CAROTID ENDARTERECTOMY

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Contents

Summary

Carotid endarterectomy (CEA) has been performed since the 1960s. In 1995, a landmark study (ACAS) described the relative benefit of carotid endarterectomy in stroke risk reduction in asymptomatic patients. Along with a similar randomized trial looking at the effect of CEA with patients with symptomatic carotid occlusive lesions (NASCET), these two studies served to consolidate the important role of CEA in stroke risk reduction in patients with and without neurologic symptoms. This chapter will summarize the pertinent historical details about the role of surgery in extracranial carotid disease, examine the robust data upon which current vascular surgical opinion is based, describe the surgical technique and finally, will review the evidence behind a newer treatment modality; carotid artery stenting (CAS).

1. Introduction

Carotid endarterectomy (CEA) has been performed since the 1960s with increasing evidence of potential benefit of various modalities in treating carotid artery stenosis and occlusive disease, including carotid endarterectomy, carotid artery stent, and best medical management. The present authors have been interested in this subject over many years. J. B. Chang has reported the potential benefit of carotid endarterectomy with vein patch since 1985. The peri-operative risk including minor stroke is 1.4% (Chang, 1985). In 1992, J. B. Chang reported on 450 carotid endarterectomies performed since 1976. The risk of post-endarterectomy stroke was 0.4%, including stroke related mortality of 0.2%, myocardial infarction (MI) 0.4%, and myocardial infarction-related mortality 0.2%. In the last 300 consecutive endarterectomies performed using a protocol consisting of general anesthesia, endoluminal shunt and vein patch, there was no peri-operative major morbidity/mortality related stroke or MI (Chang, 1985). The potential benefit of carotid endarterectomy and vein patch has been reported by the authors' group (Chang and Stein, 1997; Chang and Stein, 1998; Chang and Stein, 1997; Chang and Stein, 1998) with a ten-year outcome after saphenous vein patch angioplasty in males and females. This study showed five- and ten-year survival rates in males were 81.9% and 62.2%, respectively. The five- and ten-year survival rates in females were 82.6% and 73.0% respectively. The five- and ten-year ipsilateral stroke free rates after carotid endarterectomy were 98.3% and 93.9% in males and 96.7% and 95.6% in females. The respective five- and ten-year restenosis free rates were 96.7% and 93.3% in males and 88.6% and 82.8% in females ($P<0.001$). During this study, the incidences of ipsilateral stroke were similar in females and males. However, the hemodynamically significant restenosis rate was higher in females. The importance of post-operative follow-up with clinical and duplex scan evaluation for long-term assurance of the patient's safety was stressed (Chang and Stein, 2002). A rare but interesting complication with a temporary left- hand hemiplegia following right carotid endarterectomy was reported by our group (Borrero and Chang, 1984). The potential importance of surgeons' case volumes and type of arteriotomy closure may have a positive influence in outcomes, particularly with a saphenous vein patch (Chang and Stein TA 2003). The important diagnostic value of computer tomography in the decision for carotid endarterectomy was also studied (Chang et al, 2002). It was suggested suggested that the greater saphenous vein patch should be used when the diameter of the internal carotid arteries are less than 4mm after restenosis, and for all females. In that report, our ipsilateral stroke rate was 2.2% after primary closure and 0.5% after vein patch graft. In addition, this study showed that the long-term outcome after vein patch angioplasty following carotid endarterectomy is better than primary repair (Chang and Stein, 2000). During carotid endarterectomy, the nerve damage can be minimized if the surgeon dissects and divides the muscles carefully, identifies and preserves the nerves, and avoids aggressive stretching of the nerves during retraction of the muscles. The incidence of cranial nerve injuries is similar among transverse and vertical incisions. Skilled surgeons can minimize nerve damage with any approach by careful dissection while attempting to identify nerves and their branches, dividing the muscle carefully and avoiding any unnecessary aggressive stretching of nerves during retraction of the muscles. Occasionally, when it is necessary to divide vessels and nerves to increase exposure, only minor branches may have been sacrificed. While stretch injury will resolve in months, dividing a major nerve will have long-lasting effects (Chang and Stein, 2000; Skillman et al, 1994).

