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Association of heart rate at admission and angiographic and clinical results of ST elevation myocardial infarction patients undergoing primary angioplasty on the left circumflex artery

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Abstract--Goal: Heart rate is a factor that predicts cardiovascular diseases such as heart failure, high blood pressure, stroke and coronary artery diseases. This study examined the association between admission heart rate of STEMI* patients undergoing PCI† on the LCX‡ artery and their clinical and angiographic results. Materials and procedure: This retrospective cross-sectional study was carried out on 155 patients with acute inferior or posterior STEMI who underwent angioplasty on the LCX at the Shahid Madani Hospital of Tabriz, Iran, from 2018 to 2021. To gather data, all the files of the STEMI patients undergoing PPCI§ on the LCX artery were identified at

* ST Elevation Myocardial Infarction

† Percutaneous Coronary Intervention

‡ Left circumflex artery

§ Primary Percutaneous Coronary Intervention

the Medical Records Department of the hospital, and registered in the questionnaire. Patients' heart rate at admission was obtained from the ECGs recorded in the files. The patients were divided into three groups of under 70 beats (low), 70-100 beats (normal), and over 100 beats (high) per minute. Findings: The studied group consisted of 155 patients, including 31 ones (20%) with low heart rates, 107 ones (69%) with normal heart rates and 17 ones (11%) with high heart rates. The number of patients with diabetes, high blood pressure and tobacco consumption was greater in the group with the high heart rate of over 100. Admission heart rate was found to be not significantly associated with hospital and long-term complications ($p>0.05$). Angiographic results did not note a statistically significant difference between the three groups of patients in terms of the number of vessels involved and the location of the vessels involved. Conclusion: In STEMI patients, heart rate at admission did not note an association with the angiographic results and hospital complications such as hospital death and long-term complications, although the frequency of complications was greater in patients of high heart rates.

Keywords---heart rate, angiography, complications, heart attack.

Introduction

Heart rate (HR) is a factor that predicts admitted patients with cardiovascular diseases such as heart failure, high blood pressure, strokes and coronary artery diseases (1-3). In addition, the long-term prognostic value of HR for death caused by ischemic heart disease was also noted in healthy populations without documented cardiovascular diseases (4). Several studies have examined the prognostic value of HR and long-term cardiovascular results. A study by Diamond demonstrated that the rising HR was independently associated with the increased risk of all-cause mortality within 10 months. Of course, the prognostic value of HR in myocardial infarction patients was greater than that in patients with heart failure (5). A study on STEMI patients who underwent [Primary Percutaneous Coronary Intervention](#) (PPCI) suggested that the heart rate at discharge could be used to predict death for up to 4 years (6). Another study showed that high blood pressure at admission was associated with the rising mortality within a 6-month follow-up process, suggesting an association between HR and poor cardiovascular outcomes in patients with STEMI (7); however, the nature of the study did not provide the possibility of the relationship between angiography and determination of prognostic implications of HR as depending on the infarction artery. PPCI is taken as the golden standard blood reperfusion strategy in patients who present with STEMI (8). There are various reasons why the high heart rate following STEMI is associated with a poor prognosis, including increased cardiac oxygen demand and decreased coronary artery perfusion due to a shortened diastolic period (9).

Considering the high prevalence of myocardial infarction in Iran and high burden of this disease on the society, no study has ever examined the association between admission heart rate of patients with STEMI who have undergone PPCI

on the LCX artery and their angiographical and clinical results. Also, in view of the fact that beta-blocker drugs are accessible drugs, and that in case this association is established the drugs can be used to improve the prognosis of these patients, we decided to conduct a study to establish the relationship between the admission heart rate of patients with STEMI undergoing PPCI on the LCX artery and their angiographic and clinical outcomes.

Materials and procedure

This retrospective cross-sectional study was carried out on 155 patients with acute inferior or posterior STEMI who underwent angioplasty on the LCX at the Shahid Madani Hospital of Tabriz, Iran, from 2018 to 2021. Exclusion criteria included patients with hepatic and renal and severe blood diseases, malignancies, those who, after angiography, were candidates to the coronary bypass or medication therapy, those who received thrombolytics and later underwent coronary angioplasty, those with a history of coronary angioplasty on the LCX artery, and presented with stent thrombosis, those with complete heart block, Mobitz type II block, and 2:1 AV block and those with incomplete files.

Diagnosis and treatment of STEMI were determined based on the European Society of Cardiology Guidelines on STEMI (10). Cardiovascular death during hospitalization has been defined as one caused by myocardial infarction (MI), heart failure (HF) or sudden death without an unknown cause.

The tool to gather data was a questionnaire which was designed based on research variables. This tool includes demographic characteristics, risk factors, laboratory indicators, medications used, echocardiography data, angiography results and hospital and long-term complications of the patients.

