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Incidence and Predictors of TIAs and Strokes Following Coronary Artery Bypass Grafting: Report and Collective Review

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ABSTRACT

Background: Neurologic complications account for some of the most devastating problems following coronary artery bypass surgery. In this study we determined the incidence and predictors of perioperative transient ischemic attacks (TIAs) and strokes in patients undergoing coronary artery bypass grafting at our institution.

Methods: Data was prospectively collected from 4,518 consecutive patients undergoing isolated coronary artery bypass grafting at Brigham & Women's Hospital between 1993 and 1997.

Results: One hundred and twenty of the 4,518 patients sustained either a TIA (30 patients, 0.7%) or a stroke (90 patients, 2.0%), for an overall incidence of 2.7%. Significant univariate predictors of TIA/stroke included a history of : 1) cerebral vascular disease, 2) peripheral vascular disease, 3) diabetes, 4) renal failure, 5) preoperative myocardial infarction, 6) hypertension, and 7) age > 70 years. Multivariate logistic regression analysis revealed the following significant associations (incidence of TIA/stroke, odds ratio): 1) cerebral vascular disease (6.4%, OR 2.5); 2) peripheral vascular disease (5.3%, OR 1.6); 3) renal failure (5.6%, OR 1.6); 4) myocardial infarction (3.2%, OR 1.5); 5) diabetes (3.7%, OR 1.5); 6) age > 70 (3.5%, OR 1.5). Perioperative TIA/stroke was significantly associated with postoperative low cardiac output and atrial fibrillation. Patients with TIA/stroke had a significantly longer ICU stay (4 vs. 2 median days), length of hospitalization (14 vs. 7 median days), and higher mortality rate (22% vs. 2.6%).

Conclusions: Perioperative TIA/stroke occurred in less than 3% of patients following coronary artery bypass grafting but was associated with significant mortality. The strongest predictors were cerebral and peripheral vascular disease.

INTRODUCTION

Neurologic complications constitute a major area of morbidity and mortality following coronary artery bypass grafting (CABG). Despite a heightened awareness of the dangers of coexistent cerebrovascular and coronary artery disease, the incidence of perioperative stroke has not changed over this last decade. This may be due in part to an older surgical population with greater comorbid diseases. In this study we determined the incidence and predictors of TIA and strokes in patients undergoing CABG at our institution. This was compared with all other large cohort studies in the literature.

MATERIALS AND METHODS

Clinical data was prospectively collected from 4,518 consecutive patients undergoing isolated CABG at Brigham & Women's Hospital, between January 1992 and December 1997. Patients who underwent CABG in addition to any other procedure (i.e., valve surgery, carotid endarterectomy, aortic reconstruction) were excluded from the study to eliminate the effects of confounding factors. Patients undergoing primary as well as reoperative surgery were included in the study.

Screening carotid ultrasonography was performed in 746 patients. Scans were obtained selectively based on a history of prior CVA, carotid disease, unexplained neurologic symptoms, or carotid bruits. Data on the character of the ascending aorta or aortic arch was not analyzed in this paper because no consistent method of evaluation was

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Table 1. Univariate analysis in patients stratified by postoperative neurological event following CABG

	No Stroke n = 4398	TIA or Stroke n = 120 (2.7%)	*p* Value
n	4,398	120 (2.7%)	—
Preoperative demographics			
Mean age (years)	65	69	—
Age > 70 (%)	37	50	0.004*
Gender (% male)	73	69	0.22
Body mass index (kg/m^2)			
Thin (<23) (%)	13	16	0.21
Obese (>27) (%)	51	47	0.28
Risk factors			
Hypertension (%)	64	73	0.02*
Diabetes (%)	30	43	0.002*
Renal failure (%)	7	15	0.002*
Peripheral vascular disease (%)	13	28	<0.0001*
Cerebral vascular disease (%)	14	34	<0.0001*
Previous carotid endarterectomy (%)	1	3	0.10
Previous myocardial infarction (%)	60	72	0.006*
Previous cardiac surgery (%)	13	14	0.46
Smoking history (%)	66	72	0.13
Hypercholesterolemia (%)	68	73	0.15
Ejection fraction < 30% (%)	7	10	0.14
NYHA functional class IV (%)	19	29	0.004*
Clinical presentation			
Unstable angina (%)	82	89	0.03*
Emergent operation (%)	7	15	0.002*
Cardiogenic shock (%)	1	2	0.44
Intraoperative			
Median number of vessels grafted	3	3	0.19
Median pump time (min)	86	97	0.002*
Median cross-clamp time (min)	58	66	0.06
Postoperative			
Atrial fibrillation (%)	24	33	0.01*
Myocardial infarction (%)	3	8	0.01*
Low cardiac output (%)	8	29	<0.0001*
Median days on ventilator	1	2	<0.0001*
Median days in ICU	2	4	<0.0001*
Median days in hospital	7	14	<0.0001*
In-hospital mortality (%)	3	22	0.004*

*$p < 0.05$.

used and review of the intraoperative findings was not deemed reliable.

