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Alejandro Lemor

Gabriel A. Hernandez

Mir B. Basir

Sati Patel

Pedro A. Villablanca

See next page for additional authors

Authors
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Impact of Prior Coronary Artery Bypass Grafting in Patients ≥75 Years Old Presenting With Acute Myocardial Infarction (From the National Readmission Database)

Alejandro Lemor, MD, MS[a,*], Gabriel A. Hernandez, MD[b], Mir B Basir, DO[a], Sati Patel, MD[a], Pedro A. Villablanca, MD, MS[a], Khaldoon Alaswad, MD[a], and William O'Neill, MD[a]

Patients ≥75 years old presenting with acute myocardial infarction (AMI) have complex coronary anatomy in part due to prior coronary artery bypass grafting (CABG), percutaneous coronary interventions (PCI), calcific and valvular disease. Using the National Readmission Database from January 2016 to November 2017, we identified hospital admissions for acute myocardial infarction in patients ≥75 years old and divided them based on a history of CABG. We evaluated in-hospital outcomes, 30-day mortality, 30-day readmission and predictors of PCI in cohorts. Out of a total of 296,062 patients ≥75 years old presenting with an AMI, 42,147 (14%) had history of previous CABG. Most presented with a non-ST segment elevation myocardial infarction, and those with previous CABG had higher burden of co-morbidities and were more commonly man. The in-hospital mortality was significantly lower in those with previous CABG (6.7% vs 8.8%, adjusted odds ratio, 0.88, 95% confidence interval, 0.82 to 0.94). Medical therapy was more common in those with previous CABG and 30-day readmission rates were seen more frequently in those with prior CABG. Predictors of not undergoing PCI included previous PCI, female, older ager groups, heart failure, dementia, malignancy, and higher number of co-morbidities. In conclusion, in patients ≥75 years old with AMI the presence of prior CABG was associated with lower odds of in-hospital and 30-day mortality, as well as lower complications rates, and a decreased use of invasive strategies (PCI, CABG, and MCS). However, 30-day MACE readmission was higher in those with previous CABG. **(Am J Cardiol 2020;135:9−16)**

Background

Acute cardiovascular disease is a leading cause of morbidity and mortality in adults of any age, however elderly patients are at a higher risk for adverse outcomes, including mortality and rehospitalizations.[1] With improvement in revascularization options for both stable and acute coronary disease and resultant increase life expectancy, elderly patients presenting with acute myocardial infarction (AMI) have complex coronary anatomy in part due to previous coronary artery bypass grafting (CABG), percutaneous coronary interventions (PCI), calcific and valvular disease.[1,2] Moreover, aging is also associated with higher rates of non-cardiac co-morbidities such as renal disease, cognitive dysfunction and polypharmacy which complicates treatment strategies such as antiplatelet and anticoagulant therapies, risk of contrast-induced nephropathy and timely discharge. With this inherent age disparity and less invasive revascularization approach for AMI in elderly patients we sought to investigate whether preexisting CABG has any impact in the treatment plan and in hospital outcomes.

Methods

The study cohort was derived from the National Readmission Database (NRD), a publicly available database of all-payer hospital inpatient stays developed by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. The NRD was constructed from 22 States with reliable and verified patient linkage numbers in the State Inpatient Databases that could be used to track the patient across hospitals within a State, while adhering to strict privacy guidelines. We used the NRD database from January 2016 to November 2017.

The NRD database includes approximately 14 million patients and around 2,000 hospitals per year. National estimates are obtained using sampling weights provided. Patients have a unique identifier, which allows each patient to be tracked (the variable named "NRD_visitlink"). We determined the time between the first admission and the readmission by using the variable "NRD_daystoevent" and calculating the difference between that variable and the length of stay. A detailed explanation of all the variables in the NRD is available online (https://www.hcup-us.ahrq.gov/nrdoverview.jsp). Institutional Review Board (IRB) review and approval was not required as the NRD is a

[a]Department of Cardiology, Henry Ford Hospital, Detroit, Michigan; and [b]Department of Cardiology, University of Mississippi Medical Center, Jackson, Mississippi. Manuscript received July 14, 2020; revised manuscript received and accepted August 18, 2020.

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*Corresponding author: Tel: (313) 932-5272

E-mail address: alejandrolemor@outlook.com (A. Lemor).

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publicly available database containing de-identified patient information.

