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Original Research Article

A Hospital-Based Assessment of the Association of Blood Pressure and Serum Electrolyte Levels with Ejection Fraction in Individuals with Acute Myocardial Infarction

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Abstract

Aim: To investigate the correlation between blood pressure, serum electrolyte levels, and ejection fraction in individuals with acute myocardial infarction.

Materials and Methods: This study was done in the Department of Physiology and Pathology, Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India from March 2018 to February 2019. A total of 52 patients of AMI were included in this study. All patients were male. This study was a longitudinal, interventional study. Patients with any of the conditions such as anemia, valvular heart disease, myocarditis, and cardiac tamponade, endocrinal disorders such as thyroid dysfunction, vitamin deficiency such as Vitamin B1 deficiency, pericardial effusion, and atrial fibrillation were excluded to minimize the possibility that these conditions may influence the outcome of study.

Results: 50% of patients have normal systolic BP while 40.4% have high SBP and few (9.6%) have low SBP. All patients have normal diastolic BP. About 80.8% of patients with normal SBP showed improved EF after PCI while 80% of patients with low SBP and 76.2% of patients with high SBP showed improvement in EF. Hence, it is found that those patients who had abnormal SBP showed less improvement in EF (P = 0.93). We found that 75.9% of patients who have normal serum calcium level showed improvement in EF and 81.8% of hypocalcemia patients showed improved EF after PCI. There was only one patient with hypercalcemia and he showed improvement in EF. Hence, it is found that those patients who had normal serum calcium level showed less improvement in EF (P = 0.76). 69.2% of cases have normal serum potassium level, while 21.2% of cases have hyperkalemia and 9.6% of cases have hypokalemia. It has been found that all the five hypokalemia patients showed improvement in EF while 83.3% of the patients having normal serum potassium level showed improvement in EF.

Conclusion: The study's results indicate that higher levels of serum sodium and potassium are linked to a worse prognosis in patients with acute myocardial infarction (AMI) following PCI. Conversely, younger age and a normal body mass index (BMI) are related with a better prognosis in these patients.

Keywords: BMI, AMI, PCI, serum electrolyte levels

Introduction

Acute myocardial infarction (AMI), commonly known as a heart attack, is a critical cardiovascular event resulting from the sudden blockage of blood flow to the heart muscle. This blockage typically occurs due to the rupture of an atherosclerotic plaque in a coronary artery, leading to the formation of a thrombus that impedes blood flow. The impact of AMI on cardiac function can be profound, often resulting in significant morbidity and mortality. One of the key parameters used to assess cardiac function following an AMI is the ejection fraction (EF), which measures the percentage of blood ejected

from the left ventricle with each contraction. Reduced EF is a hallmark of impaired cardiac function and is associated with poor clinical outcomes. [1,2] The relationship between blood pressure, serum electrolyte levels, and EF in AMI patients is complex and multifaceted. Blood pressure is a critical determinant of myocardial oxygen demand and perfusion. Both hypertension and hypotension can adversely affect cardiac function, influencing the extent of myocardial damage and the recovery of cardiac function post-AMI. Hypertension can exacerbate the stress on the myocardium, leading to greater myocardial ischemia and necrosis, whereas hypotension can compromise coronary perfusion, further aggravating myocardial injury. [3] Serum electrolyte levels, particularly sodium, potassium, calcium, and magnesium, play crucial roles in maintaining cardiac electrophysiology and contractility. Electrolyte imbalances are common in AMI patients and can significantly impact cardiac function and outcomes. Hypokalemia and hyperkalemia, for example, can cause arrhythmias and affect myocardial contractility, while disturbances in calcium and magnesium levels can alter myocardial excitability and contractile function. [4] Blood pressure management in AMI patients is a critical component of clinical care. Elevated blood pressure (hypertension) at the time of AMI can increase myocardial oxygen demand and exacerbate ischemia, potentially leading to larger infarct sizes and worse EF. Conversely, hypotension can result in inadequate coronary perfusion, limiting the delivery of oxygen and nutrients to the ischemic myocardium, and thereby impairing the recovery of EF. [5]

