




## Sliding arterioplasty: A novel technique for carotid endarterectomy

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### ABSTRACT

Carotid endarterectomy is the procedure of choice in the surgical treatment of atherosclerotic disease of carotid arteries to prevent ischemic and embolic cerebral complications. Traditionally, carotid endarterectomy is performed using primary repair, patch plasty and eversion endarterectomy techniques. We present a novel technique of carotid endarterectomy that preserves vessel continuity without stenosis, avoids the use of autologous or synthetic patches, and ensures complete endarterectomy.

**Keywords:** Arterioplasty; carotid artery stenosis; endarterectomy.

Carotid endarterectomy (CEA) is a widely accepted method for the treatment of stenosis of the carotid arteries. The efficacy of CEA has been clearly shown for the prevention of cerebral ischemia and stroke in selected patients with hemodynamically significant stenosis of the internal carotid artery (ICA).<sup>[1-5]</sup> Technically, conventional CEA (cCEA) and eversion CEA (eCEA) techniques are well-described techniques.<sup>[3,5]</sup> In cCEA, a longitudinal arteriotomy is made and, then, extended beyond the plaque both proximally and distally. This is typically followed by primary repair or the use of an autologous or synthetic patch angioplasty closure. While primary repair may cause restenosis postoperatively, the use of patch may be associated with suture line complications such as bleeding, pseudoaneurysm or infection.<sup>[1,6]</sup> Alternatively, eCEA method can be preferred with oblique transection of the ICA at the origin of carotid bifurcation, extirpation of the plaque through eversion and re-implantation of the ICA into the carotid bulb. Its use is rare due to technical difficulties in small arteries and weak vessel wall. To minimize the morbidities of these traditional techniques such as restenosis, bleeding and aneurysm formation, the decision was made

for this approach. In this report, we describe a novel surgical technique for CEA, namely sliding arterioplasty. This technique can be more practical, feasible, and reasonable compared to the other techniques and their potential morbidities after CEA operations.

### SURGICAL TECHNIQUE

An oblique incision that parallels anterior border of the sternocleidomastoid muscle is performed on cervical region. The incision line is centered over the carotid bifurcation. The incision carried down through the platysma and sternocleidomastoid muscle is retracted laterally with self-retaining retractors. The external jugular vein is retracted laterally and the common facial vein is ligated. The carotid sheath is opened along the anterior border of the vein. Dissection is continued anterior to the common carotid artery (CCA) to avoid an injury to the vagus nerve. The vagus nerve usually lies in a posterior lateral position within the carotid sheath, but occasionally may spiral anteriorly, particularly in the lower end of the incision. During dissection, attention should be paid to cranial nerves

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IX (glossopharyngeal nerve), X (vagus nerve), XI (accessory nerve), and XII (hypoglossal nerve) and the marginal mandibular branch of VII (facial nerve). The CCA is mobilized proximal to the carotid lesion. Dissection is continued upward to isolate the external carotid artery (ECA). The ICA is mobilized up to a point where the vessel is completely normal.

This technique allows the use of intravascular shunt during CEA, if needed. In patients with significant contralateral carotid artery stenosis, poor collateral circulation, poor backflow from ICA, low pressure of the ICA or an abnormal data from intraoperative neuromonitorization such near-infrared spectroscopy, a shunt is placed by inserting the distal end of the shunt into the normal ICA distal to the lesion. After confirmation of back-bleeding and insertion of the distal end of the shunt, the proximal end is placed well into the CCA, proximal to the plaque (Figure 1a, 2a).

