and treatment of hyperkalemia were as follows: 65 patients had been dialysis, 22 patients admitted to the word, 8 patients passed in the emergency room (ER), 2 discharge and given medical advice and 3 patients admitted to CCU.

Table 1: Correlation between potassium level and sex of the patients.

SEX	K	Mild	Moderate	Severe	Total
female	Count	17	24	6	47
	% within SEX	36.1%	51.6%	12.7%	100.0%
	% within K	48.2%	48.9%	30.3%	47.0%
male	Count	18	24	11	53
	% within SEX	33.9%	45.2%	20.8%	100.0%
	% within K	51.8%	51.1%	70.8%	53.0%
Total	Count	35	48	17	100
	% within SEX	35.0%	48.0%	17.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 1)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.610	2	P < 0.472

Table 2: Correlation between potassium level and ECG finding.

Normal ECG	K	Mild	Moderate	Severe	Total
negative	Count	7	47	13	67
	% within NR.ECG	10.0%	67.1%	19.9%	100.0%
	% within K	18.4%	97.9%	100.0%	67.0%
Positive	Count	29	4	0	33
	% within NR.ECG	96.7%	12.3%	.0%	100.0%
	% within K	81.6%	2.1%	.0%	33.0%
Total	Count	36	51	13	100
	% within NR.ECG	36.0%	51.0%	13.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 2)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	63.510	2	P < 0.0005

Table 3: Correlation between potassium level and wide QRS.

Wide QRS	K	Mild	Moderate	Severe	Total
Negative	Count	36	44	4	84
	% within WIDEQRS	42.4%	52.3%	4.7%	100.0%
	% within K	100.0%	92.7%	31.3%	84.0%
Positive	Count	0	5	11	16
	% within WIDEQRS	.0%	31.2%	73.3%	100.0%
	% within K	.0%	7.3%	68.8%	16.0%
Total	Count	36	49	15	100
	% within WIDEQRS	36.0%	49.0%	15.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 3)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	45.362	2	P < 0.0005

Table 4: Correlation between potassium level and peaked T wave.

Peaked T wave	K	Mild	Moderate	Severe	Total
Negative	Count	34	4	7	45
	% within PEAKDT	75.5%	8.8%	15.5%	100.0%
	% within K	86.9%	6.2%	43.8%	45.0%
Positive	Count	1	46	8	55
	% within PEAKDT	1.8%	83.6%	14.5%	100.0%
	% within K	13.1%	93.8%	56.3%	55.0%
total	Count	35	50	15	100
	% within PEAKDT	35.0%	50.0%	15.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 4)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	64.125	2	P < 0.0005

Table 5: Correlation between potassium level and AV delay.

AV-delay	K	Mild	Moderate	Severe	Total
Negative	Count	36	19	10	65
	% within AVDELAY	55.3%	29.2%	15.3%	100.0%
	% within K	97.2%	34.5%	64.5%	65.0%
Positive	Count	1	30	4	35
	% within AVDELAY	2.8%	85.7%	11.4%	100.0%
	% within K	2.8%	65.5%	35.5%	35.0%
Total	Count	37	49	14	100
	% within AVDELAY	36%	49.0%	14.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 5)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	38.559	2	P < 0.0005

Table 6: Correlation between potassium level and sine-wave.

Sine-wave	K	Mild	Moderate	Severe	Total
Negative	Count	36	49	10	95
	% within SINEWAVE	37.8%	51.5%	10.5%	100.0%
	% within K	100.0%	95.9%	62.5%	95.0%
Positive	Count	0	0	5	5
	% within SINEWAVE	.0%	0%	100%	100.0%
	% within K	.0%	4.1%	37.5%	5.0%
Total	Count	36	49	15	100
	% within SINEWAVE	36.0%	49.0%	15.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 6)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	38.500	4	P < 0.0005

Table 7: Correlation between potassium level and asystole.

Asystole	K	Mild	Moderate	Severe	Total
Negative	Count	36	47	15	98
	% within asystole	36.7%	47.9%	15.3%	100.0%
	% within K	100.0%	95.9%	85.5%	98.0%
Positive	Count	0	0	2	2
	% within asystole	.0%	0%	100%	100.0%
	% within K	.0%	4.1%	14.5%	2.0%
Total	Count	36	47	17	100
	% within asystole	36.0%	47.0%	17.0%	100.0%
	% within K	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests (Table 7)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	51.500	4	P < 0.0005

DISCUSSION

In this study as with other studies the magnitude of potassium elevation was small, with 81% of cases demonstrate potassium level <7 meq/l Our findings were consistent with cardiovascular instability associated with changes in serum potassium.[13]

Our study showed that chronic kidney disease (CKD) patients can present with typical ECG finding of hyperkalemia including small hyperacute peaked T-wave, prolonged PR, wide QRS, and sine wave which agree with a study done by Cobo Sanchez JL et al who stated that hyperkalemic patients with ESRD present with ECG alteration similar to healthy population with hyperkalemia[13], in contrast to other studies which confirmed that the typical ECG manifestations attributed to hyperkalemia, are rare, especially among severely hyperkalemic HD patients "5,6,7,8,9". Despite this, none of the previous studies had investigated all ECG parameters and their potential relationship with electrolyte disturbances in this population. Aslam et al reported that patients on HD show no specific ECG manifestations in relation with hyperkalemia. "6"

Previous data have suggested that the rate of rise of serum potassium level is more relevant compared to its actual serum concentration. They explained that a slow elevation in serum potassium value, like in ESRD patients, permits compensatory mechanisms to minimize the effects of hyperkalemia "6". Despite this, the relevance of the condition should not be underestimated. In a case series, The most important relevance of the problem is when a HD patient comes to the emergency department for any medical problem, without typical ECG features of hyperkalemia among HD patients, the attending doctors may fail to diagnose; hence the potential life threatening consequences of hyperkalemia may occur.

In our study We found that the most frequent ECG finding was presence of hyperacute T-wave in the precordial leads which is the same finding in study done by Cobo Sanchez JL et al who included 39 patients in the study, 58.9% were women and 41.1% men, with a mean age 67.35 years (24-89), our study had more men than women (53% men and 47% women with mean age of 50.5). In their study mean Serum potassium was 5.07

mEq/L, 29.4% of the sample presented levels > or = 5.5 mEq/l while in our study mean serum potassium was 6.6 mEq/l due to our large sample (100 patients) compared to their sample (39 patients). They found that the most frequent alteration in the ECG was high and peaked T waves in leads V2 to V4. In the hyperkalaemia cases, the mean elevation of T wave was 7 mm. In 2 hyperkalaemia patients there was no elevation of T wave: one T wave was negative (K+ = 6 mEq/L) and another one stayed normal (K+ = 5.6 mEq/L). In our study, of the 65 patients with abnormal ECG, 55 of them showed hyperacute peaked T-wave (84.2%) mainly in the chest leads.

CONCLUSIONS

The ECG continues to be a good tool of early hyperkalaemia detection, related to it's level of severity. Patients with end stage renal disease (ESRD) present electrocardiographic alterations similar to patients with hyperkalemia due to causes other than ESRD.

Alot of patients with end stage renal disease (ESRD) showd featurs of inadequacy of haemo dialysis.

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