Cardiovascular Topics

Predictive values of stress hyperglycaemia and glycosylated haemoglobin on admission for long-term recovery of cardiac function in patients with acute myocardial infarction after primary percutaneous coronary intervention

Jinfeng Xiao, Chuanchao Luo, Lixin Yang

Abstract

We aimed to explore the predictive values of stress hyperglycaemia (SHG) and glycosylated haemoglobin (HbA_{1c}) levels on admission for long-term recovery of cardiac function in patients with acute myocardial infarction (AMI) after primary percutaneous coronary intervention (PPCI). A total of 210 AMI patients were randomly selected. The levels of SHG and HbA_{1c} were measured on admission, and all patients were treated with PPCI and followed up for one year. According to the recovery status of cardiac function during follow up, the patients were divided into a good recovery group and a poor recovery group. At one year after treatment, there were statistically significant differences in the levels of SHG (6.75 ± 0.69 vs 7.81 ± 0.92 mmol/l) and HbA_{1c} (5.13 ± 0.25 vs 5.91 ± 0.39%) between the good and poor recovery groups ($p < 0.05$). The levels of SHG and HbA_{1c} were associated with long-term recovery of cardiac function ($p < 0.05$). The receiver operating characteristic curves were plotted, and the area under the curves of SHG and HbA_{1c} for predicting the long-term recovery of cardiac function were > 0.70. The levels of SHG and HbA_{1c} were closely associated with long-term recovery of cardiac function after PPCI in AMI patients, displaying high predictive values.

Keywords: acute myocardial infarction, cardiac function, haemoglobin, hyperglycaemia, percutaneous coronary intervention, stress

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Acute myocardial infarction (AMI) is one of the most serious types of coronary heart disease.[1] The pathogenesis of AMI is the rupture and erosion of coronary atherosclerotic plaques, followed by secondary thrombus. This results in stenosis or occlusion of the vascular lumen and myocardial ischaemia or necrosis, which can lead to abnormalities of relevant biomarkers and damage to cardiac diastolic and systolic function.[2]

AMI, with clinical manifestations of severe retrosternal pain, fever, heart failure and arrhythmia, is characterised by acute onset, severe conditions and rapid changes in condition, which can seriously endanger the life and health of residents and impose a great burden on society.[3] Additionally, AMI can increase the secretion of catecholamine, glucocorticoid and other stress hormones by exciting the sympathetic nervous system and endocrine system, accelerating the decomposition of hepatic glycogen, fat and protein, and enhancing insulin resistance, resulting in elevation of blood glucose levels.[4]

Primary percutaneous coronary intervention (PPCI) is a reperfusion therapy with an ability to significantly improve the prognosis of AMI patients, making it one of the most effective treatments for coronary heart disease at present. However, technical difficulties are still encountered during interventional surgery due to hyperglycaemia and hypertension in some patients, and the long-term prognosis is unsatisfactory.[5,6] Therefore, it is of importance to explore effective indicators for predicting the long-term prognosis of AMI patients after PPCI.

The levels of stress hyperglycaemia (SHG) and glycosylated haemoglobin (HbA_{1c}) are closely associated with the occurrence and development of AMI. SHG refers to a temporary increase in blood glucose levels in non-diabetic patients under stress conditions, such as major trauma, sepsis, stroke and AMI, which is very common in AMI patients. As shown in the survey, the short- and long-term mortality rates of AMI patients with SHG are significantly higher than those of AMI patients without SHG.[7]

The level of HbA_{1c} reflects the mean blood glucose level within eight to 12 weeks prior to detection, which is the most commonly used indicator of chronic glucose metabolism, and has been verified to be closely related to the occurrence of cardiovascular diseases.[8] Therefore, it can be inferred that the levels of SHG and HbA_{1c} may be related to the long-term recovery of cardiac function after PPCI in AMI patients. In view of this, the association of SHG and HbA_{1c} levels with long-term recovery of cardiac function after PPCI in AMI patients and the predictive value of the two were investigated in this study.

Methods

A total of 210 AMI patients treated with PPCI in our hospital from January 2020 to August 2022 were randomly selected as the subjects. This study was approved by the ethics committee of our hospital, and written informed consent was obtained from all patients.

Inclusion criteria were as follows: patients meeting the diagnostic criteria for AMI and diagnosed by imaging and related examinations,[9] those with an increase or decrease in troponin levels, and those undergoing PPCI. Exclusion criteria included: patients with severe hepatic or renal insufficiency, those with a history of AMI, those complicated with heart disease, myocarditis, cardiomyopathy or connective tissue disease, or patients administered glucocorticoids before admission.

