



Effects of previous coronary artery bypass graft surgery on in-hospital mortality in ST-segment elevation myocardial infarction: National dataset analysis

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ABSTRACT

Background: Association of history of coronary artery bypass graft surgery (CABG) with clinical outcomes in patients presenting with ST-segment elevation myocardial infarction (STEMI) is unclear from current data.

Methods: Using Nationwide Inpatient Sample (NIS) data from 2003 to 2014, adult patients hospitalized with principal diagnosis of STEMI were extracted. The cohort was divided into patients with a history of CABG and those without a history of CABG. The primary outcome measure was in-hospital mortality (IHM).

Results: 2,710,375 STEMI patients were included in final analysis of which 110,066 had history of CABG. Patients with history of CABG had higher unadjusted (12.2% vs. 8.8%, $P < 0.001$) and adjusted (odds ratio [OR] 1.16; 95% confidence interval [CI] 1.14 to 1.19, $P < 0.001$) IHM compared to those without previous CABG. Compared to a trend of decreasing IHM in STEMI patients without previous CABG, a trend of increasing IHM was observed over the study period in those with a history of previous CABG. Although patients with previous CABG when treated with primary PCI (PPCI) had a higher unadjusted IHM compared to those without previous CABG, (4.8% vs 4.3%, $P < 0.001$), after adjusting for comorbidities and in-hospital complications no significant increase in IHM was observed in patients with previous CABG treated with PPCI.

Conclusion: STEMI patients with previous CABG have a significantly higher IHM compared to those without previous CABG. PPCI improves IHM with no independent mortality disadvantage attributable to previous CABG.

1. Introduction

Timely acute reperfusion therapy is the cornerstone of treatment of patients presenting with acute ST-segment elevation myocardial infarction (STEMI), with an unequivocal recommendation favoring the use of primary percutaneous coronary intervention (PPCI) [1]. The complexity of patients presenting to the interventional cardiovascular catheterization laboratory has been increasing over the past several decades. Patients with previous coronary artery bypass graft surgery (CABG) present a particularly challenging interventional subset, with known outcome disadvantage in the overall PCI cohort [2]. Analyses of in-hospital outcomes of patients with previous CABG presenting with STEMI has revealed conflicting results. Several observational datasets as well as post-hoc analyses of randomized controlled trials have showed no difference in short-term outcomes between patients with previous

CABG compared to without [3,4], whereas others have indicated higher mortality in this cohort [5,6].

We sought to analyze the trends of prevalence of previous CABG in the STEMI cohort from a non-participation based national database and analyzed the differences in in-hospital mortality (IHM) between patients presenting with STEMI with a history of CABG with those without a history of CABG.

2. Methods

2.1. Source of data

The National Inpatient Sample (NIS) is the largest readily available all-payer inpatient database maintained by the Agency for Healthcare Research and Quality Healthcare and Cost and Utilization Project. NIS

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discharges represent a stratified sample from all discharges in the United States from non-federal and community hospitals. The data includes demographic information, diagnoses and procedures in the form of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and Clinical Classification Software (CCS) codes. The NIS has adapted discharge weights to delineate regional and national estimates.

2.2. Study population

From January 2003 to December 2014, hospitalizations with primary diagnosis of STEMI in patients ≥ 18 years of age were extracted by using the ICD-9-CM codes for STEMI (410.0x, 410.1x, 410.2x, 410.3x, 410.4x, 410.5x, 410.6x, and 410.8x). Patients with prior history of CABG were identified using the ICD-9-CM code V45.81. Patients with missing data were excluded from final analysis. Fig. 1 demonstrates data extraction and patient selection methods.

Patient related comorbidities and procedural characteristics were extracted by using ICD-9-CM codes mentioned in the Supplementary Table 1. Charlson score was calculated by Elixhauser methods using Agency for Healthcare Research and Quality comorbidity variables. Weighted samples were used for analyses. Primary PCI (PPCI) and vascular complications were defined as described in Supplemental Table 1.