The study population was identified using the International Classification of Diseases, Tenth Edition, Clinical Modification (ICD-10-CM) diagnostic codes for a primary discharge diagnosis of acute myocardial infarction (ICD-10-CM code I21.x) and those ≥75 years old. Patients were then divided into 2 cohorts based on a previous history of CABG using the ICD-10-CM diagnostic code of Z95.1 (Presence of aortocoronary bypass graft). The exclusion criteria consisted of patients admitted during the month of December, as NRD patient tracking is limited to a single calendar year, (n = 33,093), younger than 75 years old (n = 810,154), same day admission-transfers (n = 22,943), out of state patients (n = 21,264), and patients who did not have mortality data (n = 94) (**Figure 1**). Baseline characteristics, such as age, gender, and relevant comorbidities were collected. The severity of co-morbid conditions was defined using a validated Deyo modification of Charlson Co-morbidity Index.[3,4] Other characteristics such as teaching status of the hospital, median household income, insurance status, and discharge disposition were also included.

The primary outcome was in-hospital mortality. Secondary outcomes included 30-day mortality, 30-day readmission rate, 30-day major adverse cardiovascular events (MACE) readmissions, acute kidney injury (AKI), AKI requiring dialysis, acute ischemic stroke, acute respiratory failure, acute liver failure, palliative care consultation, length of stay, and hospital costs. Thirty-day MACE readmissions included all patients with a primary readmission diagnosis of acute coronary syndrome, acute heart failure, and ventricular tachycardia/fibrillation. Principal etiologies of readmission were also evaluated for both cohorts.

Univariate differences in baseline characteristics between both cohorts were evaluated using Pearson chi-square tests for categorical variables and Wilcoxon rank-sum tests for continuous variables. Multivariate linear and logistic regression were used to compare hospital outcomes between groups, adjusting for potential confounders, such as age, gender, type of acute coronary syndrome, hypertension, diabetes, dyslipidemia, heart failure, previous myocardial infarction (MI), previous PCI, smoker, end stage renal disease (ESRD), chronic obstructive pulmonary disease (COPD), dementia, peripheral artery disease (PAD), malignancy, obesity, atrial fibrillation, Do not resuscitate (DNR) status, Charlson comorbidity index, teaching status, hospital bed size, and median household income. Statistical analysis was performed with STATA version 14 (StataCorp, Texas). A p-value less than 0.05 was considered significant for all the analyses.

Results

A total of 296,062 patients ≥75 years old presented with an acute myocardial infarction, out of which 14% (N = 42,147) had history of previous CABG. The majority

