The Heart Surgery Forum #2002-18620
6 (1), 2003

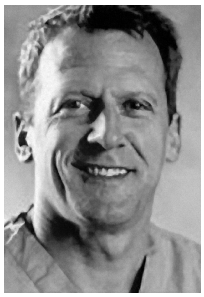
Online address: www.hsforum.com/vol6/issue1/2002-18620.html

Increased Incidence of Proximal Aortic Atherosclerotic Disease in Patients with Internal Carotid Occlusion

(#2002-18620 . . . July 1, 2002)

Yvon R. Baribeau, MD, Benjamin M. Westbrook, MD,
David C. Charlesworth, MD, Christopher T. Maloney, MD

Catholic Medical Center, Manchester, New Hampshire, USA



Dr. Baribeau

ABSTRACT

Background: Atherosclerotic involvement of the proximal aorta is a major cause of embolic operative stroke in cardiac surgery. Its incidence is less well known in patients with severe carotid disease.

Methods: We reviewed the incidence of proximal atherosclerotic aortic disease in patients with internal carotid occlusion (group 1) and then compared it to a group of patients with normal carotids undergoing cardiac surgery (group 2). Both groups had preoperative carotid Doppler and epiaortic ultrasound analysis at the time of surgery.

Results: Epiaortic ultrasound results showed that the degree of atherosclerosis in group 1 was normal in 9 patients (10.2%), mild in 34 (38.6%), moderate in 29 (33%), and severe in 16 (18.2%). In group 2, the degree of atherosclerosis was normal in 70 patients (9.3%), mild in 466 (61.8%), moderate in 150 (19.9%), and severe in 68 (9.0%). Stroke rate was higher in group 1 at 4.5% versus 1.1% for group 2 ($P = .029$). No difference in surgical mortality was found.

Conclusions: Patients with internal carotid occlusions undergoing heart surgery have a higher incidence of proximal aortic atherosclerotic disease. Epiaortic ultrasound examination is strongly recommended.

INTRODUCTION

Despite the reduction in operative mortality in the last 2 decades of heart surgery, stroke has remained a terrible complication. The role of the proximal aorta as a source of cerebral (and systemic) emboli has been clearly shown in both the surgical [Hosoda1991, Ribakove 1992] and medical [Davila-Roman 1994, Amarenco1994] patient population. Although the idea is still controversial, carotid disease has been implicated as well [Brener 1984], particularly at the end of the spectrum in cases of bilateral disease or occlusion [Brener 1987, Schwartz 1995, Mickleborough 1996]. Surgical results of carotid endarterectomy in these patients may be influenced by a higher incidence of proximal aortic disease, particularly if no means of detection are used at the time of cardiac and aortic manipulation, such as epiaortic and transesophageal ultrasound analyses, and subsequent embolization may result from indiscriminate manipulation.

With this eventuality in mind, we reviewed our cardiac surgical population in which both unilateral and bilateral internal carotid occlusions were shown preoperatively and in which epiaortic ultrasound examination had been performed at the time of surgery.

MATERIAL AND METHODS

A prospective analysis was carried out for all patients undergoing cardiac surgery between July 1994 and July 1998 and who were found preoperatively to have occlusion of 1 or both internal carotid arteries on duplex examination (group 1). A second group of patients was studied for which carotid duplex studies showed no significant disease of the internal carotid arteries at 0% to 39% bilaterally (group 2). Both groups had an epiaortic ultrasound examination at the time of surgery. Three patients with carotid occlusion but who had no epiaortic ultrasound examination at surgery were excluded. During the study period, 4926 patients underwent cardiac surgery at our center.

Indications for carotid Doppler interrogation preoperatively were patients older than 60 years, a history of cerebrovascular symptoms, renal failure, and physical examination indicating carotid bruit or a brachial gradient greater than 15 mm Hg. No mass screening was carried out in our base population.

Peripheral vascular disease was defined as prior vascular surgery, claudication, ischemic wound of the lower extremity, brachial gradient greater than 15 mm Hg, aneurysmal disease, or an ankle brachial index of less than 0.9. Cerebrovascular symptoms or disease was defined as prior stroke or transient ischemic attack.

