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Original Article

Carotid Artery Disease as a Predictor of In-Hospital Postoperative Stroke After Coronary Artery Bypass Grafting From 1999 to 2011

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Background: In this study, the risk factors for stroke after coronary artery bypass grafting (CABG) were examined. In particular, the role of asymptomatic carotid artery stenosis (both unilateral and bilateral) as a predictor of in-hospital postoperative stroke was investigated. Finally, the trends surrounding in-hospital postoperative stroke from 1999 to 2011 also were examined. The purpose of the study was to appropriately identify patients at high risk for stroke after CABG and spark discussion about the perioperative management of such patients.

Materials and Methods: Data from the Nationwide Inpatient Sample from 1999 to 2011 were analyzed retrospectively. The study cohort was identified using the International Classification of Diseases, Ninth Revision, Clinical Modification and Projection Clinical Classification Software codes. Exploratory statistics, univariate analyses, and multivariable regression were used for this study.

Results: The analysis demonstrated that both asymptomatic unilateral and bilateral carotid stenoses were independent risk factors for in-hospital postoperative stroke. In addition, increasing age, female sex, increasing van Walraven score, paralysis, neurologic disorders, history of infective endocarditis, asymptomatic basilar stenosis, and cerebral occlusion all were demonstrated to be statistically significant predictors of stroke. Patients with carotid stenosis and a van Walraven score > 14 were found to be particularly vulnerable to in-hospital postoperative stroke. Lastly, predictors of carotid stenosis were examined, and increasing age, female sex, and increasing van Walraven score all were found to be significant predictors of asymptomatic carotid stenosis.

Conclusions: This study examined risk factors for stroke after CABG in a large, longitudinal, and population-based database. The study found that both unilateral and bilateral asymptomatic carotid stenoses are indeed risk factors for in-hospital postoperative stroke. In addition, a number of other predictors were identified. These results can be used to identify patients at high risk for perioperative stroke and hopefully decrease the rate of a devastating complication of CABG.

Key Words: perioperative stroke; asymptomatic carotid artery stenosis; coronary artery bypass grafting

PERIOPERATIVE STROKE, defined as a new neurologic deficit within 30 postoperative days, is among the most devastating complications of coronary artery bypass grafting (CABG) surgery. Perioperative stroke is associated with a 5-fold increase in both morbidity and mortality, and it places a substantial drain on hospital resources.[1,2] Perioperative stroke occurs in 0.8% to 5.2% of patients who undergo CABG.[3–7] Most strokes related to CABG occur postoperatively, whereas the remainder of strokes occur intraoperatively.[8] Postoperative

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stroke presents a significant burden to the health care system because post-CABG complications add an incremental cost of $15,468 per patient.[2] The contribution of postoperative stroke to in-hospital mortality also places a burden on resources. CABG is the most commonly performed heart surgery in the United States, with approximately 650,000 procedures a year. This results in anywhere between 5,000 and 35,000 strokes each year,[5] possibly making CABG the single greatest cause of perioperative stroke in the United States.[5,9]

Perioperative strokes are most commonly embolic and ischemic. For this reason, it has been hypothesized that both symptomatic and asymptomatic carotid stenoses predispose patients to intraoperative or perioperative stroke because there may be hypoperfusion distal to the stenotic artery.[10]

There is much discussion surrounding the role of asymptomatic carotid stenosis in the pathogenesis of perioperative stroke. Even though some studies have concluded that it is not an independent risk factor,[11,12] the data in these studies are subject to a number of limitations because they are small, single-center, retrospective cohort trials. Other studies have examined the role of asymptomatic carotid stenosis as a surrogate for significant aortic atheroma, which is known to significantly increase the risk of perioperative stroke.[13–16] These studies concluded that asymptomatic carotid stenosis is an epiphenomenon rather than a causal factor for stroke.[10] However, none of these hypotheses has been tested on a large population-based database, a perspective which this study provides. Furthermore, the impact of vertebral, basilar, and intracranial stenoses on the risk of perioperative stroke has not been evaluated.

Finding an association between carotid artery stenosis and perioperative stroke would help guide future preoperative screening and evaluations. It also would add another data point to the discussion surrounding revascularization procedures as preventative interventions.[10,17] In addition, the detection of cerebral hypoperfusion and other relevant stroke biomarkers could be improved with the use of intraoperative neurophysiologic monitoring.[18,19]

In this study, the authors investigated strokes that occurred within the same hospitalization as the procedure, and for the sake of accuracy, these strokes were referred to as “in-hospital, postoperative” rather than “perioperative.”

Methods

Data Source

Data from the National Inpatient Sample (NIS) Health Cost Utilization Project from1999 to 2011 were analyzed. Data were extracted using the International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis and procedure codes. Codes dealing with specifically postoperative stroke were used (see Table 1 for a full list of codes). In addition, the Projection Clinical Classification Software (CCS) was used to identify certain comorbidities and procedures. This study was institutional review board exempt because the NIS does not contain any identifiable information about research subjects.

Table 1
Relevant International Classification of Diseases, Ninth Revision-Clinical Modification Codes

Risk Factors and Diagnoses	ICD-9-CM Codes
Procedures	
CABG	CCS 44
Carotid endarterectomy	CCS 51
Heart valve procedures	CCS 43
Percutaneous transluminal coronary angioplasty	CCS 45
Postoperative Stroke	
Postoperative stroke	997.00-997.02 431 432 433.01 433.21 433.31 433.81 433.91 434.01 434.11 434.91 436
Carotid Stenosis and Other Stenosis	
Unilateral asymptomatic carotid stenosis	433.10
Bilateral asymptomatic carotid stenosis	433.30
Vertebral artery stenosis	433.20
Basilar artery stenosis	433.00
Stenosis and occlusion of precerebral arteries	433.80, 433.90
Occlusion of cerebral arteries	434.00, 434.10, 434.90
Aortic atherosclerosis	440.0
Comorbidity Factors of Interest	
Left ventricular dysfunction and cardiac failure	398.91, 402.11, 402.91, 404.11, 404.13,404.91, 404.93, 428.x
Diabetes mellitus	Elixhauser Comorbidity Index
Hypertension	Elixhauser Comorbidity Index
Atrial fibrillation	427.31
Peripheral vascular disease	Elixhauser Comorbidity Index
Renal failure	Elixhauser Comorbidity Index
H/o cerebrovascular disease (previous stroke/TIA)	V12.54, 434.91, 434.11
History of infective endocarditis	421.0, 421.1
Prior MI and CAD/angina	412 and 414.01, 414.0, 413.9
Previous cardiac surgery	15.1
Previous h/o other cardiovascular procedures including CEA and CAS	V45.89, CEA-38.12, CAS-00.61, 00.63
Previous H/o CAD with CABG	V45.81
Cardiopulmonary bypass	39.61

Abbreviations: CAD, coronary artery disease; CAS, carotid artery stenting; CEA, carotid endarterectomy; h/o, history of; ICD-9-CM, International Classification of Diseases, Ninth Revision-Clinical Modification; MI, myocardial infarction; TIA, transient ischemic attack.

Patient Population

The study included patients who underwent CABG (CCS 44). Patients who underwent combined CABG with carotid endarterectomy, valve surgery, or other simultaneous cardiac procedures were not included in the study population. Patients who underwent valve procedures (CCS 43), carotid endarterectomy (CCS 51), and percutaneous transluminal coronary angioplasty (CCS 45) were excluded. Patients younger than 18 years and older than 100 years also were excluded. Relevant International Classification of Diseases, Ninth Revision, Clinical

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