Early and late outcomes of emergency coronary bypass grafting in non-ST-segment elevation acute myocardial infarction

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ABSTRACT

The majority of patients undergoing emergency coronary artery bypass grafting for non-ST-segment elevation myocardial infarction are of advanced age and have many comorbidities, which pose challenges for operation. This study aimed to determine the early and midterm outcomes of this subgroup. The study conducted a retrospective analysis on 89 patients who experienced non-ST-elevation acute myocardial infarction and underwent emergency coronary artery bypass graft surgery at Hanoi Heart Hospital in Hanoi, Vietnam, between January 1, 2020, and December 31, 2022. The primary outcome variable was in-hospital mortality, and the secondary outcome variable was midterm mortality. The mean age of the cohort was 66.4 years. Female accounted for 31.46%. Over half of patients (53.9%) were operated on within 24 hours from the onset of symptoms. The average European System for Cardiac Operative Risk Evaluation (EuroSCORE II) was 10.55%. The number of coronary bypasses was 3.4. Aortic cross-clamp and cardiopulmonary bypass times were 64.2 and 94.4 minutes. The in-hospital mortality rate was 10.11%. Significant predictors determining in-hospital mortality were the EuroSCORE II score. The mean follow-up time was 28.2±12.2 months. Survival rates at 1 year and 2 years were 97.5% and 96.02%, respectively. Emergency coronary bypass surgery in patients with non-ST segment elevation myocardial infarction had poor early but good midterm outcomes. A high EuroSCORE II score was a predictor of in-hospital mortality.

Introduction

Acute myocardial infarction (AMI), known as the most serious consequence of coronary artery disease, can result in long-term disability and mortality. AMI is an event of myocardial necrosis, diagnosed and assessed based on clinical evaluation, the electrocardiogram [with ST-segment elevation (STEMI) or without ST-segment elevation (NSTEMI)], biochemical testing, invasive and noninvasive imaging, and pathological evaluation.[1]

Technological advances have resulted in the widespread use of percutaneous coronary intervention (PCI), which has improved the results of AMI treatment. As a result, there have been notable reductions in the need for emergency coronary artery bypass grafting (CABG).[2,3] In patients with STEMI, prompt and timely reperfusion is essential, so primary PCI is recommended if immediately available.[4] In patients with NSTEMI, either PCI or CABG could be recommended, depending on the patient's characteristics and coronary lesion.[5]

Recently, PCI has become the primary treatment, not only for STEMI, regardless of the extension of the coronary artery

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Key words: coronary artery bypass, CABG, emergency, acute myocardial infarction, NSTEMI.

Contributions: all authors gave a substantial contribution to the conception and design of the work, data acquisition, analysis and interpretation, and drafting and revision of the article. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of interest: the authors declare that they have no competing interests, and all authors confirm accuracy.

Ethics approval and consent to participate: all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of Hanoi Medical University (Ref:672/GCN-HĐĐĐNCYSH-ĐHYHN) and the Ethics Committee of Hanoi Heart Hospital (Ref: 517/BVT- GCNHĐĐĐ).

Patient consent for publication: the authors certify that they have obtained all appropriate patient consent forms.

Funding: none.

Availability of data and materials: data and materials are available from the corresponding author upon request.

Received: 24 September 2024.
Accepted: 28 October 2024.

Licensee PAGEPress, Italy
Italian Journal of Medicine 2025; 19:1808
doi:10.4081/itjm.2025.1808

disease, but also for NSTEMI patients with single- or double-vessel disease. CABG is reserved for patients with multivessel disease or left main stem stenosis and is most often performed as an elective or semi-acute procedure after stabilization of acute ischemic symptoms.[6,7]

However, the need for CABG still remains in patients with AMI, especially in patients with NSTEMI.[3] A small proportion of these procedures are performed in emergencies, most often because of ongoing ischemia, multivessel disease, or anatomic unsuitability for PCI.[8] Patients undergoing emergency CABG are considered at very high risk for early mortality and morbidity.[9-11]