After discharge, all patients were followed up for one year until 1 August 2023, and were re-examined at three, six and 12 months after PPCI. According to the imaging and examination results, they were divided into a good recovery group (no significant myocardial ischaemia, heart failure and severe ventricular arrhythmia, as well as stable haemodynamics) and a poor recovery group (presence of the above symptoms and no significant change in condition).

For laboratory assays, fasting venous blood (5 ml) was drawn from each patient on admission and centrifuged. The serum was separated and refrigerated. Then, fasting blood glucose, triglyceride, total cholesterol, and low- and high-density lipoprotein cholesterol levels were measured using a CS-1200 biochemical analyser (Jilin Dirui Industrial Co, Ltd, China).

HbA_{1c} level was determined by high-pressure liquid-phase ion exchange method using a kit purchased from Yunnan Haoxu Biotechnology Co, Ltd (China). The peak value of creatine kinase isoenzyme was determined by immunosuppression assay via the kit purchased from Jilin Dirui Industrial Co, Ltd (China). The levels of fasting blood glucose, total cholesterol, triglyceride, low- and high-density lipoprotein cholesterol, HbA_{1c} and creatine kinase isoenzyme were recorded for both groups.

Statistical analysis

SPSS Statistics for Windows, version 26.0 (Armonk, NY: IBM Corp, USA) was used for the normality test of measurement data. Measurement data of normal distribution were described by mean and standard deviation and compared with the independent-samples *t*-test between the two groups. Count data were described as numbers and percentages and compared with the chi-squared test. The correlations of SHG and HbA_{1c} levels with long-term recovery of cardiac function after PPCI in AMI patients were analysed by multivariate logistic regression analysis. The receiver operating characteristic curves were plotted and the area under the curve was calculated to test the predictive value of SHG and HbA_{1c} for long-term recovery of cardiac function after PPCI in AMI patients. A value of $p < 0.05$ was considered statistically significant.

Table 1. Baseline data

Demographics	*Good recovery group (n = 156)*	*Poor recovery group (n = 54)*	*Statistical value*	p-*value*
Age (year), mean ± SD	67.37 ± 12.39	66.79 ± 12.64	0.295#	0.768
Gender, *n* (%)				
Male	112 (71.79)	35 (64.81)	0.931*	0.335
Female	44 (28.21)	19 (35.19)		
History of hypertension				
Yes	83 (53.21)	29 (53.70)	0.004*	0.950
No	73 (46.79)	25 (46.30)		
History of hyperlipidaemia				
Yes	11 (7.05)	4 (7.41)	0.048*	0.827
No	145 (92.95)	50 (92.59)		
History of coronary heart disease				
Yes	26 (16.67)	8 (14.81)	0.101*	0.750
No	130 (83.33)	46 (85.19)		
History of stroke				
Yes	9 (5.77)	2 (3.70)	0.054*	0.816
No	147 (94.23)	52 (96.30)		
History of PCI				
Yes	10 (6.41)	3 (5.56)	0.011*	0.918
No	146 (93.59)	51 (94.44)		
History of smoking				
Yes	72 (46.15)	24 (44.44)	0.047*	0.828
No	84 (53.85)	30 (55.56)		

PCI: percutaneous coronary intervention. #*t*-test, * χ^2 test.

Results

During the one-year follow up, 54 patients experienced a poor recovery, with a rate of 25.71%. There were no statistically significant differences in age, gender and history of hypertension, hyperlipidaemia, coronary heart disease, stroke, PPCI and smoking between the two groups ($p > 0.05$) (Table 1).

After one year of treatment, the poor recovery group had higher levels of fasting blood glucose and HbA_{1c} but a lower level of low-density lipoprotein cholesterol than the good recovery group, and the differences were statistically significant ($p < 0.05$). The levels of total cholesterol, triglyceride, high-density lipoprotein cholesterol and creatine kinase isoenzyme showed no statistically significant differences between the two groups ($p > 0.05$) (Table 2).

