Management of Carotid Artery Stenosis: A Review


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Abstract. Carotid endarterectomy clearly benefits high stroke-risk patients, but its value for asymptomatic patients is still being debated. If a high exposure is necessary for redo procedures or distal aneurysms, mandibular subluxation and styloidectomy may be required. Perioperative mortality and morbidity are acceptably low. Restenosis occurs in few patients.

Introduction

Carotid artery disease is a manifestation of progressive atherosclerosis. The disease is associated with age, cigarette smoking, hyperlipemia, heredity, obesity, diabetes mellitus, anxiety, and stress [1]. It frequently coexists with other peripheral arterial diseases. Almost 50% of the patients with significant carotid artery disease also have coronary artery disease [2]. Occlusive disease of the lower extremity arteries coexists in approximately 60% of patients with carotid artery disease [3,4]. Carotid artery disease was also found in 10% of patients who have abdominal aortic aneurysms [5,6]. Another study found that 20% of patients with carotid artery disease also had abdominal aortic aneurysms [7].

A moderate, progressive growth of the atheromatous plaque occurs in 60% of the patients [8]. The interior of the plaque becomes necrotic when oxygen and nutrients are unable to reach the center of the atheroma. The fibrous cap of the plaque thins and raptures causing subintimal hemorrhaging. The shear force from turbulent blood flow can erode the unstable fibrous plaque, releasing embolic plaque material into the artery, which can be deposited in a distant artery causing ischemic events, such as a stroke, transient ischemic attack, or amaurosis fugax.

Benefits of Carotid Endarterectomy

Multicenter collaborative studies in North America and Europe have determined that carotid endarterectomy for symptomatic 70–99% stenotic carotid artery disease can reduce the risk of an ipsilateral ischemic stroke [9,10]. After more than 17,000 carotid endarterectomies for symptomatic disease, the 30-day perioperative risk was 5.6% for any stroke or death, 1.6% for any stroke, and 0.9% for a fatal stroke [11]. Since the perioperative mortality and morbidity rates are acceptably low, most of these patients benefit from carotid endarterectomy. Many patients with asymptomatic carotid stenosis also have a reduced risk for stroke after endarterectomy [12–14], but the benefit must outweigh the risk for complications. Attitudes toward carotid endarterectomy have changed from being popular in 1984 with 126 procedures per 100,000 adults in California, then declining to 66 per 100,000 in 1989, and now returning in popularity with 99 per 100,000 in 1995 [15].

Carotid endarterectomy should be done for symptomatic lesions when the stenosis exceeds 70% in diameter, bilateral stenoses exceed 50% in diameter, the stenosis exceeds 50% in diameter and the contralateral artery is occluded, a stenosis greater than 50% progresses rapidly, and when plaque is markedly ulcerated. The procedure is particularly beneficial for patients who had a recent hemispheric ischemic attack, a retinal transient ischemic attack, or nondisabling stroke [9].

A successful outcome after a carotid endarterectomy necessitates obtaining a detailed medical history and complete physical assessment of the patient, a carotid duplex scan, a computed tomographic and/or magnetic resonance imaging of the head to rule out infarction and nonvascular pathology, a cardiac evaluation, and arteriography, of the aortic arch.

Preparation for Carotid Endarterectomy

Preparation includes using an intravenous line for fluid replacement and pharmacological regulation of blood pressure, radial artery catheterization for intraoperative and postoperative pressure monitoring, and electroencephalography for brain function monitoring. Since the continuous intraoperative monitoring of the middle cerebral arterial blood flow is complementary to electroencephalography, it may be of value to use both techniques to prevent ischemic complications [16].
**Procedure**

The patient is in a semi-Fowler position with the neck extended and rotated to the contralateral side [17]. Routinely, a semivertical incision is made along the anterior border of the sternocleidomastoid muscle but occasionally a transverse incision is made under the mandible at the level of the bifurcation in younger female patients. After the sternocleidomastoid muscle is freed and retracted laterally, the facial branch of the internal jugular vein should be located, because the carotid artery usually bifurcates below this vein. The vein is freed, ligated and divided, and the carotid sheath is carefully opened. The common carotid artery is freed, and further dissection exposes the carotid artery bifurcation. Then a local anesthetic is infiltrated into the carotid body to minimize hemodynamic complications. The common carotid artery is freed proximal to the plaque, and dissection distally exposes the bifurcation. The first branch of the external carotid artery is identified and the proximal external carotid is freed and encircled with a vessel loop. Then dissection of the internal carotid artery is extended distally. The hypoglossal nerve should be identified and preserved intact. Frequently a branch can be identified running anteriorly and medially or occasionally laterally along the artery.