Carotid duplex scanning was carried out with the 5-MHz scanning probe 128XP (Accuson, Mountain View, CA, USA). Groups 1 (100%) and 2 (0%-40%) were determined according to published criteria [Bluth 1988]. Epiaortic ultrasound examination was performed with the 7-MHz probe 128XP (Accuson). The entire ascending and transverse aorta was

Submitted June 18, 2002; accepted July 1, 2002.

Address correspondence and reprints requests to: Dr. Yvon Baribeau, Catholic Medical Center, 100 McGregor St, Manchester, NH 03102, USA; 1-603-663-6340; fax: 1-603-663-6822 (e-mail: baribeau@nhheart.com).

Table 1. Demographic and Clinical Characteristics*

	Group 1 (n = 88)	Group 2 (n = 754)	*P*
Age, y	70.3 ± 6.7	70.9 ± 8.3	.576
Male sex, n (%)	71 (80.7%)	476 (63.1%)	.002
Insulin-dependent diabetes, n (%)	17 (19.3%)	71 (9.4%)	.009
Hypertension, n (%)	69 (78.4%)	530 (70.3%)	.143
Hyperlipidemia, n (%)	42 (47.7%)	435 (57.7%)	.095
Peripheral vascular disease, n (%)	43 (48.9%)	95 (12.6%)	<.001
Prior stroke/TIA, n (%)	31 (35.2%)	78 (10.3%)	<.001
Prior MI, n (%)	59 (67.0%)	413 (54.8%)	.037
Creatinine, mg/dL	1.40 ± 0.48	1.33 ± 0.37	.148

*Data are presented as the mean ± SD as indicated. TIA indicates transient ischemic attack; MI, myocardial infarct.

imaged in both cross section and on the long axis. Severity of atherosclerosis was graded as normal, mild (<3 mm intimal thickening), moderate (3-5 mm intimal thickening or calcification), or severe (>5 mm in thickness or protruding or mobile atheromas).

Standard cardiopulmonary bypass, if used, consisted of normothermic perfusion and warm antegrade blood cardioplegia. Ascending aortic cannulation was carried out with either an 8F Sarns soft flow cannula (Sarns/3M Health Care, Ann Arbor, MI, USA) or a DLP 22F cannula (Medtronic DLP, Grand Rapids, MI, USA). Technical alterations were carried out on the basis of epiaortic ultrasound examination and palpation of the aorta, and a variety of maneuvers were used to lessen the risk of embolism from the severely atherosclerotic aorta. These maneuvers included the avoidance of aortic clamping, axillary cannulation, circulatory arrest, and beating heart surgery [Wareing 1992, Baribeau 1998, Baribeau 1999].

All carotid procedures were done after general anesthesia and prior to the heart operation at normothermia. Standard or eversion carotid endarterectomies were performed. Selective shunting was based on stump pressure (less than 50 mm Hg), the patient's history of stroke, and/or a frontal oximetry (Invos, Somanetics Corporation, Troy, MI) (drop of greater than 20% from baseline after general anesthesia or absolute saturation below 40%). Patch arterioplasty of the carotid was performed with bovine pericardium (VascuGuard; Bio-Vascular, St. Paul, MN, USA).

Stroke was defined as a hemispheric or cerebellar deficit occurring within 30 days of surgery. Patients who were without deficit at discharge but who had demonstrated a positive computed tomography scan of the head showing recent infarct postoperatively were still considered as having had a stroke. Mortality was defined according to the Society of Thoracic Surgery guidelines, ie, any death occurring within 30 days of surgery or during the hospitalization.

Statistical Analysis

Homogeneity of the 2 cohorts was ascertained for a number of demographic and clinical variables (sex, age, hyperlipidemia, high blood pressure, creatinine level, preoperative myocardial infarct, peripheral vascular disease, cerebrovascular disease, and the number of operations). Differences between the 2 groups were assessed through proportion comparisons using the Pearson chi-square test or the Fisher exact test when appropriate, and means were compared with 2-tailed unpaired Student *t* tests. A significance level of 5% ($P < .05$) was considered statistically significant.