Studies have shown that both elevated systolic and diastolic blood pressures are associated with adverse outcomes in AMI patients. For instance, higher systolic blood pressure at presentation has been linked to increased mortality and lower EF at discharge. The management of blood pressure in the acute phase of AMI is therefore crucial, with guidelines emphasizing the need to achieve a delicate balance that optimizes myocardial perfusion without increasing myocardial workload excessively. [6] Electrolytes are essential for normal cardiac function, and their disturbances can have profound effects on the heart, especially in the context of AMI. Potassium is a key regulator of myocardial excitability and contractility. Both hypokalaemia and hyperkalaemia are associated with increased risks of arrhythmias and impaired myocardial function, which can adversely affect EF. Hypokalaemia can lead to increased susceptibility to ventricular arrhythmias, while hyperkalaemia can cause bradyarrhythmia and asystole, both of which can compromise EF. [7] Calcium plays a vital role in myocardial contraction through its involvement in excitation-contraction coupling. Hypocalcaemia can result in decreased myocardial contractility, thereby reducing EF, whereas hypercalcemia can lead to increased myocardial contractility but may also cause arrhythmias. Magnesium is another critical electrolyte, with low levels (hypomagnesemia) being linked to increased risks of arrhythmias and reduced myocardial function. The interplay between blood pressure and serum electrolytes is crucial in determining the overall impact on EF in AMI patients. Optimal management of these parameters can significantly influence recovery and outcomes. For instance, maintaining adequate potassium and magnesium levels can mitigate the risk of arrhythmias and support better myocardial contractility, thus preserving EF. Similarly, careful blood pressure management can enhance myocardial perfusion and reduce ischemic damage, supporting better EF outcomes . [8,9]

Materials and Methods

This study was done in the Department of Physiology and Pathology, Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India from March 2018 to February 2019. A total of 52 patients of AMI were included in this study. All patients were male. This study was a longitudinal, interventional study. Patients with any of the conditions such as anemia, valvular heart disease, myocarditis, and cardiac tamponade, endocrinal disorders such as thyroid dysfunction, vitamin deficiency such as Vitamin B1 deficiency, pericardial effusion, and atrial fibrillation were excluded to minimize the possibility that these conditions may influence the outcome of study. This study was done after obtaining ethical clearance from the Institutional Ethical Committee and written, informed consent from the patients. Serum calcium, sodium, and potassium level were measured after admission in the cardiology emergency. In general examination, pulse rate and BP (sphygmomanometer) were measured. Echocardiography (ECHO) method was used to measure EF within 6–8 h of diagnosis of AMI. Coronary angiography was done and then patients underwent coronary angioplasty (PCI). After angioplasty, EF was measured with the help of ECHO. The EF obtained before and after PCI was analyzed. Improvement in these patients is defined by two criteria – (1) relieved chest pain and discomfort and (2) improvement in EF from the baseline value.

Statistical software Statistical Package for the Social Sciences Version 22 was used for analysis of data. "$P < 0.05$" was considered to be statistically significant at two-tailed test.

Results

In this study, 52 male patients with AMI were enrolled. The mean age is 57.92 years with standard