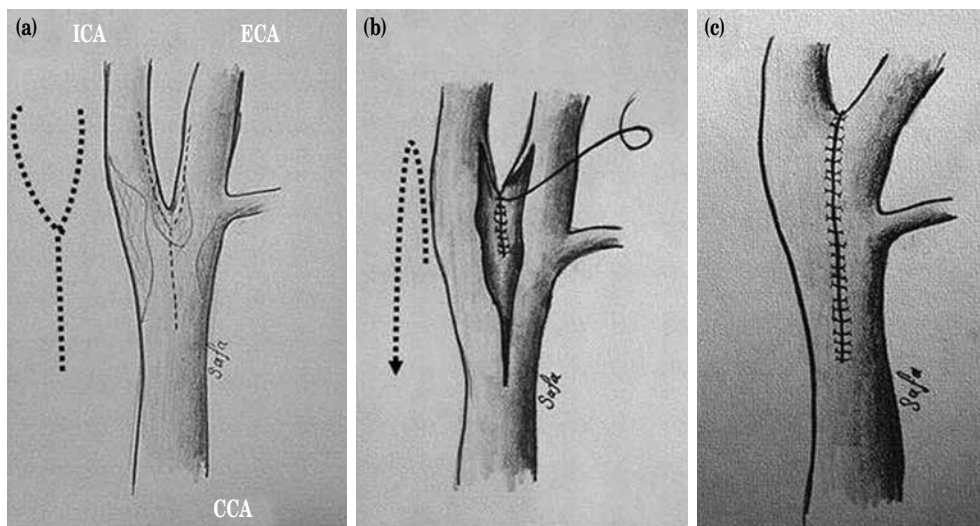
#### Y-shaped arteriotomy incision

Heparin (5,000-7,000 U) is administered intravenously. The internal, common and external carotid arteries are clamped respectively. A Y-shaped incision for arteriotomy is made using a No. 11 blade. The incision starts anteriorly along the CCA proximal to the lesion and extending cephalad through the plaque. At the bifurcation level,

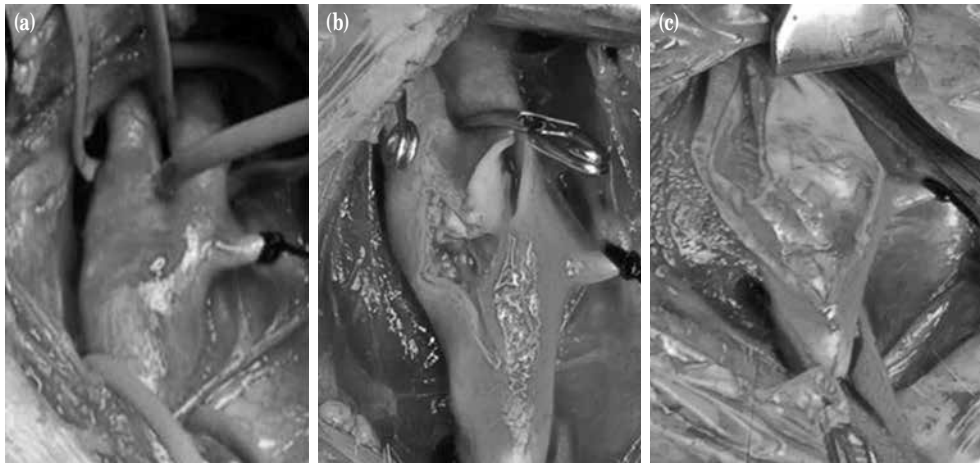
incision line is extended cranially into the external and ICAs with 30 degree Potts scissors. The two-arms of Y-incision beyond bifurcation is cut in a facing-fashion towards each other. Distally to the plaque, the arteriotomy incision is extended until it reaches a point where the ICA is relatively normal (Figure 1b, 2b).

#### Endarterectomy

The endarterectomy proper is begun with a Penfield elevator. The optimal endarterectomy plane is that between the inner and outer medial layers. The proximal endpoint is obtained by sharply dividing the plaque in the CCA. The plaque can be elevated under full vision while the endarterectomy is continued into the carotid bulb. Carotid plaque that extends a short distance into the ICA may be ridded medially toward the origin of the ECA to achieve an adequate endpoint. The plaque can also be divided in the bulb so that the internal and external carotid endarterectomies can be conducted, respectively. If a smooth distal end is not achieved, placement of interrupted 7-0 monofilament tacking sutures may be necessary to secure the outflow. After completion of endarterectomy, all residual debris and medial fibers are removed due to their potential contribution to embolization or hyperplastic restenosis. The endarterectomy surface is irrigated with heparinized saline solution to facilitate visualization and removal of all debris. Before the clamps are removed, flushing



**Figure 1.** (a) Carotid arteries and Y-shaped incision from CCA extending to internal and external carotid arteries. (b) Appearance of carotid arterial splitting by Y-shaped incision. Note the direction of suture closure from the posteroinferior edge of the incision line towards superiorly. (c) Closure of incision line and final view of bifurcation site as combining ICA and ECA. CCA: Common carotid artery; ICA: Internal carotid artery; ECA: External carotid artery.



