Incidence, Predictors, and Outcomes of Early Acute Myocardial Infarction Following Coronary Artery Bypass Grafting

Mohamad Alkhouli, MD[a,b,*], Fahad Alqahtani, MD[a], Mohammed Alreshidan, MD[c], and Chris C. Cook, MD[c]

Large-scale data on early postdischarge acute myocardial infarction (AMI) after coronary artery bypass grafting (CABG) are lacking. We queried the National Readmission Database (2015 to 2016) to identify patients who underwent CABG between January 1 and June 31 (i.e., had 6 months of follow-up). The study's end points were the incidence, predictors, and outcomes of early post-CABG AMI. Of the 203,760 included patients, 3,829 (1.8%) were readmitted for AMI. Compared with patients without readmissions for AMI, those with AMI were younger (65 ± 11 vs 66 ± 10 years), had more females (35.5% vs 25.1%), and higher prevalence of hypertension, diabetes, obstructive lung disease, anemia, vascular disease, renal insufficiency, and liver cirrhosis, but less atrial fibrillation (p <0.001). They also had a distinctive profile of their index CABG surgery. The strongest predictors of post-CABG AMI readmission were female gender (odds ratio [OR] 1.46, 95% confidence interval [CI] = 1.36 to 1.57), heart failure (OR 1.37, 95% CI = 1.27 to 1.50), dialysis (OR 1.5%, 95% CI = 1.25 to 1.78), cirrhosis (OR 1.61, 95% CI = 1.14 to 2.27), nonelective CABG (OR 1.70, 95% CI = 1.57 to 1.84), perioperative mechanical circulatory support (OR 1.37, 95% CI = 1.23 to 1.51), low-volume centers (OR 1.36, 95% CI = 1.18 to 1.56), and nonhome discharge after CABG (OR 1.47, 95% CI = 1.35 to 1.59). In the patients who were readmitted for AMI, 86.3% had non-ST-elevation AMI and 13.7% had ST-elevation AMI. Coronary angiography was performed in 2,096 patients (54.7%). Of those, 63.5% received percutaneous coronary intervention, and 1.7% had redo-CABG. Readmissions for AMI were associated with significant in-hospital mortality (5.7%), acute kidney injury (22.1%), and new dialysis (2.1%). Median length-of-stay was 3 days (25th/75th percentile 2,6), and the mean hospital cost was $22,207 ± 29,071. **(Am J Cardiol 2019;124:1027−1030)**

Coronary artery bypass grafting (CABG) is the gold standard revascularization strategy in selected patients with multivessel coronary artery disease, diabetes, or left ventricular dysfunction.[1] The impact of perioperative acute myocardial infarction[2] after CABG has been well documented.[3−5] However, nationwide data on post-CABG acute myocardial infarction (AMI) beyond hospital discharge are lacking. We sought to assess the incidence, predictors, and outcomes of AMI within 6-month after CABG using a national representative database.

Methods

The National Readmission Database (NRD) was used to derive patient-relevant information between January 1, 2015 and December 31, 2016. The NRD is a publicly available database of all-payer inpatient stays that includes data from 21 geographically dispersed states that account for ~60% of all hospitalizations in the United States. The NRD also contains verified patient linkage numbers that can be used to track readmissions across hospitals for individual patients. National estimates of the entire US hospitalized population were calculated using the Agency for Healthcare Research and Quality sampling and weighting method.

Patients who underwent CABG were identified using the International Classification of Diseases-Ninth and Tenth Revision-Clinical Modification procedural codes (Online Table 1). We excluded patients who died during the hospitalization. To include patients who consistently had 6 months of follow-up, we included patients who underwent CABG between January 1 and June 30 in each of the study years. We then combined these 2 years together arriving at the final study cohorts of patients who underwent CABG between January 1 and June 30 in 2015 and 2016.

Our study has the following end points: (1) Incidence of early AMI (within 6 months) after CABG, (2) predictors of early admission for AMI after CABG, and (3) outcomes of early post-CABG AMI. The readmission was considered readmission for AMI if the principle discharge diagnosis was one of the AMI codes outline in Online Table 1.

Descriptive statistics were presented as frequencies with percentages for categorical variables. Mean, standard deviation, median, and interquartile ranges were reported for

[a]Division of Cardiology, Department of Medicine, West Virginia University, Morgantown, West Virginia; [b]Department of Cardiology, Mayo Clinic, Rochester, Minnesota; and [c]Department of Cardiothoracic Surgery, West Virginia University, Morgantown, West Virginia. Manuscript received May 11, 2019; revised manuscript received and accepted June 19, 2019.

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*Corresponding author: Tel: (304) 598-4687; fax: (304) 599-0860.
E-mail address: Mohamad.Alkhouli@wvumedicine.org (M. Alkhouli).

