**Clinical Characteristics, Management Strategies & Outcomes of Acute Myocardial Infarction Patients with Prior Coronary Artery Bypass Grafting**

Ahmad Shoaib1 MD Mohamed Mohamed1 MBChB, Muhammad Rashid1 PhD, Safi U. Khan2 MD, Purvi Parwani3 MD, Tahmeed Contractor3 MD, Hafsa Shaikh4 MBBS, Waqar Ahmed5 MD, Eoin Fahy1 MBChB, James Prior1,6 PhD, David Fischman7 MD, Rodrigo Bagur1 MD, Mamas A Mamas1,7 DPhil

1. Keele Cardiovascular Research Group, Centre for Prognosis Research, Keele University, UK
2. Department of Medicine, West Virginia University, Morgantown, WV, USA.
3. Division of Cardiology, Department of Medicine, Loma Linda University Health, Loma Linda, CA.
4. Department of Medical Sciences, University College London, UK
5. King Fahd Armed Forces Hospital, Jeddah, Saudi Arabia
6. Midlands Partnership NHS Foundation Trust, Trust Headquarters, St. George's Hospital, Stafford, UK
7. Department of Medicine (Cardiology), Thomas Jefferson University Hospital,

Philadelphia, PA, USA

**Corresponding author:**

Prof. Mamas A. Mamas

Keele Cardiovascular Research Group,

Centre for Prognosis Research

Keele University,

Stoke-on-Trent, UK

E-mail: mamasmamas1@yahoo.co.uk

**Tel:** +44 1782 671654 **Fax:** +44 1782 734719

**External funding**: None

**Conflict of interest**: None

**Running title**: PCI in Prior CABG

**Total Word count**: 2,995

**Abstract**

**Objective:** To investigate the management strategies, temporal trends, and clinical outcomes of patients with a history of coronary artery bypass graft (CABG) surgery and presenting with acute myocardial infarction (MI).

**Patients & Methods:** We undertook aretrospective cohort study using the National Inpatient Sample database from the United States (January 2004-September 2015), identified all inpatient MI admissions (records: 7,250,768) and stratified according to prior history of CABG (Group-1: CABG Naïve (94%), Group-2: Prior CABG (6%)).

**Results:** Patients in Group-2 were older, less likely to be female, had more comorbidities and were more likely to present with Non-ST-elevation myocardial infarction compared to Group-1. More patients underwent coronary angiography (68% vs 48%) and percutaneous coronary intervention (PCI) (44% vs 26%) in Group-1 compared to Group-2. Following multivariable logistic regression analyses, the adjusted odd ratio (OR) of in-hospital major adverse cardiovascular and cerebrovascular events (MACCE, (OR 0.98, CI 0.95-1.005, P=.11)), all-cause mortality (OR:1, CI:0.98-1.04, P=.6) and major bleeding (OR:0.99, CI:0.94-1.03, P=.54) were similar to Group-1. Lower adjusted odds of in-hospital MACCE (OR:0.64, CI: 0.57-0.72, P<.001), all-cause mortality (OR:0.45, CI:0.38-0.53, P<.001) and acute ischaemic stroke (OR:0.71, CI:0.59-0.86, P<.001) were observed in Group-2 patients who underwent PCI compared to those managed medically without any increased risk of major bleeding (OR:1.08, CI:0.94-1.23, P=.26).

**Conclusion:** In this national cohort, MI patients with prior-CABG had a higher risk profile, but similar in-hospital adverse outcomes compared to CABG-naïve patients. Prior-CABG patients who received PCI had better in-hospital clinical outcomes compared to those who received medical management.

**Key words**: Percutaneous coronary intervention, Coronary artery bypass grafting, Mortality

**Abbreviation**s

PCI: Percutaneous Coronary Intervention

CABG: Coronary artery bypass graft

MI: Myocardial infarction

OR: Odds ratio

**Introduction**

Coronary artery bypass grafting (CABG) is one of the most common surgical procedures in the United States.1 Despite achieving complete revascularization with CABG, attrition and occlusion of bypass grafts are common and only 85% of internal mammary artery (IMA) and 60% of saphenous vein grafts (SVG) remain patent after 10 years of surgery.2, 3 Furthermore, surgical grafting of native coronary arteries accelerates the development of atherosclerosis, thrombosis and calcification.4-8 The occlusive disease of grafts and native coronary arteries may result in increased risk of recurrent ischaemic events, including angina (>6% at 1 year), myocardial infarction (MI) (>7% after 6 years, or >10% within 10 years) and death (>2% at 1 year, rising 4-9% after 5 years).9-16 Owing to a large number of CABG survivors worldwide, the proportion of patients admitted with acute MI with prior history of CABG has increased in recent years.5, 17

Current American and European guidelines provide class 1 recommendation for early invasive assessment with a coronary angiogram and revascularization for high-risk patients presenting with acute MI.18-20 However, some of the key randomized controlled trials that have established the evidence basis of an invasive approach in acute MI have excluded patients with previous CABG. 21-24 Furthermore, inconsistent findings have been reported associated with an invasive approach in different studies, for instance in a Swedish registry of 10,837 patients with prior CABG, 1-year adjusted mortality was 50% less in those who received revascularization compared to those who were treated conservatively.25 In contrast, a post-hoc analysis of the ACUITY (Acute Catheterization and Urgent Intervention Triage Strategy) trial, found that adjusted 30-days and 1-year risk of MACE (Major Adverse Cardiovascular Events) were increased in prior CABG patients treated with revascularization rather than medically.8 In an analysis of 3,853 acute coronary syndrome (ACS) patients with prior CABG in the GRACE (Global Registry of Acute Coronary Events) registry data, the 6-months adjusted mortality outcomes were similar in patients who received revascularization versus those who treated medically.26 Optimal treatment strategy and clinical outcomes are not well defined in prior CABG patients who present with acute MI.

The objective of this study was to investigate treatment strategies and clinical outcomes of patients presenting with acute MI with a history of prior CABG in contemporary clinical practice and to study the in-hospital clinical outcomes associated with an invasive or conservative approach (medical management) using national data from the United States.

**Methods**

**Study settings:** National Inpatient Sample **(**NIS) is the largest publicly available all-payer inpatient healthcare database of the United States (US), designed by the Healthcare Cost and Utilization Project (HCUP) and supported by the Agency for Healthcare Research and Quality (AHRQ).27 The NIS records discharge level data on diagnosis and procedures from approximately 1,000 hospitals, including 20% of all community hospitals in the US and 7 million hospitalizations annually.28 The NIS dataset constitutes a 20% stratified sample of US community hospitals and discharge weights are used to determine national estimated and weighted data, which represents more than 95% of the US population. As NIS is an anonymised publicly available database, ethical approval was not required for this study.

**Study design**: This is a retrospective cohort analysis of all records in the NIS database of patients admitted with acute MI, Non-ST segment elevation MI (NSTEMI) & ST Segment elevation MI (STEMI)) from January 2004 to September 2015. We used the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes to identify patients. Records with missing data for age, gender, primary diagnosis and inpatient mortality were excluded from this study (Supplement figure 1).

Data regarding patients’ clinical characteristics, comorbid conditions and in-hospital clinical outcomes were extracted by using the ICD-9 diagnosis and procedures codes provided in Supplementary table 1. We also collected information regarding hospital characteristics including number of beds, location, region and teaching status. Hospital bed sizes within NIS are defined using different regions of US and ranges from 1-249 beds for a small hospital, 25-449 for a medium hospital and 50+ to 450+ for a large size hospital.

Patients with acute MI were stratified into two groups according to background history of CABG; Group 1: CABG Naive, Group 2: Prior CABG. Clinical outcomes of interest were: in-hospital all-cause mortality, Major Acute cardiovascular and Cerebrovascular Events (MACCE, defined as a composite of all-cause mortality, stroke and cardiac complications), acute ischaemic stroke and major bleeding. Major bleeding was defined as a composite of gastrointestinal, retroperitoneal, intracranial and un-specified haemorrhage.

