Conventional Carotid Endarterectomy with Shunt versus Eversion Carotid Endarterectomy without Shunt does the Technique Influence the Outcome in Symptomatic Critical Carotid Stenosis

Abstract

Introduction: Carotid endarterectomy (CEA) is a surgical procedure done to prevent future embolic stroke in patients with internal carotid artery (ICA) stenosis. Conventional CEA (c-CEA) and eversion CEA (e-CEA) are two surgical techniques used for the above. As carotid shunt is rarely used in e-CEA, a certain amount of cerebral ischemia occurs in patients who were already having carotid stenosis. In this study, we have evaluated the outcome of two surgical techniques in severe carotid stenosis and impact of carotid shunting on the postoperative outcome. Materials and Methods: In this single-center prospective nonrandomized trial, a total of 62 patients who underwent CEA (c-CEA, n = 31; e-CEA, n = 31) for symptomatic ipsilateral ICA stenosis ≥50% between January 2018 and December 2019 were included. Results: A total of 62 patients who underwent CEA (c-CEA, n = 31; e-CEA, n = 31) for symptomatic ipsilateral ICA stenosis ≥50% were included in the study. There was no major stroke or stroke related death in both the study groups. One patient in e-CEA had carotid occlusion and minor stroke. There was no statistically significant difference in minor stroke (e-CEA [3.2%], c-CEA [3.2%], P = 1), transient ischemic attack (e-CEA [3.2%], c-CEA n = 0, P = 0.3), postoperative MI (e-CEA [3.2%], c-CEA [3.2%], P = 1), hematoma (e-CEA [3.2%], c-CEA n = 0, P = 0.3), and re-exploration (e-CEA [3.2%], c-CEA n = 0, P = 0.3). The incidence of cranial nerve (CN) dysfunction was significantly higher in eversion group as compared to c-CEA (e-CEA n = 6 [19.4%], c-CEA n = 1, [3.2%] P = 0.045). Conclusion: Our study showed that the early outcomes of both c-CEA and e-CEA techniques are comparable. The routine insertion of carotid shunt even though decreases the cerebral ischemic time, it does not offer any additional advantage of decreasing perioperative stroke. The choice of the CEA technique depends on the experience and familiarity of the individual surgeon as both the techniques have their own advantages and disadvantages.

Keywords: Carotid endarterectomy, carotid shunting, conventional carotid endarterectomy, eversion carotid endarterectomy

Introduction

Carotid endarterectomy (CEA) is a surgical procedure done to prevent future embolic stroke in patients with internal carotid artery (ICA) stenosis.1 Conventional CEA (c-CEA) and eversion CEA (e-CEA)2 are two surgical techniques used for the above. Most of the centers are performing c-CEA routinely because it is performed under the protection of a carotid shunt and is technically easier. Whenever the operative time gets prolonged in c-CEA, the brain gets antegrade blood flow through the shunt. In c-CEA, the arteriotomy is always patch closed, whereas in e-CEA, ICA is transected from the carotid bulb, endarterectomy is performed, and ICA is primarily anastomosed to the carotid bulb in end-to-side manner. As carotid shunt is rarely used in e-CEA, a certain amount of cerebral ischemia occurs in patients who were already having carotid stenosis. In this study, we have evaluated the outcome of two surgical techniques in severe carotid stenosis.

Materials and Methods

A total of 62 patients who underwent CEA (c-CEA, n = 31; e-CEA, n = 31) in division of vascular surgery between January 2018 and December 2019 for symptomatic ipsilateral ICA stenosis ≥50%...
Operative procedure details of conventional carotid endarterectomy

All c-CEAs were performed under general anesthesia. A longitudinal incision along the anterior border of sternocleidomastoid muscles was made, carotid sheath was opened, and common carotid artery (CCA) ICA and external carotid artery (ECA) were looped. Neuroprotective medications such as methylprednisolone (30 mg/kg) and thiopentone (1 mg/kg) were administered and systemic heparinization was done. First ICA and then CCA, followed by ECA, were clamped. Longitudinal arteriotomy was made from ICA extending to the CCA [Figure 1a]. Pruitt Inahara shunt (Le Maitre vascular, USA) was inserted [Figure 1b and c]. The plaque was removed ensuring proper distal feathering. The arteriotomy was closed using a supramalleolar great saphenous vein (GSV) patch [Figure 1d]. If the vein was not available, then bovine pericardial patch was used using a continuous 6-0 Prolene suture. After proper de-airing, the clamps are released sequentially ECA and CCA first, followed by ICA.