1.1. Historical Background Leading to Current Randomized Studies

The first recorded operations on the carotid arteries were done by Hevenstreit in 1793, and Abernathy in 1798 for control of hemorrhage, while Astley Cooper performed the first carotid artery ligation for aneurysm in 1805 (Friedman, 1989). In 1914, Ramsay Hunt described the role of carotid artery occlusion in the production of symptomatic vascular lesions of the brain (Hunt, 1914), and of course, Miller Fisher in the early 1950's not only re-emphasized the role of the carotid arteries in the causation of stroke but provided admirable descriptions of carotid pathology. Great credit goes to Dr. Fisher, a neurologist, for suggesting the possibility that surgical intervention upon the carotid bifurcation might be an effective therapeutic modality in stroke prevention (Fisher, 1951, 1954). In 1953, Dr. Michael DeBakey successfully performed a thromboendarterectomy of the common and internal carotid arteries of a 53-year old man who suffered repeated attacks of transient left-sided cerebral hemispheric strokes. However, he did not report this experience until 1975, three years after the patient died from unrelated causes, neurologically intact, having suffered no additional small strokes (DeBakey, 1975). The most profound effect upon carotid surgery resulted from the operation reported by Eastcott, Pickering, and Rob, who on May 19, 1954, operated on a 66-year old female and performed a resection of the left carotid bifurcation with end-to-end anastomosis between the common and internal carotid arteries (Eastcott et al, 1954).

With the major roles played by Dr. Michael DeBakey and a neurologist, Dr. William Field, the NIH (National Institute of Health) sponsored a perspective study of carotid endarterectomy. In 1962, twenty-one university services were participants, nineteen of which randomized patients for surgical treatment. The participants in the Joint Study of Extracranial Arterial Occlusions (JSEAO) (Fields and North, 1968; Hass and Fields, 1968; Bauer and Meyers, 1968; Blaisdell et al, 1969; Fields and Maslenikof, 1993) agreed to perform four-vessel angiographic studies to include visualization of the intracranial vessels on all patients who presented with complex neurologic symptoms, including devastating acute strokes that might possibly be due to cerebral ischemia. The goal was to surgically correct all accessible extracranial arterial lesions producing 30% or more stenosis, whether affecting the anterior or posterior circulation, and whether deemed “appropriate” to focal symptoms or not. Various non-invasive vascular technologies have evolved in the evaluation of carotid artery bifurcation by Gee, Kartchner, and Standnis (Gee et al, 1975; Kartchner and McCrae, 1977; Roederer and Langlois, 1984). The failure of the Extracranial-Intracranial Bypass Randomized Clinical Trial in 1988 to show a definite beneficial effect in patients with internal carotid occlusion further spurred the negative skepticism towards surgical intervention (EC-IC Bypass Study Group, 1985).

1.2. Randomized Clinical Trials examining Carotid Endarterectomy

The North American Symptomatic Carotid Endarterectomy Trial (NASCET) (NASCET Trial Collaborators, 1991) study randomized 652 patients for two years. These patients were divided into two groups; medical group, 331 patients, and surgical group, 321 patients. The medical group had an ipsilateral stroke rate of 26% and the surgical group 9%, indicating an absolute risk reduction of 17$\pm$3.5% (P< 0.001). Non-fatal ipsilateral stroke rate was 13.1% in the medical group and 2.5% in the surgical group, indicating an absolute risk reduction of 10.6$\pm$2.6% (P<0.001). In this study, if the degree of stenosis was 70-79%, the absolute risk reduction in two years was 12$\pm$4.8%, and if the degree of stenosis was 80-89%, absolute risk reduction was 18$\pm$6.2%. Furthermore, if the stenosis was 90-99%, the absolute risk reduction in two years was 26$\pm$8.1%. On the other hand, with the medical group, the ipsilateral stroke rate in two years in the low risk group was 17%, the moderate risk group was 23%, and the high risk group was 39% indicating a statistically significant outcome (P<0.001).

To answer the question of effectiveness of CEA in asymptomatic patients, the Asymptomatic Carotid Artery Surgery (ACAS) trial was conducted. This compared CEA with best medical therapy of that time. It randomized 1662 patients with carotid stenosis between 60-99% in 39 medical centers. The well-scrutinized findings showed a 5 year stroke risk of 11% in the medical arm and 5% in the surgical arm. Along with the NASCET trial, this study provided the bulk of the impetus for vascular clinicians to offer CEA in good risk patients with significant stenosis. (ACAS Executive Committee 1995).

1.3. Carotid Endarterectomy – Surgical Technique

There are many different ways to give anesthesia. Some prefer general and others, local anesthesia. We prefer giving general anesthesia with endotracheal tube under normotensive and normocarbic conditions. In addition, we routinely use an intraluminal shunt during the procedure.