RESULTS

Eighty-eight patients were found to be in group 1. Unilateral occlusion was present in 79 patients, 33 (37.5%) on the left and 46 (52.3%) on the right. The remaining 9 patients (10.2%) had bilateral carotid occlusions. Twenty-eight patients (31.8%) had an angiogram confirming the duplex findings, and these patients included 8 having a brachial pressure gradient and who were also studied by angiogram prior to surgery. Group 2 consisted of 754 patients without any significant carotid disease as defined above. Patients in group 1 were more often men with insulin-dependent (type 1) diabetes mellitus and a history of coronary, cerebral, or peripheral vascular disease. Demographic and clinical variables are shown in Table 1.

Epiaortic ultrasound results showed that the degree of atherosclerosis in group 1 was normal in 9 patients (10.2%), mild in 34 (38.6%), moderate in 29 (33%), and severe in 16 (18.2%). In group 2, the degree of atherosclerosis was normal in 70 patients (9.3%), mild in 466 (61.8%), moderate in 150 (19.9%), and severe in 68 (9.0%). Statistical significance was reached for the mild, moderate, and severe groups (Table 2).

Cardiac surgeries performed in group 1 were 74 coronary artery bypasses, 8 aortic valve replacements that included 6 coronary bypasses, 1 ascending aorta replacement, 1 aortic endarterectomy, and 6 mitral valve replacements, 5 of which involved coronary bypass and 1 of which involved a left ventricular aneurysm resection. Six of the 16 cases of severe aortas had no technical modification for aortic clamping and cannulation. Fibrillatory arrests without cross-clamping of the aorta were used in 4 patients, with 1 patient requiring circulatory arrest with arch endarterectomy, patch aortoplasty, and retrograde cerebral perfusion. Another patient required axillary cannulation and circulatory arrest. The other 5 patients underwent coronary artery bypass grafting on a beating heart (of a total of 14 cases), thereby eliminating the need for cannulation and cardiopulmonary bypass.

Table 2. Results of Epiaortic Ultrasound Examinations

	Group 1 (n = 88)	Group 2 (n = 754)	*P*
Normal	9 (10.2%)	70 (9.3%)	.925
Mild	34 (38.6%)	466 (61.8%)	<.001
Moderate	29 (33.0%)	150 (19.9%)	.007
Severe	16 (18.2%)	68 (9.0%)	.012

Table 3. Surgical Morbidity and Mortality

	Group 1 (n = 88)	Group 2 (n = 754)	*P*
Redo procedure	10 (11.4%)	70 (9.3%)	.662
Stroke	4 (4.5%)	8 (1.1%)	.029
Major bleeding	5 (5.7%)	44 (5.8%)	.999
Myocardial infarct	3 (3.4%)	4 (0.5%)	.028
Death	6 (6.8%)	24 (3.2%)	.117

In 21 patients (23.9%), combined carotid endarterectomy and cardiac surgery were performed because of significant (80%-99%) contralateral stenosis. All cervical procedures were carried out together after general anesthesia and prior to the heart operation. Standard carotid endarterectomy was performed in 18 patients, and eversion endarterectomy was carried out in 3 patients. Selective shunting was used in 10 patients (47.7%). Patch arterioplasty was carried out in 6 (33.3%) of the standard carotid endarterectomies. One additional patient had a carotid exploration to confirm occlusion. In group 2, the surgeries performed were 91 aortic valve replacements, 56 of which were carried out with coronary bypass; 77 mitral valve repairs or replacements, including 58 with coronary bypass; 24 double-valve repairs or replacements; 1 triple-valve repair or replacement; and 561 coronary bypass operations. Overall, there was a significantly greater proportion of valve surgeries ($P = .046$) in the group without carotid disease (26%) than in the group with internal carotid occlusion (16%).

There were no statistical differences in the cross-clamp times or extracorporeal circulation times between the 2 groups for patients who went on bypass: 49.9 minutes and 68.8 minutes, respectively, for group 1 versus 49.7 minutes and 66.1 minutes for group 2.