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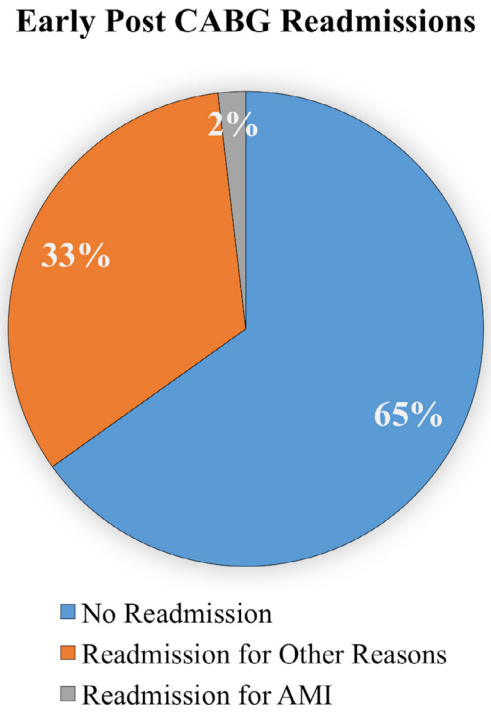
continuous measurements. Baseline characteristics between patients with or without readmission for AMI after CABG were compared using a Pearson chi-squared test and Fisher's exact test for categorical variables and an independent samples *t* test for continuous variables. A type I error rate of <0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 24 (IBM Corporation, Armonk, New York).

Results

A total of 203,760 patients were included in our study. Of whom, 3,829 (1.8%) were readmitted for AMI, and 67,205 (33%) were readmitted for other reasons within 6 months (Figure 1). In patients readmitted for AMI, 8.5% of readmissions occurred within 3 days after discharge and >50% occurred within 60 days after discharge (Online Table 2, Online Figure 1). The median time from index CABG to AMI readmission was 54 days (25th, 75th percentile 14,107). Compared with patients without readmissions for AMI, those with AMI within 6 months were younger (65 ± 11 vs 66 ± 10 years), had more females (35.5% vs 25.1%), and higher prevalence of hypertension, diabetes, obstructive lung disease, anemia, vascular disease, renal insufficiency, liver cirrhosis, conduction disorders, but less atrial fibrillation (p <0.001). They also had a distinctive profile of their index CABG surgery characterized by higher incidences of nonelective and off-pump CABG, concomitant valve repair/replacement, nonarterial revascularization, perioperative circulatory support devices use, perioperative complications, and prolonged hospitalizations (Table 1).



Figuer 1. Six months readmission rates after coronary artery bypass grafting. AMI = acute myocardial infarction; CABG = coronary bypass grafting; PCI = percutaneous coronary intervention; STEMI = ST-elevation myocardial infarction.

Table 1
Baseline characteristics of the study population

Baseline characteristics	Readmissions for AMI		p Value
	No (n = 200,241)	Yes (n = 3,591)	
Age (mean ± SD)	66±10	65±11	<0.001
Women	25.1%	35.5%	<0.001
Hypertension	84.0%	86.9%	<0.001
Diabetes mellitus	49.7%	57.2%	<0.001
Obstructive lung disease	20.4%	26.0%	<0.001
Atrial fibrillation	35.1%	31.5%	<0.001
Anemia	17.7%	25.4%	<0.001
Conduction abnormalities	4.8%	6.6%	0.09
Peripheral vascular disease	15.0%	20.5%	<0.001
Renal insufficiency	18.4%	26.8%	<0.001
Chronic dialysis	2.0%	5.1%	<0.001
Liver cirrhosis	0.5%	1.0%	
Cardiogenic shock	5.3%	8.3%	<0.001
Congestive heart failure	13.0%	21.8%	<0.001
Nonelective CABG	49.5%	68.2%	<0.001
Isolated CABG	86.9%	83.9%	<0.001
Off-pump CABG	18.5%	21.4%	<0.001
Nonarterial revascularization	22.1%	25.3%	<0.001
Perioperative MCS	7.9%	13.5%	<0.001
Teaching hospital	76.4%	78.5%	<0.001
High surgical centers (>300/year)	72.0%	68.8%	<0.001
Postoperative stroke	1.7%	2.0%	0.09
Postoperative kidney injury	18.5%	26.1%	<0.001
Vascular complications	3.4%	2.9%	<0.001
Blood transfusion	22.0%	23.4%	<0.001
Pacemaker implantation	3.7%	6.4%	<0.001
Non-home discharge	19.9%	30.0%	<0.001
Median LOS (25th, 75th percentile)	8 (6,12)	10 (7,14)	<0.001

AMI = acute myocardial infarction; CABG = coronary artery bypass grafting; LOS = length of stay; MCS = mechanical circulatory support; SD = standard deviation.