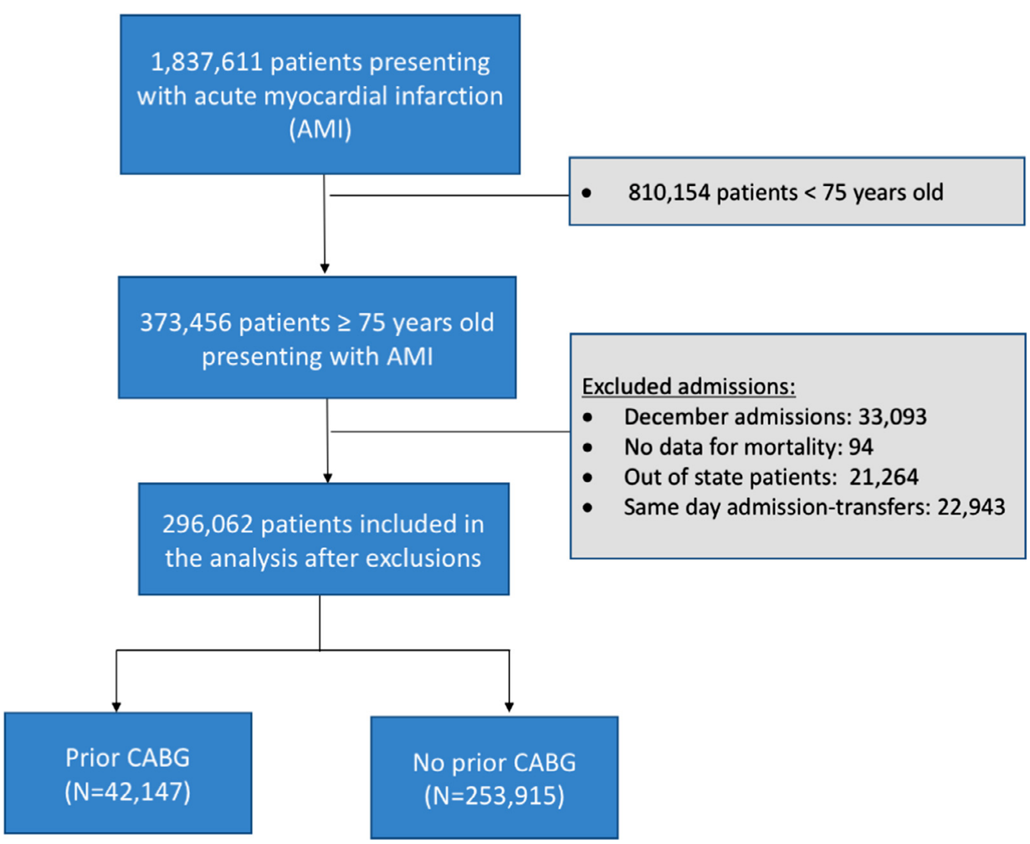


Figure 1. Flowchart with patient selection. A total of 1,837,611 patients with acute coronary syndrome were identified from 2016 to 2017; among which 373,456 were ≥75 years. After exclusion criteria, 296,062 patients were included in the analysis; 42,147 (14.2%) had a prior CABG and 253,915 didn't have a prior CABG. CABG = coronary artery bypass grafting.

Table 1
Baseline characteristics

Variable	Overall (N = 296,062)	Prior CABG YES (N = 42,147)	Prior CABG NO (N = 253,915)	p Value
Type of myocardial infarction				
NSTEMI	79.3%	89.2%	77.7%	<0.001
STEMI	20.7%	10.8%	22.3%	
Anterior wall	32.5%	17.4%	33.7%	<0.001
Inferior wall	42.9%	45.9%	42.7%	
Other	24.6%	36.8%	23.6%	
Age (median [IQR])	83 (78-88)	82 (78-87)	83 (78-88)	<0.001
Men	49.8%	69.0%	46.5%	<0.001
Hypertension	86.3%	91.3%	85.4%	<0.001
Diabetes Mellitus	37.6%	48.7%	35.8%	<0.001
Heart failure	45.1%	52.9%	43.8%	<0.001
Systolic heart failure	25.5%	31.1%	24.6%	<0.001
Dyslipidemia	65.8%	77.8%	63.8%	<0.001
Prior percutaneous coronary intervention	16.8%	28.2%	14.9%	<0.001
Obesity	9.4%	9.8%	9.3%	0.017
Smoker	1.0%	0.8%	1.0%	0.004
Chronic obstructive pulmonary disease	22.8%	22.6%	22.9%	0.427
End Stage Renal Disease	3.1%	4.0%	3.0%	<0.001
Peripheral artery disease	15.6%	21.4%	14.7%	<0.001
Atrial fibrillation	31.9%	34.7%	31.5%	<0.001
Prior implantable cardioverter defibrillator	2.3%	6.0%	1.6%	<0.001
Do Not Resuscitate (DNR) Status	20.2%	18.6%	20.5%	<0.001
Dementia	16.4%	13.8%	16.8%	<0.001
Malignancy	5.3%	5.0%	5.3%	0.044
Charlson Comorbidity Index ≧3	65.8%	76.1%	64.1%	<0.001
Other characteristics				
Teaching hospital	62.8%	62.5%	62.9%	0.513
Hospital Bed Size				
Small	15.5%	15.7%	15.5%	0.686
Medium	29.9%	30.1%	29.9%	
Large	54.6%	54.3%	54.7%	
Median household income percentile				
0 - 25th	27.5%	26.9%	27.5%	0.037
26th - 50th	28.7%	29.6%	28.6%	
51st - 75th	25.0%	25.0%	25.0%	
76th - 100th	18.8%	18.5%	18.9%	
Primary Payer				
Medicare	94.3%	94.6%	94.3%	<0.001
Medicaid	0.9%	0.6%	1.0%	
Private Insurance	3.2%	3.1%	3.3%	
Self-pay/ Other	1.6%	1.8%	1.5%	
Discharge disposition				
Home	71.9%	76.8%	71.0%	<0.001
Nursing Home/ Facility	24.6%	19.7%	25.5%	
Other	3.5%	3.5%	3.5%	

presented with non-ST segment elevation myocardial infarction (NSTEMI) (79%), with an even higher frequency in those with previous CABG (89.2% vs 77.7%, p <0.001). In patients presenting with ST segment elevation myocardial infarction (STEMI) (21%), inferior wall STEMI was most commonly seen (42.9%), followed by anterior wall MI (32.5%), and 24.6% were located on another wall or unspecified location of MI. The median age for those with previous CABG was 82 years and those without previous CABG had a median age of 83 years old. Patients with previous CABG were more likely to be male compared wih those without it (69% vs 46.5%, p <0.001) and those with CABG had a higher burden of comorbidities (**Table 1**).