Many surgeons routinely use a temporary shunt of the carotid artery, and others use it selectively in the presence of a contralateral occlusion [18]. Some surgeons have indicated that a carotid endarterectomy can be safely performed without a shunt, even when the contralateral artery is occluded [19]. When a single arteriotomy is difficult to perform on a critically stenotic lesion, two separate arteriotomies are done with one on the proximal common carotid artery and one on the distal internal carotid artery. The arteriotomies are connected after the shunt is inserted and opened. If there is extensive stenosis in the external and internal carotid artery, the arteriotomy is extended from the common carotid artery to points distal to the plaque in the internal and external carotid arteries. Usually the arteriotomy is extended beyond the proximal branches of the external carotid artery to observe back flow. After the plaque is removed, the walls of the internal and external carotid arteries are apposed and sutured, and a vein graft is used to close the arteriotomy. This procedure is called a carotid artery bifurcation advancement.

Most plaques terminate at 2–3 cm above the carotid bifurcation and sharp and blunt dissection will readily expose the stenosed carotid artery. When the plaque location is higher and at the level of the second cervical vertebra, the "slang vessels" are carefully freed, ligated, and divided. The hypoglossal nerve is further freed distally. The ansa hypoglossal nerve is located and is usually mobilized with the hypoglossal nerve, and rarely will require division. The posterior belly of the digastric muscle can be divided to gain additional distal exposure to about the middle of the first cervical vertebra, but care must be taken to avoid injury to the glossohygngal nerve [20]. With these maneuvers, temporary subluxation or dislocation of the mandible joint is seldom necessary to facilitate adequate exposure of the distal artery.

In some patients, a high carotid endarterectomy may require mandibular subluxation, detachment of the styloid process, or mandibulotomy [21]. Preparation necessitates an oral examination and panoramic maxillomandibular radiographs of the teeth and temporomandibular joint by an oral surgeon. An incision is made along the anterior border of the sternocleidomastoid muscle and extended cephalad by dissection. The underlying internal carotid artery is dissected above and below the hypoglossal nerve. After the mental foramen is located, the ramus of the mandible is displaced anteriorly by subluxation and sustained by intermaxillary fixation. Subluxation of the mandible can extend the exposure to about 2 cm from the skull base and a styloidectomy can increase the exposure an additional 0.5 cm cephalad [21,22]. This approach makes a triangular-shaped exposure into a rectangular space, which better facilitates dissection, and has been used routinely for distal carotid aneurysms or recurrent stenosis.

**Complications**

Complications of carotid endarterectomy include cranial nerve injuries in 8–16% of the patients, with vocal cord paralysis in 6%, hypoglossal nerve injury in 5%, facial nerve injury in 2%, and spinal accessory nerve injury in <1% [23]. Most of the nerve dysfunctions are temporary and are a consequence of aggressive retraction. After a subluxation of the mandible, some patients will experience transient temporomandibular joint pain for 2–3 days [23].

Perioperative strokes are believed to be related to the technical errors made during endarterectomy and/or reconstruction of the carotid artery, which caused ischemia during cross-clamping, postoperative thrombosis and embolism, intracerebral hemorrhage, and other surgical problems [24].

**Post-Endarterectomy**

After the endarterectomy, all possible debris is removed from the arterial lumen. The indwelling shunt catheter is removed before completing closure of the arteriotomy, and all possible air or clot is removed from the shunt and arterial system. The circulation is restored first to the external carotid artery and then to the internal carotid artery, while brain function is being monitored by electroencephalography.

The arteriotomy can be directly closed in male patients if the diameter of the internal carotid artery is ≥4 mm [25]. The greater saphenous vein graft has been preferred by many surgeons for males with arteries <4 mm in diameter, for all females, and after restenosis because it has yielded excellent results [25]. It is important that all scored media is excised [26]. The vein graft should be anastomosed only to healthy intima beyond the margins of the endarterectomy. Kinking of the internal carotid artery is corrected by shortening the segment by plication. The vein graft tends to straighten the carotid arterial system, but the angle of branching remains unchanged with a primary closure. Usually, a 6 cm (2.5 inch) length of proximal greater saphenous vein is harvested from above the knee to obtain a width >3.5 mm to avoid rupture of the vein graft [25,27,28]. No graft ruptures have occurred after 631 vein grafts in our 526 patients. Ruptures occur primarily in vein grafts obtained from the distal vein [27].