deviation of 10.68 years. Data from all the patients were collected and analyzed. Table 1 shows that 71.2% of cases were above 50 years and as the age advances, there is less chance of improvement in EF (P = 0.38). The patients having age >50 years, only 75.7% showed improvement after PCI while 86.7% of patients with age up to 50 years showed improvement in EF. It is also evident that 63.5% of the admitted patients were overweight and obese while 28.8% have normal body mass index (BMI) and few patients are underweight too (7.7%). It is found that as the BMI increases, improvement in EF decreases (P = 0.53). Patients who have BMI ≥23 kg/m2 showed less improvement in comparison to those patients who have normal BMI and BMI <18.5 kg/m2. All the four underweight patients showed improvement in EF. It has been noticed [Table 1] that 50% of patients have normal systolic BP while 40.4% have high SBP and few (9.6%) have low SBP. All patients have normal diastolic BP. About 80.8% of patients with normal SBP showed improved EF after PCI while 80% of patients with low SBP and 76.2% of patients with high SBP showed improvement in EF. Hence, it is found that those patients who had abnormal SBP showed less improvement in EF (P = 0.93). Pulse rate of 78.8% of patients was in normal range while some of them have tachycardia (15.4%) and some have bradycardia (5.8%). About 80.5% of patients who have normal pulse rate showed improvement while 33.3% of patients having bradycardia and 87.5% of patients having tachycardia showed improvement. Hence, it can be said that as the pulse rate (PR) increases, improvement in EF increases (P = 0.13).

Table 2 shows that 55.8% of cases have normal serum calcium level, while 42.3% of cases showed hypocalcemia and only 1 case (1.9%) had hypercalcemia. We found that 75.9% of patients who have normal serum calcium level showed improvement in EF and 81.8% of hypocalcemia patients showed improved EF after PCI. There was only one patient with hypercalcemia and he showed improvement in EF. Hence, it is found that those patients who had normal serum calcium level showed less improvement in EF (P = 0.76). It has been noticed [Table 2] that 69.2% of cases have normal serum potassium level, while 21.2% of cases have hyperkalemia and 9.6% of cases have hypokalemia. It has been found that all the five hypokalemia patients showed improvement in EF while 83.3% of the patients having normal serum potassium level showed improvement in EF. Only 54.5% of hyperkalemia patients showed improved EF after PCI. Hence, it can be said that as serum potassium level increases, improvement decreases within the group (P = 0.06). It is also evident [Table 2] that 84.6% of patients have normal serum sodium level, while few cases (13.5%) have hyponatremia and only 1 case (1.9%) has hypernatremia. Patients having low and normal serum sodium level showed improvement in EF after PCI. About 100% of patients who have low serum sodium level showed improved EF while 77.3% of patients who have normal serum sodium level showed improvement in EF. Only one patient had hypernatremia and he did not show improvement in EF. Hence, it can be said that as serum sodium level increases, improvement decreases within the group (P = 0.06).

Table 1: Baseline characteristics of patients categorized by improvement in EF after coronary angioplasty

Baseline characteristics	Improved status		Total no. of cases	$\chi 2$	P-value
	Yes	No			
BMI* (kg/m^2)					
<18.5 (underweight)	4 (100)	0 (0)	4 (7.7)	1.27	0.53
18.5–22.9 (normal weight)	12 (80)	3 (20)	15 (28.8)		
≥23 (overweight and obese)	25 (75.76)	8 (24.24)	33 (63.5)		
Age group (years)					
21–50	13 (86.7)	2 (13.3)	15 (28.8)	0.77	0.38
51–80	28 (75.7)	9 (24.3)	37 (71.2)		
SBP (mmHg)					
≤108 (low SBP)	4 (80)	1 (20)	5 (9.6)	0.15	0.93
110–130 (normal range)	21 (80.8)	5 (19.2)	26 (50)		
132–160 (high SBP)	16 (76.2)	5 (23.8)	21 (40.4)		
PR (/min)					
<60 (bradycardia)	1 (33.3)	2 (66.7)	3 (5.8)	4.15	0.13
60–90 (normal range)	33 (80.5)	8 (19.5)	41 (78.8)		
>90 (tachycardia)	7 (87.5)	1 (12.5)	8 (15.4)		

Table 2: Blood parameters of patients categorized by improvement in EF after coronary angioplasty

