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ORIGINAL ARTICLE

Potassium Imbalance Leading to Arrhythmias in Patients Undergoing Cardiac Surgery on Cardiopulmonary Bypass

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ABSTRACT

Objective: To determine the frequency of factors that cause potassium imbalance in patients with postoperative arrhythmias after cardiac Bypass surgery

Material and methods: During the time period of 2 November 2018 through 10 January 2020, 100 patients with heart disease receiving open-heart surgery were enrolled in a prospective observational research conducted by the cardiac surgery department at the Punjab Institute of Cardiology in Lahore. Both genders of age 17-70 years were included and patients with cyanotic heart disease congenital heart disease, previous cardiac surgery and urgent CABG were excluded.

Results: Our results showed that of 100 patients, 59 (59%) were male and 41 (41%) were female and the mean age was14.243 ± 50.12 years. 6 patients had preexisting renal failure and 9 had postoperative renal failure. Overall potassium imbalance was noted in 39 patients, 33 were hypokalemic and 6 were hyperkalemic and the mean potassium with S.D was 3.95±0.83 and 37 had postoperative arrhythmias out of which 18 (54.5%) were hypokalemic and 2 (33.3%) were hyperkalemic. Preoperative drugs, preexisting renal failure, CPB time, aortic cross clamp time, intraoperative potassium levels, time on ventilation, postoperative urine output, potassium infusion, postoperative renal failure, arrhythmias and total hospital stay were found to be statistically significant.

Conclusion: Potassium imbalance post-cardiopulmonary bypass is major factor that may lead to increased risk of postoperative arrhythmias.

Keywords: Potassium imbalance, cardiopulmonary bypass, postoperative arrhythmias, renal failure, hypokalemia

INTRODUCTION

One of the greatest achievements in field of medicine is the development of cardiac surgery, which became safer and easier after the advancement in cardiopulmonary bypass. Most of the valvular and congenital surgeries as well surgeries of IHD are done on CPB. [1-3] As like other operations, surgeries on CPB come with a cost. Most common and important complications are PE, MI, bleeding, pulmonary edema, hemo or pneumothorax, CVA, renal failure, electrolyte imbalance and infections. Electrolyte imbalance is very common among patients undergoing cardiac surgeries on CPB.[4-6]

During weaning from CPB the electrolyte imbalance may cause disruption in excitation contraction coupling which finally results in failure to separate patient from CPB. This failure can be multi factorial like alteration in glucose metabolism, acid base balance and cell function. K imbalance is noticed in about more than 20% of patients in hospital after cardiac surgery.[7,8] During CPB blood levels of potassium can be affected by cardioplegia, hemodilution, hemofiltration, decrease in temperature, bicarbonate infusion, insulin, diuretics and dextrose etc.[9, 10]

The most worrying aspect of hypokalemia is the possibility of changes in ECG e.g. appearance of U wave, QT prolongation, ST segment depression or T wave flattening which can mimic fatal arrhythmias. Association of hypokalemia with pro arrhythmic settings e.g. PVCs, SVTs, AF, VT or VF can increase the pro arrhythmic risk of hypokalemia and can results in life threatening ventricular arrhythmias. The appearance of U waves in ECG can mimic the atrial flutter. Hypokalemic patients with sacred or ischemic myocardium, LVH, CHF or MI are at high risk of ventricular tachyarrhythmia and it may cause difficulty in weaning from CPB during cardiac operation. Therefore we conducted this study to get evidence regarding relationship of cardiac arrhythmias with post-surgical potassium level.

MATERIALS AND METHODS

It was a prospective observational study that was conducted at cardiac surgery department of Punjab Institute of Cardiology Lahore from 2nd November 2018 to 10th January 2020. Sample size of 100 cases was calculated with 95% confidence level, 8% margin of error and percentage of potassium imbalance i.e. 20% in patients with heart disease undergoing open heart surgery. Patients of both genders of age 17-70 years were included and exclusion criteria include patients with cyanotic heart disease, congenital heart disease, ejection fraction <30%, previous cardiac surgery and urgent CABG. Patients who fulfilled above stated selection criteria were enrolled by using Non-probability Purposive sampling technique. All patients undergo bypass surgery under general anesthesia by a single surgical team to prevent bias in the study. After procedure, patients were shifted to post-surgical wards and were followed-up there for 5 days or until discharge. Blood sample was taken and evaluated for potassium level after surgery. Reports were assessed and potassium level was recorded. Patients were divided in two groups i.e. patients with abnormal potassium level and normal potassium level. Then patients were examined for outcome of potassium imbalance including arrhythmias, hospital stay and mortality. Data was analyzed using SPSS version 22.0.0.0. Chi-square test was applied to compare both groups for arrhythmias and mortality, while independent samples t-test was applied to compare man hospital stay in both groups. P-value ≤ 0.05 was kept as significant.