2.3. Statistical methods

We used IBM SPSS Statistics version 27 (IBM Corporation, Armonk, NY). Categorical variables were expressed as proportions, whereas central tendencies of continuous variables were expressed as median and IQR. Categorical variables were analyzed using Pearson Chi-square test and continuous variables were analyzed using Mann-Whitney *U* test. Standardized mean difference was calculated using Cohen's *d* for length

of hospital stay and cost of hospitalization. We compared baseline and hospital characteristics of patients with a history of previous CABG to patients without history of previous CABG. A 2-sided *p* value of <0.05 was considered statistically significant. Binary logistic regression using forward selection was performed to identify independent predictors of in-hospital mortality. Age, gender, cardiogenic shock, cardiac arrest, gastrointestinal bleeding, acute stroke, hypertension, hemodialysis, primary PCI, smoking, and Charlson comorbidity index were entered as independent variables. We used a receiver operating characteristic (ROC) derived area under the curve (AUC) to determine the statistical significance of our model.

3. Results

3.1. Baseline characteristics and in-hospital outcomes of study population

From January 2003 to December 2014, a total of 446,348,443 patients were hospitalized in the United States. A total of 373,129,976 adult patients (age ≥ 18 years) were extracted, of which 2,717,685 patients presented with STEMI as a primary diagnosis. We excluded 7,310 patients with missing data on in-hospital mortality. In the final analysis 2,710,375 patients were included. 110,066 (4.1%) patients had a history of coronary artery bypass graft (CABG) and 2,600,309 (95.9%) patients did not have a history of CABG.

Table 1 shows baseline characteristics of the study population. A significant decrease in the number of discharges of STEMI patients with previous CABG was noted over the study period (4.7% in 2003 vs 3.5% in 2014, *P* for trend < 0.001). IHM trends are shown in Fig. 2. IHM in patients with STEMI without previous CABG showed a decreasing trend over the study period. Contrary to this, an increase in IHM was observed over the same time period in patients with STEMI with previous history of CABG. Trends of comorbidity burden and in-hospital adverse outcomes are shown in Supplementary Figs. 1–4

