

## METHODS

## Carotid endarterectomy – Surgical nuances

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Carotid endarterectomy (CEA) is a crucial surgical intervention developed to prevent cerebrovascular accidents in patients with significant carotid artery stenosis/narrowing. This procedure involves the removal of plaques from the intimal surface of the carotid artery to restore adequate cerebral perfusion and reduce the risk of embolic events. As one of the most common vascular surgeries, CEA requires strict adherence to surgical protocols to minimize complications and ensure favorable patient outcomes. Typically performed under general anesthesia, CEA necessitates precise anatomical visualization and careful dissection of the common, internal, and external carotid arteries. This article provides an in-depth review of surgical considerations, including patient positioning, arterial clamping, plaque removal, arterial closure techniques, and intraoperative shunting based on neuromonitoring feedback. In addition, it outlines essential postoperative care to monitor and address potential complications, aiming to offer neurosurgeons a comprehensive guide to achieving optimal outcomes in CEA.

**Keywords:** Carotid, endarterectomy, stenosis, atherosclerosis, technique

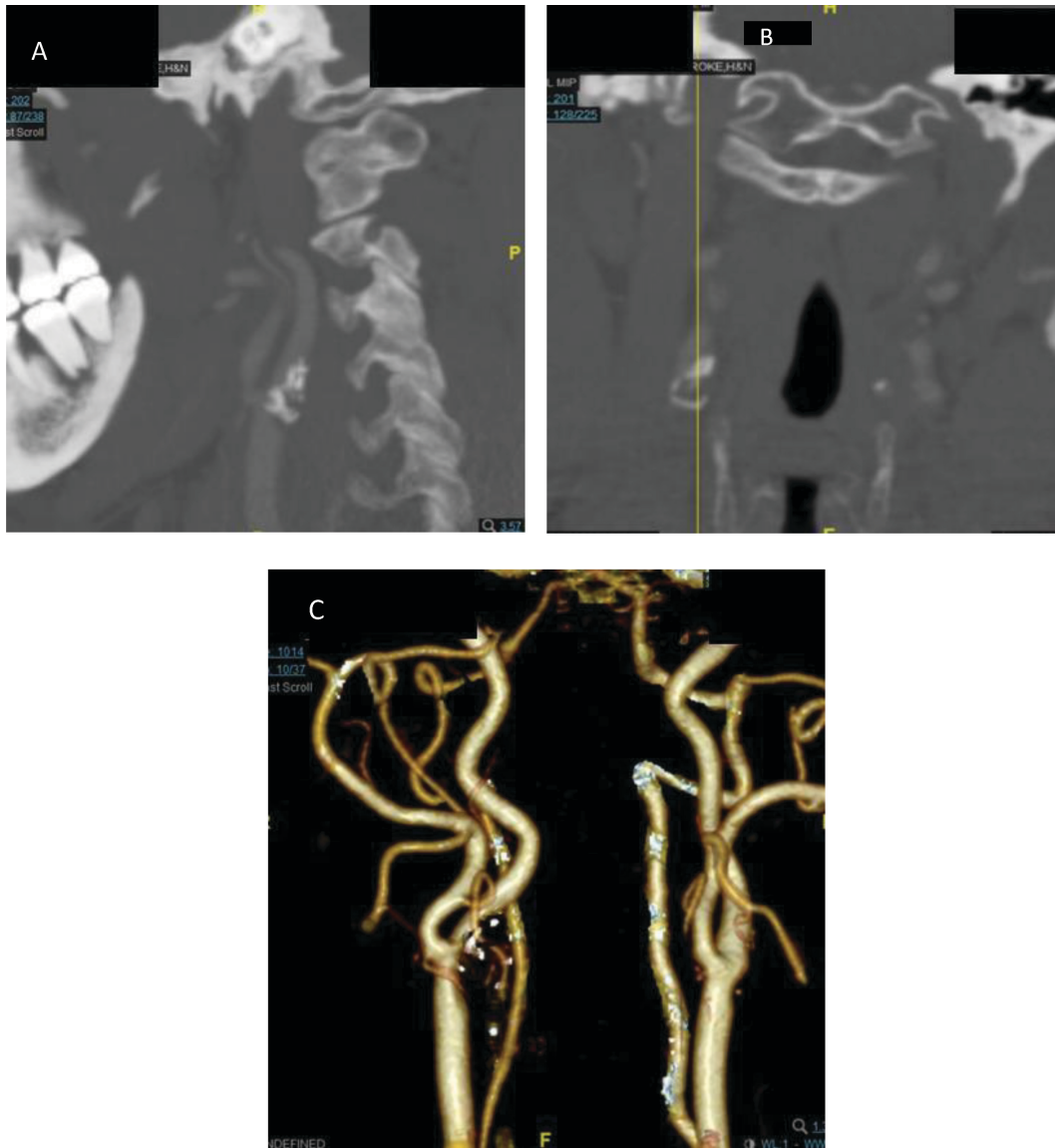
### Introduction

Carotid endarterectomy constitutes a significant surgical intervention aimed at mitigating the incidence of cerebrovascular accidents in individuals presenting with substantial carotid artery (CA) stenosis, predominantly attributable to the accumulation of atherosclerotic plaques. This operative procedure entails the excision of the plaque from the intimal surface of the CA, thereby re-establishing sufficient cerebral perfusion and diminishing the probability of embolic occurrences. As one of the most frequently executed vascular operations, carotid endarterectomy necessitates scrupulous adherence to surgical protocols to reduce the risk of complications and to guarantee favorable patient prognosis (1).

The surgical intervention, conventionally conducted under general anesthesia, requires meticulous anatomical visualization and deliberate dissection to effectively delineate the common CA (CCA), internal CA (ICA), and external CA (ECA). Intraoperative neuromonitoring techniques, which

encompass somatosensory-evoked potentials (SSEP), motor-evoked potentials (MEP), and bispectral index (BIS), are integral to assessing the anesthetic depth and ensuring the patient's safety throughout the operative procedure (2, 3).

The manuscript delineates the intricate surgical considerations associated with carotid endarterectomy, underscoring the criticality of appropriate patient positioning, meticulous arterial clamping, the excision of plaque, and the methodologies for arterial closure. Furthermore, it elaborates on the criteria guiding the judicious application of intraoperative shunting, contingent upon neuromonitoring feedback, in addition to the requisite postoperative care to vigilantly observe for potential complications and facilitate an uneventful recovery. Through a comprehensive and methodical approach, the ensuing content aspires to furnish an exhaustive guide for neurosurgeons and vascular surgeons undertaking carotid endarterectomy, accentuating optimal practices and pivotal considerations for attaining favorable surgical outcomes (4).