Step 1

The patient is evaluated pre-operatively with carotid duplex scan, MRI or CTA with MRI or CT of the brain to confirm the surgical lesion, and to rule out any evidence of acute infarction. The patients should have medical and cardiac evaluation and clearance.

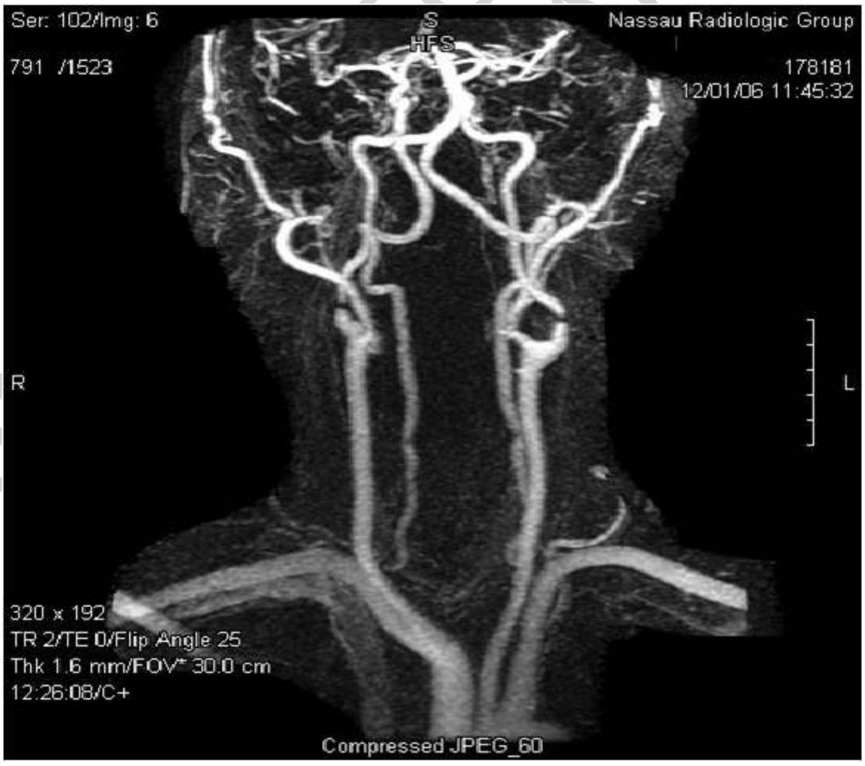

Figure 1. Magnetic Resonance Angiogram showing high grade stenosis at the bilateral internal carotid arteries (arrows)

Figure 2. Magnetic Resonance Angiogram showing severe stenosis at the internal carotid artery (arrow)

Figure 3. Magnetic Resonance Angiogram showing critical stenosis at the internal carotid artery (arrow)

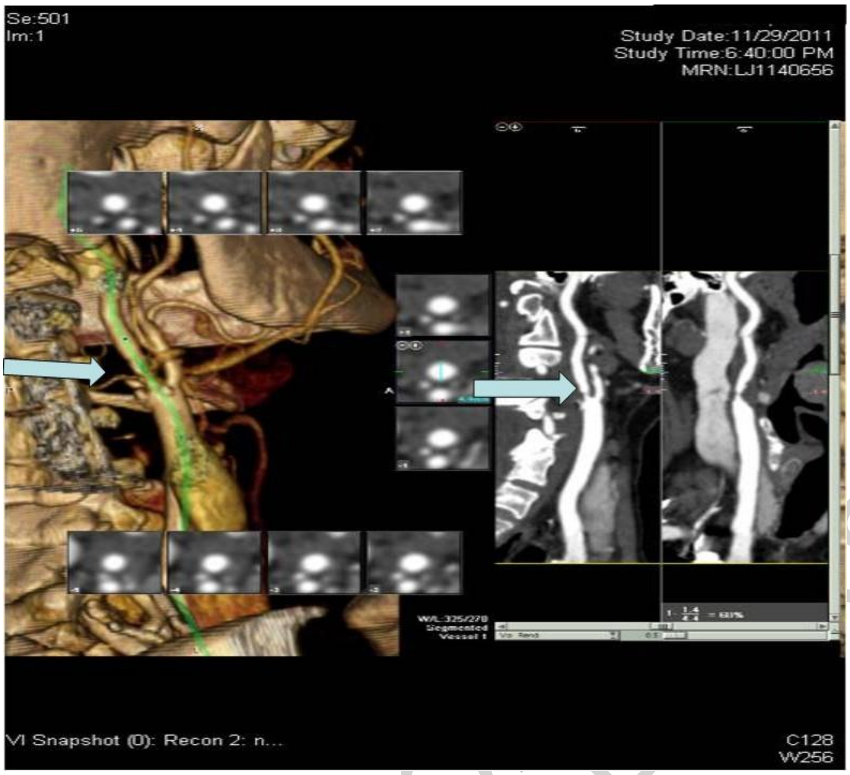

Figure 4. Computed Tomography Angiogram showing severe stenosis at the internal carotid artery (arrows)