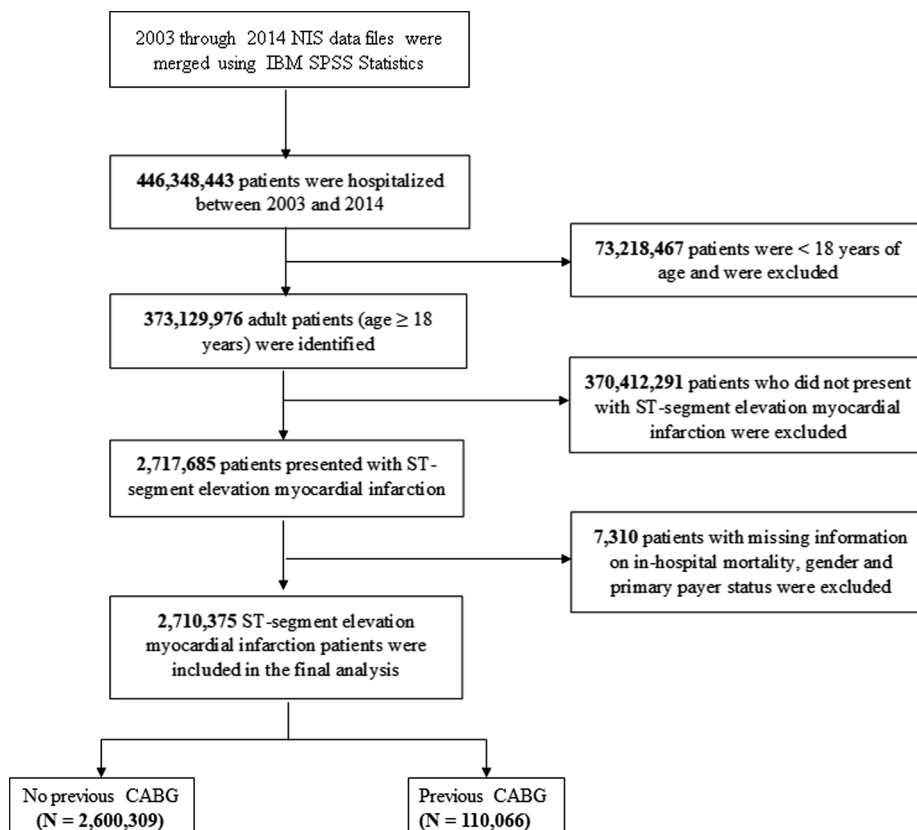


Fig. 1. Study Design. The data extraction process is outlined.

Table 1
Baseline characteristics of study population.

Characteristic	History of previous CABG ^a		P Value
	Yes (n = 110066)	No (n = 2600309)	
Age (Years) (Median/IQR ^b)	72.0 (62.0–80.0)	64.0 (54.0–76.0)	<0.001
Female	31,986 (29.1%)	914,087 (35.2%)	<0.001
Male	78,065 (70.9%)	1,685,751 (64.8%)	<0.001
Race			<0.001
White	73,741 (83.5%)	1,616,398 (78.6%)	
Black	4927 (5.6%)	160,897 (7.8%)	
Hispanic	5457 (6.2%)	150,429 (7.3%)	
Asian or Pacific Islander	1627 (1.8%)	46,107 (2.2%)	
Native American	514 (0.6%)	10,778 (0.5%)	
Other	2088 (2.4%)	70,884 (3.4%)	
Comorbidities			
Prior Stroke	2339 (2.1%)	35,334 (1.4%)	<0.001
Hypertension	76,846 (69.8%)	1,550,826 (59.6%)	<0.001
Diabetes mellitus	43,740 (39.7%)	742,983 (28.6%)	<0.001
Congestive heart failure	37,875 (34.4%)	607,507 (23.4%)	<0.001
Peripheral vascular disease	14,617 (13.3%)	183,251 (7.0%)	<0.001
Chronic kidney disease	14,731 (13.4%)	180,699 (6.9%)	<0.001
Valvular heart disease	1741 (1.6%)	31,831 (1.2%)	<0.001
Long term use of anticoagulation	4655 (4.2%)	46,106 (1.8%)	<0.001
Smoking	30,162 (27.4%)	969,993 (37.3%)	<0.001
Alcoholism	1656 (1.5%)	74,112 (2.9%)	<0.001
Drug abuse	17,615 (16.0%)	753,537 (29.0%)	<0.001
BMI 25–29.9 kg/m ²	168 (0.2%)	7117 (0.3%)	<0.001
BMI 30–39.9 kg/m ²	6033 (5.5%)	190,289 (7.3%)	<0.001
BMI ≥ 40 kg/m ²	1993 (1.8%)	57,992 (2.2%)	<0.001
Uninsured	4009 (3.6%)	216,761 (8.3%)	<0.001
Charlson comorbidity index (median/IQR)	3.0 (2.0–4.0)	2.0 (2.0–3.0)	<0.001

^a CABG = Coronary Artery Bypass Grafting.

^b IQR = Interquartile Range.

Unadjusted in-hospital outcomes are shown in **Table 2**. Anterior wall STEMI, Cardiac arrest and cardiogenic shock were observed significantly less frequently in patients with previous CABG. A non-routine

disposition was more frequently observed in patients with previous CABG compared to those without previous CABG (36% vs 27.4%, $P < 0.001$). Unadjusted IHM was significantly higher in patients with a history of CABG compared to patients without a history of CABG (12.2% vs. 8.8%, $P < 0.001$). Unadjusted length of stay and cost of hospitalization were statistically significantly lower among patients with history of CABG although the difference was not clinically significant (Cohen's d for patients with history of CABG vs. no history of CABG, 0.144 for hospital length of stay and 0.287 for cost of hospitalization.)