Most patients underwent medical management irrespective of the history of CABG (69.2% in those with previous CABG and 58.1% in those without previous CABG). As expected, those with previous CABG had lower rates redo CABG (0.9% vs 5.6%, p <0.001) and interestingly, lower rates of PCI (30% vs 36.7%, p <0.0001). When patients were evaluated by type of AMI, those with CABG presenting with STEMI had lower rates of PCI (52.2% vs 65.7%, p <0.001). Among patients presenting with NSTEMI, the overall revascularization rate was 33.5%, with lower rates

Table 2
Procedural outcomes

		Prior CABG		
All AMI	Overall (N = 296,062)	YES (N = 42,147)	NO (N = 253,915)	p Value
Coronary Angiogram	55.9%	51.5%	56.6%	<0.001
Percutaneous coronary intervention	35.8%	30.0%	36.7%	<0.001
Single-vessel PCI	27.7%	23.3%	28.4%	<0.001
Multivessel PCI	8.1%	6.7%	8.4%	<0.001
Coronary artery bypass grafting	4.9%	0.9%	5.6%	<0.001
Medical treatment	59.7%	69.2%	58.1%	<0.001
Intra-aortic balloon pump	2.8%	1.2%	3.1%	<0.001
Impella	0.8%	0.4%	0.8%	<0.001
STEMI	*Overall (N = 61,185)*	*YES (N = 4,560)*	*NO (N = 56,625)*	*p Value*
Coronary Angiogram	74.2%	66.2%	74.9%	<0.001
Percutaneous coronary intervention	64.7%	52.2%	65.7%	<0.001
Single-vessel PCI	52.5%	40.4%	53.5%	<0.001
Multivessel PCI	12.2%	11.7%	12.3%	0.561
Coronary artery bypass grafting	3.7%	0.9%	3.9%	<0.001
Medical treatment	32.6%	47.3%	31.4%	<0.001
Intra-aortic balloon pump	7.1%	4.5%	7.3%	<0.001
Impella	1.4%	0.6%	1.5%	<0.001
NSTEMI	*Overall (N = 234,877)*	*YES (N = 37,587)*	*NO (N = 197,290)*	*p Value*
Coronary angiogram	51.1%	49.7%	51.4%	0.002
Percutaneous coronary intervention	28.2%	27.4%	28.4%	0.008
Single-vessel PCI	21.2%	21.2%	21.2%	0.882
Multivessel PCI	7.1%	6.1%	7.3%	<0.001
Coronary artery bypass grafting	5.2%	0.9%	6.0%	<0.001
Medical treatment	66.7%	71.9%	65.7%	<0.001
Intra-aortic balloon pump	1.7%	0.8%	1.8%	<0.001
Impella	0.6%	0.4%	0.6%	<0.001

of PCI and CABG in the cohort of patients with previous CABG. Patients with previous CABG had less likelihood of undergoing multivessel PCI. The use of mechanical circulatory support, such as Intra-aortic balloon pump (IABP) and Impella, was lower in those with previous CABG, regardless of the type of AMI (**Table 2**)

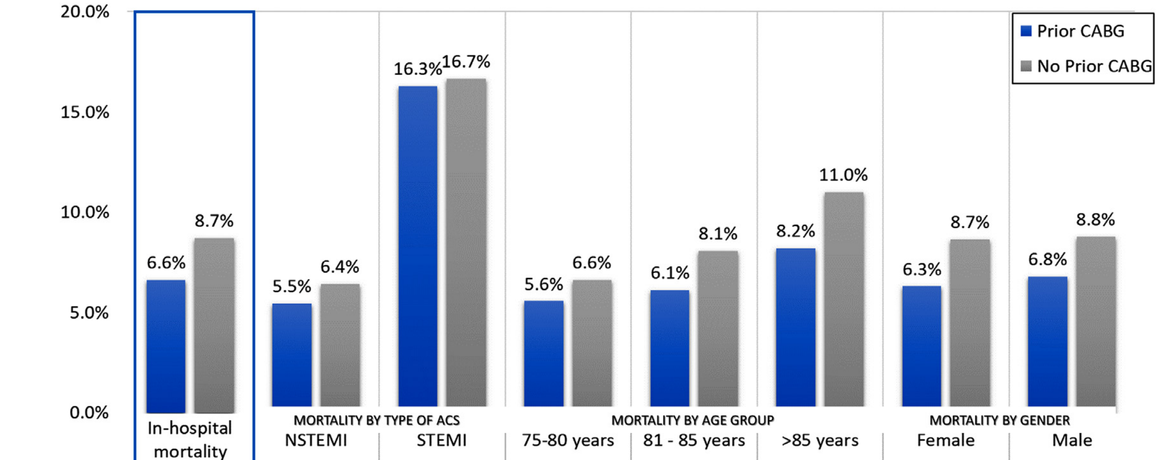
The primary outcome, in-hospital mortality, was significantly lower in those with previous CABG (6.7% vs 8.8%, adjusted odds ratio [aOR]: 0.88, 95% confidence interval [CI] 0.82 to 0.94). When analyzed by type of AMI, those presenting with STEMI and previous CABG had no significant difference in mortality when compared to those without CABG (16.3% vs 16.7%, aOR 0.99 95% CI 0.86 to 1.13); however, those with NSTEMI and previous CABG had significant lower odds of in-hospital mortality (5.5% vs 6.4%, aOR 0.83, 95% CI 0.76 to 0.90). A subgroup analysis by age groups (75 to 80 years, 81 to 85 years, and >85 years) demonstrated that those patients in older age groups with previous CABG had significantly lower mortality than those without previous CABG (**Figure 2**).