**Figure 2.** (a) Perioperative view of the carotid bifurcation. (b) Y-shaped incision from CCA through the bifurcation and distally along the facing surfaces of ICA and ECA. (c) Appearance of sutured posterior part of Y shaped incision extending to ICA and ECA, superior thyroid artery. CCA: Common carotid artery; ICA: Internal carotid artery; ECA: External carotid artery.

must be done from each direction. The ICA is unclamped last.

#### Closure of arteriotomy incision

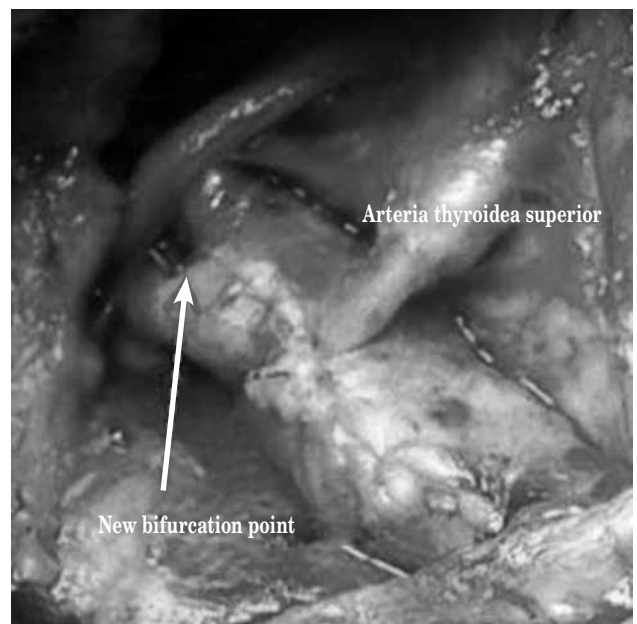
The Y-shaped arteriotomy incision is closed continuously with one 6/0 prolene suture, starting from the lower end of posterior incision line towards the superior end of posterior incision line, namely new bifurcation point (Figure 3). Then, with a separate prolene suture, arteriotomy is closed continuously from the lower end of anterior part of incision to upper tip of incision towards the new bifurcation site. Thus, both anterior and posterior edges of the Y-shaped arteriotomy incision are attached to each other and vessel wall continuity is ensured. The proximal ECA is conjoined with the proximal ICA. Therefore, the bifurcation site is transferred to a higher point than the first location (Figure 1c, 3). This technique provides effective increasing in luminal diameter of endarterectomy area without luminal narrowing and lowers the risks of primary repair technique such as restenosis (Figure 4).

## DISCUSSION

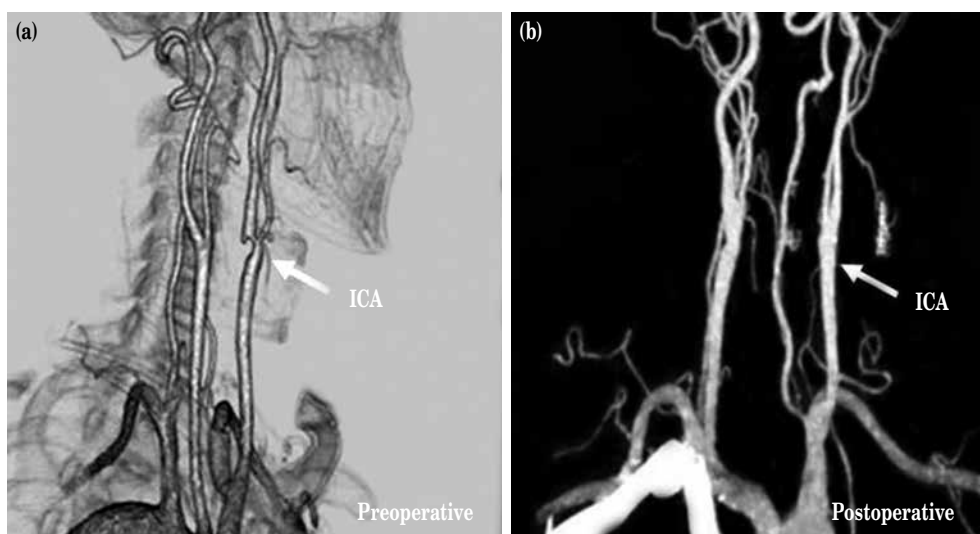
There are two basic techniques for performing CEA procedure including conventional technique with primary closure or with patch angioplasty and eversion endarterectomy technique. Primary closure of a longitudinal arteriotomy incision is the simple and most efficient way to close an arteriotomy, but it may result in a stenosis of the vessel after surgery.<sup>[1,3,5]</sup> Although the ideal patch material is yet to be defined, several

randomized trials and studies also demonstrated that clinically relevant outcome measures favor patch closure over primary closure.<sup>[1-5]</sup> Kresovik et al.<sup>[4]</sup> reported outcomes of more than 10,000 CEAs performed in several states and found that use of a patch, in particular a prosthetic patch, was a statistically significant indicator for improved outcomes.