Emergency CABG is a relatively rare procedure.[3] There have been few reports on outcomes after emergency CABG and most studies have included a few patients from single institutions. The early mortality for emergency CABG is highly variable (3-13%) and markedly higher than for elective procedures.[10,12,13]

There have been fewer reports of this issue in Vietnam. Previously, we reported 71 patients undergoing emergency CABG regardless of type of AMI with high in-hospital mortality (9.9%).[14] Recently, utilization of CABG decreased among AMI hospitalizations, with a more pronounced decrease in STEMI compared with NSTEMI hospitalizations.[3]

This study continued to determine the in-hospital and the midterm outcomes among the NSTEMI patients undergoing emergency CABG in a large volume institute in Vietnam.

Materials and Methods

Study design and patients

A retrospective evaluation of prospectively collected data at the Hanoi Heart Hospital (Hanoi, Vietnam) was conducted. From January 1, 2020, to December 31, 2022, a total of 48,240 patients underwent coronary angiography for AMI, of which 3569 patients had NSTEMI, accounting for 74%. There were 307 patients (8.6%) who underwent coronary artery bypass surgery; among them, 89 had to be operated on in emergency. The clinical profile, preoperative characteristics, medications, intraoperative data, and postoperative outcomes were retrieved from prospective patients' medical records and computerized databases. From January 1, 2020, to December 31, 2022, a total of 89 NSTEMI patients underwent an emergency CABG in Hanoi Heart Hospital and were included in this study.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of Hanoi Medical University (Ref:672/GCN-HĐĐĐNCYSH-ĐHYHN) and the Ethics Committee of Hanoi Heart Hospital (Ref: 517/BVT- GCN-HĐĐĐ). Because this was a retrospective study, individual patient informed consent was waived. The personal information of the subjects was kept confidential and encrypted.

Preoperative and anesthesia management

The decision for emergency CABG surgery was made by a standard heart team of experienced physicians (including one cardiologist, one interventionist, one anesthetist, and one surgeon) and was based on clinical examination (chest pain severity, hemodynamic status), changes in cardiac enzymes [creatine kinase-myocardial band (CKMB), high-sensitivity cardiac troponin T], changes in an electrocardiogram, lesion complexity on the coronary angiogram, and echocardiography findings (ejection fraction). Patients undergoing emergency surgery were those who were indicated until they arrived in the operating room before the next working day [classified on the European System for Cardiac Operative Risk Evaluation (EuroSCORE II)].[15]

Towards surgical preparation for special cases, in case of hemodynamic instability and/or acute pulmonary edema, we conducted endotracheal intubation, central venous line, and invasive blood pressure monitoring line in waiting operating room preparation. Intra-aortic balloon counterpulsation (IABP) and/or extracorporeal membrane oxygenation (ECMO) were performed when the medical support failed to stabilize hemodynamics. When patients were preoperatively on antiplatelet agents (clopidogrel and/or ticagrelor), we prepared 4 units of red blood cells, 2 units of platelet pool, and 2 units of factor VIII to eliminate postoperative bleeding.

Surgical technique

The specific surgical approach was chosen according to the surgeon's preference. The patients underwent operations using extracorporeal circulation and cardioplegic cardiac arrest. Internal mammary artery grafts were combined with venous grafts for revascularization in stable patients, whereas venous grafts only were used in patients requiring resuscitation or presenting with major hemodynamic instability. The left radial artery was used as an arterial conduit in stable patients under 70 of age. A perioperative IABP was selectively used in the early days but now is considered in patients weaning extracorporeal circulation with high doses of inotropes. Tranexamic acid is administered in a routine fashion.