RESULTS

The total 100 patients were enrolled in the study, out of total 100 patients 49 (49%) were females and 59 (59%) were males undergoing cardiac surgery and the mean age was 14.243 ± 50.12 years. 6 (6%) patients had preexisting renal failure and 9 (9%) had postoperative renal failure. Overall potassium imbalance was found in 39(39%) patients and the mean potassium was 3.95 ± 0.83. Out of the total, 37 (37%) had postoperative arrhythmias. Out of 39 patients of potassium imbalance 33 (33%) were hypokalemic and 6 (6%) were hyperkalemia. Out of 33 patients of hypokalemia 1 (3.0%) had preexisting renal failure, 11 (33.3%) were on loop diuretic therapy, bypass time was >90 in 15 (45.5%) and <90 in 18

(54.5%) patients, X.clamp time was >60 in 14 (42.4%) and <60 in 19 (57.6%) patients, intraoperative potassium was >3.5 in 7 (21.2%) patients and 1 (3.0%) patient had postoperative renal failure, ventilation time was 14.98±.59, postoperative urine output was 10987.78±7476.91, potassium infusion was given in all 33(100.0%) patients and total hospital stay was >5 days in 28 (84.8%) patients and no hospital mortality was associated with hypokalemia. Out of 6 patients of hyperkalemia 2 (33.3%) had preexisting renal failure, 2 (33.35%) on loop diuretic and 1 (16.7%) on potassium sparing diuretic, bypass time >90 and X. Clamp time >60 in all 6 (100%) patients, intraoperative potassium was >5.5 in 2 (33.3%) patients, ventilation time 11.13±7.77, postoperative urine volume 2165.79±1198.01, potassium infusion was given in 3 (100.0%) (Table 1). Postoperative renal failure was in 2 (33.3%) patients, arrhythmias were in 2 (33.3%) patients and hospital stay was >5 days in 5 (83.3%). No hospital mortality was found to be statistically significant (table 2). Flow rate, diabetes mellitus, preoperative potassium levels, preoperative urine output, hypothermia, number of blood cardioplegia, intraoperative urine output, total drain, pH, inotropic support was not found to be statistically significant.

Table 1: Intraoperative Characteristics

Variables		Potassium Category			p-value
		<3.5	3.5-5.5	>5.5	
CPB Time (Min)	<90	18 (54.5%)	26 (42.6%)	0 (0.0%)	0.044
	>90	15 (45.5%)	35 (57.4%)	6 (100%)	
Aortic Cross clamp Time (Min)	<60	19 (57.6%)	30 (49.2%)	0 (0.0%)	0.034
	>60	14 (42.4%)	31 (50.8%)	6 (100.0%)	
Intraoperative Potassium	<3.5	7 (21.2%)	12 (19.7%)	2 (33.3%)	0.010
	3.5-5.5	26 (78.8%)	46 (75.4%)	2 (33.3%)	
	>5.5	0 (0.0%)	3 (4.9%)	2 (33.3%)	
Hypothermia (˚c)	<30	31 (93.9%)	52 (85.2%)	4 (66.7%)	0.152
	>30	2 (6.1%)	9 (14.8%)	2 (33.3%)	
Number Of Blood Cardioplegia		2.9 ± 2.0	3.2 ± 2.2	3.1 ± 2.4	0.113
Intraoperative Urine Output(Ml)		1010.08 ± 848.63	1298.65 ± 910.76	1039.87 ± 880.60	0.395

Table 2: Postoperative characteristics

Variables		Potassium Category			P-Value
		<3.5	3.5-5.5	>5.5	
Time On Ventilation (Hours)		14.98 ± 5.59	8.82 ± 6.45	11.13 ± 7.77	0.011
Total Drain (Ml)		1199.53 ± 780.98	1211.13 ± 992.81	1201.56 ± 751.69	0.162
Postoperative Urine Output (Ml)		10987.78 ± 7476.91	8674.38 ± 3968.88	2165.79 ± 1198.01	0.025
pH	<7.35	6 (18.2%)	12 (19.7%)	1 (16.7%)	0.079
	7.35-7.45	22 (66.7%)	36 (59.0%)	1 (16.7%)	
	>7.45	5 (15.2%)	13 (21.3%)	4 (66.7%)	
Potassium Infusion	Yes	33 (100%)	50 (82.0%)	3 (50.0%)	0.002
	No	0 (0.0%)	11 (18.0%)	3 (50.0%)	
Inotropic Support	Yes	27 (81.8%)	55 (90.2%)	5 (83.3%)	0.498
	No	6 (18.2%)	6 (9.8%)	1 (16.7%)	
Postoperative Renal Failure	Yes	1 (3.0%)	6 (9.8%)	2 (33.3%)	0.054
	No	32 (97.0%)	55 (90.2%)	4 (66.7%)	
Arrhythmias	Yes	18 (54.5%)	17 (27.9%)	2 (33.3%)	0.037
	No	15 (45.5%)	44 (72.1%)	4 (66.7%)	
Total Hospital Stay (Days)	<5	5 (15.2%)	23 (37.7%)	1 (16.7%)	0.056
	>5	28 (84.8%)	38 (62.3%)	5 (83.3%)	
In Hospital Mortality	Yes	0 (0.0%)	3 (4.9%)	1 (16.7%)	0.134
	No	33 (100.0%)	58 (95.1%)	5 (83.3%)	