Cardiac morbidity was higher in group 1, with myocardial infarction occurring in 3 patients (3.4%); in group 2, only 4 patients (0.5%) had a perioperative myocardial infarct ($P < .028$). In group 1, 4 patients (4.5%) had a stroke postoperatively. Two strokes occurred at the time of surgery: the stroke in 1 patient was related to carotid endarterectomy, and in the other patient it was related to severe aorta and no technical modification. Two patients had embolic events postoperatively, 1 with severe aorta and 1 arising from atrial fibrillation. Of the patients with severe atheromatous disease of the aorta and who had undergone technical modification, none suffered a neurologic complication. Stroke rate was lower in the group without carotid disease at 1.1% (8 patients) with $P = .0286$. Half of the strokes in this group occurred postoperatively as well.

Operative mortality occurred in 6 patients (6.8%) in the group with occlusions. Three patients undergoing combined coronary artery bypass and valve surgery died in the early postoperative period from low cardiac output and bleeding. One patient who underwent reoperative coronary artery bypass grafting and carotid endarterectomy died on the sixth postoperative day from myocardial infarction secondary to graft occlusion. The other 2 patients died from multisystem failure, 1 on postoperative day 7, and the other on day 25. Twenty-four patients of the group without carotid disease died, for a surgical mortality of 3.1% ($P = .1172$). Table 3 compares the surgical morbidity and mortality of both groups.

DISCUSSION

Despite numerous studies and controversies, there is little doubt that significant carotid disease is related to the stroke rate in cardiac surgical patients [Brener 1984]. Moreover, the stroke rate in cardiac surgical patients with carotid disease is proportional to the severity of stenosis [Brener 1987, Schwartz 1995, Mickleborough 1996]. At the end of the spectrum, patients with carotid occlusion have been shown to have a very high stroke rate. Brener described a stroke rate of 15.6% in a subgroup of 32 patients with carotid occlusion who had undergone heart surgery [Brener 1984]. Mickleborough and colleagues showed a stroke rate of 27.27% for 22 patients with carotid occlusion who had undergone coronary bypass [Mickleborough 1996]. Dashe and colleagues reported an 8% stroke rate in 25 patients with carotid occlusion who had undergone coronary artery bypass [Dashe 1997]. Mackey and colleagues in 1996 reported a perioperative stroke rate of 9% in a higher-risk group of patients who had received combined procedures [Mackey 1996]. A high percentage of their patients (28%) had carotid occlusion. More recently, Tunio and associates

Table 4. Review of the Literature for Patients with Internal Carotid Occlusion Having Cardiac Surgery

Authors	Patients with ICAO, n	Stroke Rate, % (n)	Contralateral ICAE, n	Stroke Rate, % (n)	Epiaortic
Brener 1984	32	15.6% (5)	7	14.29% (1)	No
Dashe 1997	25	8.0% (2)			No
Faggioli 1990	6	0% (0)			No
Mickleborough 1996	22	27.27% (16)	9	33.33% (3)	No
Rizzo 1992			20	15% (3)	No
Schwartz 1995	21	4.8% (1)			No
Tunio 1999	61	6.5%	2	100% (2)	No
Wareing 1992			13	0% (0)	Yes
Present study	88	4.5% (4)	21	4.76% (1)	Yes

reported on 61 patients with carotid occlusions who had undergone coronary bypass [Tunio 1999]. The stroke rate was 6.5%. Interestingly, the group having contralateral internal carotid endarterectomy in their study had a 100% stroke rate (2 of 2 patients). Rizzo and colleagues suggested in 1992 that the combined procedure was useful but did note a 15% stroke risk for those with contralateral occlusion [Rizzo 1992]. In their same study, Mickleborough and colleagues had 9 patients with concomitant carotid endarterectomy, 3 of whom had a stroke, an incidence of 33.33% [Mickleborough 1996]. None of these studies used ultrasonic interrogation of the proximal aorta prior to manipulation.

Hosoda and colleagues and then Wareing and colleagues [Hosoda 1991, Wareing 1992] demonstrated the importance of intraoperative epiaortic ultrasound in assessing the severity of atherosclerosis of the ascending and transverse aorta prior to cardiac surgery. Transesophageal evaluation of the aorta was also found to be of value. Modification of the surgical technique in patients with severe disease of the aorta has been shown to reduce the risk significantly [Wareing 1992, Baribeau 1998, Baribeau 1999].

