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Original article

Clinical outcomes after acute myocardial infarction according to a novel stratification system linked to a rehabilitation program

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ABSTRACT

Background: A risk classification of acute myocardial infarction (AMI) linked to a rehabilitation program has not been established.
Methods: We allocated 292 patients with AMI into the low- (L) ($n = 108$), intermediate- (I) ($n = 72$), and high- (H) ($n = 112$) risk groups according to our original risk classification. The primary endpoint was major adverse cardiac events (MACE), defined as the composite of cardiac death, non-fatal AMI, stent thrombosis, and ischemia-driven target vessel revascularization. The mean follow-up period was 252 days.
Results: The length of coronary care unit (CCU) stay and hospital stay was shortest in the L-risk group (CCU stay, 1.0 ± 1.0 days; hospital stay, 5.6 ± 3.2 days), followed by the I-risk group (CCU stay, 2.3 ± 1.8 days; hospital stay, 8.1 ± 2.7 days), and longest in the H-risk group (CCU stay, 5.1 ± 5.0 days; hospital stay, 14.6 ± 12.6 days) ($p < 0.001$). MACE were most frequently observed in the H-risk group (26.8%), followed by the I-risk group (5.6%), and least in the L-risk group (1.9%) ($p < 0.001$).
Conclusions: The lengths of hospital stay and CCU stay were significantly shortest in the L-risk group, followed by the I-risk group, and longest in the H-risk group. MACE were most frequently observed in the H-risk group, followed by the I-risk group, and least in the L-risk group. These results support the validity of our new classification system.

Introduction

Clinical outcomes of acute myocardial infarction (AMI) have been dramatically improved by developments, such as primary percutaneous coronary interventions (PCI) [1], optimal medical therapy [2–5], and cardiac rehabilitation [6,7]. Nevertheless, in-hospital mortality of AMI is still high, ranging from 7% to 8% [8,9], which indicates poor clinical outcomes of high-risk patients, even in the current primary PCI era. Furthermore, an in-hospital rehabilitation program stratified according to the risk of AMI has not been established. While earlier risk scores such as the Global Registry of Acute Coronary Events (GRACE) risk score or the Thrombolysis in Myocardial Infarction (TIMI) risk score were associated with in-hospital and long-term outcomes [10,11], they were not used to stratify AMI patients for more suitable in-hospital rehabilitation programs.

Compared with Western countries, the length of hospital stay for AMI was significantly longer in Japan [12]. However, early unplanned readmission was significantly less in Japan than in Canada or the USA [12,13], suggesting that the length of hospital stay was determined by socioeconomic factors rather than by AMI risk stratification. Therefore, there is an unmet need to establish AMI risk stratification linked to an in-hospital rehabilitation program for fewer unplanned readmissions as well as shorter length of hospital stay.

In our clinical practice, we introduced an originally novel AMI Risk Stratification (nARS) that was closely linked to the in-hospital rehabilitation program. We hypothesized that the nARS could efficiently reduce the length of hospital stay without re-admission and could predict clinical outcomes. The purpose of this study was to compare in-hospital and mid-term clinical outcomes among patients stratified according to the nARS, and to validate the nARS.

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Materials and methods

Study design

We included AMI patients treated at our institution between April 2015 and March 2016. We divided AMI patients into a L- (low) risk group, an I- (intermediate) risk group, and a H- (high) risk group according to our nARS, considering primary PCI, global ejection fraction (EF), right ventricular infarction, apical aneurysm, optimal medical therapy, pericardial effusion, occurrence of mechanical complications, use of mechanical support, and other high-risk comorbidities [14–20] (Table 1). The AMI risk for each patient was discussed and determined in our daily coronary care unit (CCU) conference at the next day of admission (the next day of primary PCI or coronary angiography). We allocated AMI patients to the L-, I-, or H-risk groups. All AMI patients must pass three rehabilitation tests (keep standing for 2 min, 200-m walk, 500-m walk) before hospital discharge. The schedule for each test is described in Fig. 1. Risk crossover (from the L-risk group to the H-risk group or from the I-risk group to the H-risk group) was available when the patient could not pass the scheduled rehabilitation test.