All operations were performed using systemic hypothermia and cold crystalloid cardioplegia. Temperatures were allowed to drift during the cross-clamp period. Cannulation of the aorta was performed in an area without palpable plaque. Intraoperative transesophageal and/or epiaortic ultrasound was used in patients selectively. Cardiopulmonary bypass flow rates were between 1.8 and 2.0 L/min per square meter and mean arterial pressure was maintained between 40 and 80 mmHg. Patients with known cerebrovascular disease were maintained at the higher end of this spectrum. Proximal anastomoses were performed in the majority of cases using a single cross-clamping technique.

Operative mortality was defined as death during the initial hospitalization or within 30 days of the operation. Postoperative neurologic events were verified by computed tomography scanning and a neurologic consultation, and defined as either a transient ischemic attack or stroke. The statistical analysis was performed using Stata version 5 (Stata Corporation, College Station, Texas). Predictors of TIA/stroke were determined using univariate models and multiple logistic regression analyses. Statistical significance was associated with a p value of less than 0.05.

Table 2. Multivariate analysis for TIA or stroke following CABG

Preoperative Risk Factor	Incidence	Odds Ratio	95% CI	*p* Value
Cerebral vascular disease	6.4 %	2.5	1.7–3.8	<0.0001
Peripheral vascular disease	5.3 %	1.6	1.1–2.5	0.03
Renal vailure	5.6 %	1.6	0.9–2.8	0.09
Myocardial infarction	3.2 %	1.5	1.0–2.3	0.04
Diabetes mellitus	3.7 %	1.5	1.0–2.2	0.04
Age > 70	3.5 %	1.5	1.0–2.1	0.04

RESULTS

The preoperative demographics of the study group are presented in Table 1 (◎). One hundred and twenty patients sustained either a TIA (30 patients, 0.7%) or a stroke (90 patients, 2.0%), for an overall incidence of 2.7%. Significant univariate predictors of TIA/stroke are shown in Table 1 (◎). There were no significant differences in either gender or body mass index between groups. Unstable angina and an emergent operation were each associated with postoperative neurologic events. There were no differences in the median number of vessels grafted or cross-clamp times between groups. Patients with postoperative stroke/TIA had a slightly longer pump time and were more likely to have atrial fibrillation, a perioperative myocardial infarction, and low cardiac output (defined as the use of an IABP or inotropes to keep CI > 2.0 L/min per meter squared). Patients with TIA/stroke also had a significantly longer ICU stay, length of hospitalization and higher mortality rate.

Logistic regression analysis identified five independent predictors of postoperative TIA/stroke and calculated the factor-adjusted odds ratios associated with each predictor (see Table 2 ◎). Preoperative cerebral vascular disease (defined as any patient with a previous CVA, TIA, or carotid stenosis) was the strongest predictor, followed by peripheral vascular disease, renal failure, myocardial infarction, diabetes and age > 70.

Perioperative TIA/strokes occurred in 4.2% of the 736 patients that underwent preoperative carotid duplex screening. A carotid stenosis of greater than 70% was detected preoperatively in 5.7% (42 of 736) of the screened patients. Stroke occurred in 11.9% (5 of 42) of the patients

Table 3. Postoperative TIA/stroke studies following >1000 patients: perioperative events following CABG

Reference	Year	Number of patients	Stroke (%)	TIA/RIND (%)	Overall Mort. (%)	Stroke Mort. (%)	Preoperative risk factors									
							RF	CVD	MI	PVD	DM	AGE	Ao	EF	HTN	CP
Jones	1984	5,676	0.9									X	X			
Gardner	1985	3,279	1.7		3.7	23		X				X	X			
Hise	1991	2,029	1.5			17										
Frye	1992	10,098	1.9									X				
Rizzo	1992	3,012	1.4	0.4	4.0											
Lynn	1992	1,000	2.7	1.6							X		X			
Rao	1995	3,910	1.4		1.9	22		X		X	X	X				
Roach	1996	2,108	3.0	0.1	2.0	21		X				X	X			
D'Agostino	1996	1,835	2.5		2.2	13		X		X			X	X		X
Mickleborough	1996	1,631	1.2	0.6	1.2	26		X	X	X		X	X	X		
McKhann	1997	1,776	3.9		3.2	19		X			X	X			X	
Dashe	1997	1,022	2.2					X								
Mean		3114	2.0	0.7	2.6	20										
Range		1,000–10,098	0.9–3.9	0.4–1.6	1.2–4.0	13–26										
Present series	1998	4518	2.0	.7	2.6	22	X	X	X	X	X	X				X

