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Carotid Endarterectomy: Outcome of "Old-Fashioned" Approach

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The purpose of this study is to assess the 30-day postoperative incidence of death, myocardial infarction, stroke, wound complication, and cranial nerve damage after carotid endarterectomy using induced hypertension (systolic pressure ≥160 mmHg), selective shunting, and primary closure. We retrospectively analyzed the records of 206 patients who underwent a total of 239 carotid endarterectomy surgeries between January 2002 and August 2009 to identify the impact of selective shunting and primary closure on morbidity and mortality. Two hundred thirty-nine surgeries were performed on 206 patients. The study population was 55% men and 45% women with average age of 67 years (range 33–85 years). Of these patients, 181 had hypertension (88%), 82 had diabetes (40%), 73 had peripheral vascular disease (35%), 107 had coronary artery disease (52%), 142 had tobacco abuse (69%), and 146 had dyslipidemia (71%). Twenty-six patients (13%) presented with history of stroke, 77 (37%) with transient ischemic attack (TIA), 14 (7%) with amaurosis fugax, and 108 (52%) were asymptomatic. The average internal carotid stenosis was 74% as indicated by duplex, computed tomography, magnetic resonance imaging, or angiogram. Of the 239 surgeries, 3 (1%) required patch closure, and 7 (3%) required shunt. Thirty-day postoperative complication rates are as follows: stroke, 3 (1.3%); TIA, 4 (1.7%); bleeding, 5 (2.1%); superficial wound infection, 2 (0.8%); heart attack, 1 (0.4%); cranial nerve injury, 0; and hospital death, 0. One patient (0.4%) died at home from an unknown cause. In conclusion, carotid endarterectomy with selective shunting and primary closure is a safe and effective surgical means of preventing stroke.

Key words: Carotid endarterectomy – Induce hypertension – Primary closure

Stroke is the third leading cause of death in the United States and is a significant source of morbidity and mortality in the modern health care system. In the United States, someone suffers a stroke every 45 seconds. Roughly 150,000 individuals die as a result of a stroke each year.[1] The sheer magnitude of these numbers as well as the morbidity endured by patients and the health care costs

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incurred during treatment necessitate an effective means of preventing new or recurrent episodes of stroke.

The first reported surgical means of stroke prevention was introduced in 1954 with the excision of a stenotic portion of a patient's internal carotid artery in an attempt to stop the patient's recurrent attacks of hemiplegia.[2] The first true endarterectomy was reported by Dr Michael DeBakey in 1965 when he discussed his completion of thromboendarterectomy on a patient 11 years earlier.[2] Another significant contribution in the early history of carotid surgery was made by Dr Denton Cooley when he introduced the first intravascular shunt comprised of polyvinyl tubing with large bore needles fixed to each end as a means of bypassing the carotid circulation during the endarterectomy.[3]

Since the introduction of the endarterectomy in the 1950s, the popularity of the procedure has grown dramatically. From 1971 to 1985, the number of carotid endarterectomies performed in the United States increased by more than sevenfold.[4] Along with the increasing number of surgical procedures performed, many surgical preferences have evolved. Some surgeons use shunt and/or patch closure in all patients, whereas other surgeons rely on induced hypertension and primary closure with the selective use of shunt and patch. The purpose of this study was to explore the surgical outcome of the carotid endarterectomy surgical technique as experienced by one surgeon in his practice. Thirty-day postoperative morbidity and mortality as well as long-term follow-up were studied to assess the safety of carotid endarterectomy with induced hypertension and primary closure as a surgical means of stroke prevention.

Materials and Methods

The study design was a retrospective analysis of patients who underwent carotid endarterectomy between January 2002 and August 2009 using the surgical approach of induced hypertension with electroencephalographic (EEG) monitoring and primary closure. A few select patients required shunt and/or patch closure.

Preoperative

Preoperative evaluation included imaging with one or more of the following modalities: carotid duplex, computed tomography (CT) angiography, magnetic resonance (MR) angiography, or conventional angiography. Of the patients in the study, 204 (85%) had a carotid duplex, 44 (18%) had a CT angiogram, 75 (31%) had an MR angiogram, and 82 (34%) had a conventional angiogram. The average stenosis before surgical intervention was 75% by carotid duplex, 74% by CT angiography, 71% by MR angiography, and 74% by conventional angiography. The average stenosis regardless of imaging modality was 74%.

Table 1 Demographics and clinical characteristics of patients undergoing endarterectomy

Age (y, range)	33–85
Men	113
Women	93
Hypertension	181
Diabetes	82
Peripheral vascular disease	73
Coronary artery disease	107
Tobacco abuse	142
Dyslipidemia	146

Data presented as n unless otherwise indicated.

Demographics and clinical features

There were a total of 206 patients included in the study. Ninety-three were women, and 113 were men. The average age was 67 years (range 33–85 years). Thirty-three patients underwent bilateral procedures bringing the total number of surgeries to 239.

The population involved in this study had significant comorbidities. The comorbidities under review included hypertension, diabetes, peripheral vascular disease (PVD), coronary artery disease (CAD), tobacco abuse, and dyslipidemia. Patients were concluded to have one or more of these conditions if the diagnosis was mentioned in clinic notes, hospital notes, or correspondence from outside physicians. Of the 206 patients in the study, 181 (88%) had hypertension, 82 (40%) had diabetes, 73 (35%) had PVD, 107 (52%) had CAD, 142 (69%) had tobacco abuse, and 146 (71%) had dyslipidemia (Table 1).