Multivariate logistic regression analysis was performed with long-term recovery status of cardiac function after PPCI in AMI patients as the dependent variable (good recovery = 1, poor recovery = 2) and statistically significant variables as

Table 2. Laboratory indicators

Variables	*Good recovery group (n = 156)*	*Poor recovery group (n = 54)*	t	p-*value*
Fasting blood glucose (mmol/l)	6.75 ± 0.69	7.81 ± 0.92	8.889	< 0.001
Total cholesterol (mmol/l)	4.43 ± 0.50	4.39 ± 0.53	0.499	0.618
Triglycerides (mmol/l)	1.52 ± 0.09	1.50 ± 0.12	1.286	0.120
Low-density lipoprotein cholesterol (mmol/l)	2.97 ± 0.18	2.83 ± 0.14	5.195	< 0.001
High-density lipoprotein cholesterol (mmol/l)	1.15 ± 0.16	1.17 ± 0.20	0.740	0.460
HbA_{1c} (%)	5.13 ± 0.25	5.91 ± 0.39	16.912	< 0.001
Peak value of creatine kinase isoenzyme (U/l)	2178.23 ± 205.46	2203.11 ± 200.35	0.772	0.441

HbA_{1c}: glycosylated haemoglobin.

Table 3. Associations of SHG and HbA_{1c} levels with long-term recovery of cardiac function after PPCI in AMI patients

Influencing factor	β	Standard error	Wald	p-value	Odds ratio	95% CI Lower limit	95% CI Upper limit
Fasting blood glucose	1.914	0.302	40.286	< 0.001	6.779	3.754	12.241
HbA_{1c}	7.041	1.029	46.854	< 0.001	1142.694	152.172	8580.751

AMI: acute myocardial infarction; HbA_{1c}: glycosylated haemoglobin; PPCI: primary percutaneous coronary intervention; SHG: stress hyperglycaemia.

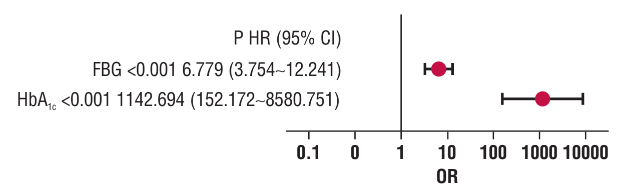

Fig. 1. Forest plot of clinical characteristics based on multivariate logistic regression analysis.

independent variables. The results showed that the levels of SHG and HbA_{1c} were correlated with long-term recovery of cardiac function after PPCI in AMI patients ($p < 0.05$) (Table 3, Fig. 1).

With the long-term recovery status of cardiac function after PPCI in AMI patients as the state variable (good recovery = 1, poor recovery = 2), and the levels of SHG and HbA_{1c} on admission as the test variables, receiver operating characteristic curves were plotted (Fig. 2). The results showed that the areas under the curve of SHG and HbA_{1c} for predicting long-term recovery of cardiac function after PPCI in AMI patients were > 0.70, suggesting a certain predictive value, especially for HbA_{1c} (Table 4).

Discussion

SHG can, to some extent, increase the incidence of heart failure and cardiogenic shock in non-diabetic AMI patients, thus increasing the in-hospital mortality rate.[10] As one of the indicators that can best reflect long-term glycaemic control, HbA_{1c} can also elevate the incidence of cardiovascular disease in AMI patients, and its level is directly proportional to this rate.[11] The non-recovery rate of long-term cardiac function after PPCI in AMI patients remains high,[12] similar to that in this study (25.71%), suggesting a high recurrence rate after PPCI. Therefore, it is important to explore the effective indicators for predicting the long-term recovery of cardiac function after PPCI in AMI patients.

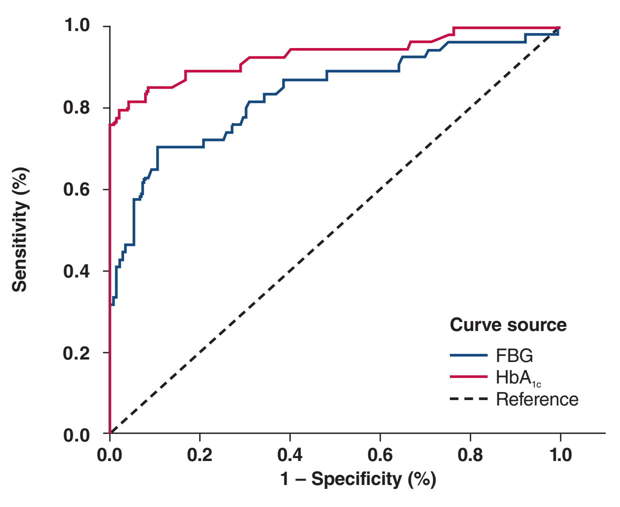

Fig. 2. Receiver operating characteristic curves of SHG and HbA_{1c} levels for predicting the long-term recovery of cardiac function after PPCI in AMI patients. AMI: acute myocardial infarction; HbA_{1c}: glycosylated haemoglobin; PPCI: primary percutaneous coronary intervention; SHG: stress hyperglycaemia.

