33 Carotid Endarterectomy
Eli M. Baron, Darric E. Baty, and Christopher M. Loftus

Indications

- For symptomatic patients, according to North American Symptomatic Carotid Endarterectomy Trial (NASCET)/European Carotid Surgery Trial criteria, carotid artery stenosis of 70% or more and a subgroup of patients with 50% or more
- For asymptomatic patients, according to Asymptomatic Carotid Atherosclerosis Study/Asymptomatic Carotid Surgery Trial criteria, patients with 60% or more cervical internal carotid artery stenosis

◆ Preoperative

Evaluation and Planning

- Consider a duplex ultrasound of the neck
- Magnetic resonance angiogram/computed tomographic angiogram of the neck
- Strongly recommend arteriography; according to NASCET methodology, percent stenosis is measured by percent stenosis = 1 – N/D × 100 (where N is the linear diameter at the region of greatest narrowing and D is the greatest diameter of the normal arteries distal to the carotid bulb)
- Also consider medical work-up for risk stratification and concurrent medical comorbidities

Special Operative Equipment

- Carotid endarterectomy instruments
- Well balanced vascular pick-ups
- Dissecting scissors
- Micro ring tip forceps
- Cross clamps
- Shunt clamps
- Potts scissors
- Micro-type needle drivers
- Indwelling shunt

Operating Room Set-up

- 3.5 x loupes
- Monopolar cautery
- Bipolar cautery
- Headlamp
Positioning

- The patient is placed in the supine position with the head extended and turned slightly away from the site of the operation.
- Folded sheets or pillow cases should be placed beneath the shoulder blades to aid in extension of the neck as needed.
- Leads should be placed on the head by the electroencephalogram (EEG) technologist. Additionally, monitoring with somatosensory evoked potential may be considered.

I Intraoperative

- After the patient is positioned, a linear incision is made along the anterior border of the sternocleidomastoid muscle, which may extend as high as the retroauricular region and as low as the suprasternal notch (Fig. 33.1A).
- The skin and subcutaneous tissues are then dissected sharply down through the platysma, inevitably transecting the transverse cervical nerve. Meticulous hemostasis is obtained.
- The anterior edge of the sternocleidomastoid muscle is located and retractors are placed.
- Attention is directed to the middle of the incision where dissection proceeds down the sternocleidomastoid muscle and internal jugular vein is reached and identified. Caution should be taken to avoid injuring the spinal accessory nerve. The jugular vein typically lies lateral, parallel, and slightly anterior to the internal carotid artery (ICA) and common carotid artery (CCA). The medial jugular vein is fully exposed and the jugular is retracted using a blunt blade.
- The facial vein and several smaller veins are usually doubly ligated and divided. The common facial vein is an important landmark as it crosses the field in the region of the carotid bulb.
- Afterward, 5000 units of intravenous heparin is given.
- Individual vessels are dissected out and circled with silk ties or vessel loops. If significant vital sign changes occur, 1% lidocaine may be given via a 25-gauge needle to the carotid sinus.
- The CCA and external carotid artery (ECA) are dissected circumferentially where 0 silk ties are placed around them. They are not, however, dissected free of tissue along their back walls to minimize kinking of the vessels. The ICA is freed posteriorly.
- A Rummel tourniquet is used with a 0 silk tie that passes around the CCA. Mosquito clamps are used to secure the ECA and ICA ties, which are placed with a baby right angle clamp.
- Superior thyroid artery is dissected out of the surrounding connective tissue and a double loop 00 silk ligature is placed around the vessel. Mosquitoes are placed around each of the ties to keep them taught. Care must be taken to keep the field uncluttered.

Cross-clamping of the Carotid

- Cross-clamping should only occur after the ICA is dissected beyond the distal border of the plaque. Additionally, the hypoglossal nerve should be recognized high in the carotid sheath, swinging medially. This should be mobilized and gently retracted from the field using a vessel loop.
- A small ECA branch to the sternocleidomastoid muscle may require ligation to facilitate mobilization of the hypoglossal nerve.
Fig. 33.1 (A) The patient is positioned supine with his or her neck in extension and turned to the contralateral side. (B) Carotid artery exposure. Note the ligatures around the internal and external carotid arteries and the superior thyroid artery. Note the vessel loop around the hypoglossal nerve. The arteriotomy site has been marked with a marking pen from the common carotid artery to the internal carotid artery (ICA) with care taken to make sure it runs beyond the extent of the plaque. (C) Loftus-type encircling pinch clamps are used to hold shunt tubing in place in the distal ICA. (D) Completed closure of arteriotomy using a Dacron patch and Prolene suture. A Dacron patch was used toward the distal end of the closure due to a thinned vessel wall.
Deep within the carotid sheath lies the vagus nerve. This should be identified to avoid inadvertently cross-clamping it. Additionally, Horner syndrome may occur if the sympathetic chain, which lies adjacent to the carotid, is injured.

Prior to planning the arteriotomy, adequate control and exposure of the cervical ICA distal to the plaque is mandatory. A sterile marking pen is used to draw the proposed arteriotomy. The EEG technician is notified of an impending clamp.

After baseline EEG is obtained, the ICA is occluded first, with a small bulldog clamp. The CCA is next occluded with a large DeBakey clamp, and the ECA are then occluded with second straight bulldog clamp, usually a bit larger and stronger than the ICA bulldog.

An arteriotomy is made with a no. 11 scalpel blade and Potts scissors are used to extend the incision once the lumen is fully visualized (Fig. 33.1B). The marked arteriotomy line is incised from the CCA up to the bifurcation and then up the ICA until normal vessel is encountered. This can be quite challenging in severely stenotic vessels and great caution must be taken to avoid incising the back wall of the carotid. The possibility of a false lumen should be ruled out before placing a shunt.