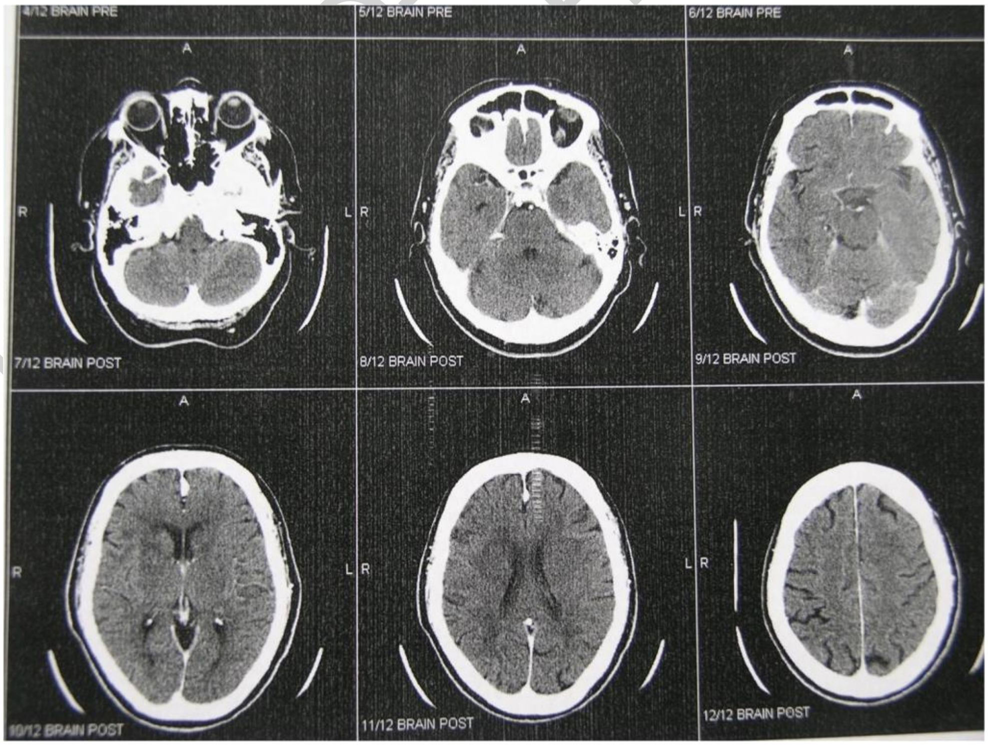

Figure 5. Pre-operative Computed Tomography Angiogram of the brain showing no evidence of an acute infarct

Step 2

During the operation, the patient is placed in the supine position and general endotracheal tube anesthesia is administered. The patient is given peri-operative antibiotics intravenously at the time of induction. A dose of 4mg of Decadron (a steroid) for prevention of post-perfusion brain edema, is given. The patient's shoulders are slightly elevated and the neck is turned to the opposite side and slightly hyper-extended.

The patient's proximal greater saphenous vein is pre-operatively mapped in the vascular laboratory for the best quality and localization of the appropriate vein patch segment.