**FIGURE 1 | (A–C)** Preoperative contrast CT scan. (bone window) and 3D recon showing a calcified plaque at the CCA/ICA with luminal narrowing > 70%.

## Preparation and anesthesia

Following pre-operative workup (**Figure 1**), surgical fitness is obtained by a neuroanesthesia team and consent is obtained. Patient is given general anesthesia, with an extended head and tilted to the opposite side. Intraoperative neuromonitoring is used including SSEP, MEP, and BIS to evaluate the depth of anesthesia.

## Incision

A longitudinal incision is made along the side of the neck, along the medial margin of the sternocleidomastoid. The incision is typically about 4–6 inches long.

## Exposure of the CA

The skin, subcutaneous tissue, and underlying muscles are carefully separated to expose the CA. The artery is dissected free from surrounding tissues. The CCA, the ICA, and the ECA are exposed. It is important to expose the entire length of the plaque as well as a segment of the ICA beyond the plaque.

## Clamping of the carotid arteries

Once the complete exposure of the required length is obtained, heparin 3000 IU is given intravenously. Then, ties are placed around the CCA, ICA, and ECA in case a



**FIGURE 2 | (A,B)** Post-operative CT with 3D Recon showing complete plaque removal.

bypass shunt is necessary. An elective shunt may be placed to maintain blood flow to the brain during the procedure; however, we do not use a shunt routinely in our patients. A shunt is placed only if the MEP and SSEP show a drop after clamping of the ICA. The clamping is performed in the following order—ICA, CCA, and ECA. The clamping is done either with a bulldog clamp or with multiple standard temporary aneurysm clips.

## Artery incision

An incision is made along the CA to access the plaque. The plaque is carefully removed from the artery wall.

**VIDEO 1 | Carotid Endarterectomy: Surgical Nuances.**  
<https://youtu.be/wtz7RHXh3go>

## Plaque removal

The plaque is carefully dissected and removed from the inner lining of the artery. The artery is inspected to ensure that all plaques are removed and the inner surface is smooth.

## Closure of the artery

The artery is repaired, usually by closing the incision in the artery with 6/0 proline sutures. We rarely use a patch to augment closure.

## Restoration of blood flow

The clamps are removed, in the reverse order of application, i.e., ECA, CCA, and then ICA. Blood flow is restored to the CA, which is measured with an intraoperative Doppler. The shunt, if used, is also removed.

## Closure of the incision

The layers of tissue and skin are sutured back together. The incision is closed in layers, typically with absorbable sutures or staples.

## Postoperative care

The patient is monitored for complications such as bleeding, infection, or changes in neurological function. Medications and follow-up care are provided to support recovery and prevent complications. A postoperative CT angiography (**Figure 2**) is performed to document plaque removal.

## Conflict of Interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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