Operative procedure details eversion carotid endarterectomy

All e-CEAs were also performed under general anesthesia. A transverse skin crease incision is made centered over the carotid bifurcation. Dissection and order of clamping were the same as in c-CEA. Here, ICA is then disconnected from the carotid bulb cutting obliquely [Figure 2a]. Then, the assistant everts the ICA and endarterectomy is completed. This is followed by distal CCA and ECA endarterectomy. ICA was then re-anastomosed to the side of the CCA bulb in an end-to-side fashion using continuous 6-0 Prolene suture [Figure 2b].

Statistical analysis

Student’s t-test was used to compare the group’s baseline characteristics and continuous measures. Chi-square statistical analysis was used to compare the groups with discontinuous variables. All statistical tests were two-tailed, and \( P < 0.05 \) was considered to represent statistical significance. All data analyses were done using the Windows Excel 2010 and IBM SPSS Statistics, Version 26.0. Armonk, NY.

Results

Demographic profile

The study population was divided into eversion (\( n = 31 \)) and conventional (\( n = 31 \)) groups and both the groups were statistically similar in comparison. A total of 58% in e-CEA group and 58% within c-CEA group had a stroke prior to CEA (\( P = 1 \)). The percentage of patients with transient ischemic attack (TIA) was 41.9% in e-CEA and 43.3% in c-CEA group (\( P = 0.912 \)). Hence, the number of patients with stroke and TIA were similar in both the groups (\( P = 1.00 \)). Demographics data are listed in Table 1.

Carotid endarterectomy in bilateral carotid disease

The patients with asymptomatic contralateral carotid stenosis were 19.35% in e-CEA and 29.03% in c-CEA. There were two patients in c-CEA and one patient in e-CEA with Contralateral (C/L) ICA occlusion. There was no statistically significant difference in the number of patients with bilateral carotid stenosis in both eversion and c-CEA (\( P = 0.263 \)). The right- and left-sided
CEAs were matched in both eversion and conventional groups ($P = 0.793$); Table 2.

**Primary endpoint of the study**

There was no major stroke or stroke-related death in both the study groups. One patient in e-CEA had carotid occlusion and presented with minor stroke [Table 3].

**Secondary endpoints of the study**

There was no statistically significant difference in the secondary endpoints like minor stroke (e-CEA $n = 1$ [3.2%], c-CEA $n = 1$ [3.2%], $P = 1$), TIA (e-CEA $n = 1$ [3.2%], c-CEA $n = 0$, $P = 0.3$), postoperative Myocardial Infarction (MI) (e-CEA $n = 1$ [3.2%], c-CEA $n = 1$ [3.2%], $P = 1$), hematoma (e-CEA $n = 1$ [3.2%], c-CEA $n = 0$, $P = 0.313$), re-exploration (e-CEA $n = 1$ [3.2%], c-CEA $n = 0$, $P = 0.313$), and reperfusion syndrome (e-CEA $n = 1$ [3.2%], c-CEA $n = 1$ [3.2%], $P = 1$). The incidence of cranial nerve dysfunction was significantly higher in eversion group as compared to c-CEA (e-CEA $n = 6$ [19.4%], c-CEA $n = 1$, [3.2%] $P = 0.045$) [Table 4].

**Difference in clamp time between eversion versus conventional carotid endarterectomy**

The clamping time in e-CEA was significantly higher around ($20.77 \pm 8.504$ min) as compared to c-CEA ($13.81 \pm 6.332$ min) and this difference was statistically significant ($P = 0.001$); Table 5.

**Discussion**

All c-CEAs were performed with cerebral protection using intracerebral shunt and arteriotomy closed with supramalleolar GSV patch. All e-CEAs were performed without shunt and ICA is anastomosed primarily to CCA.
Table 4: Secondary endpoints of the study

|                    | Eversion, n (%) | Convention, n (%) | P     | OR    | 95% CI for OR |
|--------------------|-----------------|-------------------|-------|-------|---------------|
| Minor stroke       | 1 (3.2)         | 1 (3.2)           | 1     | 1     |               |
| TIA                | 1 (3.2)         | 0                 | 0.313 |       |               |
| Postoperative MI   | 1 (3.2)         | 1 (3.2)           | 1.000 | 1     | 0.06-16.737   |
| CNI                | 6 (19.4)        | 1 (3.2)           | 0.045 | 0.14  | 0.02-1.23     |
| Bleeding           | 0               | 0                 |       |       |               |
| Hematoma           | 1 (3.2)         | 0                 | 0.313 | 0     |               |
| Re-exploration     | 1 (3.2)         | 0                 | 0.313 | 0     |               |
| Reperfusion syndrome | 1 (3.2)      | 1 (3.2)           | 1     | 1     | 0.06-16.737   |
| Wound infection    | 0               | 0                 |       |       |               |