3.2. Unadjusted predictors of in-hospital mortality

Patients who died were significantly older (median age 77.0 vs. 63.0, $P < 0.001$). Females had higher in-hospital mortality (48% vs. 33.6%, $P < 0.001$). Diabetes mellitus (30.8% vs. 28.9%, $P < 0.001$), congestive heart failure (43.7% vs. 21.9%, $P < 0.001$), chronic kidney disease

Table 2
In-hospital outcomes of the study population.

Characteristic	History of previous CABG ^a		P value
	Yes (n = 110066)	No (n = 2600309)	
Acute stroke	1553 (1.4%)	41,264 (1.6%)	<0.001
Gastrointestinal bleeding	2700 (2.5%)	63,139 (2.4%)	<0.001
Acute kidney injury	11,314 (10.3%)	241,472 (9.3%)	<0.001
Vascular complications	607 (0.6%)	24,060 (0.9%)	<0.001
Cardiac arrest	8184 (7.4%)	220,332 (8.5%)	<0.001
Cardiogenic shock	7009 (6.4%)	230,573 (8.9%)	<0.001
Pneumonia	6418 (5.8%)	140,513 (5.4%)	<0.001
Length of stay (days) (median/IQR ^b)*	3.0 (2.0–5.0)	3.0 (2.0–5.0)	<0.001
Cost of hospitalization (\$) (median/IQR ^b)†	29,788 (12,778–56469)	47,842 (26,926–78,908)	<0.001
Disposition			<0.001
Routine	56,902 (51.7%)	1,658,578 (63.8%)	
Short term hospital	18,751 (17.0%)	249,868 (9.6%)	
Intermediate care facility	11,349 (10.3%)	247,183 (9.5%)	
Home health care	8442 (7.7%)	194,172 (7.5%)	
Against medical advice	1098 (1.0%)	18,988 (0.7%)	
Destination unknown	55 (0.0%)	1469 (0.1%)	
In-hospital mortality	13,469 (12.2%)	230,051 (8.8%)	<0.001

* Cohen's d = 0.144, 95% CI (0.138–0.150).

† Cohen's d = 0.287, 95% CI (0.280–0.293).

^a CABG = Coronary Artery Bypass Grafting.

^b IQR = Interquartile Range.

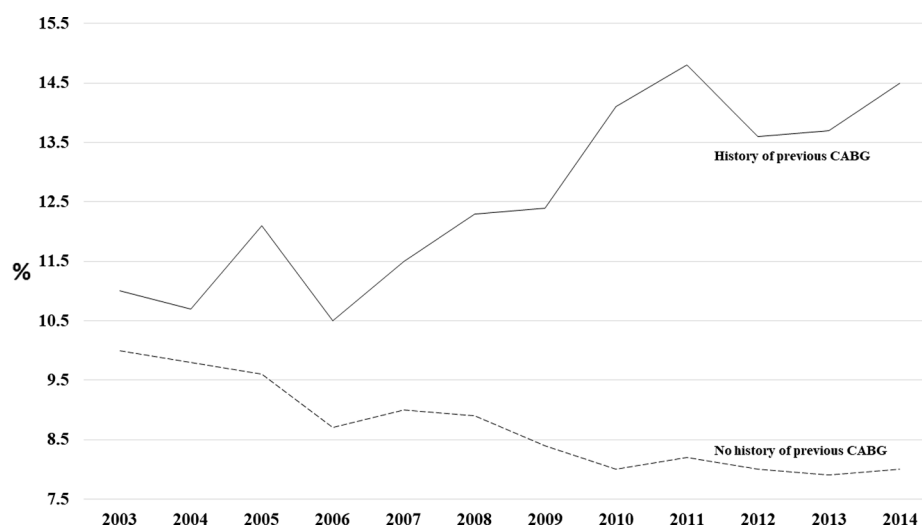


Fig. 2. Trends of In-hospital Mortality in Patients with or without Previous CABG. An increasing trend of in-hospital mortality was noted in patients with previous CABG compared to those without previous CABG showing a decreasing in-hospital mortality trend.