In 1995, Demopoulos and associates used transesophageal echocardiography to show a strong association between protruding atheromas of the aortic arch and symptomatic carotid disease [Demopoulos 1995]. The patients with the most severe atheromas also had the most severe degrees of carotid stenosis. Protruding aortic arch atheromas were present in 38% of patients with carotid disease, compared with only 16% for control subjects.

Further indirect evidence for the importance of the aorta in the etiology of stroke was noted in the study of Hertzer and colleagues of patients who underwent combined carotid endarterectomy and coronary artery bypass [Hertzer 1997]. They found that 77% of the strokes that occurred in conjunction with combined procedures were situated in the contralateral hemisphere, both hemispheres, the posterior circulation, or a combination of these locations.

We found a 9% incidence of severe atherosclerotic proximal aorta detected by epiaortic ultrasound at the time of surgery in our control group; these results are in concordance with incidences of 5.3% [Wareing 1992] to 8% [Baribeau 1999] described in other studies. The 18% incidence seen in patients with carotid occlusion is of primary importance for the cardiovascular team, because the stroke rate in patients with severe atherosclerotic aorta without technical modification may be as high as 23% [Hosoda 1991] to 50% [Ribakove 1992]. It was 33.33% in this study (2 of 6 patients with severe aortas who had received no surgical modification had a stroke). Most studies of cardiac surgical patients with carotid occlusion did not use ultrasonic interrogation of the proximal aorta prior to manipulation. On the contrary, Wareing and colleagues reported no strokes in patients with concomitant contralateral carotid endarterectomy (to carotid occlusion) at the time of heart surgery, when ultrasonic interrogation was used and modifications were made accordingly at the time of manipulation [Wareing 1993]. Table 4 summarizes the various studies of patients with internal carotid occlusion and who had concomitant heart surgery.

Our finding of increased proximal atherosclerotic disease in patients with carotid occlusion may partially explain the higher stroke rate seen in these patients when they undergo heart surgery without modification in the manipulation of the aorta. In the same way, the higher stroke rate in combined procedures (carotid endarterectomy and heart surgery) may have more to do with aortic manipulation than with the carotid endarterectomy. This conclusion is reinforced by results of surgical series of patients with internal carotid occlusion undergoing contralateral carotid endarterectomy only, which fail to show an increased stroke risk [Perler 1992, Da Silva 1997].

Although there are limits to this study, including the lack of transesophageal or transthoracic echocardiograms to evaluate the left atrium and ventricle for the source of potential emboli and the surgical mix of valve and coronary surgery, we feel the study strongly emphasizes the need for a global investigative approach in these difficult cases. The greater proportion of valve surgeries in the group with normal carotid arteries should favor the occluded carotid group, because most investigators agree that valve surgery entails a greater stroke risk than does coronary bypass alone [Shaw 1993]. Last but not least, half of the strokes in both groups occurred postoperatively, most often in relation to atrial fibrillation or a severely atherosclerotic aorta. This observation has influenced us to use postoperative anticoagulation early in cases of atrial fibrillation or in patients having showed mobile debris in the proximal aorta at the time of the epiaortic echocardiogram.

Because of the increased incidence of severe proximal atherosclerotic involvement of the aorta in patients with carotid occlusion at the time of cardiac surgery, ultrasonic interrogation before heart manipulation is recommended. Careful modifications in cases of a severe degree of atherosclerosis allow an acceptable degree of morbidity and mortality, even in cases with concomitant contralateral carotid endarterectomy.

REFERENCES

Amarenco P, Cohen A, Tzourio C, et al. 1994. Atherosclerotic disease of the aortic arch and the risk of ischemic stroke. N Engl J Med 331:1474-9.

Baribeau YR, Westbrook BM. 1990. Intra-operative epicardial echocardiography. In: Izzat MB, Sanderson JE, St. John Sutton MG, editors. Echocardiography in adult cardiac surgery. 8th ed. Oxford, UK: Isis Medical Media. p 223-9.

Baribeau YR, Westbrook BM, Charlesworth DC, Maloney CT. 1998. Arterial inflow via an axillary artery graft for the severely atheromatous aorta. Ann Thorac Surg 66:33-7.

Bluth EL, Stavros AT, Marich KW, Wetzner SM, Aufrichtig D, Baker JD. 1988. Carotid duplex sonography: a multicenter recommendation for standardized imaging and Doppler criteria. Radiographics 8:487-506.