DISCUSSION

Electrolyte abnormalities contribute to a wide range of ICU problems, including ventricular and supraventricular arrhythmias. During and soon after cardiac surgery, patients are more vulnerable to the onset of tachyarrhythmias. Therefore, one of the primary goals of treatment for these individuals should be to prevent electrolyte abnormalities. Despite the fact that these patients' potassium levels are routinely monitored, other electrolytes such as magnesium, phosphate, and calcium are monitored far less often.[11]

The normal levels of K in blood is 3.5 to 5 mEq/L. if potassium levels are between 5.1 to 6 mEq/L, it is considered mild hyperkalemia, between 6.1 to 7 mEq/L is moderate hyperkalemia and potassium levels above 7 mEq/L it is considered severe hyperkalemia. Potassium levels between 3.5 to 4 mEq/L is defined as relative hypokalemia in certain group of patients with heart diseases e.g. MI, CHF, LVF, or scared myocardium. Potassium levels between 2.5 to 3.5 mEq/L are moderately severe hypokalemia and below 2.5 mEq/L is severe hypokalemia.[1, 12]

Increased potassium levels happen when its homeostasis is disturbed. Its causes are increase TLC, thrombocytosis, impaired excretion, repeated clenching of fist with tourniquet in place, hemolysis, drugs (K sparring diuretic, Na channel blockers, pentamidine, NSAIDs, heparin, ACE inhibitor, tacrolamus etc.), massive tissue breakdown (trauma, rabdomylomas, burns), and increased potassium intake.[13] During or after cardiopulmonary bypass increased levels of potassium are multi factorial e.g. cardioplegia, heparin, renal shutdown, ongoing or recent MI etc. Cardioplegia is potassium rich solution which is infused into the coronaries after the aorta is cross clamped. It stops the heart and additional hypothermia is also induced to decreases the energy demand of myocardium thus increasing the myocardial protection time and provides motionless and blood free field for the operation.[14]

In this study potassium imbalance during open heart surgery was dependent upon many preoperative intraoperative and postoperative factors and is associated with the development of new arrhythmias. These results are comparable with the previous study of Bagheri 2013 reported that imbalance in potassium and sodium levels during cardiac surgery can cause postoperative complications.[15] Polderman 2004 reported that patients undergoing cardiac surgery with extracorporeal circulation are at high risk of electrolyte depletion.[16] Dieter conclude that preoperative diuretic therapy major cause of hypokalemia postoperatively. [17] Donald O Weber conclude that various preoperative factors and intraoperative factors are risk factors of postoperative

hyperkalemia in cardiac surgery on cardiopulmonary bypass.[18] Giovanno Peretto reported that the post common cause of postoperative arrhythmias after cardiac surgery is hypokalemia and hyperkalemia.[19]

Uluganyan et al. (2016) conducted research on 277 individuals who had had a myocardial infarction between 2010 and 2013 to determine whether or not there was a correlation between potassium levels and the occurrence of arrhythmias and death. Patients with elevated potassium levels (>5.2 mEq/L) were shown to have a greater risk of cardiac arrhythmias and death, and a statistically significant correlation was found between potassium levels below 3.5 and above 5 with the prevalence of ventricular arrhythmias.[20, 21] In a 2015 study, Peng et al. looked at how patients who had had coronary angiography fared in terms of arrhythmias and death as compared to those who had not. Patients with potassium levels of 3.5 or less mEq/L, or 5 or more mEq/L, had a substantially greater incidence of arrhythmias and death compared to those with normal potassium levels.[22]

Chio et al. conducted research to see whether there was a link between blood potassium levels and the occurrence of arrhythmias and other cardiac events. A higher rate of arrhythmias was seen in individuals whose potassium levels were either above 4.5 or below 3.5. As a result, they concluded that potassium levels have a role in the onset of ventricular arrhythmias, but found no correlation between potassium and death over the long term.[23] In 2013, Krijthe et al. conducted a study to determine if there was a correlation between serum potassium levels and the development of atrial fibrillation; they found that patients with hypokalemia had a higher risk of developing the condition.[24]

Gheorghiade et al., indicated that 25.3% of 47,647 patients with heart failure had hyponatremia at the time of admission.[25] Wahr et al., found that Perioperative arrhythmias occurred in 53.7% cases, with 10.7% cases having intraoperative arrhythmias, 13.7% having postoperative non-atrial arrhythmias, and 36%having postoperative atrial flutter or fibrillation. The incidence of adverse outcomes was 3.6% for death, 2.0% for cardiac death, and 3.5% for CPR. Serum potassium level < 3.5 mmol/L was a predictor of serious perioperative arrhythmia (OR, 2.2; 95% CI, 1.2-4.0), intraoperative arrhythmia (OR, 2.0; 95% CI, 1.0-3.6), and postoperative atrial fibrillation (OR, 1.7; 95% CI, 1.0-2.7).[26]

CONCLUSION

Potassium imbalance <3.5 and >5.5 which is termed as hypokalemia and hyperkalemia respectively in cardiac surgery on bypass can cause life threatening arrhythmias and giving an attention to various preoperative, intraoperative and postoperative factors that affect them and possible managements are required to prevent them.

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