**Statistical Analysis:** Descriptive statistics were performed to compare differences in baseline demographics, clinical characteristics and crude outcomes between two cohorts. Continuous variables are presented as median and interquartile ranges (IQR). Chi square and Wilcoxon Rank Sum test were used to determine statistical differences between two groups. We performed temporal analysis to assess management strategy during the study period from 2004-2015 and assessed statistical significance by p for trend. Logistic regression models were fitted using maximum likelihood estimation and described as Odds Ratios (OR) with 95% confidence intervals (95% CI). Analysis was initially crude, followed by adjustment for; age, gender, year of procedure, comorbidities (anaemia, arthritis, congestive heart failure, coagulopathy, chronic lung disease, depression, Diabetes Mellitus (DM), Diabetic chronic complications, drug abuse, hypertension, hypothyroidism, liver disease, lymphomas, fluid and electrolyte disturbances, metastatic cancer, neurological disorders, obesity, paralysis, peripheral vascular disease, psychosis, renal failure, solid tumour without metastasis, weight loss), hospital bed size, hypercholesterolaemia, prior history of coronary artery disease (CAD), family history of CAD, previous MI, previous cerebrovascular accident (CVA), previous PCI, shock during admission, use of Intra-aortic balloon pump, atrial fibrillation or flutter (AF), ventricular tachycardia, ventricular fibrillation or flutter, NSTEMI presentation, STEMI presentation, and procedures like coronary angiogram, PCI or CABG undertaken during admission. We also performed univariate and multivariate sensitivity analyses on patients with a background of history CABG to assess the effect of PCI procedures on clinical outcomes compared to those who received medical management only.

All statistical analyses were undertaken by using Stata 14.2 (College Station, Texas, USA). All statistical analyses were two-tailed, and an alpha of 5% was used throughout.

**Results**

***Baseline & comorbidity profile***

A total of 7,250,768 patients were admitted with a diagnosis of acute MI between January 2004 and September 2015, of which 449,548 (6%) had prior history of CABG. The process of patients’ inclusion and exclusion is presented in Supplement figure 1. The proportion of patients with an acute MI and a history of prior CABG increased during the study period from 5.5% in 2004-09 to approximately 7% in 2011-2015 (Supplement figure 2). Patients with prior CABG were significantly older and more likely to be male, Caucasian and present with NSTEMI. Furthermore, patients with prior CABG had a higher prevalence of comorbid conditions such as AF, previous MI & PCI, anaemia, DM, peripheral vascular diseases (PVD), renal failure and lower prevalence of STEMI presentation, shock, VT, VF, & cardiac arrest during admission (Table 1).

**Management strategy & crude clinical outcomes**

Almost half of prior CABG patients (48%) and two-thirds of the CABG naïve group (68%) underwent an invasive coronary angiogram during admission. The proportion of patients who received PCI (26% vs 44%) and CABG (1% vs 9%) were significantly lower in patients with a background history of CABG as opposed to those with no prior CABG history (Table 2).

***Temporal Changes***

In a temporal analysis to assess management strategy during the study period, we observed an increase in the invasive management (received either PCI or CABG) over time in both CABG naïve (P for trend <.001) and prior CABG cohorts (P for trend <.001) (Supplement Figure 3).

***Clinical outcomes in naïve-CABG vs. prior-CABG patients***

In-hospital MACCE, all-cause mortality, acute ischaemic stoke, major bleeding & cardiac complications were higher in CABG naïve patients compared to those with prior CABG (Table 2). After adjustment of baseline clinical differences, odds of in-hospital MACCE (OR: 0.98, CI 0.95 – 1.005, P=.11), all-cause mortality (OR: 1, CI 0.98 – 1.04, P=.6) and major bleeding (OR: 0.99, CI 0.94 – 1.03, P=.54) were similar between the two groups. However, adjusted risk of acute ischaemic stroke was slightly lower in prior CABG patients (OR: 0.89, CI 0.84 – 0.95, <.001) compared to the CABG naïve cohort (Table 3).

***PCI vs. medical management in prior-CABG***

We performed a sensitivity analysis in prior-CABG patients to compare and contrast clinical and demographical characteristics and adverse outcomes in those who received PCI compared to those who received medical management only. Clinical characteristics of both cohorts are described in Supplementary table 2. In crude analysis, unadjusted MACCE (3.5% vs 8%, P<.001), in-hospital mortality (2% vs 7%, P <.001), ischaemic stroke (0.85% vs 1.45%, P <.001) and major bleeding (2.3% vs 3.4%, P <.001) were significantly lower in those prior-CABG patients who received PCI compared to those who received medical management only (Supplement table 3). However, the frequency of cardiac complications (composite of “cardiac tamponade, hemopericardium, coronary artery dissection, pericardial effusion and Pericardiocentesis”) was significantly higher in PCI cohort (0.63% vs 0.04%, P <.001). Median total charge (US Dollars) was higher in PCI group ($59,242, IQR 42,106 – 87,595) compared to those who received medical management only ($21,930, IQR 12,269 – 38,770).

After adjustment of all baseline factors in the multivariable analyses, odds of in-hospital MACCE (OR: 0.64, CI 0.57 0.72, P <.001), all-cause mortality (OR: 0.45, CI 0.38-0.53, P <.001) and acute ischaemic stroke (OR: 0.71, CI 0.59 – 0.86, P <.001) were significantly lower in those who received PCI compared to medical management (Table 4). However, risk of all-cause bleeding was similar (OR: 1.08, CI 0.94 – 1.23, P = .26) between the two groups. We observed reduced MACCE and in-hospital mortality in patients who received PCI compared to those who received medical management only, irrespective of prior history of CABG (Supplement figure 4).

An overview of our findings is presented in figure 1.

In multivariate analyses, history of prior CABG in acute MI was independently associated with lower odds of receipt of an in-hospital coronary angiogram (OR: 0.37, 95% CI 0.36 – 0.38, P <.001) and PCI (OR: 0.49, 95% CI 0.48 – 0.50, P <0.001) (Supplement tables 4-5).

**Discussion**

This is the first national analysis to examine clinical characteristics, management, temporal trends and clinical outcomes of patients presenting with an acute MI, with or without a prior history of CABG. After adjustment, we observed similar odds of MACCE, all-cause mortality and major bleeding between the two groups. However, sensitivity analysis of the prior-CABG patients who received PCI showed they had better clinical outcomes in the form of in-hospital MACCE and all-cause mortality compared to those who received medical management despite patients with prior-CABG were less likely to receive invasive management.

The European Society of Cardiology (ESC) and American College of Cardiology/American Heart Association guidelines recommend an early invasive approach along with medical therapy in patients who present with AMI and have a high risk of adverse clinical outcomes.29-31 Patients with prior CABG are recognized as a high-risk cohort and therefore, an early invasive approach with a possibility of revascularization is favored in this group. However, these recommendations are based on limited data. Patients with prior CABG have been excluded from many important clinical trials including 32 VINO and RITA3 24, 33-36 and only contributed to small numbers of patients in other ACS clinical trials (In OASIS-5: 1,643/20,078, LIPSIA-NSTEMI: 41/600, Italian elderly ACS: 29/313 and After Eighty Study: 76/457). 37-42 Apart from a recently published pilot study, where Lee and colleagues reported 12 months outcome data of 60 prior CABG patients (invasive group, n=31; medical group, n=29), no major clinical trials exclusively examined clinical outcomes of invasive versus medical approach in patients who presented with acute MI and had prior CABG.40, 43

In our study, only half of prior CABG patients underwent invasive coronary angiography. There are many logistical and clinical factors, which affect the selection of a management approach for prior CABG patients presenting with acute MI. For instance, patients with a previous CABG surgery often have more comorbid conditions and more extensive coronary artery disease that may potentially bias clinicians to adopt either conservative approach or selective invasive management strategy.44 These findings are consistent with CRUSADE Quality Improvement Initiative, demonstrating that higher risk patients are less likely to receive invasive therapies despite a greater possible benefit from a more aggressive management approach.45 However, it is possible that some of the prior CABG patients underwent computed tomography coronary angiogram (CTCA) before invasive coronary angiography and were therefore not offered an invasive approach.

In the present study, revascularization, which was primarily in the form of PCI, was performed in one quarter of prior-CABG patients and half of those who underwent coronary angiography. There are many possible explanations of this observation. Comorbid conditions and frailty may limit the potential for revascularization to improve patients’ quality of life. There might be a subset of the patients who underwent assessment of viable myocardium, with or without CTCA/invasive coronary angiogram, and were not offered revascularization due to the absence of viability. Despite using modern drug eluting stent platforms and techniques, long-term outcomes of Saphenous vein graft (SVG) PCI are suboptimal. Lesions within SVGs are often thrombus laden and degenerate, and predispose distal embolization. The risk of no-reflow and peri-procedural MI are reported to be higher in SVG-PCI compared to native vessel PCI in many studies.5, 46 Furthermore, bypass grafts enhance the progression of atherosclerosis and calcification in native coronary arteries with up to 43% of the bypassed native vessels developing chronic total occlusions (CTO) after one year of surgery.4 Indeed, PCI to either SVGs or in native coronary arteries in prior CABG patients are technically more challenging compared to CABG-naïve patients. This may reveal uncertainties about performing complex PCI when the procedural risk may be felt to be higher than potential benefits.