We excluded patients with AMI due to coronary artery spasm as well as patients with AMI who underwent emergent or urgent coronary bypass grafting during hospitalization. We also excluded patients with AMI who did not undergo coronary angiography. The primary endpoint was major adverse cardiac events (MACE), defined as the composite of cardiac death, non-fatal AMI, stent thrombosis (ST), and ischemia-driven target vessel revascularization (TVR). In-hospital and mid-term clinical events were acquired from our hospital records. This study was approved by the institutional review board, and written informed consent was waived because of the retrospective study design. This study data collection and storage was performed anonymously, according to the guideline made by Japan Ministry of Health, Labour and Welfare [21].

Definitions

In the present study, AMI was defined as detection of a rise in a cardiac biomarker (preferably cardiac troponin with at least one value above the 99th percentile upper reference limit) and with at least one of the following: (1) symptoms of ischemia, (2) new or presumed new significant ST-segment–T wave changes or new left bundle branch block, (3) development of pathological Q waves on the electrocardiogram, (4) imaging evidence of new loss of viable myocardium or new regional wall motion abnormality, (5) identification of an intracoronary thrombus by angiography or autopsy, according to the universal definition [22]. Only the definite ST according to the academic research consortium (ARC) definition was considered as ST [23]. Hypertension was defined as systolic blood pressure >140 mmHg, diastolic blood pressure >90 mmHg, or medical treatment for hypertension. Diabetes mellitus was defined as a hemoglobin A1c level >6.5% or treatment for diabetes mellitus. Hyperlipidemia was defined as a total cholesterol level >220 mg/dl, a low-density lipoprotein cholesterol level >140 mg/dl, or treatment for hyperlipidemia. Chronic kidney disease was defined as a creatinine clearance level <60 ml/min. Shock was defined as a systolic blood pressure <90 mmHg or vasopressors required to maintain blood pressure or an attempt of cardiopulmonary resuscitation. Ejection fraction was measured by a modified Simpson method. Ejection fraction measured by Teichholz methods was adopted only when a modified Simpson method was not available. Right ventricular infarction was defined as ST-segment elevation in V4R (≥1 mm) or abnormal right ventricular wall motion in echocardiogram, accompanying clinical symptoms such as hypotension.

Statistical analysis

Data were expressed as mean ± SD or percentage. Categorical variables were presented as numbers (percentage) and were

Table 1
Algorithm for risk classification.

	Risk classification		
	L- (low) risk group	I- (intermediate) risk group	H- (high) risk group
Criteria	L-risk group must satisfy *all* of the following criteria	Patients who were neither L- or H-risk group were categorized as I-risk	H-risk group must have *at least one* of the following criteria
Timing of primary PCI	Primary PCI within 12 h from onset of symptoms	–	Primary PCI more than 24 h from onset of symptoms
Results of primary PCI	TIMI-3 flow grade	–	TIMI 0, 1, 2 flow grade
Global EF	More than 40%	–	Less than 30%
Medications	Introduce ACE-I/ARB and beta-blockers the day of or the next day after admission	–	–
Residual stenosis	No residual stenosis (from April 2015 to December 2015). From January 2016, "no residual stenosis" was not a requirement for L-risk	–	Residual stenosis and unsuccessful rehabilitation (keep standing, 200-m walk, 500-m walk) (from January 2016–)
High-risk comorbidities	None	–	Asthma, steroid user, etc.
Right ventricular infarction	None or right ventricular infarction that does not affect hemodynamic status	–	Right ventricular infarction that affects hemodynamic status
Pericardial effusion	None or less than 10 mm by echocardiography	–	More than 10 mm by echocardiography
Apical aneurysm	None	–	Apical aneurysm requiring anticoagulation therapy
Mechanical complication (ventricular septal perforation, free wall rupture, papillary muscle rupture)	None	–	Yes or post-surgery of mechanical complications
IABP support	None or IABP less than 48 h	–	Requiring more than 48 h
Very low-risk (from January 2016–)	Only troponin I elevation (≥99th percentile of URL)	–	–
Very high-risk (from January 2016–)	–	–	Unsuccessful rehabilitation even in the H-risk program

PCI, percutaneous coronary intervention; TIMI, Thrombolysis in Myocardial Infarction; IABP, intra-aortic balloon pumping; EF, ejection fraction; CCU, coronary care unit; ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; URL, upper range limit.

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