Data analysis

All statistical analyses were performed with Stata® 15 (StataCorp LLC, College Station, TX, USA). All data was first performed by a visual inspection for coding errors, outliers, or funky distributions. We divided early outcome study variables into two groups: the survival group and the non-survival group. Categorical variables are expressed as frequencies and percentages and were compared by use of the $\chi 2$ or Fisher exact test. Continuous variables are expressed as mean ± standard deviation and interquartile range and compared by Mann–Whitney U-test (not normally distributed) or *t*-test (normally distributed). We used univariate logistic regression analysis to identify risk factors of early death. Forward stepwise logistic regression analysis (likelihood ratio) was used to discriminate risk factors of 30-day mortality. The Kaplan-Meier survival estimate was used to analyze overall survival. Odds ratios with 95% confidence intervals were constructed.

Results

A total of 89 patients undergoing emergency CABG were included in the analysis. Nine patients (10.11%) died during the in-hospital stay period. The mean age of the cohort was 66.4±9.28 years. The mean weight, height, and body mass index were 54.35 kg (±9.17, range 37-77), 158.96 cm (±7.64, range 145-179), and 21.48 kg/m^2 (±3.08).

Table 1 showed that there were no differences between the two groups in terms of age, gender, comorbidities, complexity of coronary artery disease as well as level of troponin T and CKMB. However, the non-survival group had a higher EuroSCORE II score, and a higher level of N-terminal pro–B-type natriuretic peptide, while the left ventricular ejection fraction and creatinin clearance were significantly lower than the survival group.

Table 2 showed that there were no differences between the two groups in terms of grafts used, number of bypasses, cross-clamp time, and length of postoperative stay. However, the non-survival group had a longer cardiopulmonary bypass time and intubation time.

In the postoperative period, there were many events occurring in both groups but the frequencies of each event were small (Table 3). The patients in the non-survival group were prone to having more severe events.

Patients that died significantly more often were male, had a short period from onset of symptom to surgery, low left ventricular ejection fraction (LVEF), preoperative mitral valve regurgitation, elevation preoperative CKMB, elevated EuroSCORE II value, postoperative respiratory infection and renal insufficiency in cardiogenic shock or were in need of IABP support preoperatively. These factors were used for a multivariable regression model. The EuroSCORE II was the only independent predictor of in-hospital mortality (Table 4).

The mean follow-up time of these patients was 28.2±12.2 months (Figure 1). There were three patients who died in follow-up time: two patients died because of stroke in the 4th and 7th month after discharge, and one patient had a recurrent myocardial infarction and died in the 16th month after discharge. Survival rates at 1 year and 2 years were 97.5% and 96.02%, respectively.

There were two patients who had recurrent myocardial infarction (2.5%): one patient mentioned above, and one had nonfatal recurrent myocardial infarction in the 48th month.

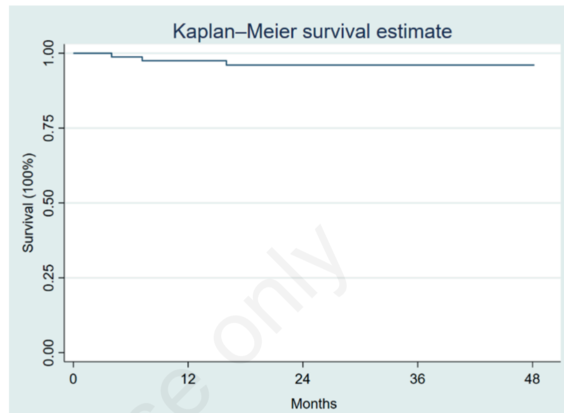

Figure 1. Kaplan-Meier estimate of survival after emergency coronary artery bypass grafting.

