Experience of 352 Carotid Endarterectomy Cases Operated on without Any Shunt and a Technical Modification: Thirty-Day Results

Şant Kullanılmadan Gerçekleştirilen 352 Karotis Arter Endarterektomi Deneyimi ve Teknik Bir Modifikasyon Tarifi: Erken Dönem Sonuçlar

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ABSTRACT Objective: The necessity for an indwelling arterial shunt during carotid endarterectomy (CEA) is one of the most widely debated and long-standing controversies in carotid surgery. We developed a modified technique for carotid endarterectomy without using a shunt and have achieved successful results with this procedure. The aim of this study is to present these 352 isolated CEA cases and evaluate the results. **Material and Methods:** In our clinic, 352 isolated CEA were performed on 320 consecutive patients without using a shunt between 2005 and 2012. In 32 of the cases, bilateral CEA were performed. Among the patients, 36.8 % (n=118) were neurologically asymptomatic, and 63.2 % (n=202) were symptomatic. Complete occlusion was present in the contralateral carotid arteries of 23 patients. All patients were operated on under general anesthesia, and no intraluminal shunts were used. This operative technique is a modification of an eversion carotid endarterectomy in which a longitudinal arteriotomy is begun on the common carotid artery (CCA) and purposely skewed towards the origin of the external carotid artery. The mean cross-clamp time in our study was 12±4.62 minutes. **Results:** There was one case of postoperative mortality (0.28%) that was caused by myocardial infarction. We observed 1 (0.28%) case of permanent neurologic deficit, 27 (7.6%) cases of peripheral nerve damage, 4 (1.1%) cases of early postoperative transient neurologic attack, 3 (0.85%) cases of hoarseness and 3 (0.85%) cases of neurocognitive impairment. **Conclusion:** The results indicate that this mini-modified eversion CEA surgery performed without the use of a shunt can be successful for patients with carotid stenosis.

Key Words: Endarterectomy, carotid; ischemic attack, transient; stroke

ÖZET Amaç: Karotis arter endarterektomi (CEA) cerrahisinde şant kullanım gerekliliği, yama kullanımı, eversiyon ve konvansiyonel endarterektomi teknikleri halen tartışılan konulardır. Kliniğimizde CEA operasyonları şant kullanılmadan yapılmaktadır. Yine bu operasyonlarda kliniğimizde geliştirilmiş olan farklı bir arteriyotomi tekniği kullanılmaktadır. Bu çalışmada şant kullanılmadan gerçekleştirilen 352 izole CEA olgusu değerlendirilmiş ve kliniğimizce geliştirilmiş olan tekniğinin tarifi ve erken dönem sonuçları tartışılmıştır. **Gereç ve Yöntemler:** Kliniğimizde 2005-2012 yılları arasında 320 hastaya 32'si bilateral olmak üzere, toplam 352 izole CEA operasyonu uygulandı. Hastaların %36,8 (n=118)'i nörolojik olarak asemptomatik, %63,2 (n=202)'si ise semptomatik hastalardan oluşmaktaydı. Tüm hastalar genel anestezi altında ve şant kullanılmadan opere edildi. Endarterektomi, ana karotis arterden eksternal karotis artere longitudinal bir arteriyotomi insizyonu ile gerçekleştirildi. Ortalama kros klemp zamanı 12±4,62 dakika olarak ölçüldü. **Bulgular:** Genel anestezi altında ve şant kullanılmadan gerçekleştirilen CEA operasyonlarında oldukça iyi sonuçlar alınabildiği görülmüştür. Ayrıca, tarif ettiğimiz teknikte -uygun olgular için- aterosklerotik plağın kolayca çıkarılabildiği, internal karotis arterde dikiş hattı olmaması sayesinde yama kullanım gerekliliğinin olmadığı görülmüştür. **Tartışma:** Olgularımızdan biri (%0,28) postoperatif dönemde gelişen akut myokardiyal infarktüs nedeniyle kaybedildi. Bir olguda (%0,28) kalıcı nörolojik defisit, 27 (%7,6) olguda ekstrakraniyal periferik sinir hasarı, 4 (%1,1) olguda erken post operatif geçici (transient) nörolojik atak, 3 olguda (%0,85) ses kısıklığı ve 3 olguda da (%0,85) geçici bilişsel bozukluk oluştuğu gözlemlendi.

Anahtar Kelimeler: Endarterektomi, karotid; iskemik atak, geçici; inme, felç

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Carotid endarterectomies were first introduced in 1954 by Eastcott, Pickering, and Rob.[1] Since their introduction, they continued to develop and are currently in use in many centers for the management of stroke.