(14.1% vs. 6.5%, $P < 0.001$), prior stroke (2.6% vs. 1.3%, $P < 0.001$), and valvular heart disease (1.8% vs. 1.2%, $P < 0.001$) were associated with higher IHM. Acute stroke (5.4% vs. 1.2%, $P < 0.001$), gastrointestinal bleeding (6.2% vs. 2.1%, $P < 0.001$), acute kidney injury (32.3% vs. 7.1%, $P < 0.001$), cardiac arrest (35.5% vs. 5.8%, $P < 0.001$), cardiogenic shock (36.4% vs. 6.0%, $P < 0.001$), vascular complications (1.2% vs. 0.9%, $P < 0.001$), and mechanical circulatory support (20.9% vs. 7.4%, $P < 0.001$) were significantly associated with higher IHM. PPCI as expected, was associated with a significant reduction in IHM (21.2% vs. 46.1%, $P < 0.001$).

3.3. Independent predictors of in-hospital mortality

History of CABG was independently associated with higher mortality (1.16, 95% C.I [1.14–1.19], $P < 0.001$). Other independent predictors of IHM were older age (1.05, 95% C.I [1.05–1.05], $P < 0.001$), female gender (1.22, 95% C.I [1.21–1.24], $P < 0.001$), cardiogenic shock (6.12, 95% C.I [6.05–6.19], $P < 0.001$), cardiac arrest (9.94, 95% C.I [9.82–10.07], $P < 0.001$), hemodialysis (1.88, 95% C.I [1.83–1.93], $P < 0.001$), acute stroke (2.45, 95% C.I [2.39–2.51], $P < 0.001$), gastrointestinal bleeding (1.42, 95% C.I [1.39–1.45], $P < 0.001$) and Charlson comorbidity index (1.16, 95% C.I [1.16–1.17], $P < 0.001$). Reperfusion with PPCI independently predicted lower IHM (0.36, 95% C.I [0.35–0.36], $P < 0.001$). Our multivariate model showed excellent discrimination (ROC derived AUC = 0.88, $P < 0.001$).

3.4. Invasive strategy utilization

68.6% of patients with previous CABG did not receive any invasive cardiac procedure on the day of admission, compared to 46.3% of patients with STEMI without previous CABG ($P < 0.001$). 8.9% of patients with STEMI without previous CABG underwent diagnostic cardiac catheterization without PCI on the day of admission, compared to 8.2% of patients with previous CABG ($P < 0.001$). 23.2% of patients with previous CABG underwent PPCI compared to 44.8% without previous CABG ($P < 0.001$), with an increasing trend observed the study period in both cohorts [Supplementary Fig. 5](#). 34.6% had a PCI performed before discharge in the previous CABG cohort compared to 60.9% of those without previous CABG ($P < 0.001$). 1.5% with previous CABG had a redo-CABG before discharge, while 8.2% of patients without previous CABG, underwent CABG before discharge. 49.9% of patients with STEMI and previous CABG did not receive a cardiac catheterization procedure or a PCI throughout their hospital stay, compared to 24% of STEMI patients without previous CABG ($P < 0.001$).

Patients with previous CABG treated with PPCI had a small but significantly higher incidence of vascular complications (1.1% vs. 0.9%, $P < 0.01$), need for blood transfusion (3.2% vs. 3%, $P < 0.03$), and need for hemodialysis (1.5% vs. 0.7%, $P < 0.001$) compared to those without previous CABG, with no significant difference observed in acute stroke (0.9% vs. 0.8%, $P > 0.25$). Utilization of mechanical circulatory support (MCS) was lower in patients with previous CABG (6.8% vs. 9.2%, $P < 0.001$).