Table 1. Difference in preoperative data among the in-hospital mortality patient group and the in-hospital survival patient group

Preoperative variables	All patients (n=89)	In-hospital mortality No (n=80)	Yes (n=9)	p
	Count (% of total) or mean (SD)			
Female	28 (31.5)	26 (32.5)	2 (22.2)	0.416^F
Age (years)	66.4 (9.7)	65.88 (9.7)	71.1 (7.9)	0.143^M
Diabetes	33 (37.1)	27 (36)	5 (55.6)	0.372
Hypertension	66 (74.2)	55 (73.3)	7 (77.8)	0.915
Hyperlipidemia	29 (32.6)	25 (33.3)	4 (44.4)	0.222
Smoking	38 (42.7)	33 (41.3)	5 (55.5)	0.639
Creatinine clearance (mL/min)	62.2 (25,7)	64.3 (24.6)	43.5 (29.0)	0.018^M
Platelet inhibitors use				
Aspirin	89 (100.0)	80 (100.0)	9 (100.0)	
Clopidogrel	48(53.9)	43 (53.8)	5 (55.6)	0.918
Ticagrelor	38 (42.7)	35 (43.8)	3 (33.3)	0.549
Critical preoperative state	24 (26.9)	17 (21.3)	7 (77.8)	0.001^F
Time from the onset of symptom to surgery under 24 hours	48 (53.9)	43 (53.8)	5 (55.6)	0.601^F
EuroSCORE II (%)	10.55 (11.78)	8.17 (8.86)	31.66 (13.95)	0.0003^M
Left main disease	41 (46.1)	36(45.0)	5 (55.6)	0.547
3- vessel disease	80 (89.9)	73(91.2)	7 (77.8)	0.204
LVEF (%)	46.29 (12.2)	47.46 (11.9)	36 (9.9)	<0.001^M
LVEF <30%	8 (8.9)	5 (6.3)	3 (33.3)	0.032^F
Mitral regurgitation over moderate degree	28 (32.6)	22 (28.6)	6 (66.7)	0.030^F
Troponin-T (ng/L)	1307.69 (2019.51)	1246.70 (1872.95)	1822.67 (3098.83)	0.3004^M
CKMB (U/L)	88.70 (104.78)	83.70 (102.85)	128.12 (117.86)	0.1116^M
NT-ProBNP (pg/mL)	4237.60 (8084.70)	2922.68 (5678.26)	14318.67 (15026.85)	<0.001^M

^{M}Mann- Whitney's test; ^{F}Fisher exact tes; SD, standard deviation; EuroSCORE, European System for Cardiac Operative Risk Evaluation; LVEF, left ventricular ejection fraction; CKMB, creatinine kinase-myoglobin; NT-ProBNP, N-terminal pro–B-type natriuretic peptide.

Table 2. Difference in perioperative data among the in-hospital mortality patient group and the in-hospital survival patient group.

Preoperative variables	All patients (n=89)	In-hospital mortality No (n=80)	In-hospital mortality Yes (n=9)	p
		Count (% of total) or mean (SD)		
Grafts use				
LIMA	83 (93.3)	74 (92.5)	9 (100.0)	0.517[F]
RIMA	2 (2.3)	2 (2.5)	0 (0.00)	0.807[F]
Radial artery	8 (9.0)	8 (10.0)	0 (0.00)	0.410[F]
Saphenous vein	85 (95.5)	76 (95.0)	9 (100.0)	0.648[F]
Number of bypass	3.39 (0.6)	3.41 (0.7)	3.22 (0.4)	0.3288[M]
Mitral plasty	6 (6.74)	4 (5.0)	2 (22.2)	
Cross-clamp time (minute)	64.17 (21.09)	64.02 (21.16)	65.44 (21.70)	0.6979[M]
CPB time (minute)	94.37 (31.35)	91.11 (27.77)	122.22 (46.25)	0.0877[M]
Intubation time (hour)	52.22 (76.80)	39.62 (44.13)	216 (182.38)	<0.001[M]
Length of postoperative stay (day)	12.39 (5.77)	12.50 (5.89)	7.66 (4.04)	0.1873[M]

[M]Mann- Whitney's test; [F]Fisher exact test; SD, standard deviation; LIMA, left internal mammary artery; RIMA, right internal mammary artery; CPB, cardiopulmonary bypass.