To gather data, first, all the files of STEMI patients who had undergone PPCI on the LCX artery were gathered from the Medical Document Department of the Tabriz's Madani Hospital. Later, data required were extracted from the files and entered into the questionnaire. The admission heart rates of the patients were obtained from the admission ECGs recorded in the files. Angiography criteria, including the location of vessel involvement, post-PCI TIMI, TIMI base, and dominance and number of the vessels involved, were investigated by the cardiologist. The patients were divided into three groups of under 70 beats (low), 70-100 beats (normal), and over 100 beats (high) per minute.

Because the patients' files were selected retrospectively, the study was conducted by emphasizing the patients' data confidentiality. Data were provided in the form of absolute and relative frequency, mean and standard deviation. For the comparison of the groups, the chi-square tests, for the comparison of classified variables, the Fisher's exact test, and for the comparison of quantitative variables in heart rate grouping, the Mann-Whitney U as well as Kruskal Wallis tests were used. Kolmogorov-Smirnov test was also used to investigate the normality of the quantitative variables, as data were analyzed by the SPSS.22 software.

Findings

The experimental group consisted of 155 patients, including 31 people (20%) with low heart rates, 107 ones (69%) with normal heart rates and 17 ones (11%) with high heart rates. The mean age of the groups with low heart rate, natural heart rate and high heart rate were 59.8 ± 1.1 , 58.9 ± 1.1 and 63.5 ± 1.4 years, respectively ($P=0.29$). 84.5% of the patients were males and 15.5% were females. The number of patients with diabetes, high blood pressure and tobacco consumption was higher in the group with a heart rate of over 100 (Table 1).

Severity of mitral valve insufficiency, location of myocardial infarction and left ventricular ejection fraction did not have a statistically significant difference in the three groups under study (Table 2). The degree of thrombolysis in myocardial infarction (TIMI) did not show a statistically significant difference in the three groups, either ($P=0.94$); however, the degree of thrombosis and dominance had a statistically significant difference in the three groups ($P<0.05$) (Table 3).

Hospital and long-term complications were not significantly correlated with heart rates ($P>0.05$). In total, two patients (1.3%) and 5 others (3.2%) died during the hospitalization and after the discharge, respectively, (Table 4).

Most blood and blood pressure indicators were found to be not significantly correlated with heart rate ($P>0.05$). The mean rate of troponin in the group of patients with low heart rates was significantly higher than the other two groups ($P=0.01$). Also, the mean DTB (Door-to-Balloon) time and the total ischemic time in the group of patients with low heart rates were greater than those of other two groups (Table 5).

Discussion

Rising heart rates are associated with basal metabolic rates and lead to an increase of oxygen demand and a decrease of its supply due to the shortened diastolic period. Also, rising heart rates in patients may lead to constricted coronary arteries and thus disrupt the extra oxygen supply (11). The ischemic exacerbation mechanism is responsible for the build-up of infarction. Previous studies noted that the incidence of ischemic episodes in a group of patients with heart rates of over 80 times was two times as high as those of the patients with heart rates of under 70 (12). Rising heart rates are also linked with the progression of atherosclerosis and may cause the unstable atherosclerotic plaque to rupture that could lead to myocardial infarction (13). There are various reasons why rising heart rates following STEMI may be harmful which may include increased oxygen demand of myocardia and decreased perfusion of coronary arteries due to shortened diastolic period (14).

In our study, the number of patients with diabetes, high blood pressure and tobacco consumption was higher in the group with a heart rate of over 100. Noman et al.'s study also noted a higher frequency of diabetes and tobacco consumption in people with high heart rates (15). Also, the study by Cosmidou et al. suggested that the rising heart rates of the patients was associated with rising frequency of blood pressure, development of diabetes and consumption of tobacco

(16). The study by Salva et al. also demonstrated that the increased heart rates was associated with the increased diabetes and high blood pressure, but with the declining number of smoking patients (17).

Our findings concluded that admission heart rates were not associated with hospital and long-term complications after the discharge; meanwhile, long-term complications such as death, heart failure and ischemia in patients with heart rates of under 70 beats per minute and over 100 beats per minute were a slightly higher than in the patients with natural heart rates. The study by Salave et al. reported the frequency of cases of death in patient with heart beats of fewer than 60, and also the rising number of deaths with the increased heart rates of over 80 beats (17). Parodi et al. (7) demonstrated that heart rates of over 80 times per minute could predict the six-month death in the studied population. Higher mortality was noted in the group with $HR < 60$ bpm, which is consistent with our findings. The study by Anthony et al. (6) showed that heart rates at discharge was a strong predictor of mortality, with the patients with heart rates of $70 \leq$ experiencing twice as much risk of cardiovascular mortality as those with a heart rate of $70 >$ in a 1 and 4-year follow-up. Jensen et al. also concluded that the STEMI patients revealed a U-shaped relationship between the admission heart rates and death at the hospital, with the risk of death gradually increasing with the low or high heart rates (18).