Unadjusted in-hospital mortality was higher in patients who underwent PPCI and had a history of previous CABG compared to those without previous CABG (4.8% vs. 4.3%, $P < 0.001$). After adjusting for age, gender, and comorbidities including hypertension, cardiac arrest, cardiogenic shock, tobacco use, chronic kidney disease, history of old stroke, and Charlson score, there was no significant difference in in-hospital mortality (Odds-ratio 1.027, 95% CI [0.96–1.1], $P > 0.4$).

4. Discussion

Our data suggest that patients with a previous history of CABG presenting with STEMI, have a significantly higher adjusted IHM, and more frequent noncardiac complications compared to those presenting with STEMI without a previous history of CABG. Although a significant

increase in comorbidity burden and in-hospital adverse events such as acute stroke, need for hemodialysis and transfusion requirement were noted in the cohort with previous CABG, the increase in IHM in the previous CABG cohort was not entirely explained by these covariates. This difference in IHM might be driven by other unmeasured confounders such as differences in procedural outcomes including the rates of re-establishment of thrombolysis in myocardial infarction (TIMI) grade III flow as well as ST-segment resolution, well-known to impact IHM [7,8], in addition to the higher complexity and extent of coronary artery disease in patients with previous CABG.

Anterior wall STEMI was less frequently observed in the previous CABG cohort, likely driven by the high utilization and durable patency rates of left internal mammary bypass graft conduits to left anterior descending artery. Cardiogenic shock was also less frequently observed in patients with previous CABG. This could be related to the mechanism of STEMI in patients with previous CABG involving either graft occlusion or “no-culprit vessel” as observed previously [3], with a higher likelihood of preserved resting flow proximal to the graft insertion provided by stenosed but non-occluded native vessels, and lesser myocardium at risk from graft occlusion as most bypass are anastomosed in non-proximal locations or to branch vessels.

We observed an encouraging trend of increase in utilization of PPCI in patients with or without previous CABG. Despite a similar utilization of diagnostic cardiac catheterization, patients with previous CABG received PPCI less frequently compared to those without previous CABG. The reasons for this finding are not clearly identifiable from this analysis, although may well be related to anatomic complexity and relative paucity of intervenable targets as observed previously in the general PCI cohort [9]. In those patients with previous CABG and STEMI who received PPCI, a significant improvement in in-hospital mortality was observed, corroborating the efficacy of catheter-based emergent reperfusion strategy in this cohort, when feasible.

In the cohort receiving PPCI, a clinically relevant and significantly higher incidence of need for hemodialysis was observed in patients with previous CABG compared to those without previous CABG, with an increase of smaller magnitude observed in the need for transfusion and vascular access site complications. Meticulous attention and management of pre-procedural renal injury risk, and safer vascular access site choice might help mitigate some of this outcome disadvantage.

While a trend of decreasing IHM in STEMI patients without previous CABG was observed over the study period, a trend of increasing IHM in STEMI patients with previous CABG was noted. This trend in IHM is likely related to the small but significant increase in the trends of in-hospital adverse events observed in patients with previous CABG. This finding emphasizes the need for development of treatment strategies designed to address the different pathophysiologic mechanisms driving the outcomes in this unique cohort.

Our study has several limitations that need to be recognized. NIS, although a non-participation-based database and hence more inclusive, is an administrative database with inherent limitations dependent on appropriate coding and attribution. It also lacks important granular information such as door-to-balloon times, procedural and other relevant details, leading to unmeasured confounding. A similar analysis from a registry with more granular information may be of value.

5. Conclusion

STEMI patients with previous CABG have a higher adjusted IHM compared to those without previous CABG. Despite increase in utilization of PPCI, IHM demonstrates an increasing trend over the study period.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijcha.2021.100878>.

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