Table 3. Difference in postoperative data among the in-hospital mortality patient group and the in-hospital survival patient group.

Preoperative variables	All patients (n=89)	In-hospital mortality No (n=80)	In-hospital mortality Yes (n=9)	p
		Count (% of total) or mean (SD)		
IABP	7 (7.9)	3 (3.8)	4 (44.4)	<0.001
ECMO	1 (1.1)	0	1 (11.1)	0.003
Reoperation for bleeding	3 (3.4)	2 (2.5)	1 (11.1)	0.309
Ventricular fibrillation	3 (3.4)	1 (1.2)	2 (22.2)	0.001
Respiratory infection	25 (28.1)	21 (26.2)	4 (44.4)	0.250
Sepsis	4 (4.5)	2 (2.5)	2 (22.2)	0.007
Stroke	7 (7.9)	5 (6.2)	2 (22.2)	0.076
Renal failure	10 (11.2)	6 (7.5)	4 (44.4)	0.001
Lower limb ischemia	4 (4.5)	0	4 (44.4)	<0.001F
Mesenteric ischemia	1 (1.1)	0	1 (11.1)	0.003

[F]Fisher exact test; IABP, intra-aortic balloon pulsation; ECMO, extracorporeal membrane oxygenation; SD, standard deviation.

Table 4. Risk factors of in-hospital mortality in regression analysis.

Factors	OR	95% CI	p
Female	0.27	0.02-3.81	0.337
Time from on set of symptom to surgery	0.73	0.06-9.02	0.809
LVEF<30%	3.41	0.23-49.3	0.368
Preoperative mitral valve regurgitation	1.23	0.07-20.3	0.884
EuroSCORE II	1.13	1.01-1.26	0.026
Preoperative CKMB	1.00	0.99-1.01	0.204
Postoperative Respiratory infection	1.27	0.14-11.2	0.829
Postoperative renal insufficence	3.35	0.29-38.1	0.330

LVEF, left ventricular ejection fraction; EuroSCORE, European System for Cardiac Operative Risk Evaluation; CKMB, creatinine kinase-myoglobin; OR, odds ratio; CI confidence interval.

Discussion

Our study was the largest series of emergency CABG in Vietnam with an in-hospital mortality of 10.11%. This rate was high when compared to similar studies in the developed countries.

Depending on each report and selection of patients, the mortality rate varies widely, ranging from 3-13%.[10,12,13]

There were two reports with similar topics from major centers in Europe, both published in 2015. Axelsson *et al.*, including patients from four surgical centers in Northern Europe, undergoing emergency or "salvage" CABG according to the EuroSCORE II classification, showed that the mortality rate in the emergency group was 13%.[10] This rate was higher than that in our study. There were some reasons for the patient selection: 38% of patients had STEMI, 33% of patients underwent emergency CABG after failed intervention and 7% suffered serious complications during the intervention. However, when using the EuroSCORE II to predict in-hospital mortality, the average score in Axelsson *et al.*'s emergency CABG group was only 4.28%. The author supposed that the EuroSCORE II score seemed to underestimate their operative risk in the emergency CABG group.[10]

In the same year, Biancari *et al.* also published a report from four large centers in Italy and Finland, using criteria for emergency surgery according to EuroSCORE II on patients with acute coronary syndrome (from unstable chest pain to STEMI). The in-hospital mortality in that study was 10.1%, which is similar to ours. However, the EuroSCORE II score in this study was 16.3% and the authors believed that EuroSCORE II overestimated the operative risk in their patients.[11]

A recent study carried out in the period 2017-2019, including 71 cases of emergency CABG at Hanoi Heart Hospital (all types of myocardial infarction), reported an in-hospital mortality rate of 9.9% and a mean EuroSCORE II of 14.69% that seemed to overestimate the operative risk in the patients.[14] In the present cohort, the in-hospital mortality was 10.11%, and the mean EuroSCORE II was 10.55%, which showed a suitable preoperative risk prediction.