CNI—Cranial nerve injury; OR—Odds ratio; CI—Confidence interval; TIA—Transient Ischemic Attack; MI—Myocardial Infarction

Table 5: Clamp time in eversion-carotid endarterectomy and conventional-carotid endarterectomy

| Group          | n   | Clamp time (min), mean±SD | t   | P     |
|----------------|-----|---------------------------|-----|-------|
| e-CEA          | 31  | 20.77±8.504               | 3.659 | 0.001 |
| c-CEA          | 31  | 13.81±6.332               |     |       |

CEA—Carotid endarterectomy; e-CEA—Eversion CEA; c-CEA—Conventional CEA; SD—Standard deviation

c-CEA clamp time in e-CEA is longer. This is because all our c-CEAs are performed under shunt, the clamp time is calculated by adding the time from carotid clamping to shunt insertion and from shunt removal to completion of anastomosis. During the rest of the procedure, the brain is getting antegrade cerebral blood through the shunt. The ischemia time in e-CEA was calculated from the time of carotid clamping till the completion of procedure as all e-CEA is done without shunt. In the EVEREST trial, the shunt was used only in 16% of patients in c-CEA and 11% of patients in e-CEA.

In our study, even though the operative technique was different between the two groups, in c-CEA group, all patients had shunts used and the same was not used in e-CEA. There was no statistical difference in perioperative neurological outcomes between the study population. Previous studies showed that intraoperative cerebral ischemia is a relatively rare cause of intraoperative stroke during CEA when compared to embolic stroke. A cerebral shunt can prevent only the ischemic stroke, but it will increase the risk for embolic stroke if not inserted properly. However, we are not denying the fact that when severe cerebral ischemia occurs, it can lead to perioperative stroke, but cerebral embolism is the most common cause of stroke during CEA shown in various studies.

A warning note is that we found significantly higher rate of cranial nerve injury (CNI) in e-CEA group (eversion n = 6 [19.4%], conventional n = 1, [3.2%] P = 0.045). In EVEREST trial, e-CEA neither resulted in a high rate of CNI nor caused more frequent neck hematomas compared with c-CEA. The most common CNI in our study is a marginal mandibular nerve (n = 4/6 in e-CEA and n = 1/1 in c-CEA), followed by hypoglossal (n = 1; e-CEA) and recurrent laryngeal branch of vagus (n = 1; c-CEA), but in majority of studies, the most common CNI reported was vagus followed by hypoglossal nerve. The major mechanism of CNI proposed was excessive use of electrocautery, excessive retraction, injuries by forceps, or the application of arterial clamps. The vagus nerve lies posteriorly in the carotid sheath, inadvertently may get entrapped in a vascular clamp. Hypoglossal nerve injury occurs during the dissection of the distal ICA in case of a high ending plaque, as the nerve crosses the upper part of the ICA. In our study, the high incidence of marginal mandibular nerve dysfunction may be due to the excessive upward traction for opening the transverse incision in e-CEA toward the mandible where the nerve normally runs through. We recommend that longitudinal incision is better so that it can be extended with ease in case of high ending plaque, whatever the technique used for CEA.

The limitations of our study are that this is a nonrandomized study, and the sample number was small. Furthermore, long-term follow is still required in these patients to look for delayed complications of the two surgical techniques.

**Conclusion**

Our study showed that e-CEA is a safe technique even if the clamp time is higher when compared to c-CEA. Furthermore, routine insertion of carotid shunt even though decreases the cerebral ischemic time, it does not offer any additional advantage of decreasing perioperative stroke when compared to nonshunting. The choice of the incision sometimes had detrimental effects on cranial nerve function. Hence, the choice of the CEA technique depends on the experience and familiarity of the individual surgeon as both the techniques have their own advantages and disadvantages.

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**Conflicts of interest**

There are no conflicts of interest.
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