In a multivariate logistic regression analysis, the strongest predictors of readmission for AMI after CABG were female gender (odds ratio [OR] 1.46, 95% confidence interval [CI] 1.36 to 1.57), congestive heart failure (OR 1.37, 95% CI 1.27 to 1.50), chronic dialysis (OR 1.5%, 95% CI 1.25 to 1.78), liver cirrhosis (OR 1.61, 95% CI 1.14 to 2.27), nonelective CABG (OR 1.70, 95% CI 1.57 to 1.84), perioperative mechanical circulatory support (OR 1.37, 95% CI 1.23 to 1.51), surgery at low-volume centers (OR 1.36, 95% CI 1.18 to 1.56), and discharge to an intermediate care facility after CABG (OR 1.47, 95% CI 1.35 to 1.59). Other significant independent predictors are shown in Table 2.

In the patients who were readmitted for AMI (n = 3,829), 3,304 (86.3%) had non-ST-elevation AMI and 526 (13.7%) had ST-elevation AMI (Figure 2). Cardiogenic shock was uncommon (4.2%). Coronary angiography was performed in 2,096 (54.7%), whereas the reminders were managed medically (Table 3). Of the 2,096 patients who underwent angiography, 1,332 (63.5%) received percutaneous coronary intervention, and 36 (1.7%) underwent redo-CABG. Readmissions for AMI were associated with significant in-hospital mortality (5.7%), acute kidney injury (22.1%), and new dialysis (2.1%). Median length-of-stay was 3 days

Table 2
Predictors of early (≤6 months) readmission for acute myocardial infarction after coronary artery bypass surgery

Predictors	Univariate regression			Multivariate regression		
	OR	95% CI	p Value	OR	95% CI	p Value
Baseline characteristics						
Age	0.99	0.98-0.99	<0.001	0.99	0.98-0.99	<0.001
Female sex	1.46	1.36-1.57	<0.001	1.46	1.36-1.57	<0.001
Hypertension	1.24	1.12-1.37	<0.001	1.24	1.12-1.37	<0.001
Diabetes	1.12	1.04-1.20	0.002	1.12	1.04-1.20	0.002
Obstructive lung disease	1.19	1.10-1.29	<0.001	1.19	1.10-1.29	<0.001
Atrial fibrillation	0.83	0.77-0.89	<0.001	0.83	0.77-0.89	<0.001
Congestive heart failure	1.37	1.26-1.50	<0.001	1.38	1.27-1.50	<0.001
Anemia	1.18	1.09-1.29	<0.001	1.18	1.09-1.28	<0.001
Conduction disorder	1.33	1.16-1.52	<0.001	1.33	1.16-1.53	<0.001
Peripheral vascular disease	1.32	1.21-1.43	<0.001	1.32	1.21-1.43	<0.001
Chronic renal insufficiency	1.16	1.06-1.28	0.002	1.16	1.06-1.28	0.002
Dialysis	1.41	1.16-1.71	0.001	1.50	1.25-1.78	<0.001
Liver cirrhosis	1.60	1.14-2.27	0.007	1.61	1.14-2.27	0.007
CABG characteristics						
Nonelective admission	1.70	1.57-1.83	<0.001	1.70	1.57-1.84	<0.001
Isolated CABG	1.22	1.10-1.36	<0.001	1.23	1.11-1.37	<0.001
Nonarterial revascularization	1.21	1.12-1.31	<0.001	1.21	1.12-1.31	<0.001
Off-pump CABG	1.06	0.98-1.16	0.153			
Perioperative MCS	1.36	1.23-1.50	<0.001	1.37	1.23-1.51	<0.001
Low volume center	1.35	1.18-1.55	<0.001	1.36	1.18-1.56	<0.001
Intermediate volume center	1.10	1.02-1.20	0.017	1.11	1.02-1.20	0.015
CABG outcomes						
Stroke	0.82	0.65-1.04	0.11			
Acute kidney injury	1.12	1.02-1.22	0.01	1.12	1.03-1.23	0.01
Permanent pacemaker	1.12	0.95-1.31	0.17			
Blood transfusion	0.91	0.84-0.99	0.026	0.91	0.84-0.99	0.02
Vascular complications	1.09	0.90-1.32	0.37			
Nonhome discharge	1.47	1.35-1.59	<0.001	1.47	1.35-1.59	<0.001
Prolonged hospitalization (>10 days)	1.22	1.12-1.32	<0.001	1.22	1.13-1.32	<0.001

CABG = coronary artery bypass grafting; CI = confidence interval; OR = odds ratio.