To reduce mortality and early postoperative complications in high-risk patients, many authors tended to perform off-pump coronary artery bypass (OPCAB). Ito *et al.* published a report in 2016 about this issue. Their patients underwent emergency CABG for AMI requiring preoperative IABP; they reported the following: an average EuroSCORE score of 10.2%, the number of bypasses was 2.6, the complete revascularization rate was 71.3%, and the in-hospital mortality was very low of 2.6%. However, regarding OPCAB, it was still controversial and depended on the habits of each center and surgeon.[12]

There are several reasons for the high in-hospital mortality rate in our study. Table 1 showed that 29.97% of patients had preoperative hemodynamic instability, more than half of the patients had surgery within the first day from the symptom's onset, nearly one-third of patients had severe mitral valve regurgitation, and the mean of EuroSCORE II was high. Ischemic mitral regurgitation accounted for approximately one-fifth of AMI patients and half of patients with congestive heart failure.[16] It was a common complication of coronary artery disease and had a worse prognosis.[17] In reports on the same topic, the authors often excluded patients having ischemic mitral valve regurgitation, but we still recruited these patients. Although that increased operative time and mortality, it represented a fairly common feature in patients with AMI. Ischemic mitral valve regurgitation was associated with high mortality with statistical significance in univariate regression (Table 1). Regarding mitral valve surgery in patients with moderate to severe regurgitation, there was still controversy: repair, replacement, or just isolated coronary artery bypass?[18-20] Only 6 out of 28 patients with moderate to severe mitral valve regurgitation in our study had the mitral valve repaired by narrowing the valve annulus; no cases underwent mitral valve replacement.

Despite the emergency situation, we still used the internal thoracic artery in 93.26% of patients and the mean number of bypasses was 3.4. Using conventional CABG with cardiopulmonary bypass and cardiac arrest in the context of AMI was also a factor in increasing mortality and early postoperative complications.

In the study by Axelsson *et al.*, age, extracardiac arteriopathy, poor LVEF (<30%), and preoperative use of inotropic agents and IABP were found to be independent risk factors for in-hospital death.[10] Biancari *et al.* showed that increasing emergency, recent myocardial infarction, LVEF<30%, and on-pump surgery according to the intention-to-treat principle were independent predictors of in-hospital mortality.[11] In our study, univariate analysis showed several variables associated with in-hospital mortality (Tables 1-3). However, in logistic regression, there was only EuroSCORE II as an independent predictor of in-hospital mortality (Table 4). The use of more variables in a model affords higher discrimination but also requires a larger sample to avoid overfitting, which means the model will not be reproducible. Multiple logistic regression analysis requires the absolute value of the lowest outcome variable (*i.e.*, death or survival), to be at least 10 times the number of explanatory variables.[21] We supposed that the sample size in the present study was small, so it was difficult to identify the independent predictors.

Although the early mortality was high, the late outcome was satisfactory, with survival rates at 1 year and 2 years of 97.5% and 96.02%, respectively. Moreover, the rate of free of recurrent myocardial infarction was 2.5%. The survival rates in the present study were higher in the previous studies.[10,11] However, data on their quality of life after surgery is not available, and this prevents conclusive results on the real benefits of compassionate surgery in these critically ill patients.

A number of limitations should be acknowledged. First, like most similar reports, our study was based on the retrospective evaluation of patient charts and single-center results. Second, the study had a relatively small sample size of patients and some parameters still could not be adequately measured. Third, the follow-up time was not enough long to determine the relation between certain factors with long long-term outcomes.

Conclusions

Emergency coronary bypass surgery in patients with NSTEMI had poor early but good midterm outcomes. High EuroSCORE II scores were predictors of in-hospital mortality.