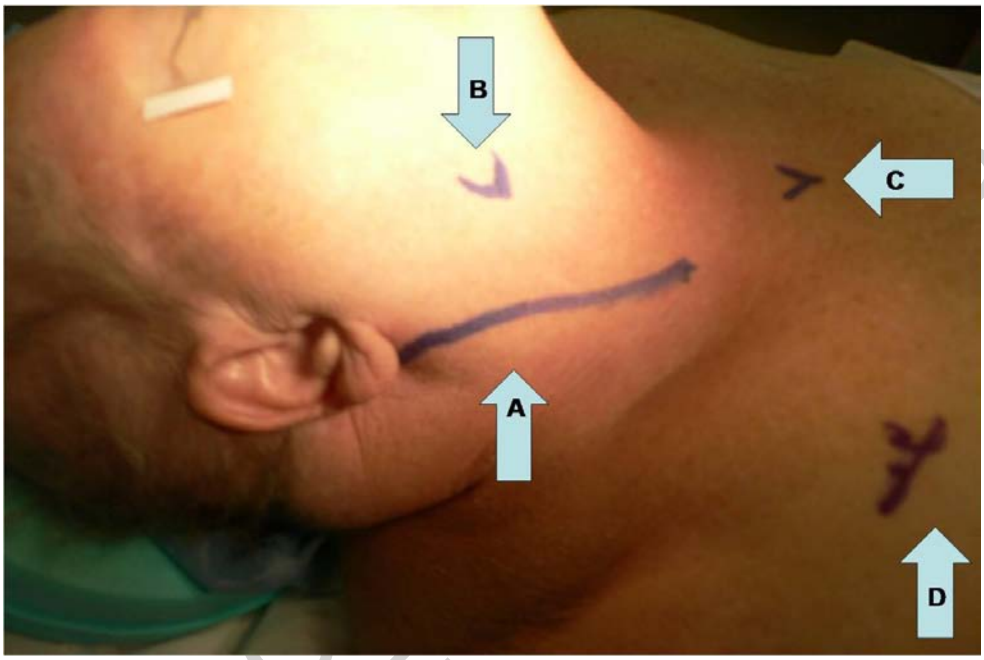

Figure 6. Photograph showing the position of the patient with slightly elevated shoulders, rotating the head to the contralateral side, marking shows the line of incision (Arrow A), which is along the anterior border of the sternocleidomastoid muscle. Arrow B indicates the angle of the mandible. Arrow C indicates the sternal notch, and Arrow D indicates the surgeon's initial confirming the side of the operative site.

Step 3

A semi-vertical incision is made on the neck along the anterior border of the sternocleidomastoid muscle.

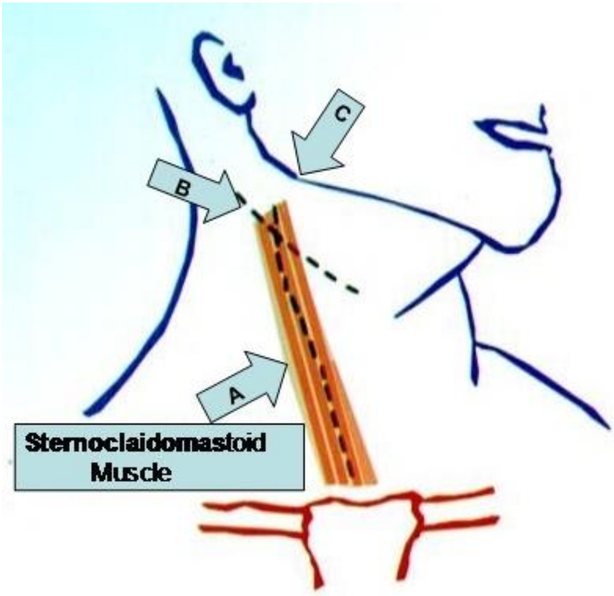

Figure 7. An incision is made along the anterior border of the sternocleidomastoid muscle (Arrow A). In some cases, the incision is made transversely in young female patients for cosmetic reasons. Arrow C indicates the angle of the mandible.

Step 4

The incision is deepened by a sharp and blunt dissection, retracting the muscle laterally.

Step 5

The carotid sheath is opened. The facial branches of the internal jugular vein are freed, isolated, ligated, and divided. Normally this vein indicates the level of the carotid bifurcation.

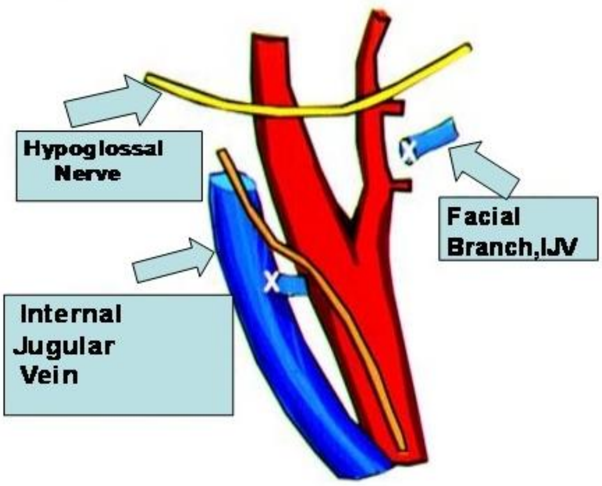

Figure 8. Exposed carotid bifurcation. The facial branch of the internal jugular vein is the landmark of anatomic level of carotid bifurcation. The hypoglossal nerve is indicated.

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