Eversion endarterectomy represents an excellent alternative technique.<sup>[7]</sup> The advantages of this



**Figure 3.** Operative view after closure of incision lines. Note the bifurcation site is in a higher localization compared to preoperative site.



**Figure 4.** (a) Three-dimensional reconstructed computed angiography at the preoperative period (left panel) showing critical stenosis in the proximal segment of the right internal carotid artery, (b) Computed angiography at postoperative three months showing no residual stenosis in the internal carotid artery. ICA: Internal carotid artery.

technique are that anastomosis can be performed rapidly and it is not prone to restenosis and, therefore, patching is not required, although a more extensive dissection is sometimes required. However, this technique has never become widely used because eversion of both the ICA and ECA proved difficult with limited visualization of the end point of the endarterectomy. Instead, CEA, through a longitudinal arteriotomy, was adopted by virtually all surgeons as the standard techniques. The use of this technique can be difficult in cases with high localized bifurcation site, fragile vessel wall and relatively decreased diameter of the ICA.

To minimize potential risks and technical difficulties of conventional techniques, we described an alternative third technique sliding arterioplasty technique for CEA that is superlative than primary closure and patch plasty.

In our hospital, we performed CEA to 52 patients with this new technique in the last year. There were no difference between this technique and other CEA techniques in terms of complication and early term results. With this technique, proximal site of ICA is enlarged without using a patch and primary closure. The continuity of arterial lumen is provided with approximating flapping part of ECA without being any residual stenosis. Nevertheless, we can speculate that this technique is a combination of primary closure and patch plasty. However, there is no need for the use of an additional patch. This technique, thus, lowers potential risks of patch materials after

surgery such as thrombosis, dilatation, aneurysm formation, infection and bleeding. Also, potential of residual stenosis due to primary closure is avoided, as the proximal ECA is exposed to the facing segment of the ICA. Anastomosis of the two facing vessels composes a wide bifurcation area. This technique is simple and takes a relatively short time compared to the other alternative approaches such as eversion and patch closure.

Nonetheless, there are some limitations or points to be clarified before the use of this technique. First issue is the position of the plaque. If the plaque is localized at the level of carotid bifurcation, which is a common finding, the technique is feasible. However, the use of this technique can be challenging in cases with high bifurcation site of native artery, previous surgery, short neck, radiotherapy or even stent implantation. Following endarterectomy, the surgeon should be careful while suturing the posterior incision line. The ties should be left on the posterior surface of the vessel, not in the lumen of carotid artery. To avoid any laceration and bleeding, the assistant should be careful on suture follow-up. Any traction to the sutures and vessel wall may cause bleeding and this should be avoided. The control of bleeding from posterior vessel wall can be difficult after declamping. Although we used two separate sutures to control tension on the suture lines, a single suture in a running fashion can also be used starting from posteriorly towards the anterior incision line. We also believe that this

technique is also an alternative to stenting. During the last six months, we performed this technique in 20 cases and observed no complication such as residual stenosis or neurological events during the postoperative period. We currently use this technique in suitable lesions and follow our patients for long-term outcomes of these procedures.

One of the longstanding controversies related to the performance of CEA is the use of intravascular shunts, including routine, selective and nonuse. Alternatively, some surgeons routinely use shunt in all cases of CEA and excellent results have been reported in several series.<sup>[1]</sup> However, all of these studies document an incidence of strokes and, in some of these cases, the cause of the stroke is attributed to technical problems related to the use of the shunt. Our technique allows the use of shunts, if needed.

In conclusion, this new technique can be alternative approach considering the difficulties in another techniques for carotid endarterectomy. However, we believe that as a results of case-control studies are obtained, the importance of this technique within carotid endarterectomy techniques will increase.

#### **Declaration of conflicting interests**

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