References

1. Anderson JL, Morrow DA. Acute myocardial infarction. N Engl J Med 2017;376:2053-64.
2. Singh M, Rihal CS, Gersh BJ, et al. Twenty-five-year trends in in-hospital and long-term outcome after percutaneous coronary intervention : a single-institution experience. Circulation 2007;115:2835-41.
3. Patlolla SH, Kanwar A, Cheungpasitporn W, et al. Temporal trends, clinical characteristics, and outcomes of emergent coronary artery bypass grafting for acute myocardial infarction in the United States. J Am Heart Assoc 2021;10:e020517.
4. Ibanez B, James S, Agewall S, et al. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the task force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the

European Society of Cardiology (ESC). Eur Heart J 2018;39:119-77.
5. Collet JP, Thiele H, Barbato E, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J 2021;42:1289-367.
6. Fox KAA, Clayton TC, Damman P, et al. Long-term outcome of a routine versus selective invasive strategy in patients with non-ST-segment elevation acute coronary syndrome a meta-analysis of individual patient data. J Am Coll Cardiol 2010;55:2435-45.
7. Authors/Task Force members, Windecker S, Kolh P, et al. 2014 ESC/EACTS guidelines on myocardial revascularization: the task force on myocardial revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). Eur Heart J 2014;35:2541-619.
8. Lawton JS, Tamis-Holland JE, Bangalore S, et al. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2022;145:e4-17.
9. Rastan AJ. Emergency coronary artery bypass graft surgery for acute coronary syndrome: beating heart versus conventional cardioplegic cardiac arrest strategies. Circulation 2006;114:I477-85.
10. Axelsson TA, Mennander A, Malmberg M, et al. Is emergency and salvage coronary artery bypass grafting justified? The Nordic Emergency/Salvage coronary artery bypass grafting study. Eur J Cardiothorac Surg 2016;49:1451-6.
11. Biancari F, Onorati F, Rubino AS, et al. Outcome of emergency coronary artery bypass grafting. J Cardiothorac Vasc Anesth 2015;29:275-82.
12. Ito H, Mizumoto T, Tempaku H, et al. Emergency off-pump coronary artery bypass graft surgery for patients on preoperative intraaortic balloon pump. Ann Thorac Surg 2016;102:821-8.
13. Rojas SV, Trinh-Adams ML, Uribarri A, et al. Early surgical myocardial revascularization in non-ST-segment elevation acute coronary syndrome. J Thorac Dis 2019;11:4444-52.
14. Hung DQ, Minh NT, Vo HL, et al. Impact of pre-, intra- and post-operative parameters on in-hospital mortality in patients undergoing emergency coronary artery bypass grafting: a scarce single-center experience in resource-scare setting. Vasc Health Risk Manag 2021;17:211-26.
15. Nashef SAM, Roques F, Sharples LD, et al. EuroSCORE II. Eur J CardioThoracic Surg 2012;41:734-45.
16. Chaput M, Handschumacher MD, Tournoux F, et al. Mitral leaflet adaptation to ventricular remodeling: occurrence and adequacy in patients with functional mitral regurgitation. Circulation 2008;118:845-52.0
17. Bursi F, Enriquez-Sarano M, Nkomo VT, et al. Heart failure and death after myocardial infarction in the community: the emerging role of mitral regurgitation. Circulation 2005;111:295-301.
18. Piérard LA, Carabello BA. Ischaemic mitral regurgitation: pathophysiology, outcomes and the conundrum of treatment. Eur Heart J 2010;31:2996-3005.
19. Nonaka DF, Fox AA. Ischemic mitral regurgitation: repair, replacement or nothing. Semin Cardiothorac Vasc Anesth 2019;23:11-9.
20. Malhotra AK, Evans AS, Weiner MM, Ramakrishna H. Ischemic mitral regurgitation: a paradigm shift in surgical management? J Cardiothorac Vasc Anesth 2018;32:580-5.
21. Caceres M, Weiman DS. Optimal timing of coronary artery bypass grafting in acute myocardial infarction. Ann Thorac Surg 2013;95:365-72.