



## Some Technical Aspects of Carotid Endarterectomy Performing

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### Abstract

**Background:** The aim of this study is to improve Carotid Endarterectomy (CEA) results by developing of techniques of carotid bifurcation reconstruction.

**Methods:** Between January 2012 and December 2017, 1503 patients underwent CEA in the Department of Vascular Surgery, including 461 (31%) according to conventional technique and 1042 (69%) - to eversion technique. The average age of patients was  $61,8 \pm 9,5$ . These operations were performed in patients with more than 70% stenoses of the Internal Carotid Artery (ICA). 1449 reconstructions were performed under general anaesthesia, 54- under locoregional anaesthesia.

Pre-operative examination included Duplex Ultrasound (DUS), Transcranial Doppler (TCD) and magnetic resonance angiography. 135 (9%) patients underwent eversion CEA (eCEA) method with a prolonged incision on ICA and External Carotid Artery (ECA) formation of "extended" anastomosis between these arteries. CEA with the "Neo Bifurcation" technique by means of Y-shape arteriotomy of Common Carotid Artery (CCA), ICA and ECA was utilized in 60 (4%) patients. In order to prevent floatation of the proximal portion of the atherosclerotic plaque cut in the CCA it was fixed by sutures.

**Results:** Long-term outcomes (average  $25 \pm 14$  months) of eCEA with the formation of "extended" anastomosis were seen in 69 (51%) patients. No strokes or deaths occurred. A significant restenosis (more than 70% ICA lumen) was observed in two patients.

After CEA with the "Neo Bifurcation" there were no damages of cerebral circulation in immediate postoperative period. In long-term period (average  $27 \pm 15$  months) 29 (48%) patients were examined. No strokes or deaths occurred. Restenoses of carotid arteries were not revealed in control DUS.

**Conclusion:** A preliminary marking of carotid bifurcation by DUS allows optimizing the length of access in CEA. A routine use of intra-operative DUS provides the opportunity for revealing floating parts of intima, thrombotic mass and to take actions to eliminate these defects in proper time. The method of the neo bifurcation formation of carotid arteries can be used in their prolonged stenosis lesions. It allows avoiding the use of a prosthetic patch with possible unfavorable consequences (patch infection and aneurysm formation). This method let reduce the time of the main stage of operation substantially.

**Keywords:** Carotid Endarterectomy; Eversion Endarterectomy; Carotid Artery Bifurcation; Neo Bifurcation Formation; Extended Anastomosis

### Introduction

Carotid Endarterectomy (CEA) is one of the most used vascular reconstructions and is the 'gold standard' of surgical treatment of carotid arteries atherosclerotic lesions that is proved by multi-centre randomized trials NACSET, ECST, ACAS [1-3]. This type of surgery is performed by three basic methods: conventional CEA with patch, eversion CEA (eCEA) and operation of Internal Carotid Artery (ICA) prosthetics [4].

Despite the seeming technical simplicity of CEA, this method is still one of the most difficult in vascular surgery. The assessment of CEA results on the surgical stage is based on the perioperative stroke frequency and the following mortality. In long-term period, efficacy of operation is determined by the frequency of restenosis and strokes [5].

Every above-mentioned CEA method has some definite advantages and disadvantages.

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Received Date: 17 Jul 2018

Accepted Date: 13 Aug 2018

Published Date: 16 Aug 2018

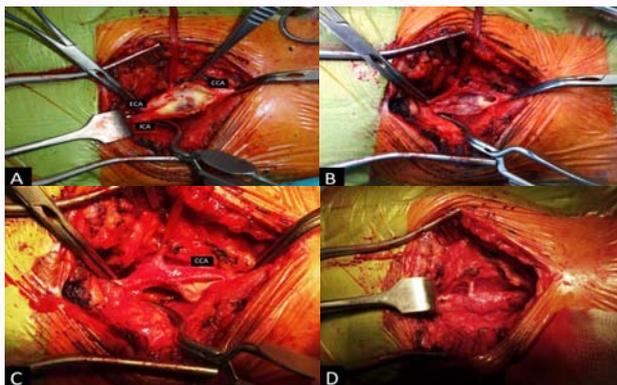
#### Citation:

Ignatyev IM. Some Technical Aspects of Carotid Endarterectomy Performing. Clin Surg. 2018; 3: 2068

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**Figure 1:** "Extended" anastomosis formation between ICA and ECA in eCEA. A) Incision prolongation on ICA and ECA; B) suturing on posterior wall of anastomosis; C) anastomosis is completed.



**Figure 2:** Stages of the "Neo Bifurcation" formation. A) Y-shape incision of CCA, ICA and ECA; B) suturing of a cut plaque caudal end in CCA; C) posterior wall suture; D) arteriotomy closure completed.