When comparing secondary outcomes between cohorts, we found those with previous CABG had a lower rate of 30-day mortality, cardiogenic shock, AKI, acute ischemic stroke, blood transfusions, acute respiratory failure, and acute liver failure. The 30-day MACE readmission and 30-day all-cause readmission was higher in those with previous CABG (**Figure 3**). Hospital costs were significantly higher in those without previous CABG (**Figure 4**). Factors that associated either with increased or lower odds for PCI during index admission for AMI are shown in **Figure 5**.

Discussion

Using real-world data, we evaluated a large cohort of patients ≥ 75 years old who presented with AMI and provided new insights about the relationship of previous CABG and in-hospital outcomes (**Figure 6**). The key findings of our study are (1) despite lower rates revascularization, patients with previous CABG had significantly lower in-hospital mortality. (2) Subgroup analysis demonstrated lower mortality rates in those older than 80 years old. (3) Those with previous CABG had lower rates of in-hospital complication, such as cardiogenic shock, AKI, respiratory failure, liver failure, acute ischemic stroke, and blood transfusions. (4) Rates of revascularization (PCI or CABG) and use of MCS were lower in those with previous CABG. (5) 30-day readmission rates for MACE were higher in those patients with previous CABG, nonetheless, the 30-day mortality was still lower in those with previous CABG.

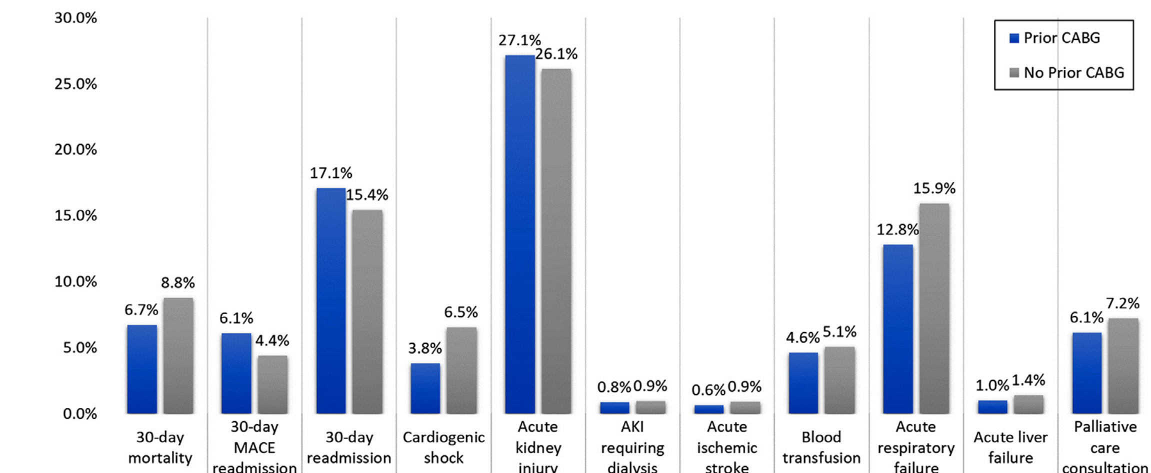
Even though rates of CABG in the United States have decreased,[5] the prevalence of patients who have had CABG will remain the same or will increase as the morbidity and mortality in this patient population improves. Elderly patients with previous CABG presenting with AMI can represent a challenge for physicians, as they can present with atypical symptoms, ECGs may be less diagnostic than in younger patients, and reperfusion therapies are less



	In-hospital mortality	NSTEMI	STEMI	75-80 years	81 - 85 years	>85 years	Female	Male
Odds Ratio*	0.88	0.83	0.99	0.91	0.83	0.86	0.87	0.87
95% CI	0.82 - 0.94	0.76 - 0.90	0.86 - 1.13	0.80 - 1.03	0.72 - 0.96	0.78 - 0.95	0.77 - 0.98	0.80 - 0.95
p value	0.001	0.001	0.851	0.142	0.012	0.003	0.023	0.002