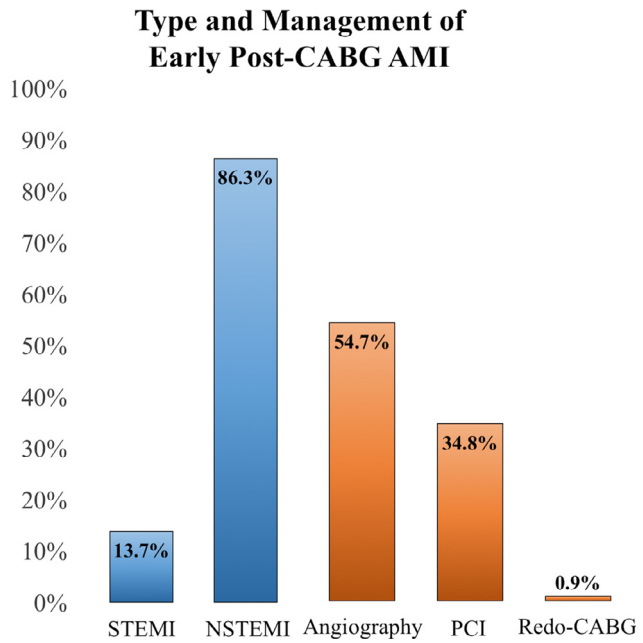


Figure 2. Clinical presentation and management of early acute myocardial infarction following coronary artery bypass grafting. AMI = acute myocardial infarction; CABG = coronary bypass grafting; PCI = percutaneous coronary intervention; STEMI = ST-elevation myocardial infarction.

Table 3
Characteristics and outcomes of early (≤6 months) post-CABG acute myocardial infarction

Characteristics of early post-CABG AMI	
Time from CABG to AMI readmission (days) median (25th, 75th percentile)	54 (14, 107)
Type of AMI	
STEMI	13.7%
NSTEMI	86.3%
Cardiogenic shock	4.2%
Management of AMI	54.7%
Angiography	54.7%
PCI	34.8%
Redo-CABG	0.9%
Use of mechanical circulatory support	2.4%
In-hospital outcomes of early post-CABG AMI	
Death	5.7%
Acute kidney injury	22.1%
Acute kidney injury requiring dialysis	2.1%
Nonhome discharge	16.2%
LOS-median (25/75 percentile)	3 (2, 6)
Total hospital cost − $ (mean ± SD)	$22,207 ± 29,071

AMI = acute myocardial infarction; CABG = coronary artery bypass grafting; LOS = length of stay; NSTEMI = non-ST-elevation myocardial infarction; PCI = percutaneous coronary intervention; SD = standard deviation; STEMI = ST-elevation myocardial infarction; $ = US dollar.

(25th/75th percentile 2,6) and the mean hospital cost was $22,207 ± 29,071.

Discussion

Our analysis showed that early (≤6 month) AMI after CABG is rare (<2%). Albeit reassuring, it should be noted that the overall rate of early post-CABG coronary complications is likely higher because our study only included patients who suffered AMI beyond discharge. Patients who suffered a perioperative AMI, and those were stented for stable or unstable angina, or had asymptomatic graft failure were not included in this study. The latter factor is particularly important, as the majority of early graft failures are not symptomatic. In the project of PREVENT-IV trial, 42.8% of patients had graft failure at 12 to 18 months, but only 7.1% of graft failures were seen during angiographic examinations performed for clinical indications.[6]

Our analysis identified a few potentially modifiable predictors of early post-CABG AMI including nonarterial revascularization (vein graft CABG only), and low-intermediate surgical volume. The other predictors of early post-CABG AMI show in this study (e.g., chronic dialysis, discharge to an intermediate care facility, etc.), although nonmodifiable, may serve to discern high-risk patients who may benefit from closure monitoring and/or aggressive risk factor modification.

This study also documents the presentation and management patterns of patients with AMI within 6 months after CABG. Only half of patients with AMI underwent angiography. Although reasons for this could not be identified due to the administrative nature of the NRD, it is possible that some patients might have had non-ST-elevation AMI in the setting of heart failure or other acute illnesses (type II-MI), or had contraindication to angiography. Nonetheless, majority of patients who underwent angiography had a revascularization procedure (percutaneous coronary intervention > redo CABG).

Our analysis also showed that despite their rarity, readmissions for AMI within 6-month CABG are associated with significant morbidity and mortality. The 5.7% mortality associated with early post-CABG AMI is higher than the operative mortality of CABG in contemporary practice even in higher risk patients.[2] Further studies are needed to identify effective strategies to minimize the incidence of early post-CABG AMI and to optimize its outcomes.

Our study is hampered by the possibility of under or over coding, lack of laboratory or imaging data, and lack of granular information about the rational for invasive versus conservative management of post-CABG AMI. Nonetheless, this analysis is the largest contemporary nationwide analysis documenting very low rates of early post-CABG AMI, and identifying its predictors.

Disclosures

The authors have no conflicts of interest to disclose.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2019.06.023.

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