Once baseline differences were adjusted for, we observed that the odds of in-hospital mortality, MACCE and major bleeding were similar between prior-CABG and CABG-naïve cohorts. Our findings are consistent with previously reported observational studies data by Teixeira et.al. and Kim et.al. In an analysis of 1,495 consecutive patients (Prior CABG: 73), Teixeira et.al. reported no significant differences in in-hospital mortality (9.5% vs 5.9%, P= 0.2), or mortality at 1-year (9.8% vs 9.1, P=0.84), MACCE at 1-year (22 vs 17%, P=0.37) and almost 50% patients underwent invasive coronary angiogram during hospital admission.47 However, relatively small numbers, single center data and lack of robust adjustments for differences in baseline clinical characteristics were the main limitations of this study. In an analysis of 47,557 NSTEMI patients (Prior CABG: 8,790), Kim and colleagues observed similar adjusted odds of bleeding (OR: 1, 95% CI 0.92 – 1.11) and in-hospital mortality (OR: 0.99, 95% CI 0.87 – 1.11). However, in contrast to our study, neither of these studies analyzed the effect of PCI on clinical outcomes in prior CABG patients. There are many possible explanations of these observations. It has been previously reported that acute MI patients who had prior CABG presented with smaller sized infarcts as measured by peak creatinine kinase levels or with subsequent formation of Q waves on ECG.48, 49 Prior CABG patients develop collateral circulations, which reduced infarct size. 48, 50 Secondly, these patients may have obstruction of a segment that is distal to the graft anastomosis, resulting in small area myocardial infarction. Thirdly, prior CABG patients may have a MI due to occlusion of small branch, wherein the native coronary artery is protected by a patent graft.51. Alternatively, if the graft occluded during an MI, the downstream myocardium may still be perfused through the native coronary vessel.

Our analysis indicates lower adjusted odds of in-hospital mortality, acute ischaemic stroke & MACCE in those prior-CABG patients who received PCI compared to medical management without any additional risk of major bleeding. This is an important finding in this study as PCI was under-utilized as the revascularization strategy of choice in acute MI patients who had prior CABG, even though it was associated with better clinical outcomes compared to medical management. These findings may provide insight to physicians around the utility of an invasive management strategy in this patient group. Prospective, randomized control clinical data are needed to validate these observational findings.

**Strengths and limitations**

This study has several strengths. This is the largest ever study to assess management strategies, temporal trends, and clinical outcomes of patients with a history of coronary artery bypass graft (CABG) surgery and presenting with acute MI. Large sample size of this study gives us adequate statistical power to capture differences in clinical outcomes between the patient grouped studied. Moreover, given patients with prior CABG are often excluded or under-represented in landmark PCI trials, and so our data represents best available current evidence in this cohort.

This study has several limitations. First, the NIS is an administrative database that may be vulnerable to coding inaccuracies, although the utilization of ICD-9 codes has been validated in many previous publications.52, 53 Second, although the NIS dataset included many variables of interest, additional information like blood investigations, imaging details, antiplatelets and antithrombotic regimens, procedural details, operator experience, information about culprit vessels, infarct size, pharmacotherapy and lesion characteristics are not routinely collected and may provide additional information for risk stratification, case complexity and procedural outcomes. Third, NIS only records in-hospital clinical outcomes and it is possible that long-term follow-up data may demonstrate even greater differences in clinical outcomes between PCI and medical management in prior CABG patients. Fourth, it is possible that type 2 myocardial infarctions were also coded as acute MI and hence included in the study. If so, it is possible that there were more type 2 myocardial infarctions (e.g. sepsis etc) in patients that had prior CABG, because there were older and had more comorbidities. This may contribute to a less “invasive” approach, and many of these patients would not even undergo coronary angiography. Finally, it is not clear from NIS dataset whether the ACS event was due to a ruptured plaque in either the graft or native vessel, which may impact on clinical outcomes differently.

**Conclusion**

Our study demonstrates that invasive coronary angiography was offered in less than half of patients with prior CABG who presented with acute MI with only a quarter of patients receiving PCI. The odds of receiving invasive management remained low in the prior-CABG patients even after adjustment of baseline differences. We did not observe any significant difference in in-hospital MACCE, mortality and major bleeding between prior CABG & CABG naïve patients who presented with acute MI. Lower odds of in-hospital MACCE and mortality were observed in prior CABG patients who underwent PCI compared to medical management without any increased odds of major bleeding. A randomized control clinical trial is needed to assess differences between contemporary invasive and medical therapies in prior CABG patients who presented with acute MI.

**References**

**1.** Roger VL, Go AS, Lloyd-Jones DM, et al. Heart disease and stroke statistics--2011 update: a report from the American Heart Association. *Circulation.* 2011;123:e18-e209.

**2.** Goldman S, Zadina K, Moritz T, et al. Long-term patency of saphenous vein and left internal mammary artery grafts after coronary artery bypass surgery: results from a Department of Veterans Affairs Cooperative Study. *Journal of the American College of Cardiology.* 2004;44:2149-2156.

**3.** Solo K, Lavi S, Kabali C, et al. Antithrombotic treatment after coronary artery bypass graft surgery: systematic review and network meta-analysis. *Bmj.* 2019;367:l5476.

**4.** Pereg D, Fefer P, Samuel M, et al. Native coronary artery patency after coronary artery bypass surgery. *JACC. Cardiovascular interventions.* 2014;7:761-767.

**5.** Brilakis ES, O'Donnell CI, Penny W, et al. Percutaneous Coronary Intervention in Native Coronary Arteries Versus Bypass Grafts in Patients With Prior Coronary Artery Bypass Graft Surgery: Insights From the Veterans Affairs Clinical Assessment, Reporting, and Tracking Program. *JACC. Cardiovascular interventions.* 2016;9:884-893.

**6.** Brilakis ES, Rao SV, Banerjee S, et al. Percutaneous coronary intervention in native arteries versus bypass grafts in prior coronary artery bypass grafting patients: a report from the National Cardiovascular Data Registry. *JACC. Cardiovascular interventions.* 2011;4:844-850.

**7.** Gyenes G, Norris CM, Graham MM. Percutaneous revascularization improves outcomes in patients with prior coronary artery bypass surgery. *Catheterization and cardiovascular interventions : official journal of the Society for Cardiac Angiography & Interventions.* 2013;82:E148-154.

**8.** Nikolsky E, McLaurin BT, Cox DA, et al. Outcomes of patients with prior coronary artery bypass grafting and acute coronary syndromes: analysis from the ACUITY (Acute Catheterization and Urgent Intervention Triage Strategy) trial. *JACC. Cardiovascular interventions.* 2012;5:919-926.

**9.** Shoaib A, Kinnaird T, Curzen N, et al. Outcomes Following Percutaneous Coronary Intervention in Non-ST-Segment-Elevation Myocardial Infarction Patients With Coronary Artery Bypass Grafts. *Circulation. Cardiovascular interventions.* 2018;11:e006824.

**10.** Pocock SJ, Henderson RA, Rickards AF, et al. Meta-analysis of randomised trials comparing coronary angioplasty with bypass surgery. *Lancet.* 1995;346:1184-1189.

**11.** Henderson RA, Pocock SJ, Sharp SJ, et al. Long-term results of RITA-1 trial: clinical and cost comparisons of coronary angioplasty and coronary-artery bypass grafting. Randomised Intervention Treatment of Angina. *Lancet.* 1998;352:1419-1425.

**12.** Risum O, Abdelnoor M, Svennevig JL, Levorstad K, Nitter-Hauge S. Risk factors of recurrent angina pectoris and of non-fatal myocardial infarction after coronary artery bypass surgery. *European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery.* 1996;10:173-178.

**13.** Hannan EL, Racz MJ, Walford G, et al. Predictors of readmission for complications of coronary artery bypass graft surgery. *JAMA : the journal of the American Medical Association.* 2003;290:773-780.

**14.** First-year results of CABRI (Coronary Angioplasty versus Bypass Revascularisation Investigation). CABRI Trial Participants. *Lancet.* 1995;346:1179-1184.

**15.** Coronary artery bypass surgery versus percutaneous coronary intervention with stent implantation in patients with multivessel coronary artery disease (the Stent or Surgery trial): a randomised controlled trial. *Lancet.* 2002;360:965-970.

**16.** Brooks MM, Jones RH, Bach RG, et al. Predictors of mortality and mortality from cardiac causes in the bypass angioplasty revascularization investigation (BARI) randomized trial and registry. For the BARI Investigators. *Circulation.* 2000;101:2682-2689.

**17.** Berry C, Pieper KS, White HD, et al. Patients with prior coronary artery bypass grafting have a poor outcome after myocardial infarction: an analysis of the VALsartan in acute myocardial iNfarcTion trial (VALIANT). *European heart journal.* 2009;30:1450-1456.