Several epidemiologic studies have reported the linear relationship between heart rates and cardiovascular outcomes in patients with or without history of cardiac diseases (19, 20). In the study by Bangalore et al. (21), the patients with higher heart rates had had the risk of recurrent myocardial infarction reduced; as compared to the patients with lower heart rates. Parodi et al. (22) observed an association between lower heart rates at admission and mortality in patients with STEMI who had undergone primary angiography. The study by Cosmido et al. noted that bradycardia was not an independent predictor of death within 6 months. However, they suggested a significant relationship between tachycardia and one-year clinical outcomes, thereby confirming the importance of undesirable tachycardia prognosis to observe complications in patients treated with cardiovascular angioplasty (16). The Beautiful's study concluded that patients with heart rates of 70 or higher per minute saw their risk of cardiovascular deaths, hospitalization due to heart failure and heart attacks increased. An increase of 5 beats per minute was also linked with a significant increase of implications (19).

It is clinically important to understand the relationship between heart rates and complications, because heart rates can be corrected by types of rate-limiting medications of various mechanisms. Presence of tachycardia as an independent agent of outcomes is weak, because increased heart rates can be a sign of a more complicated and severe underlying disease (9).

In our study, the frequency of severe thrombosis had significantly decreased with the increased heart rates; in the study by Cosmido et al. (16), however, the frequency of thrombosis in patients had seen a rising trend from 60 beats per minute to 100 beats, which was not in line with our findings. This difference may be due to the low sample volume of our study compared to other similar studies.

Angiographic results did not show a statistically significant difference between the three groups of the patients in terms of the number of vessels involved and location of the vessel involvement. The Cosmido et al.'s study reported no evidence of the association between admission heart rate and the vessel involved and its severity (16).

According to findings from dominance and non-dominance of the vessel involved and heart rates in studied people, a significant relationship was noted, with the frequency of the left-dominant vessel involved increasing with the increased heart rates. The mean DTB time and total ischemic time in patients with heart rates of lower than 70 per minute was higher than those of the other two groups. The Noman et al.'s study reported the total ischemic time and DTB time in patients with heart rates of lower than 70 to be less than those of the patients with heart rates of over 70 beats per minute, which is not consistent with our results.

Despite a four-year survey, and the low incidence of acute infarction on the LCX arteries (incidence of around 15-17%) and absence of an appropriate context for the inter-center collaboration (to increase the statistical population) and also the removal of patients' angiographic films up until the year 2018, the statistical population was small and limited. It is noteworthy, however, that this study was done for the first time and has no similar counterpart, as other studies which examined the relationship between heart rates and clinical outcomes of STEMI patients undergoing angioplasty, had considered the patients globally, with no single study ever investigating the relationship between heart rates and the LCX thrombotic occlusion as a distinct group.

Conclusion

In patients with STEMI, heart rates at admission were not significantly correlated with the angiographic results. Also, no significant relationship was found between heart rates and hospital complications such as hospital deaths and long-term complications, although the frequency of the complications in patients with high heart rates was found to be greater.

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Appendices

Table 1: Relationship between demographic and clinical variables of patients and heart rate

	Variable of heart rate	(low)70 > No.: 31	(natural) 100-70 No.: 107	(high)100< No.: 17	P value
Demographic	Age (mean and standard deviation)	59.8±11.1	58.9±11.1	63.5±11.4	0.29
	Gender (male)	29 (93.5)	87 (81.3)	15 (88.2)	0.28
Risk factors	Creatinine <1.5	3 (9.7)	11 (10.3)	2(11.8)	0.99
	Diabetes	6 (19.4)	23 (21.5)	4 (23.5)	0.94
	High blood pressure	9 (29.0)	51 (47.7)	11 (64.7)	0.047
	HLP	4 (12.9)	9 (8.4)	2 (11.8)	0.62
	Tobacco	15 (48.4)	45 (42.1)	9 (52.9)	0.62
Previous history	Coronary artery bypass	0	3 (2.8)	0	0.99
	Angioplasty	1 (3.2)	6 (5.6)	3 (17.6)	0.14
Findings ECG	ST-resolution ECG>50%	29 (93.5)	90 (84.1)	15 (88.2)	0.46

Table 2: The relationship between variables of admission status of studied patients and coronary heart rate (left ventricular ejection fraction (LWEF))