Presenting symptoms included in the study were stroke, transient ischemic attack (TIA), and amaurosis fugax. Some patients were asymptomatic at presentation. Twenty-six patients (13%) presented with stroke, 77 (37%) with TIA, and 14 (7%) with amaurosis fugax. One hundred eight patients (52%) were asymptomatic.

Operative technique

The operations were performed under general anesthesia. Patients received 5000 units of heparin

intravenously before clamping of the artery. Induced hypertension to a systolic pressure more than 160 mmHg or at least 25% more than baseline level was used in all patients. The artery was then occluded and incision was made. The endarterectomy was completed, and the wound was closed primarily with 6-0 running Prolene (Ethicon, Sommerville, NJ, USA) sutures. Intraoperative duplex was performed to ensure adequate flow. Heparin was not reversed. Patients were monitored intraoperatively with EEG. Seven patients (3%) received intraoperative shunt because of EEG changes during the operation. Three patients (1%) underwent patch closure instead of primary closure. After the procedure, patients spent 1 night in the intensive care unit, where they received a low dose of low molecular weight dextran and a nicardipine drip for blood pressure control.

Follow-up

Patients received follow-up in the clinic at 2 weeks, 3 months, and 6 months after hospital discharge with regular appointments every 6 months thereafter. Carotid duplex was performed with every follow-up visit. The average follow-up was 22 months.

Results

Of the 239 surgeries performed, 16 were noted to have complications during the 30-day postoperative period including bleeding, infection, stroke, TIA, myocardial infarction, and death. The incidence of these events in the study population was as follows: 5 (2.1%) patients suffered bleeding, 2 (0.8%) developed infection, 3 (1.3%) had a stroke, 4 (1.7%) had a TIA, 1 (0.4%) had a myocardial infarction, and 1 (0.4%) patient died. The 1 patient who died during the 30-day postoperative period expired after his discharge. No information was available as to the cause of his death. This lead to an overall combined stroke and death rate of 1.7% during the immediate postoperative period.

Twenty-four events were noted during long-term follow-up and included stroke, TIA, repeat operation, repair of endarterectomy with stent, and death. The incidence of these events was as follows: 5 (2.4%) patients suffered a stroke, 2 (1%) had a TIA, 1 (0.5%) had a repeat operation, 2 (1%) required revision with a stent, and 14 (6.8%) patients died. Three (1.5%) patients did not take any medication for prevention of clot or lipid control after discharge from the hospital. None of these 3 patients suffered any documented morbidity or mortality during the immediate or long-term follow-up periods (Table 2).

Table 2 Morbidity and mortality after endarterectomy

30-day postoperative	
Bleeding	5
Infection	2
Stroke	3
TIA	4
Myocardial infarction	1
Death	1
Long-term follow-up	
Stroke	5
TIA	2
Repeat operation	1
Revision with stent	2
Death	14

Data presented as n unless otherwise indicated.

TIA, transient ischemic attack.

Discussion

The need for a safe and effective means of surgical prevention of stroke is apparent by the prevalence of stroke as well as the burden it places on patients, their families, and the health care community as a whole. Carotid endarterectomy was proven superior to medical therapy in symptomatic patients by 3 high-quality studies. These were the North American Symptomatic Carotid Artery Endarterectomy Trial,[5] the European Carotid Surgery Trial,[6] and the Veterans Administration Cooperative Trial.[7] Carotid endarterectomy was additionally proven beneficial in asymptomatic patients by the Asymptomatic Carotid Atherosclerosis Study,[8] European Carotid Surgery Trial,[6] and the Veterans Administration Cooperative Trial.[7]

Although the efficacy of carotid endarterectomy is widely accepted in the surgical field, there is significant controversy surrounding the various surgical techniques. The use of shunt and patch as opposed to induced hypertension and primary closure is hotly debated. This question was addressed by Dr Denton Cooley, the first surgeon to use the intraoperative shunt, who argued that temporary shunts were unnecessary for a successful endarterectomy. His stance was supported by a case series involving 25 patients on whom he successfully performed carotid endarterectomy without the aid of shunt in spite of complete occlusion of the contralateral carotid artery.[3]

Proponents of shunting argue that there is less likelihood of intraoperative stroke when compared

with induced hypertension. Research has shown, however, that selective shunting based on changes seen with intraoperative EEG and somatosensory-evoked potentials may be superior to the routine use of shunt.[9] The 1.3% incidence of postoperative stroke during the 30 days after surgery found in our study supports the argument that selective shunting with appropriate intraoperative monitoring is a safe technique for endarterectomy.

In reference to the use of patch versus primary closure of the carotid artery, some data suggest that patch closure may reduce the risk of perioperative occlusion and restenosis.[10] Although no comparison group was used in our current study, significant restenosis requiring revision was not found to be a problem with primary closure. Only 3 patients required a repeat operation or revision, which accounted for less than 1.3% of all cases in the study.

In conclusion, carotid endarterectomy is a safe and effective surgical means of stroke prevention.

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