**18.** Prejean SP, Din M, Reyes E, Hage FG. Guidelines in review: Comparison of the 2014 AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes and the 2015 ESC guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *Journal of nuclear cardiology : official publication of the American Society of Nuclear Cardiology.* 2018;25:769-776.

**19.** Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC Guideline for the Management of Patients with Non-ST-Elevation Acute Coronary Syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology.* 2014;64:e139-e228.

**20.** Jobs A, Thiele H. [ESC guidelines 2015. Non-ST-elevation acute coronary syndrome]. *Herz.* 2015;40:1027-1033.

**21.** Effects of tissue plasminogen activator and a comparison of early invasive and conservative strategies in unstable angina and non-Q-wave myocardial infarction. Results of the TIMI IIIB Trial. Thrombolysis in Myocardial Ischemia. *Circulation.* 1994;89:1545-1556.

**22.** Silva PR, Hueb WA, Cesar LA, Oliveira SA, Ramires JA. [Comparative study of the results of coronary artery bypass grafting and angioplasty for myocardial revascularization in patients with equivalent multivessel disease]. *Arquivos brasileiros de cardiologia.* 2005;84:214-221.

**23.** Fox KA, Poole-Wilson PA, Henderson RA, et al. Interventional versus conservative treatment for patients with unstable angina or non-ST-elevation myocardial infarction: the British Heart Foundation RITA 3 randomised trial. Randomized Intervention Trial of unstable Angina. *Lancet.* 2002;360:743-751.

**24.** Fox KA, Poole-Wilson P, Clayton TC, et al. 5-year outcome of an interventional strategy in non-ST-elevation acute coronary syndrome: the British Heart Foundation RITA 3 randomised trial. *Lancet.* 2005;366:914-920.

**25.** Held C, Tornvall P, Stenestrand U. Effects of revascularization within 14 days of hospital admission due to acute coronary syndrome on 1-year mortality in patients with previous coronary artery bypass graft surgery. *European heart journal.* 2007;28:316-325.

**26.** Gurfinkel EP, Perez de la Hoz R, Brito VM, et al. Invasive vs non-invasive treatment in acute coronary syndromes and prior bypass surgery. *International journal of cardiology.* 2007;119:65-72.

**27.** Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol.* 1992;45:613-619.

**28.** Rashid M, Fischman DL, Gulati M, et al. Temporal trends and inequalities in coronary angiography utilization in the management of non-ST-Elevation acute coronary syndromes in the U.S. *Scientific reports.* 2019;9:240.

**29.** Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC Guideline for the Management of Patients With Non-ST-Elevation Acute Coronary Syndromes. *A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines.* 2014.

**30.** Roffi M, Patrono C, Collet JP, et al. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology (ESC). *European heart journal.* 2016;37:267-315.

**31.** 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). *European heart journal.* 2018;39:119-177.

**32.** Wallentin L, Lindhagen L, Arnstrom E, et al. Early invasive versus non-invasive treatment in patients with non-ST-elevation acute coronary syndrome (FRISC-II): 15 year follow-up of a prospective, randomised, multicentre study. *Lancet.* 2016;388:1903-1911.

**33.** Peterson ED, Roe MT, Rumsfeld JS, et al. A call to ACTION (acute coronary treatment and intervention outcomes network): a national effort to promote timely clinical feedback and support continuous quality improvement for acute myocardial infarction. *Circulation. Cardiovascular quality and outcomes.* 2009;2:491-499.

**34.** Subherwal S, Bach RG, Chen AY, et al. Baseline risk of major bleeding in non-ST-segment-elevation myocardial infarction: the CRUSADE (Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines) Bleeding Score. *Circulation.* 2009;119:1873-1882.

**35.** Cannon CP, Weintraub WS, Demopoulos LA, Robertson DH, Gormley GJ, Braunwald E. Invasive versus conservative strategies in unstable angina and non-Q-wave myocardial infarction following treatment with tirofiban: rationale and study design of the international TACTICS-TIMI 18 Trial. Treat Angina with Aggrastat and determine Cost of Therapy with an Invasive or Conservative Strategy. Thrombolysis In Myocardial Infarction. *The American journal of cardiology.* 1998;82:731-736.

**36.** Damman P, Wallentin L, Fox KA, et al. Long-term cardiovascular mortality after procedure-related or spontaneous myocardial infarction in patients with non-ST-segment elevation acute coronary syndrome: a collaborative analysis of individual patient data from the FRISC II, ICTUS, and RITA-3 trials (FIR). *Circulation.* 2012;125:568-576.

**37.** Jolly SS, Faxon DP, Fox KA, et al. Efficacy and safety of fondaparinux versus enoxaparin in patients with acute coronary syndromes treated with glycoprotein IIb/IIIa inhibitors or thienopyridines: results from the OASIS 5 (Fifth Organization to Assess Strategies in Ischemic Syndromes) trial. *Journal of the American College of Cardiology.* 2009;54:468-476.

**38.** Thiele H, Rach J, Klein N, et al. Optimal timing of invasive angiography in stable non-ST-elevation myocardial infarction: the Leipzig Immediate versus early and late PercutaneouS coronary Intervention triAl in NSTEMI (LIPSIA-NSTEMI Trial). *European heart journal.* 2012;33:2035-2043.

**39.** Savonitto S, Cavallini C, Petronio AS, et al. Early aggressive versus initially conservative treatment in elderly patients with non-ST-segment elevation acute coronary syndrome: a randomized controlled trial. *JACC. Cardiovascular interventions.* 2012;5:906-916.

**40.** Lee MM, Petrie MC, Rocchiccioli P, et al. Non-invasive versus invasive management in patients with prior coronary artery bypass surgery with a non-ST segment elevation acute coronary syndrome: study design of the pilot randomised controlled trial and registry (CABG-ACS). *Open heart.* 2016;3:e000371.

**41.** Tegn N, Abdelnoor M, Aaberge L, et al. Invasive versus conservative strategy in patients aged 80 years or older with non-ST-elevation myocardial infarction or unstable angina pectoris (After Eighty study): an open-label randomised controlled trial. *Lancet.* 2016;387:1057-1065.

**42.** Sanchis J, Nunez E, Barrabes JA, et al. Randomized comparison between the invasive and conservative strategies in comorbid elderly patients with non-ST elevation myocardial infarction. *European journal of internal medicine.* 2016;35:89-94.

**43.** Lee MMY, Petrie MC, Rocchiccioli P, et al. Invasive Versus Medical Management in Patients With Prior Coronary Artery Bypass Surgery With a Non-ST Segment Elevation Acute Coronary Syndrome. *Circulation. Cardiovascular interventions.* 2019;12:e007830.

**44.** Kim MS, Wang TY, Ou FS, et al. Association of prior coronary artery bypass graft surgery with quality of care of patients with non-ST-segment elevation myocardial infarction: a report from the National Cardiovascular Data Registry Acute Coronary Treatment and Intervention Outcomes Network Registry-Get With the Guidelines. *American heart journal.* 2010;160:951-957.

**45.** Bhatt DL, Roe MT, Peterson ED, et al. Utilization of early invasive management strategies for high-risk patients with non-ST-segment elevation acute coronary syndromes: results from the CRUSADE Quality Improvement Initiative. *JAMA : the journal of the American Medical Association.* 2004;292:2096-2104.

**46.** Varghese I, Samuel J, Banerjee S, Brilakis ES. Comparison of percutaneous coronary intervention in native coronary arteries vs. bypass grafts in patients with prior coronary artery bypass graft surgery. *Cardiovascular revascularization medicine : including molecular interventions.* 2009;10:103-109.

**47.** Teixeira R, Lourenco C, Antonio N, et al. Can we improve outcomes in patients with previous coronary artery bypass surgery admitted for acute coronary syndrome? *Revista espanola de cardiologia.* 2010;63:554-563.

**48.** Grines CL, Booth DC, Nissen SE, et al. Mechanism of acute myocardial infarction in patients with prior coronary artery bypass grafting and therapeutic implications. *The American journal of cardiology.* 1990;65:1292-1296.

**49.** Wiseman A, Waters DD, Walling A, Pelletier GB, Roy D, Theroux P. Long-term prognosis after myocardial infarction in patients with previous coronary artery bypass surgery. *Journal of the American College of Cardiology.* 1988;12:873-880.

**50.** Charney R, Cohen M. The role of the coronary collateral circulation in limiting myocardial ischemia and infarct size. *American heart journal.* 1993;126:937-945.

**51.** Crean PA, Waters DD, Bosch X, Pelletier GB, Roy D, Theroux P. Angiographic findings after myocardial infarction in patients with previous bypass surgery: explanations for smaller infarcts in this group compared with control patients. *Circulation.* 1985;71:693-698.