* Adjusted for age, gender, type of acute coronary syndrome, hypertension, diabetes, dyslipidemia, heart failure, prior MI, prior PCI, smoker, ESRD, COPD, dementia, peripheral artery disease, malignancy, obesity, atrial fibrillation, DNR status, Charlson comorbidity index, teaching status, hospital bed size, and median household income.
(For subgroups, the adjusted OR was excluding the specific subgroup being evaluated)

Figure 2. In-hospital mortality. The in-hospital mortality was significantly lower in those with prior CABG. Subgroup analysis showed no significant difference in mortality in STEMI; however, those with NSTEMI and prior CABG had significant lower mortality. Patients in older age groups with prior CABG had significantly lower mortality than those without prior CABG.



	30-day mortality	30-day MACE readmission	30-day readmission	Cardiogenic shock	Acute kidney injury	AKI requiring dialysis	Acute ischemic stroke	Blood transfusion	Acute respiratory failure	Acute liver failure	Palliative care consultation
Odds Ratio*	0.89	1.25	1.05	0.64	0.84	0.63	0.73	0.79	0.72	0.75	0.97
95% CI	0.83 - 0.95	1.16 - 1.33	1.01 - 1.10	0.58 - 0.69	0.80 - 0.87	0.52 - 0.75	0.59 - 0.89	0.74 - 0.85	0.68 - 0.76	0.64 - 0.88	0.89 - 1.05
p value	0.001	0.001	0.012	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.409

* Adjusted for age, gender, type of acute coronary syndrome, hypertension, diabetes, dyslipidemia, heart failure, prior MI, prior PCI, smoker, ESRD, COPD, dementia, peripheral artery disease, malignancy, obesity, atrial fibrillation, DNR status, Charlson comorbidity index, teaching status, hospital bed size, and median household income.

Figure 3. Secondary outcomes. Patients with prior CABG had lower rates of 30-day mortality, however, had higher 30-day readmission and 30-day MACE readmission rates. Lower complications rates were seen in those with prior CABG.

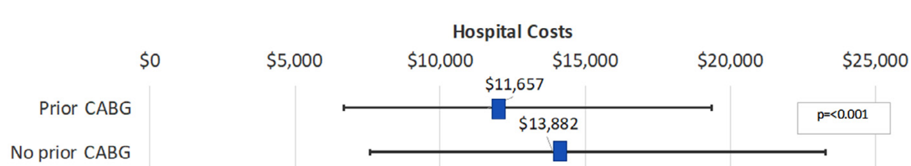


Figure 4. Total hospital costs for patients with and without prior CABG. The total hospital costs were significantly lower for patients with prior CABG.