If these occur, we do not hesitate to recommend placement of a shunt (Fig. 33.1C). The shunt is inserted first in the CCA and it is secured by pulling up on the silk ties where a Rummel tourniquet is then used to secure it in place. The shunt tubing is then cleared of debris by briefly releasing the vascular forceps allowing confirmation of blood flow through it. The lumen of the ICA is then clearly visualized and the distal end of the shunt is inserted into the ICA opening. The shunt is bled into the ICA to wash it free of debris. The bulldog on the ICA is then released and the shunt is advanced past the orifice of the ICA until its midpoint lies within the center of the arteriotomy. The shunt should slide easily up and down the ICA. Care must be taken to insert the shunt gently to avoid possible intimal dissection.

A Loftus-type encircling pinch clamp (Scanlan International, St. Paul, MN) (Fig. 33.1C) is then used to hold the shunt in the distal ICA. A Doppler can be used to confirm blood flow in the shunt tubing.

A plaque dissector or Freer elevator can be used to dissect the plaque away from the arterial wall. While the wall of the vessel is being held with a fine vascular pickup, the elevator is used to develop a plane between the carotid wall and the plaque. This is done first laterally, then medially. The plaque is then transected with a Potts scissors, leaving a smooth transition zone. A clean feathering away of the plaque is almost never possible in the CCA. Because the proximal end may create a flap despite the direction of blood flow, care should be taken to ensure that the CCA end point is not free floating.

The plaque is then dissected away from the ICA in a similar manner. In the carotid artery, however, the plaque tends to feather down smoothly, obviating the need for sharp dissection. Occasionally a shelf of tissue protrudes, which must be tacked down with a suture.

ECA plaque is then grasped and traction on it averts the ECA. In addition, the distal ECA can be pushed proximally with clamps or forceps. The plaque can then be removed distally from the ECA.
It is imperative that a complete plaque removal be done from the ECA as this can have serious consequences if a dissection and clot propagate in a retrograde manner throughout the carotid tree. If necessary a second limb of the arteriotomy may be extended up the ECA to ensure adequate plaque removal.

All loose fragments should then be sought and removed using a combination of micro-ring tip forceps, suction, and a peanut sponge.

Occasionally, removal of a stony hard plaque can be very difficult, resulting in thinning areas of posterior arterial wall where only the adventitial tissue remains. 6–0 Prolene sutures can be used, similar to a tacking suture to pli cate any thin areas, or if necessary an encircling diaper of graft material can reinforce the vessel wall.

**Closure of Arteriotomy**

- Tacking sutures in the distal internal carotid artery may be necessary. We recommend placement of a Dacron patch. The patch’s ends should be tapered to fit.
- Double arm 6–0 Prolene suture is used to attach each of the patch’s ends to the arteriotomy. Rubber-shod clamps are used to secure the needles. Running, nonlocking stitches should be used to close the medial wall suture line from the ICA anchor to the CCA anchor. The anchors should be tied together.
- The suture line should be inspected and the lateral wall is closed to the level of the carotid bulb with the remaining limb of ICA anchor stitch. The CCA anchor stitch is used to close the lateral carotid artery wall up to the ICA limb. We stress strict attention to detail, including all arterial layers and using bites 1 mm deep and 1 mm apart so that leakage will be minimized.
- If a shunt has been placed, a small opening is left in the lateral CCA wall where the shunt can be removed. The EEG technician is notified, the shunt is then double clamped with two parallel straight clamps, and then the shunt is cut between the clamps. Care must be taken to ensure suture material is not tangled with the shunt clamps and the transected shunt pieces are removed.

**Opening of the Vessels**

- ICA, ECA, and CCA are opened and closed to insure back bleeding is present. The ICA is opened and closed again to be certain there is no debris or air occupying the vessel. A heparinized saline syringe with blunt tip is inserted into the arterial lumen. The two 6–0 Prolene stitches are held tight. The heparinized saline is injected into the vessel and a surgeon’s knot is thrown as the syringe is withdrawn, allowing no air to enter the vessel. Ten or more throws are placed to complete the final stitch.
- De-clamping is then performed in the following order: first the ECA, then the CCA, then, after at least a 10-second pause, the ICA. This ensures all remaining debris enters the ECA.
- The suture line is inspected for leaks.
- Pressure and surgical gauze are then used to obtain hemostasis. Occasionally a single throw of 6–0 Prolene may be necessary for a small bleeder along the line. All pumping arterial bleeders should be secured with sutures. Oozing points only will stop with pressure, as will needle hole bleeding. Surgical gauze is then used to line the repair and all vessels are checked for patency with a handheld Doppler.
- Retractors are then removed when hemostasis is obtained. The carotid sheath is then closed and a Hemovac drain is left inside. The platysma is closed as a separate layer for cosmesis.
Postoperative

— Continue the patient on aspirin. Maintain one night in intensive care unit to watch for any signs and symptoms of stroke, labile blood pressure, or myocardial compromise.
— A low perioperative morbidity and mortality of less than 3% are necessary to justify routine carotid endarterectomy. This is reasonable at centers that do adequate volume. The majority of postoperative deaths are a result of cardiac ischemia.
— Complications including wound infection and postoperative hematomas are rare. Wound infections may be treated with antibiotics and possible exploration or washout. Hematomas are usually self limiting but symptoms such as airway compromise may require immediate exploration at the bedside.