**52.** Birman-Deych E, Waterman AD, Yan Y, Nilasena DS, Radford MJ, Gage BF. Accuracy of ICD-9-CM codes for identifying cardiovascular and stroke risk factors. *Medical care.* 2005;43:480-485.

**53.** DeShazo JP, Hoffman MA. A comparison of a multistate inpatient EHR database to the HCUP Nationwide Inpatient Sample. *BMC health services research.* 2015;15:384.

**Figure 1: Central Illustration figure**

**Legend**: Overview of important study findings

CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention, MACCE; Major adverse cardiovascular & cerebrovascular events, NSTEMI: non-ST-elevation, PVD; Peripheral vascular disease, Myocardial Infarction, STEMI: ST Elevation myocardial infarction, AF; Atrial fibrillation, DM; Diabetes Mellitus, MI; Myocardial Infarction, VT; Ventricular tachycardia, VF; Ventricular fibrillation,

**Table 1: Clinical characteristics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable/Group (%)** | **Total** | **CABG Naïve** | **Prior CABG** | **P-value** |
| Number of patients | 7,250,768 | 6,801,220 | 449,548 |  |
| Age (years), median (IQR) | 68 (57-79) | 67 (56-79) | 73 (64-82) | <.001 |
| Males, % | 60% | 60% | 69% | <.001 |
| **Ethnicity, %** |  |  |  |  |
| White | 77% | 77% | 80% | <.001 |
| Black | 10% | 10% | 7% |
| Hispanic | 7% | 7% | 7% |
| Asian/Pacific Islander | 2% | 2% | 2% |
| Native American | 1% | 1% | 1% |
| Other | 3% | 3% | 3% |
| **Clinical syndrome, %** |  |  |  |  |
| NSTEMI ACS, % | 65% | 69% | 87% | <.001 |
| STEMI, % | 29% | 31% | 13% | <.001 |
| Weekend admission, % | 26% | 26% | 27% | <.001 |
| Shock, % during admission | 5% | 5% | 3% | <.001 |
| Cardiac Arrest, % | 3% | 3% | 2% | <.001 |
| Paroxysmal Ventricular tachycardia, % | 6% | 6% | 5% | <.001 |
| Ventricular fibrillation / flutter, % | 2.7% | 2.8% | 1.5% | <.001 |
| **Comorbidities, %** |  |  |  |  |
| Hypercholesterolemia | 49% | 49% | 55% | <.001 |
| Thrombocytopenia | 3% | 3.2% | 3.2% | .58 |
| Smoking | 35% | 35% | 30% | <.001 |
| Atrial fibrillation / flutter | 17% | 17% | 21% | <.001 |
| Previous MI | 9% | 8% | 17% | <.001 |
| Previous PCI | 10% | 9% | 16% | <.001 |
| Previous CVA | 3% | 3% | 5% | <.001 |
| Family history of CAD | 7% | 7% | 4% | <.001 |
| Alcohol abuse | 3% | 3% | 1.5% | <.001 |
| Anaemia | 15% | 14% | 18% | <.001 |
| Rheumatoid arthritis/collagen  vascular diseases | 2.2% | 2.2% | 1.8% | <.001 |
| Congestive heart failure | 0.87% | 0.88% | 0.80% | <.001 |
| Chronic pulmonary disease | 21% | 21% | 22% | <.001 |
| Coagulopathy | 4.4% | 4% | 4.4% | <.001 |
| Depression | 6% | 6% | 7% | <.001 |
| Diabetes | 28% | 28% | 38% | <.001 |
| Drug abuse | 2% | 2% | 1% | <.001 |
| Hypertension | 67% | 75% | 66% | <.001 |
| Hypothyroidism | 10% | 10% | 11% | <.001 |
| Liver disease | 1.2% | 1.2% | 1% | <.001 |
| Lymphomas | 0.49% | 0.49% | 0.48% | .63 |
| Fluid and electrolyte disturbances | 19% | 19% | 17% | <.001 |
| Metastatic cancer | 0.86% | 0.87% | 0.74% | <.001 |
| Other neurological disorders | 5.8% | 5.7% | 6% | <.001 |
| Obesity | 12% | 12% | 10% | <.001 |
| Paralysis | 1.6% | 1.7% | 1.6% | .13 |
| Peripheral vascular disease | 11% | 10% | 18% | <.001 |
| Psychoses | 2% | 1.7% | 2.1% | <.001 |
| Pulmonary circulation disorder | 0.1% | 0.1% | 0.1% | .14 |
| Renal failure (chronic) | 17% | 16% | 27% | <.001 |
| Solid tumour without metastases | 1.4% | 1.4% | 1.7% | <.001 |
| Valvular heart disease | 0.25% | 0.25% | 0.27% | .17 |
| Weight loss | 2.1% | 2.2% | 1.5% | <.001 |
| Dementia | 1.9% | 1.9% | 2.1% | <.001 |
| **Hospital bed size, %** |  |  |  |  |
| Small | 11% | 11% | 12% | <.001 |
| Medium | 25% | 25% | 26% |
| Large | 64% | 64% | 62% |
| **Hospital Region, %** |  |  |  |  |
| Northeast | 19% | 19% | 20% | <.001 |
| Midwest | 23% | 23% | 21% |
| South | 41% | 40% | 41% |
| West | 17% | 18% | 18% |
| **Location/ Teaching status, %** |  |  |  |  |
| Rural | 10% | 10% | 12% | <.001 |
| Urban non-teaching | 41% | 41% | 43% |
| Urban- teaching | 49% | 49% | 45% |
| **Primary expected payer, %** |  |  |  |  |
| Medicare | 57% | 56% | 75% | <.001 |
| Medicaid | 6% | 6% | 4% |  |
| Private Insurance | 27% | 28% | 16% |  |
| Self-pay | 6% | 6% | 2% |  |
| No charge | 0.56% | 0.59% | 0.2% |  |
| other | 3% | 3% | 2% |  |
| **Median Household Income (percentile),** % |  |  |  |  |
| 0-25th | 29% | 29% | 30% | <.001 |
| 26-50th | 27% | 27% | 28% |  |
| 51-75th | 24% | 24% | 23% |  |
| 76-100th | 20% | 20% | 19% |  |

AMI: acute myocardial infarction; CABG: coronary artery bypass graft; CAD: coronary artery disease; CVA: cerebrovascular accident (stroke or transient ischaemic attack); IHD: ischaemic heart disease; IQR: interquartile range; NSTEMI ACS: non-ST-elevation MI acute coronary syndrome; PCI: percutaneous coronary intervention; STEMI: ST Elevation myocardial infarction

**Table 2: Management approach & crude clinical outcomes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable Group (%) | Total | CABG Naive | Prior CABG | P-value |
| Number of patients | 7,250,768 | 6,801,220 | 449,548 |  |
| Medical management (No CABG/PCI) | 49% | 47% | 73% | <.001 |
| Angiogram | 67% | 68% | 48% | <.001 |
| CABG | 9% | 9% | 1% | <.001 |
| **Percutaneous coronary intervention (PCI)** |  |  |  |  |
| PCI performed | 43% | 44% | 26% | <.001 |
| PCI with Bare metal stent | 12% | 12% | 6% | <.001 |
| PCI with Drug eluting stent | 30% | 30% | 18% | <.001 |
| **Number of stents** |  |  |  |  |
| 1 | 21% | 22% | 12% | <.001 |
| 2 | 8% | 9% | 5% | <.001 |
| 3 | 3% | 3% | 1.6% | <.001 |
| 4+ | 1.1% | 1.1% | 0.7% | <.001 |
| Unknown | 10% | 9% | 7% | <.001 |
| **Number of vessels stented** |  |  |  |  |
| 1 | 28% | 28% | 17% | <.001 |
| 2 | 5% | 5% | 3% | <.001 |
| 3 | 0.74% | 0.75% | 0.57% | <.001 |
| 4+ | 0.14% | 0.14% | 0.14% | .54 |
| Bifurcating PCI | 0.82% | 0.83% | 0.44% | <.001 |
| FFR assessment | 0.46% | 0.47% | 0.26% | <.001 |
| Intracoronary imaging | 1.8% | 1.9% | 0.96% | <.001 |
|  |  |  |  |  |
| Use of mechanical circulatory support (IABP or other assisted devices) | 5% | 5% | 2% | <.001 |
| **Crude outcomes** |  |  |  |  |
| MACCE, % | 7.7% | 8% | 7% | <.001 |
| All-cause mortality, % | 5.8% | 5.8% | 5.5% | <.001 |
| Acute ischaemic stroke, % | 1.66% | 1.68% | 1.3% | <.001 |
| Major bleeding, % | 3.6% | 3.63% | 3.12% | <.001 |
| Cardiac complications, % | 0.69% | 0.72% | 0.21% | <.001 |
| Length of stay (days), median (IQR) | 3 (2-6) | 3 (2-6) | 3 (2-5) | <.001 |
| Total charge (US Dollars), median (IQR) | 43,992 (22,884 – 76,729) | 44,906 (23,610 - 78,042) | 30,700 (15,454 – 56,526) | <.001 |

CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention; IABP: intra-aortic balloon pump, FFR; Fractional flow reserve, MACCE: Major acute cardiovascular and cerebrovascular events: composite of death, stroke and cardiac complications; IQR: interquartile range

Cardiac complication is composite of “cardiac tamponade, hemopericardium, coronary artery dissection, pericardial effusion and Pericardiocentesis”

**Table 3: Adjusted In-hospital clinical outcomes in CABG Naive vs Prior CABG (CABG Naive is the reference group)**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable/Group (%) | Odds Ratio | 95% CI | P-value |
| MACCE | 0.98 | 0.95 – 1.005 | .11 |
| All-cause mortality | 1 | 0.98 – 1.04 | .6 |
| Acute Ischaemic Stroke | 0.89 | 0.84-0.95 | <.001 |
| Major bleeding | 0.99 | 0.94 – 1.03 | .54 |

CABG: coronary artery bypass grafting; MACCE: Major acute cardiovascular

and cerebrovascular events: composite of death, stroke and cardiac complications; CI: confidence interval

**Table 4: Adjusted In-hospital clinical outcomes in Prior CABG patients who received PCI vs Medical management\* (Medical management is reference group)**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable/Group (%) | Odds Ratio | 95% CI | P-value |
| MACCE, % | 0.64 | 0.57– 0.72 | <.001 |
| All-cause mortality, % | 0.45 | 0.38 – 0.53 | <.001 |
| Acute Ischaemic stroke, % | 0.71 | 0.59 – 0.86 | <.001 |
| All-cause bleeding, % | 1.08 | 0.94 – 1.23 | .26 |

CABG: coronary artery bypass grafting; MACCE: Major acute cardiovascular

and cerebrovascular events: composite of death, stroke and cardiac complications

in PCI and CABG in addition to thoracic complications in CABG; CI: confidence interval

\* After exclusion of CABG naïve patients and those who have prior CABG but received redo CABG during index admission

**Supplement figure 1: Flowchart indicating available sample**

Total NIS records who admitted with Acute Myocardial Infarction during study period: 1,546,350

Missing records for primary diagnosis: 40,205

Missing records for age: 105

Missing records for gender: 159

Missing records for in-hospital death: 621

Remaining records for analysis (non-weighted): 1,505,260

* Prior CABG – 93,066
* CABG Naïve – 1,412,194

Weighted\* records for analysis: 7,250,768

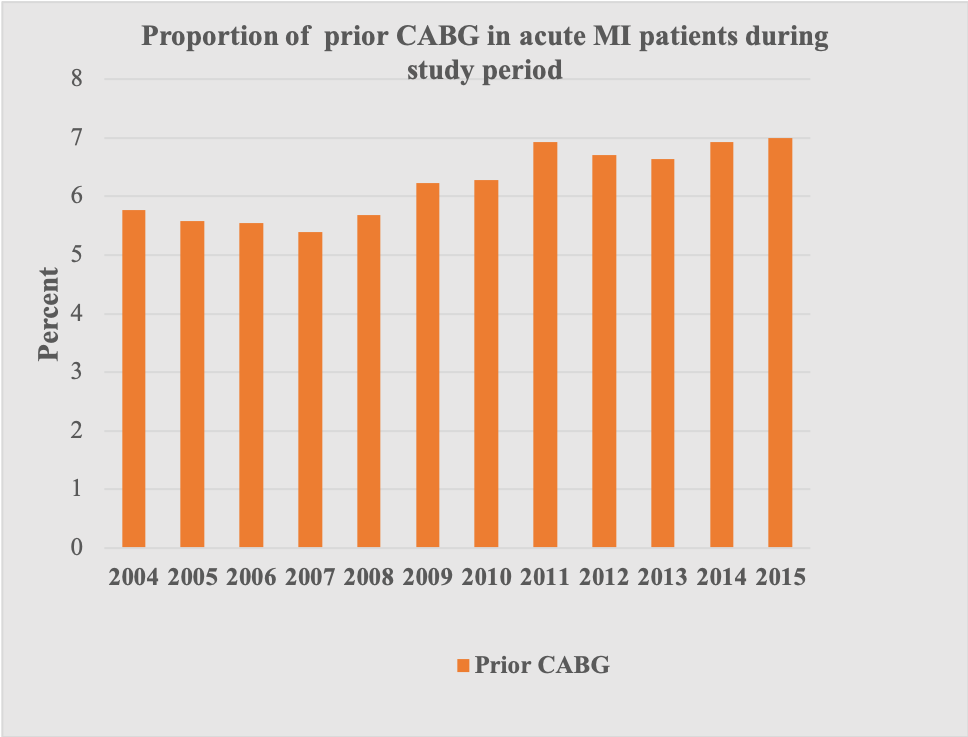
* Prior CABG: 449,548
* CABG Naive: 6,801,220

**Legend: Description of inclusion & exclusion criteria**

\* NIS data is survey data collected from 20% of hospitals from the US. “Weighted” patients are total number of patients after applying the discharge weights as per HCUP recommendations to produce national estimates

CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention, NIS; National in-patient sample, HCUP; Healthcare cost & utilization project

**Supplement figure 2: Proportion of Prior-CABG in total acute MI patients during study period**

****

**Legend: Temporal trend of percentage of prior CABG in total acute MI patients from 2004-2015**

CABG: coronary artery bypass grafting, MI: Myocardial infarction

**Supplement Figure 3: Temporal trends of management strategy from 2004-2015**



**P for trend for Management strategy in Prior CABG patients - <.001**

**P for trend for Management strategy in CABG naïve patients - <.001**

**Legend: Management approach during study period**

CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention

**Supplement figure 4: In-hospital Mortality & MACCE in patients who received PCI vs Medical Management**



**Legend: Comparisons of in-hospital & mortality & MACCE who received PCI against medical management**

MI; Myocardial Infarction, CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention, MACCE; Major adverse cardiovascular & cerebrovascular events

**Supplement table 1: Search Codes**

|  |  |  |
| --- | --- | --- |
| Variables | Source | Codes |
| Diagnosis |  |  |
| STEMI |  | 410.0x, 410.1x, 410.2x, 410.3x,  410.4x, 410.5x, 410.6x, 410.8x |
| NSTEMI |  | 410.70, 410.71, 410.72 |
| Dyslipidaemia |  | 53 |
| Smoking Status |  | V15.82, 305.1 |
| Atrial Fibrilation/flutter |  | 427.3\* |
| History of IHD |  | 414.00-07, 414.2-9 |
| Previous MI |  | 412 |
| Previous PCI |  | V45.82 |
| Previous CABG |  | V45.81 |
| Family history of CAD |  | V17.3 |
| Previous CVA (TIA and  Stroke) |  | V12.54 |
| Dementia (Presenile, Senile,  Vascular and Alzheimer’s) |  | 290.10-13, 290.20-21, 290.40-  43, 294.10-11, 331.0 |
| Thrombocytopenia |  | 287.5, 287.49 |
| Cardiac arrest |  | 427.5\* |
| Ventricular Fibrillation / Flutter |  | 427.4\* |
| In-hospital procedures and outcomes | | |
| Acute ischaemic stroke |  | 433.01, 433.11, 433.21, 433.31,  433.81, 433.91, 434.01, 434.11,  434.91, 435.0-1, 435.8-9, 436 |
| Major bleeding |  | 430 431 432\* 4590 578\* 7847 7863 99811 |
| Shock during admission |  | 785.51 |
| Coronary angiography |  | 8855 3722 3723 8854 8853 8856 0066 3601 3602 3605 3606 3607\* |
| Use of assist device or IABP |  | 37.68, 37.61 |
| Hemopericardium |  | 423.0 |
| Pericardiocentesis |  | 37.0 |
| Cardiac tamponade |  | 423.3 |
| CABG |  | 44 |
| PCI |  | 00.66, 36.01, 36.02, 36.05 |
| Coronary dissection |  | 414.12 |
| Single vessel PCI |  | 00.40 |
| Two vessel PCI |  | 00.41 |
| Three vessel PCI |  | 00.42 |
| Four vessel PCI |  | 00.43 |
| Single stent |  | 00.45 |
| Two stents |  | 00.46 |
| Three stents |  | 00.47 |
| Four stents |  | 00.48 |
| Drug eluting stent |  | 36.07 |
| Bare metal stent |  | 36.06 |