Numerous randomized trials demonstrate the advantage of eCEA because of less frequency of early and late restenosis [6]. However, the use of this method in extended stenosis is limited. In eCEA there are great difficulties in inserting of intraluminal shunt in patients with a low cerebral tolerance to ischemia. In prolonged carotid arteries lesions the use of prosthetic patch is preferable in comparison with a primary suture in terms of lower restenosis frequency [7-9]. However, though it is seldom, a patch using can lead to such complications as prosthetic patch infection and aneurysm formation in reconstruction zone [10]. Therefore, the search of new techniques of carotid bifurcation reconstruction is still of current importance.

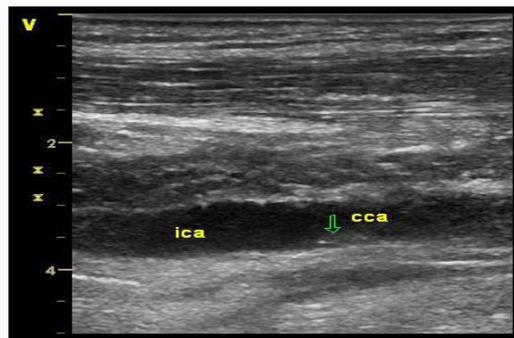
The objective of this study is to improve CEA results by developing of techniques of carotid bifurcation reconstruction.

## Materials and Methods

Between January 2012 and December 2017, 1503 patients underwent CEA in the Department of Vascular Surgery, including 461 (31%) according to conventional technique and 1042 (69%) - to eversion technique. The average age of patients was  $61,8 \pm 9,5$ . These operations were performed in patients with more than 70% stenoses of the ICA. 1449 reconstructions were performed under general anaesthesia, 54 - under locoregional anaesthesia.

Pre-operative examination included Duplex Ultrasound (DUS), Transcranial Doppler (TCD) and magnetic resonance angiography.

Traditionally, with the help of DUS we defined the degree of carotid artery stenosis and parameters of blood velocity, a characteristic of the plaque and its cap condition. We also marked localization of ipsilateral carotid artery bifurcation taking into consideration its location variability. Intra-operative monitoring of cerebral perfusion during carotid clamping was carried out by TCD (Companion III,



**Figure 3:** Carotid arteries DUS at six days after CEA. Floating plaque in CCA is indicated by arrow.

Viasys Healthcare, USA) and electroencephalography (EEG) (Nicolet One™, Viasys Healthcare, USA). The result was assessed by intra-operative DUS (VIVID i, GE Healthcare, USA).

In standard situation, the Common Carotid Artery (CCA) was isolated at the place that is more proximal than bifurcation, External Carotid Artery (ECA) and Internal Carotid Artery (ICA) - more distal than bifurcation. In case of unstable plaque, according to pre-operative DUS and appearance of microembolic signal on TCD, ICA was primarily dissected in intact part and after intravenous heparin administration (5000u unfractionated heparin) was clamped on condition that there is a cerebral tolerance to ischemia. Further manipulations on carotid arteries were carried out in the conditions of the clamped ICA.

In cases when cerebral tolerance to ischemia was low according to TCD and EEG, CEA was performed by conventional method with inserting of intraluminal balloon shunt Pruitt F3. In the case of unstable plaque and a high possibility of distal embolism we previously performed endarterectomy (partial or full) in setting of shunt. In balloon blowing one should follow the instructions strictly. It is necessary to remember that absolute safe period of time for shunt setting or removing is two minutes.

Since 2009, in case of an extended plaque in ICA, we have been using eCEA method with a prolonged incision on ICA and ECA formation of "extended" anastomosis between these arteries (Figure 1A-1C). This type of operation was performed in 135 (9%) patients.

One of the significant technical details of the operation is a fixation of a distal portion of plaque in the case one doesn't manage to remove it completely. In CCA the plaque is usually cut without fearing its flotation. Proximal part of a cut plaque in CCA we also fix by two-three 7-0 polypropylene sutures.

Conventional CEA with the "Neo Bifurcation" technique (known

in literature as “carotid bifurcation advancement technique” [11]) was utilized in 60 (4%) patients with extended lesions of ICA and ECA. The bifurcation advancement consists of a “Y” shape arteriotomy over CCA, ECA and ICA. Endarterectomy of CCA, ECA and ICA is then performed in a standard manner at the junction of the intima and medial layers. Particular attention is paid to the distal fragment of the plaque extending into the ICA and any remnants of the removed plaque which may be adherent to the wall are removed subsequently. At this stage, copious flushing and suction are recommended eliminating even the smallest plaque remnants to avoid cerebral embolization. Removal of the atherosclerotic deposits from the ECA follows a similar course. Endarterectomy of the CCA extends as far as the proximal end of the Y-shaped incision. The plaque being removed is cut off at this level if it extends into the CCA and, usually, does not require suturing at the arterial wall as the direction of blood prevents the creation of a flap. The arteriotomy closure begins at the bifurcation. A 7-0 polypropylene single running suture is tied extraluminally and continued intraluminally in the cranial direction to bring together the “arms” of the Y-arteriotomy consisting of the ICA and ECA. Upon completing the posterior aspect of the closure the needle is brought extraluminally and the suture line is continued caudal on the anterior aspect of the arteriotomy, thus approximating the ICA and ECA arms of the Y-incision.