Variable of heart rate	(low)70 > No." 31	(natural) 100-70 No.: 107	(high)100< No.: 17	P value
Severity of mitral insufficiency				
Mild	10 (37.0)	47 (61.0)	8 (72.7)	0.055
Moderate	16 (59.3)	28 (36.4)	2 (18.2)	
Severe	1 (3.7)	2 (2.6)	1 (9.1)	
Location of myocardial infarction				
Inferior MI	31 (72.1)	98 (65.4)	17 (60.7)	0.49
Lateral MI	0	14 (9.3)	4. (14.3)	
Posterior MI	12 (27.9)	38 (25.3)	7 (25.0)	
LWEF				
Mild	5 (16.1)	27 (25.3)	1 (5.9)	
Moderate	25 (80.7)	76 (71.0)	1 (94.16)	0.32
Severe	1 (3.2)	4 (3.7)	0	

Table 3: The relationship between the clinical variables of the studied patients and the heart rate (Thrombolysis in Myocardial Infarction (TIMI))

Variable of heart	(low)70 >	(natural)	(high)100<	P value
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rate	No.: 31	100-70 No.: 107	No.: 17	
TIMI POST PPCI				
1	0	1 (0.9)	0	0.94
2	3 (9.7)	13 (12.1)	1 (5.9)	
3	28 (90.3)	93 (86.9)	16 (94.1)	
Severe thrombosis)high/	26 (83.9)	66 (61.7)	10 (58.8)	0.059
Dominancy				
Left	2 (6.7)	15 (14.3)	7 (41.2)	0.017
Right	23 (76.7)	79 (75.2)	7 (41.2)	
Co-dominant	5 (16.7)	11 (10.5)	3 (17.6)	
Number of stents				
One	27 (87.1)	96 (89.7)	17 (100)	0.32
Two or more	4 (12.9)	11 (10.3)	0	
No use of thrombo- suction	28 (90.3)	101 (95.3)	14 (82.4)	0.11
One involved vessel	8 (25.8)	34 (32.4)	5 (29.4)	0.78
Location of involvement of the vessel (proximal)	18 (60.0)	52 (51.0)	11 (64.7)	0.45
Glycoprotein IIb/IIIa	14 (45.2)	34 (31.8)	10 (58.8)	0.06
No previous history of drug use	25 (80.6)	69 (64.5)	13 (76.5)	0.018

Table 4) Comparison of the complications of the studied patients with heart rate

Variable of heart rate	(low)70 > No.: 31	(natural) 100-70 No.: 107	(high)100 < No.:17	P value
Hospital complication				
None	29 (93.5)	101 (94.4)	16 (94.1)	
Death inside the hospital	1 (3.2)	1 (0.9)	0	0.6
Recurrent myocardia	0	2 (1.9)	1 (5.9)	
VT/VF	1 (3.2)	3 (2.8)	0	
Long term complication				
None	6 (17.7)	26 (23.0)	1 (5.6)	0.21
Yes	28(82.3)	87 (77.0)	17 (94.4)	

Table 5: Relationship between quantitative variables and the heart rate of the studied patients (Door-to-balloon (DTB))

Heart rate	Lower than 70	70-100	Over 100	P value
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Blood test	Blood urea nitrogen	17.5±4.9	17.5±13.1	18.9±4.4	0.04	
	Creatinine	1.1±0.2	1.5±1.3	7.2±3.0	0.32	
	Hemoglobin	15.1±1.5	14.9±2.0	15.0±2.2	0.92	
	Platelet	191.7±76.2	227.8±70.7	332.8±91.7	0.07	
	White blood cells	18.1±14.9	25.6±15.6	23.9±15.8	0.89	
	Triglyceride	136.2±75.1	128.7±82.1	144.5±111.0	0.58	
	low density lipoprotein (LDL)	114.5±29.6	101.3±29.5	115.3±45.9	0.24	
	high density lipoprotein (HDL)	39.0±13.3	39.6±11.2	35.6±7.2	0.48	
	Cholesterol	177.0±35.6	171.1±37.9	177.3±48.9	0.76	
	Systolic blood pressure	131.5±33.9	142.7±27.0	130.2±30.2	0.14	
	diastolic blood pressure	84.0±14.6	87.1±15.6	85.3±17.8	0.76	
	Troponin. Peak ng/ml	23.7±18.6	14.3±13.3	21.2±19.4	0.01	
	Average troponin. ng/ml	4.16±13.6	9.7±8.9	612.7±9.6	0.02	
	Procedure	Contrast volume (mm)	165.5±106.4	176.8±96.3	157.1±8.0	0.67
		DTB duration (minutes)	94.6±70.2	84.1±49.1	80.0±45.3	0.86
Period. ischemic (minutes)		341.0±174.8	162.2±303.6	146.2±305.6	0.46	