AMI: acute myocardial infarction; CABG: coronary artery bypass graft; CAD: coronary artery disease; CVA: cerebrovascular accident (stroke or transient ischaemic attack); IHD: ischaemic heart disease; IQR: interquartile range; NSTEMI ACS: non-ST-elevation MI acute coronary syndrome; PCI: percutaneous coronary intervention; STEMI: ST Elevation myocardial infarction

**Supplement table 2: Clinical characteristics of Prior CABG patients who received PCI vs Medical management**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable/Group (%)** | **Total** | **Medical Management** | **PCI treatment** | **P-value** |
| Number of patients | 443,855 | 327,876 | 115,979 |  |
| Age (years), median (IQR) | 73 (64-82) | 75 (66 -83) | 68 (60-77) | <.001 |
| Males, % | 69% | 67% | 74% | <.001 |
| **Ethnicity, %** |  |  |  |  |
| White | 80% | 80% | 81% | <.001 |
| Black | 7% | 8% | 7% |
| Hispanic | 7% | 7% | 7% |
| Asian/Pacific Islander | 2% | 2% | 2% |
| Native American | 0.53% | 0.49% | 0.65% |
| Other | 3% | 2% | 3% |
| **Clinical syndrome, %** |  |  |  |  |
| NSTEMI ACS, % | 81% | 84% | 73% | <.001 |
| STEMI, % | 13% | 9% | 24% | <.001 |
| Weekend admission, % | 27% | 27% | 25% | <.001 |
| Elective Admission, % | 6% | 5% | 8% | <.001 |
| **Primary expected payer, %** |  |  |  |  |
| Medicare | 75% | 78% | 64% | <.001 |
| Medicaid | 4% | 4% | 5% |
| Private Insurance | 16% | 14% | 23% |
| Self-pay | 2% | 2% | 4% |
| No charge | 0.22% | 0.17% | 0.37% |
| other | 2% | 2% | 3% |
| Median Household Income  (percentile), % |  |  |  |  |
| 0-25th | 30% | 29% | 30% | <.001 |
| 26-50th | 28% | 27% | 28% |
| 51-75th | 23% | 23% | 24% |
| 76-100th | 20% | 20% | 18% |
| Shock, % during admission | 3% | 2.5% | 3.4% | <.001 |
| Cardiac Arrest, % | 2.2% | 2.4% | 1.75% | <.001 |
| Paroxysmal Ventricular tachycardia, % | 5% | 5% | 5% | .52 |
| Ventricular fibrillation / flutter, % | 1.45% | 1.25% | 2% | <.001 |
| **Comorbidities, %** |  |  |  |  |
| Hypercholesterolemia | 55% | 51% | 65% | <.001 |
| Thrombocytopenia | 3% | 3.2% | 2.7% | <.001 |
| Smoking | 30% | 27% | 36% | <.001 |
| Atrial fibrillation / flutter | 21% | 23% | 15% | <.001 |
| Previous MI | 17% | 16.6% | 17.3% | .03 |
| Previous PCI | 16% | 15% | 20% | <.001 |
| Previous CVA | 5% | 5% | 4% | <.001 |
| Family history of CAD | 4% | 3% | 5% | <.001 |
| Alcohol abuse | 1.5% | 1.43% | 1.76% | <.001 |
| Anaemia | 18% | 20% | 12% | <.001 |
| Rheumatoid arthritis/collagen  vascular diseases | 2% | 2% | 2% | .84 |
| Congestive heart failure | 0.8% | 1% | 0.1% | <.001 |
| Chronic pulmonary disease | 22% | 24% | 18% | <.001 |
| Coagulopathy | 4% | 4% | 3% | <.001 |
| Depression | 7% | 7% | 6% | <.001 |
| Diabetes | 38% | 38% | 37% | .03 |
| Drug abuse | 1% | 0.95% | 1.12% | .03 |
| Hypertension | 75% | 74% | 77% | <.001 |
| Hypothyroidism | 12% | 12% | 9% | <.001 |
| Liver disease | 1% | 1.1% | 0.87% | .01 |
| Lymphomas | 0.48% | 0.53% | 0.34% | .63 |
| Fluid and electrolyte disturbances | 17% | 19% | 12% | <.001 |
| Metastatic cancer | 0.75% | 0.91% | 0.28% | <.001 |
| Other neurological disorders | 6% | 7% | 4% | <.001 |
| Obesity | 10% | 9% | 12% | <.001 |
| Paralysis | 2% | 2% | 1% | .13 |
| Peripheral vascular disease | 18% | 19% | 16% | <.001 |
| Psychoses | 2% | 2% | 1% | <.001 |
| Pulmonary circulation disorder | 0.08% | 0.11% | 0.01% | <.001 |
| Renal failure (chronic) | 27% | 30% | 18% | <.001 |
| Solid tumour without metastases | 2% | 2% | 1% | <.001 |
| Valvular heart disease | 0.27% | 0.36% | 0.02% | <.001 |
| Weight loss | 2% | 2% | 1% | <.001 |
| Dementia | 2% | 3% | 1% | <.001 |
| **Hospital bed size, %** |  |  |  |  |
| Small | 12% | 14% | 8% | <.001 |
| Medium | 26% | 27% | 22% |
| Large | 62% | 59% | 70% |
| **Hospital Region, %** |  |  |  |  |
| Northeast | 20% | 21% | 16% | <.001 |
| Midwest | 21% | 20% | 24% |
| South | 41% | 40% | 44% |
| West | 18% | 18% | 16% |
| **Location/ Teaching status, %** |  |  |  |  |
| Rural | 12% | 15% | 6% | <.001 |
| Urban non-teaching | 43% | 45% | 38% |
| Urban- teaching | 45% | 40% | 56% |

AMI: acute myocardial infarction; CABG: coronary artery bypass graft; CAD: coronary artery disease; CVA:

cerebrovascular accident (stroke or transient ischaemic attack); IHD: ischaemic heart disease; IQR: interquartile range; NSTEMI ACS: non-ST-elevation MI acute coronary syndrome; PCI: percutaneous coronary intervention; STEMI: ST Elevation myocardial infarction

**Supplement table 3: In-hospital clinical outcomes in Prior CABG patients who received PCI vs Medical management\***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable/Group (%) | Total | PCI | Medical Management | P-value |
| Number of patients | 443,855 | 115,979 | 327,876 |  |
| MACCE, % | 7% | 3.5% | 8% | <.001 |
| All-cause mortality, % | 6% | 2% | 7% | <.001 |
| Acute Ischaemic stroke, % | 1.3% | 0.85% | 1.45% | <.001 |
| Major bleeding, % | 3.1% | 2.3% | 3.4% | <.001 |
| Cardiac complications, % | 0.2% | 0.63% | 0.04% | <.001 |
| Length of stay (days), median (IQR) | 2 (3-5) | 2 (3-4) | 2 (3-5) | <.001 |
| Total charge (US Dollars), median (IQR) | 30,232 (15,306 – 55,244) | 59,242 (42,106 – 87,595) | 21,930 (12,269 – 38,770) | <.001 |

CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention; MACCE: Major acute

cardiovascular and cerebrovascular events: composite of death, stroke and cardiac complications; IQR: interquartile range

Cardiac complication is composite of “cardiac tamponade, hemopericardium, coronary artery dissection, pericardial effusion and Pericardiocentesis”

\* After exclusion of CABG naïve patients and those who have prior CABG but received redo CABG during index admission