An increase in SHG level not only has an association with the risk of mortality and in-hospital complications in AMI patients, but also increases, to some extent, the in-hospital mortality rate of non-diabetic AMI patients.[13,14] The rate of incidence of major adverse cardiac events in AMI patients during follow up rises with an increase in HbA_{1c} level.[15]

In another study involving patients undergoing coronary artery bypass grafting or PCI, the results of multivariate analysis demonstrated that a higher HbA_{1c} level (≥ 6.5%) could increase the risk of heart failure. Therefore, HbA_{1c} level may have higher predictive value for the short-term prognosis of AMI patients and is superior to blood glucose value alone on admission.[16] It is therefore speculated that the levels of SHG and HbA_{1c} in AMI patients may be associated with long-term recovery of cardiac function after PPCI. However, there are few studies on long-term prognosis. Based on this, the association of SHG and HbA_{1c} levels with long-term prognosis of AMI patients were studied in our research.

In this study, after one year of treatment, the levels of SHG and HbA_{1c} in the poor recovery group were higher than those in the good recovery group. The results of multivariate logistic regression analysis revealed that levels of SHG and HbA_{1c} were risk factors for long-term recovery of cardiac function after PPCI in AMI patients. The reason is that in AMI patients, SHG can cause abnormal activation of the neuro-endocrine system, release excessive cortisol and catecholamines, enhance the generation of free radicals, trigger an inflammatory response and oxidative stress, worsen endothelial dysfunction, induce thrombosis, and then lead to cell and tissue damage, resulting in expanded infarction and severe impairment of coronary blood flow.[17]

Meanwhile, hyperglycaemia can also increase the level of intercellular adhesion molecule-1, causing leukocyte aggregation in the capillaries, increasing fibrin peptide A and coagulation factor VII, platelet aggregation and platelet thrombosis, and reducing endothelium-dependent vasodilation, so that patients develop expanded infarction and decreased cardiac output, making them more prone to heart failure.[18]

Table 4. Predictive value of SHG and HbA_{1c} levels for long-term recovery of cardiac function after PPCI in AMI patients

Influencing factor	AUC	Cut-off value	95% CI	p-value	Specificity	Sensitivity	Youden index
Fasting blood glucose	0.835	5.760	0.764–0.906	< 0.001	0.963	0.923	0.886
HbA_{1c}	0.932	4.975	0.884–0.980	< 0.001	0.981	0.763	0.744

AMI: acute myocardial infarction; HbA_{1c}: glycosylated haemoglobin; PPCI: primary percutaneous coronary intervention; SHG: stress hyperglycaemia; AUC: area under the curve.

In addition, glucocorticoids can weaken the effective utilisation of glucose while enhancing gluconeogenesis, making fat an alternative substrate for oxidation and energy supply. Then the resulting fatty acids, if accumulated in the heart in large quantities, may further reduce myocardial contractility and increase the risk of heart pump failure and arrhythmia.[19] At the same time, hyperglycaemia can also reflect an impairment in insulin secretion, which stimulates lipolysis and thus increases the content of free fatty acids, which accelerates myocardial oxygen consumption, destroys the stability of ischaemic myocardial cells, promotes the proliferation and migration of vascular smooth muscle cells, results in decreased collateral circulation blood flow perfusion, and worsens local ischaemia, thus inducing ventricular arrhythmia and impaired myocardial contractility.[20]

Besides, SHG can also affect myocardial energy supply by enhancing hepatic gluconeogenesis. This will alter the polarisation state of the myocardial cell membrane, finally resulting in cardiac dysfunction and a long-term adverse prognosis.[21]

In this study, receiver operating characteristic curves were plotted, and it was found that the areas under the curve of SHG and HbA_{1c} for predicting the long-term recovery of cardiac function after PPCI in AMI patients were > 0.70, suggesting a certain predictive value, especially for HbA_{1c}. It can be seen that levels of SHG and HbA_{1c} are of positive significance in predicting the long-term recovery of cardiac function after PPCI in AMI patients. In the future, the long-term recovery of cardiac function and risk after PPCI in AMI patients can be predicted based on pre-operative levels of SHG and HbA_{1c}, and targeted treatment can be given to high-risk patients to improve their prognosis.

This study has some limitations. First, the results were obtained based on the experience of a single medical centre. Second, the follow-up time was not long enough. Further multicentre studies with more cases and longer follow-up time are ongoing in our group.

Conclusions

The levels of SHG and HbA_{1c} were closely associated with long-term recovery of cardiac function after PPCI in AMI patients, displaying a certain predictive value.

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