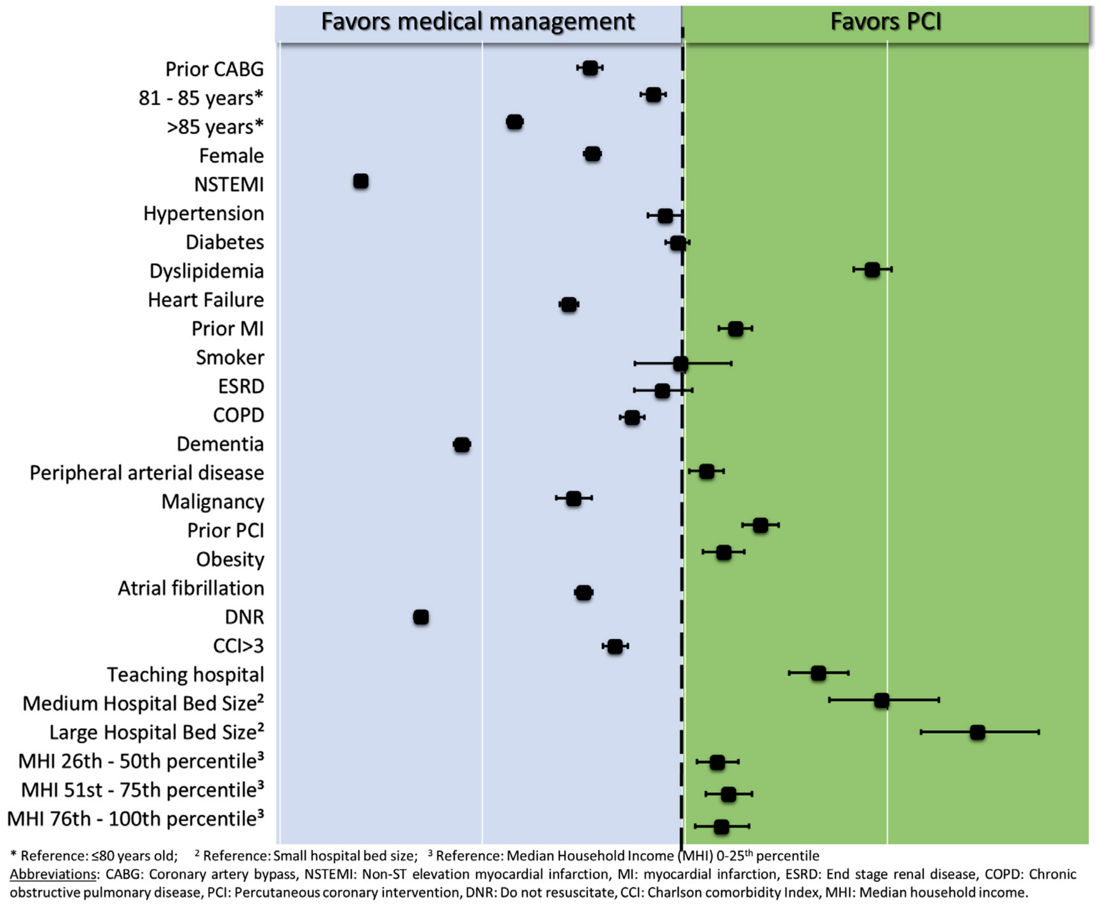


Figure 5. Predictors of PCI during index admission for AMI. In patients ≥75 years old presenting with acute myocardial infarction, a history of prior CABG, older age groups, female gender, NSTEMI, heart failure, COPD, dementia, malignancy, DNR status, atrial fibrillation, a Charlson Comorbidity Index >3 were independent predictors of medical management. Predictors of PCI included dyslipidemia, prior MI, peripheral arterial disease, prior PCI, obesity, teaching hospital, medium to large hospital size and a higher median household. AMI = acute myocardial infacrtion; CABG = coronary artery bypass grafting; PCI = percutaneous coronary intervention.

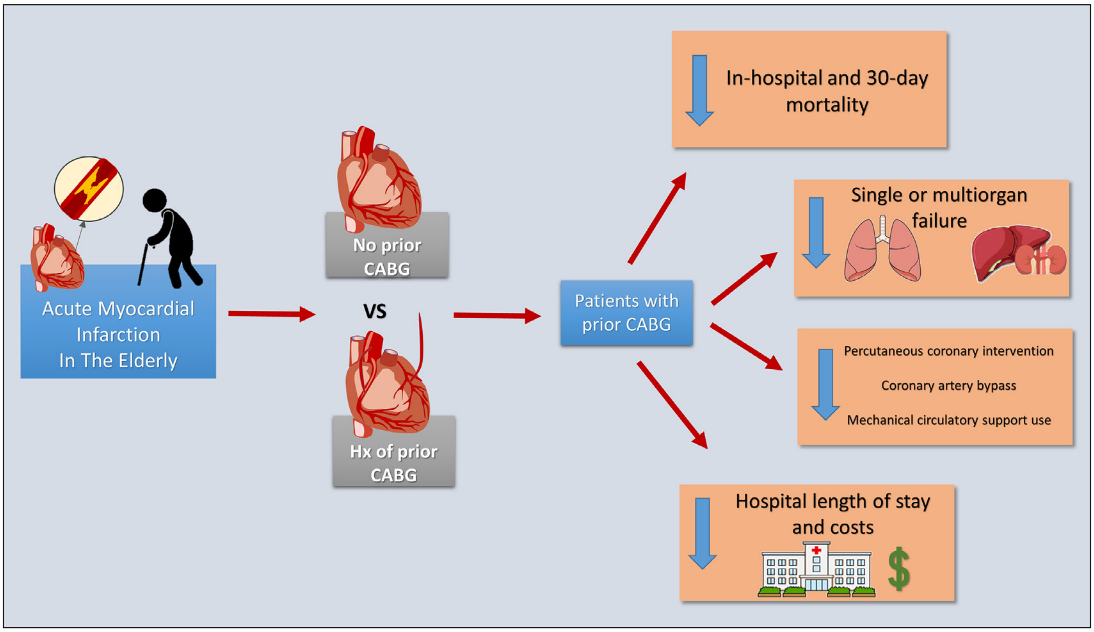


Figure 6. Summary of the study findings. Among patients 75 years and older who presented with an acute myocardial infarction, those with a history of prior CABG had lower in-hospital and 30-day mortality, as well as lower rates of organ failure, rates of PCI, CABG, MCS use, length of stay and hospital costs when compared with those without prior CABG.