The suture line is completed just past the proximal incision, with care taken to include the proximal edge of the removed plaque in the suturing. Just prior to tying the suture, ECA backflow is restored to eliminate air from the artery. Following this, CCA clamp is removed and finally ICA is declamped. The resulting closure runs in a straight line, with the “neo bifurcation” appearing now more cranial than prior to closure, everted by intraluminal pressure (Figures 2A,B,C,D). Intraluminal shunt was used in 8 cases.

## Results

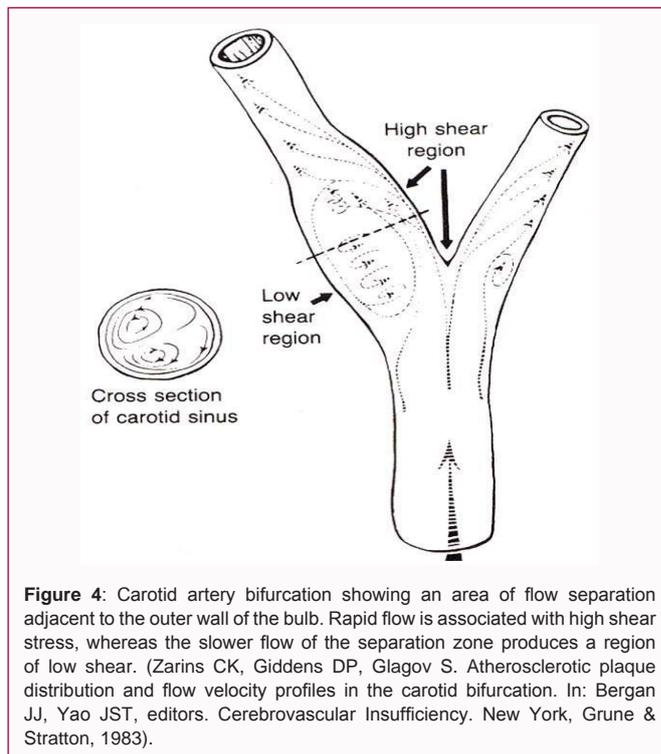
In control DUS after CEA, we paid attention to the fact that a cut plaque in CCA often floats and we consider it is connected with specific features of hemodynamic in carotid artery bifurcation, that is, blood flow division into laminar and turbulent, to the zone of which caudal end of the cut plaque can be involved (Figure 3,4). So, it is necessary to cut plaque proximal part as far from the bifurcation as possible, or to fix it by two-three 7-0 polypropylene as it is shown in Figure 2B.

Long-term outcomes (average  $25 \pm 14$  months) of eversion CEA with the formation of “extended” anastomosis were seen in 69 (51%) patients. No strokes or deaths occurred. A significant restenosis (more than 70% ICA lumen) was observed in two patients.

After CEA with the “Neo Bifurcation” there were no damages of cerebral circulation in immediate postoperative period. In long-term period (average  $27 \pm 15$  months) 29 (48%) patients were examined. No strokes or deaths occurred. Restenoses of carotid arteries were not revealed in control DUS. Because of a limited number of observations, a comparative evaluation of CEA with other techniques was not carried out.

## Conclusion

A preliminary marking of carotid bifurcation by DUS allows optimizing the length of access in CEA. A routine use of intraoperative DUS provides the opportunity for revealing floating parts of intima, thrombotic mass and to take actions to eliminate these



**Figure 4:** Carotid artery bifurcation showing an area of flow separation adjacent to the outer wall of the bulb. Rapid flow is associated with high shear stress, whereas the slower flow of the separation zone produces a region of low shear. (Zarins CK, Giddens DP, Glagov S. Atherosclerotic plaque distribution and flow velocity profiles in the carotid bifurcation. In: Bergan JJ, Yao JST, editors. Cerebrovascular Insufficiency. New York, Grune & Stratton, 1983).

defects in proper time.

The method of the “Neo Bifurcation” formation of carotid arteries can be used in their prolonged stenosis lesions. It allows to avoid the use of a prosthetic patch with possible unfavorable consequences (patch infection and aneurysm formation). This method let reduce the time of the main stage of operation substantially. This technique has an advantage over the primary suture that gives a high restenosis frequency. Despite a small number of observations, this method is a promising one in carotid arteries reconstruction.

Eversion CEA with formation of “extended” anastomosis between ICA and ECA increases the possibilities of this technique and it can be used in ICA prolonged lesion. Taking it into account, the indications to eCEA should be significantly broadened, as it is a physiological intervention (it keeps geometry of carotid arteries bifurcation, foreign tissue is absent).

The above-mentioned techniques in CEA performing allow to improve short-term and long-term results of this intervention.

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