Blood parameters	Improved status		Total no. of cases	$\chi 2$	P-value
	Yes	No			
S. Na+ (mEq/lt)					
<135 (hyponatremia)	7 (100)	0 (0)	7 (13.5)	5.67	0.06
135–145 (normal range)	34 (77.3)	10 (22.7)	44 (84.6)		
>145 (hypernatremia)	0 (0)	1 (100)	1 (1.9)		
S. K+ (mEq/lt)					
<3.5 (hypokalemia)	5 (100)	0 (0)	5 (9.6)	5.67	0.06
3.5–5 (normal range)	30 (83.3)	6 (16.7)	36 (69.2)		
>5 (hyperkalemia)	6 (54.5)	5 (45.5)	11 (21.2)		
S. Ca++ (mEq/lt)					
<4.3 (hypocalcemia)	18 (81.8)	4 (18.2)	22 (42.3)	0.54	0.76
4.3–5.3 (Normal range)	22 (75.9)	7 (24.1)	29 (55.8)		
>5.3 (hypercalcemia)	1 (100)	0 (0)	1 (1.9)		
EF: Ejection fraction					

Discussion

This is an exploratory study and after analyzing the data, we found that EF is affected by the factors under investigation though only serum sodium and serum potassium level showed some significance (P = 0.06). Lip et al. (2007) found in a study that hypertensive patients have poor prognosis. [10] In our study, it is found that hypotensive and hypertensive patients showed slightly less improvement in EF in comparison to those patients who had normal BP (P = 0.93). Hence, we can say that results are equivocal in reference to BP. It is also found that as the PR increases, improvement in EF increases within the group (P = 0.13). Hence, tachycardia has a positive effect on improvement in EF, though it is not statistically significant. Increased sodium consumption leads to increased BP. This increased BP put extra load on arterial wall and hence affecting blood flow. Hence, we can say that serum sodium level can affect outcome after PCI indirectly by affecting BP. In our study, we found that increasing serum sodium level decreases improvement (P = 0.06). Serum potassium level plays an important role in regulation of BP. When serum potassium level increases, it reduces BP but hyperkalemia can disturb the heart rhythm. It has been found in our study that increasing serum potassium level deteriorates the improvement in EF (P = 0.06). It is a well-known fact that serum calcium plays an important role in cardiovascular physiology. Normal serum calcium level is important for adequate myocardial contractility. Contrary to the previous findings, in this study, we found that the patients with normal serum calcium level showed less improvement in comparison to the patients with abnormal serum calcium level. It is clear from the findings that age has adverse effect on outcome of coronary angioplasty, especially over 50 years, though it is statistically not significant (P = 0.38). Starr et al. (1934) found that the average cardiac index slowly declines after 50 years. [11] Few studies also suggested that elderly population with AMI, who received a conservative treatment, have a higher mortality in comparison to the younger population. [12-14] In a study, Singh et al. (2018) found that AMI patients who had age more than 40 years showed less improvement after PCI. [15] It is a well-known fact that overweight and obese patients have poor prognosis after coronary intervention. In this study, we found that as the BMI increases, improvement in EF decreases (P = 0.53). Interestingly, all the four underweight patients showed improvement in EF. However, there is a controversial finding termed as “obesity paradox,” which tells that obese AMI patients have improved outcomes after PCI, in comparison to normal BMI patients. [16-19] This study has some limitations. First, we did not record serum parathyroid hormone and Vitamin D level to find more accurate correlation between serum calcium level and improvement in EF. Hence, we are not able to exclude confounding factors such as primary and secondary hyperparathyroidism. Second, we have done serum electrolytes level measurement only at the time of admission in emergency. Third, the sample size is small, so to predict the outcome accurately we need a larger sample size. Finally, it is a hospital-based study so it is vulnerable to sample selection bias.

Conclusion

The study's results indicate that higher levels of serum sodium and potassium are linked to a worse prognosis in patients with acute myocardial infarction (AMI) following PCI. Conversely, younger age and a normal body mass index (BMI) are related with a better prognosis in these patients.

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