Abbreviations: Ao, ascending aortic disease; CP, chest pain/anginal symptoms; CVD, cerebral vascular disease (defined as any patient with previous CVA, TIA, or carotid stenosis); DM, diabetes mellitus; EF, low ejection fraction; HTN, hypertension. Low cardiac output, use of an intra-aortic balloon pump or inotropes to keep CI > 2.0 L/min/m^2; PVD is defined by the history of claudication or prior peripheral bypass for occlusive arterial disease; MI, myocardial infarction; PVD, peripheral vascular disease; RF, renal failure; TIA/RIND, transient ischemic attacks and reversible ischemic neurologic deficits.

with significant stenoses and in 3.8% (26 of 694) of those without significant (<70%) stenoses.

DISCUSSION

TIA or stroke following cardiac surgery is a devastating complication. It can result in a significantly prolonged hospital stay and permanent disability. This single institution study looked at the preoperative, intraoperative and postoperative risk factors associated with perioperative TIA/stroke. Only CABG patients were included, thereby eliminating other high stroke risk cardiac operations. A review of the literature of postoperative neurologic events following isolated CABG operations in studies of 1000 or more patients is shown in Table 3 (◎). Our overall stroke-rate was 2.0 %, which compared favorably with previously published studies (including those that only included patients undergoing primary surgery [Mickleborough 1996]. The most common preoperative risk factors noted in these previous studies include cerebral vascular disease, older age, and ascending aortic disease. All but one of these studies was limited to single institution based retrospective reviews. Many studies noted a difficulty in uniformly quantifying aortic atherosclerotic disease. Future studies with blinded ultrasound-based grading system may be able to better assess the degree of atherosclerotic aortic disease.

The mechanism of TIA/strokes following CABG remains unclear. Atherosclerosis from the ascending aorta can embolize to the brain with manipulation at the time of surgery. Efforts to reduce embolic stroke can involve single cross-clamping of the aorta [Aranki 1994] or no cross-clamp, fibrillatory arrest. Additionally, intraoperative ultrasound can be used to guide the surgeon to an area of reduced aortic plaque. Carotid artery disease can result in TIA/stroke through low-flow cerebral ischemia during cardiopulmonary bypass and/or the early perioperative period. In this study, the contribution of carotid stenosis to TIA/stroke cannot be ascertained due to the small number of patients in this cohort that underwent preoperative duplex scanning. Efforts aimed at maintaining perfusion pressure on cardiopulmonary bypass and prevention of postoperative hypotension are important. Postoperative low cardiac output was found to be associated with perioperative TIA/stroke. Emboli from atrial arrhythmias or mural thrombi can also result in perioperative TIA/stroke. We noted a higher incidence of preoperative atrial arrhythmias in these patients, though a cause and effect relationship cannot be proven. Mural thrombi were not specifically assessed in our study.

Our findings suggests that careful preoperative screening can identify patients at increased risk for perioperative TIA/stroke. In those patients with a history of PVD or CVD, preoperative carotid studies and intraoperative epiaortic ultrasound scanning of the ascending aorta may result in reduced perioperative TIA/stroke.

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REVIEW AND COMMENTARY

1. Editorial Board Member MY17 writes:

The authors need to detail their use of epiaortic ultrasound to detect aortic calcification. How sensitive and reliable is it?

Authors' Response by Daniel Engelman, MD:

The traditional method used by surgeons intraoperatively to assess aortic atherosclerosis at our institution has been palpation. However, this is quite unreliable and insensitive, except in the more heavily calcified aortas. The use of a high-frequency epiaortic ultrasound involves filling the pericardium with saline prior to cannulation, inserting the transducer in a sterile sheath, and directly scanning the aorta. High-resolution transverse and longitudinal images are then obtained from the aortic valve to the proximal arch. These are quite sensitive for aortic plaque and debris, whether calcified or soft atheroma. The technique is reliable, reproducible and easy to learn. Based on these findings, operative techniques can then be modified in an attempt to reduce neurologic events.