Article published online: 2022-08-16

Original Article

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*

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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%

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Access this article online

Website: www.asianjns.org

DOI: 10.4103/ajns.AJNS_486_20

Quick Response Code:

How to cite this article: Kumar V, Ramachandran S, Sylaja PN, Pitchai S. Conventional carotid endarterectomy with shunt versus eversion carotid endarterectomy without shunt does the technique influence the outcome in symptomatic critical carotid stenosis. Asian J Neurosurg 2021;16:321-5.

Submitted: 29-Oct-2020 **Revised:** 25-Nov-2020
Accepted: 15-Feb-2021 **Published:** 28-May-2021

on computed tomography angiogram with or without contralateral ICA stenosis/occlusion were included in this prospective nonrandomized study. All symptomatic patients <50% ICA stenosis and all asymptomatic patients were excluded from the study. The choice of e-CEA or c-CEA was decided based on the discretion of surgeons who performed the procedure, and the preoperative evaluation was the same for both. Follow-up details of all patients till the third month were included. A duplex scan was done at the third month if any restenosis detected further treatment was initiated. Minor stroke was defined as any new neurologic event that persists for <24 h but completely resolves or returns to baseline within 30 days with National Institutes of Health Stroke Scale (NIHSS) score of ≤4. Major stroke was defined as any new neurologic event that persists for >24 h with NIHSS score >4.

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.

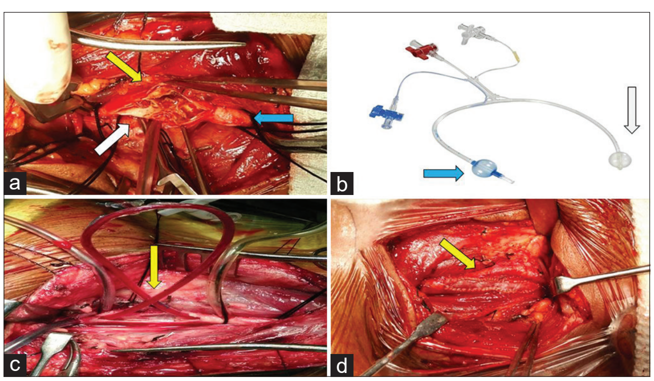

Figure 1: (a) Intraoperative picture showing ulcerated plaque and a free-floating thrombus (blue, white, and yellow arrow indicate common carotid artery, internal carotid artery, and external carotid artery end, respectively); (b) Pruitt Inahara shunt blue balloon for common carotid artery and white balloon for internal carotid artery (Le Maitre® vascular, USA); (c) Pruitt Inahara carotid shunt *in situ* in conventional carotid endarterectomy; (d) Patch closure using saphenous vein patch in conventional carotid endarterectomy

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 endarterectomyin 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

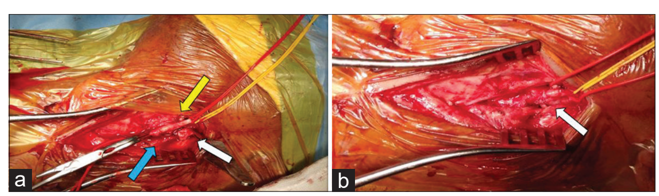

Figure 2: (a) Intraoperative picture showing atherosclerotic plaque in the internal carotid artery during eversion carotid endarterectomy (blue, white, and yellow arrow indicates common carotid artery, internal carotid artery, and external carotid artery end, respectively); (b) Primary end-to-side anastomosis of the internal carotid artery to the carotid bulb in eversion carotid endarterectomy (white arrow)

Table 1: Demographic profile

	Eversion, *n* (%)	Convention, *n* (%)	*P*	OR	95% CI for OR
Male	10 (32.3)	5 (16.1)	0.138	2.48	0.73-8.37
Female	21 (67.7)	26 (83.9)			
Age (years), mean±SD	61.0±9.2	63.3±9.6	0.342	1.027	0.973-1.084
Smoker	10 (32.3)	8 (25.8)	0.576	0.73	0.24-2.20
Dyslip	14 (45.2)	13 (41.9)	0.798	0.88	0.32-2.40
CAD	1 (3.2)	4 (12.9)	0.162	4.44	0.47-42.26
DM	21 (67.7)	24 (77.4)	0.393	1.63	0.53-5.05
Uncontrolled HTN	19 (61.3)	13 (41.9)	0.127		
Controlled HTN	12 (38.7)	18 (58.1)			
COPD	2 (6.5)	1 (3.2)	0.554	0.48	0.04-5.62
POAD	0	3 (9.7)	0.076		
Stroke	18 (58.1)	18 (58.1)	1.00	1.00	0.37-2.74
TIA	13 (41.9)	13 (41.9)	1.00	1.00	0.37-2.74
Bilateral carotid stenosis	7 (22.6)	11 (35.5)	1.00	1.00	0.37-2.74
NIHSS	2.19 (4.39)	1.71 (2.10)	0.582	0.957	0.819-1.119
mRS	1.35 (1.87)	1.13 (1.12)	0.582	0.957	0.819-1.119