frequently used.[6,7] We found lower incidence of STEMI in those with previous CABG and lower rates of PCI and redo CABG (less than 1%). As described by Fosbol et al, the rates of repeated CABG in older individuals is low and there is a significant variation between centers. Overall, there has been a declining rate of re-do CABG over the years with a steady increase in the rates of PCI.[8] A subgroup analysis in our cohort evaluating mortality in those who underwent CABG during the index admission, revealed higher mortality in patients undergoing redo CABG, although this was not statistically significant (11.6% vs 6.2%, p = 0.06). A study by Welsh et al revealed that patients with previous CABG presenting with STEMI were less likely to undergo revascularization and had a higher 90-day mortality.[9] We reported similar findings regarding a higher burden of comorbidities and lower revascularization rates in those with previous CABG, however, we found lower in-hospital and 30-day mortality in those with previous CABG. Even though in our study the patients' age was higher, the 30-day mortality was overall lower in our cohort with AMI (6.7% for those with previous CABG and 8.8% in those without previous CABG). The lower mortality seen in our study highlights the protective mechanism of CABG; because the grafts bypass the first 7-cm segment of the coronary artery, which is the most common segment for new plaque rupture.[10] This protective mechanism of CABG has been described in previous important trials, such as SYNTAX Trial and BARI Study, in which the rates of repeated revascularization and/or MI were higher in patients that underwent PCI at 5 to 10 years.[11,12]

The elderly population is typically underrepresented in randomized control trials; however, the TACTICS-TIMI 18 trial found a reduction of death or MI at 6 months in patients >75 years old undergoing an invasive versus conservative strategy, though, the rates of bleeding were higher for those undergoing an invasive strategy.[13] In our study, almost 70% of patients with previous CABG underwent a conservative treatment and around 60% of those without previous CABG also underwent a conservative approach. Lower rates of revascularization in those with previous CABG could potentially explain the increased odds of 30-day MACE readmission as well as the higher number of comorbidities. Nonetheless, in those patients with previous CABG, 8.7% underwent PCI during the readmission compared to 10.9% in those without previous CABG (p = 0.008). Emphasizing the importance of guideline-directed medical therapy in the elderly, which is less frequently accomplished when compared with younger patients.[14] Optimal medical therapy benefits preventing MACE and symptoms in this morbid population,[15] in addition to choosing early invasive strategy when appropriate, regardless of the age group.[16,17] This approach is supported by the ACC/AHA NSTEMI guidelines which recommend guideline-directed medical therapy, early invasive strategy and revascularization as appropriate for patients ≥75 years old.[18]

Lastly, we reported predictors favoring PCI versus medical management in our cohort; factors associated with lower rates of PCI included previous CABG, older age groups (81 to 85 years and >85 years), female gender, NSTEMI, higher number of comorbidities, malignancy, DNR status, and dementia among others. In contrast, predictors of undergoing PCI included previous MI, previous PCI, obesity, PAD, teaching hospital and larger hospital bed size. Hao et al[19] described similar factors associated with not performing PCI in AMI, including female gender, older age groups, acute heart failure, and NSTEMI. There are several limitations to the present study. We are not able to identify the timing of the previous CABG, and neither to differentiate if the culprit lesion was a native vessel or a graft. Mortality data does not distinguish between cardiac and non-cardiac causes of death. In addition, the study is limited to in-hospital and 30-day outcomes only and long-term outcome data are not available. The NRD data is based on ICD-10-CM codes, and like any administrative database, there is a possibility of coding error. Lack of information about laboratory results, medications, and imaging findings renders a more comprehensive analysis unfeasible with this database. Despite these limitations, our results demonstrate robust findings using real world data of the impact of previous CABG in the outcomes of patients ≥75 years old presenting with AMI.

In conclusion, patients ≥75 years old presenting with AMI are more frequently treated conservatively than by revascularization. The presence of previous CABG was associated with lower odds of in-hospital and 30-day mortality, as well as lower complication rates. Thirty-day MACE readmission rates were higher in those with previous CABG, possibly secondary to a combination of higher co-morbidities and a more frequent use of conservative management during the index hospitalization. Predictors for a conservative strategy included previous CABG, female gender, older ager groups, heart failure, dementia, malignancy, and higher number of comorbidities.

Author Contributions

Alejandro Lemor: Writing - Original Draft, Conceptualization, Formal analysis; Gabriel A. Hernandez: Conceptualization, Methodology; Mir B Basir: Resources, Writing - Original Draft; Sati Patel: Validation, Investigation; Pedro A. Villablanca: Methodology, Writing - Review & Editing; Khaldoon Alaswad: Resources, Supervision, Project administration; William O'Neill: Writing - Review & Editing, Supervision.

Disclosures

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