Brener BJ, Brief DK, Alpert J, et al. 1984. A four-year experience with preoperative non-invasive carotid evaluation of two thousand twenty-six patients undergoing cardiac surgery. J Vasc Surg 1:326-38.

Brener BJ, Brief DK, Alpert JA, et al. 1987. The risk of stroke in patients

with asymptomatic carotid stenosis undergoing cardiac surgery: A follow-up study. J Vasc Surg 5:269-79.

Da Silva AF, McCollum P, Szymanska T, de Cossart L. 1996. Prospective study of carotid endarterectomy and contralateral carotid occlusion. Br J Surg 83:1370-2.

Dashe JF, Pessin MS, Murphy RE, Payne DD. 1997. Carotid occlusive disease and stroke risk in coronary artery bypass graft surgery. Neurology 49:678-86.

Davila-Roman VG, Barzilai B, Wareing TH, et al. 1994. Atherosclerosis of the ascending aorta: prevalence and role as an independent predictor of cerebrovascular events in cardiac patients. Stroke 25:2010-6.

Demopoulos LA, Tunick PA, Bernstein NE, Perez JL, Kronzon I. 1995. Protruding atheromas of the aortic arch in symptomatic patients with carotid artery disease. Am Heart J 129:40-4.

Faggioli GL, Curl GR, Ricotta JJ. 1990. The role of carotid screening before bypass. J Vasc Surg 12:724-31.

Hertzer NR, O'Hara PJ, Mascha EJ, Krajewski LP, Sullivan TM, Beven BG. 1997. Early outcome assessment for 2228 consecutive carotid endarterectomy procedures: the Cleveland Clinic Experience from 1989 to 1995. J Vasc Surg 26:1-10.

Hosoda Y, Watanabe M, Hirooka Y, Ohse Y, Tanaka A, Watanabe T. 1991. Significance of atherosclerotic changes of the ascending aorta during coronary bypass surgery with intraoperative detection of echography. J Cardiovasc Surg (Torino) 32:301-6.

Mackey WC, Khabbaz K, Bojar R, O'Donnell TF Jr. 1996. Simultaneous carotid endarterectomy and coronary bypass: perioperative risk and long-term survival. J Vasc Surg 24:58-64.

Mickleborough LL, Walker PM, Takagi Y, Ohashi M, Ivanov J, Tamariz M. 1996. Risk factors for stroke in patients undergoing coronary artery bypass. J Thorac Cardiovasc Surg 112:1250-9.

Perler BA, Burdick JF, Williams M. 1992. Does contralateral internal carotid artery occlusion increase the risk of carotid endarterectomy? J Vasc Surg 16:347-53.

Ribakove GH, Katz ES, Galloway AC, et al. 1992. Surgical implications of transesophageal echocardiography to grade the atheromatous aortic arch. Ann Thorac Surg 53:758-63.

Rizzo RJ, Whittemore AD, Couper GS, et al. 1992. Combined carotid and coronary revascularization: the preferred approach to the severe vasculopath. Ann Thorac Surg 54:1099-109.

Schwartz LB, Bridgeman AH, Kieffer RW, et al. 1995. Asymptomatic carotid artery stenosis and stroke in patients undergoing cardiopulmonary bypass. J Vasc Surg 21:146-53.

Shaw PJ. 1993. The neurological sequelae of cardiopulmonary bypass: the Newcastle experience. In: Smith P, Taylor K, editors. Cardiac surgery and the brain. London, UK: Hodder and Stoughton. p 24-33.

Tunio AM, Hingorani A, Ascher E. 1999. The impact of an occluded internal carotid artery on the mortality and morbidity of patients undergoing coronary artery bypass grafting. Am J Surg 178:201-5.

Wareing TH, Davila-Roman VG, Barzilai B, Murphy SF, Kouchoukos NT. 1992. Management of the severely atherosclerotic aorta during cardiac operations: a strategy for detection and treatment. J Thorac Cardiovasc Surg 103:453-62.

Wareing TH, Davila-Roman VG, Daily BB, et al. 1993. Strategy for the reduction of stroke incidence in cardiac surgical patients. Ann Thorac Surg 55:1400-8.