NIHS-National Institutes of Health Stroke Scale; mRS-Modified Rankin Score; OR-Odds ratio; CI-Confidence interval; SD-Standard deviation; HTN-Hypertension; COPD-Chronic Obstructive Pulmonary Disease; POAD-Peripheral Occlusive arterial Disease; TIA-Transient Ischemic Attack; CAD-Coronary artery Disease; DM-Diabetes Melitius

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 ± 8.504 min) as compared to c-CEA (13.81 ± 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 2: Carotid endarterectomy in bilateral carotid disease

	e-CEA, *n* (%)	c-CEA, *n* (%)	*P*
Patients with B/L ICA stenosis	6 (19.35)	9 (29.03)	0.263
Right CEA	20 (64.5)	19 (61.3)	0.793
Left CEA	11 (35.5)	12 (38.7)	
Total	31 (100)	31 (100)	

CEA-Carotid endarterectomy; e-CEA-Eversion CEA; c-CEA-Conventional CEA; ICA-Internal carotid artery; B/L-Bilateral

Table 3: Primary endpoint of the study

	Eversion, *n* (%)	Convention, *n* (%)
Major stroke	0	0
Stroke death	0	0
Carotid occlusion	1 (3.2)	0

The study showed that there were no statistically significant differences in major stroke/carotid occlusion (3.2% [$n = 1$] in e-CEA and 3.2% [$n = 1$] in c-CEA) between two surgical techniques ($P = 0.3$) even though clamp time in e-CEA was significantly higher (e-CEA = 20.77 ± 8.504 min vs. c-CEA = 13.81 ± 6.332 min; $P = 0.001$). There was no difference in minor stroke, TIA, postoperative MI, hematoma, re-exploration, and reperfusion syndrome between eversion and c-CEA. Overall, there was no stroke-related death ($n = 0$) in both the study groups.

Our study results were similar to EVEREST trial which showed no differences in the rate of perioperative stroke, TIA, MI, and death between e-CEA and c-CEA (1.3% for each study group).[3] In the EVEREST trial, the clamp time in e-CEA was shorter (31.7 ± 15.9 vs. 34.5 ± 14.4 min, $P = 0.02$) which is a contradiction to our study, in which

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		
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

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.[4] A cerebral shunt can prevent only the ischemic stroke, but it will increase the risk for embolic stroke if not inserted properly.[5] 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 EVERST[3] 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.[6] 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.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Ricotta JJ, AbuRahma A, Ascher E, Eskandari M, Faries P, Lal BK. updated society for vascular surgery guidelines for management of extracranial carotid disease. J Vasc Surg 2011;54:e1-31.
2. Davidovic LB, Tomic IZ. Eversion carotid endarterectomy: A short review. J Korean Neurosurg Soc 2020;63:373-9.
3. Cao P, Giordano G, De Rango P, Zannetti S, Chiesa R, Coppi G, *et al*. A randomized study on eversion versus standard carotid endarterectomy: Study design and preliminary results: The Everest Trial. J Vasc Surg 1998;27:595-605.
4. Lareyre F, Raffort J, Weill C, Marsé C, Suissa L, Chikande J, *et al*. Patterns of acute ischemic strokes after carotid endarterectomy and therapeutic implications. Vasc Endovascular Surg 2017;51:485-90.
5. Hans SS, Catanescu I. Selective shunting for carotid endarterectomy in patients with recent stroke. J Vasc Surg 2015;61:915-9.
6. Kakisis JD, Antonopoulos CN, Mantas G, Moulakakis KG, Sfyroeras G, Geroulakos G. Cranial nerve injury after carotid endarterectomy: Incidence, risk factors, and time trends. Eur J Vasc Endovasc Surg 2017;53:320-35.