**Supplement table 4: Odds of receiving in-hospital coronary angiogram in prior CABG patients in Multivariate analysis**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Odds Ratio | P-value | Lower bound 95% CI | Upper bound 95% CI |
| Prior CABG | 0.37 | <.001 | 0.36 | 0.38 |
| Age | 0.95 | <.001 | 0.94 | 0.96 |
| Year\* 2005 | 1.14 | .05 | 0.99 | 1.31 |
| Year\* 2006 | 1.35 | <.001 | 1.19 | 1.55 |
| Year\* 2007 | 1.34 | <.001 | 1.18 | 1.52 |
| Year\* 2008 | 1.40 | <.001 | 1.22 | 1.60 |
| Year\* 2009 | 1.56 | <.001 | 1.37 | 1.78 |
| Year\* 2010 | 1.65 | <.001 | 1.44 | 1.88 |
| Year\* 2011 | 1.67 | <.001 | 1.46 | 1.91 |
| Year\* 2012 | 1.95 | <.001 | 1.73 | 2.20 |
| Year\* 2013 | 2.07 | <.001 | 1.83 | 2.33 |
| Year\* 2014 | 2.32 | <.001 | 2.05 | 2.62 |
| Year\* 2015 | 2.44 | <.001 | 2.16 | 2.77 |
| Female | 0.93 | <.001 | 0.92 | 0.94 |
| Anaemia | 0.82 | <.001 | 0.80 | 0.84 |
| Rheumatoid arthritis/collagen  vascular diseases | 1.035 | .02 | 1.004 | 1.067 |
| Chronic bleeding | 0.82 | <.001 | 0.78 | 0.86 |
| Congestive heart failure | 0.44 | <.001 | 0.41 | 0.47 |
| Chronic pulmonary disease | 0.84 | <.001 | 0.82 | 0.85 |
| Coagulopathy | 1.03 | .05 | 0.99 | 1.06 |
| Depression | 0.84 | <.001 | 0.82 | 0.86 |
| Diabetes (DM) | 0.84 | <.001 | 0.83 | 0.86 |
| DM with chronic complications | 0.75 | <.001 | 0.73 | 0.77 |
| Drug abuse | 0.59 | <.001 | 0.57 | 0.62 |
| Hypertension | 1.08 | <.001 | 1.06 | 1.10 |
| Hypothyroidism | 0.96 | <.001 | 0.95 | 0.98 |
| Liver disease | 0.74 | <.001 | 0.70 | 0.77 |
| Lymphomas | 0.86 | <.001 | 0.81 | 0.92 |
| Fluid and electrolyte disturbances | 0.77 | <.001 | 0.75 | 0.78 |
| Metastatic cancer | 0.36 | <.001 | 0.34 | 0.38 |
| Other Neurological disorders | 0.57 | <.001 | 0.56 | 0.59 |
| Obesity | 1.12 | <.001 | 1.09 | 1.15 |
| Paralysis | 0.57 | <.001 | 0.55 | 0.60 |
| Peripheral vascular disease | 1.07 | <.001 | 1.04 | 1.09 |
| Psychoses | 0.65 | <.001 | 0.63 | 0.68 |
| Renal failure (chronic) | 0.68 | <.001 | 0.67 | 0.69 |
| Solid tumour without metastases | 0.69 | <.001 | 0.67 | 0.69 |
| Weight loss | 0.78 | <.001 | 0.75 | 0.81 |
| Hospital bed size- Medium+ | 1.61 | <.001 | 1.41 | 1.84 |
| Hospital bed size - large+ | 2.52 | <.001 | 2.24 | 2.85 |
| Smoking | 1.21 | <.001 | 1.18 | 1.23 |
| Hypercholesterolemia | 1.52 | <.001 | 1.49 | 1.55 |
| Prior IHD | 5.64 | <.001 | 5.48 | 5.81 |
| Family history of IHD | 1.40 | <.001 | 1.33 | 1.47 |
| Prior MI | 0.70 | <.001 | 0.68 | 0.72 |
| Prior CVA | 0.81 | <.001 | 0.79 | 0.83 |
| Prior PCI | 0.83 | <.001 | 0.81 | 0.86 |
| Shock | 0.91 | <.001 | 0.88 | 0.94 |
| IABP Insertion | 6.88 | <.001 | 6.11 | 7.74 |
| AF | 0.92 | <.001 | 0.90 | 0.93 |
| VT | 1.35 | <.001 | 1.32 | 1.39 |
| VF | 1.41 | <.001 | 1.36 | 1.47 |
| STEMI presentation | 4.75 | <.001 | 4.54 | 4.98 |

\* Odds of getting Angio by Year of admission (reference Year 2004)

+ Small Hospital bed size is reference

AMI: acute myocardial infarction; CABG: coronary artery bypass graft; CAD: coronary artery disease; CVA: cerebrovascular accident (stroke or transient ischaemic attack); IHD: ischaemic heart disease; PCI: percutaneous coronary intervention; STEMI: ST Elevation myocardial infarction; IABP: Intra-aortic balloon pump; AF: Atrial fibrillation; VT: Ventricular tachycardia; VF: Ventricular fibrillation

**Supplement table 5: Odds of receiving in-hospital PCI in prior CABG patients in Multivariate analysis**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Odds Ratio | P-value | Lower bound 95% CI | Upper bound 95% CI |
| Prior CABG | 0.49 | <.001 | 0.48 | 0.50 |
| Age | 0.97 | <.001 | 0.97 | 0.99 |
| Year\* 2005 | 1.14 | .03 | 1.02 | 1.27 |
| Year\* 2006 | 1.35 | <.001 | 1.22 | 1.51 |
| Year\* 2007 | 1.35 | <.001 | 1.21 | 1.51 |
| Year\* 2008 | 1.50 | <.001 | 1.34 | 1.67 |
| Year\* 2009 | 1.61 | <.001 | 1.45 | 1.80 |
| Year\* 2010 | 1.65 | <.001 | 1.48 | 1.83 |
| Year\* 2011 | 1.82 | <.001 | 1.63 | 2.03 |
| Year\* 2012 | 1.99 | <.001 | 1.80 | 2.20 |
| Year\* 2013 | 2.09 | <.001 | 1.88 | 2.31 |
| Year\* 2014 | 2.27 | <.001 | 2.05 | 2.51 |
| Year\* 2015 | 2.32 | <.001 | 2.09 | 2.57 |
| Female | 0.84 | <.001 | 0.83 | 0.85 |
| Anaemia | 0.80 | <.001 | 0.79 | 0.82 |
| Rheumatoid arthritis/collagen  vascular diseases | 1.07 | <.001 | 1.04 | 1.11 |
| Chronic bleeding | 0.77 | <.001 | 0.74 | 0.81 |
| Congestive heart failure | 0.33 | <.001 | 0.31 | 0.35 |
| Chronic pulmonary disease | 0.75 | <.001 | 0.74 | 0.76 |
| Coagulopathy | 0.65 | .05 | 0.63 | 0.66 |
| Depression | 0.88 | <.001 | 0.86 | 0.90 |
| Diabetes (DM) | 0.88 | <.001 | 0.86 | 0.89 |
| DM with chronic complications | 0.75 | <.001 | 0.72 | 0.77 |
| Drug abuse | 0.65 | <.001 | 0.62 | 0.67 |
| Hypertension | 1.006 | .33 | 0.99 | 1.02 |
| Hypothyroidism | 0.97 | <.001 | 0.96 | 0.99 |
| Liver disease | 0.84 | <.001 | 0.81 | 0.88 |
| Lymphomas | 0.93 | .03 | 0.88 | 0.99 |
| Fluid and electrolyte disturbances | 0.68 | <.001 | 0.67 | 0.70 |
| Metastatic cancer | 0.53 | <.001 | 0.50 | 0.56 |
| Other Neurological disorders | 0.68 | <.001 | 0.67 | 0.69 |
| Obesity | 0.97 | <.001 | 0.95 | 0.99 |
| Paralysis | 0.59 | <.001 | 0.57 | 0.61 |
| Peripheral vascular disease | 0.89 | <.001 | 0.86 | 0.92 |
| Psychoses | 0.73 | <.001 | 0.70 | 0.75 |
| Renal failure (chronic) | 0.79 | <.001 | 0.78 | 0.80 |
| Solid tumour without metastases | 0.79 | <.001 | 0.77 | 0.82 |
| Weight loss | 0.72 | <.001 | 0.69 | 0.75 |
| Hospital bed size- Medium+ | 1.35 | <.001 | 1.22 | 1.51 |
| Hospital bed size - large+ | 1.80 | <.001 | 1.63 | 1.99 |
| Smoking | 1.18 | <.001 | 1.16 | 1.20 |
| Hypercholesterolemia | 1.48 | <.001 | 1.46 | 1.50 |
| Prior IHD | 3.78 | <.001 | 3.67 | 3.90 |
| Family history of IHD | 1.17 | <.001 | 1.14 | 1.21 |
| Prior MI | 0.76 | <.001 | 0.75 | 0.78 |
| Prior CVA | 0.86 | <.001 | 0.84 | 0.88 |
| Prior PCI | 0.96 | <.001 | 0.94 | 0.98 |
| Shock | 1.51 | <.001 | 1.46 | 1.56 |
| IABP Insertion | 0.89 | <.001 | 0.85 | 0.93 |
| AF | 0.66 | <.001 | 0.65 | 0.67 |
| VT | 1.20 | <.001 | 1.17 | 1.22 |
| VF | 1.62 | <.001 | 1.58 | 1.67 |
| STEMI presentation | 4.23 | <.001 | 4.1 | 4.35 |

\* Odds of getting Angio by Year of admission (reference Year 2004)

+ Small Hospital bed size is reference

AMI: acute myocardial infarction; CABG: coronary artery bypass graft; CAD: coronary artery disease; CVA: cerebrovascular accident (stroke or transient ischaemic attack); IHD: ischaemic heart disease; PCI: percutaneous coronary intervention; STEMI: ST Elevation myocardial infarction; IABP: Intra-aortic balloon pump; AF: Atrial fibrillation; VT: Ventricular tachycardia; VF: Ventricular fibrillation