Well known studies have documented that surgical treatment is superior to medical management in symptomatic patients with carotid disease. For example, further analysis of data from the North American Symptomatic Carotid Endarterectomy Trial (NASCET) showed a surgical benefit, albeit more modest one, for patients with angiographic stenosis of 50 % or more.[2] In addition, many major studies and trials, including the Asymptomatic Carotid Atherosclerosis Study (ACAS) and the Asymptomatic Carotid Surgery Trial (ACST), along with the American Heart Association (AHA) have advocated surgery for asymptomatic carotid stenosis in selected cases.[3-5]

However, the surgery to prevent stroke, itself carries the risk of stroke. Optimizing the anesthetic (local/general) and neuromonitoring protocols may reduce the incidence of neurologic dysfunction. It has been shown that none of these methods reached the sensitivity and specificity of neuromonitoring.[6,7]

The use of an intraluminal shunt was first recommended to reduce the risk of stroke; however, due to complications associated with it, different views have emerged with regard to its usefulness and indications.[8-14] Some surgeons routinely use a shunt under certain conditions, whether monitoring is used or not, while others never use a shunt under the same conditions.[13-15] In our clinic, we no longer use a shunt in any patients.

There are two main carotid surgery techniques in CEA. These are eversion and conventional CEA.[16] It has been shown that any incision applied to the vessel wall causes some degree of fibrosis as a natural part of the healing process, and this occurs despite the most meticulous care and use of fine suture materials.[17] In some instances, even vascular plasty techniques or the use of patch materials may result in restenosis due to vascular incisions.[18,19] Therefore, we hypothesized that by avoiding an incision in the ICA, restenosis might be prevented in patients with carotid artery disease. Here, we describe a modified carotid endarterectomy technique that may overcome the above-mentioned problems.

In this study, the outcomes of 352 patients who underwent a CEA with a mini modification of the eversion technique without the use of a shunt were analyzed, and the results were evaluated.

MATERIAL AND METHODS

Between 2005 and 2012, 352 isolated CEA surgeries were performed on 320 (229 males, 91 females) patients in TUTAV Sifa Hospital.

The study population consisted of both symptomatic (63.2%, n=202) and asymptomatic (36.8%, n=118) patients.

PREOPERATIVE EVALUATION

We used color Doppler ultrasonography (USG) without taking into account risk factors such as age, gender, diabetes mellitus (DM), or peripheral arterial diseases in the preoperative evaluation of the patients undergoing coronary artery bypass graft (CABG) surgery. All of the asymptomatic cases were determined by this method.

Our surgical policy follows the ACAS/ACST guidelines. We offered CEA surgery to cases with angiographically 60-70% ulcerated, and more than 70% stenosed common or internal carotid arteries.

All cases (symptomatic-asymptomatic) were evaluated by formal angiography including arch and selective injection of both common carotids. All patients were evaluated for the presence independent risk factors (age, gender, peripheral arterial diseases, diabetes, hypertension) affecting mortality (Table 1).

Asymptomatic carotid artery stenosis, transient ischemic attacks and previous stroke were defined as operative indications (Figure 1).

Evidence of coronary artery disease requiring CABG was present in 133 patients in this series. Two (1.5%) had cardiac valvular diseases, three

TABLE 1: Demographic characteristics of the symptomatic and asymptomatic patients. Diabetes mellitus and hypertension rates were higher in asymptomatic patients (All of the asymptomatic patients were candidates for coronary bypass surgery).

				%			
	Mean (±SD) Age	Male	Female	DM	HT	Smoking	PAD
Asymptomatic patients (n:118)	62,2± 6,7	77,1	22,9	45,5	63,5	25,9	13,5
Symptomatic patients (n:202)	63,1±4,1	68,3	31,7	26,3	42,2	26,5	8,08

DM: Diabetes Mellitus; HT: Hypertension; PAD: Peripheral Artery Diseases.

(2.2%) were identified with an ascending aortic aneurism and one (0.7%) had complex cardiac disease according to either the history of the patients or the results of a radiographic, angiographic or physical examination (Table 2).

PATIENT POPULATION

A total of 352 consecutive CEA procedures were performed in 320 patients; 177 of them had right, 143 had left and 32 had bilateral CEA. Patients with bilateral CEA underwent contralateral CEA 1-30 days after the first intervention.

Additional cardiac surgeries (valvular and aortic) were performed 2-5 days later CEA in 133 (37.8%) patients who needed CABG. Patients with concomitant CEA and CABG (not isolated CEA) and had surgery for both at the same session were not included in this study.

Carotid angiography showed complete occlusion of the contralateral carotid artery in 23 patients (Table 3). Duplex USG revealed unilateral vertebral artery stenosis of 50-69% in eight patients, but there was no bilateral vertebral artery stenosis. No intervention was performed on patients with stenotic vertebral arteries or in those with completely occluded carotid arteries.

ANESTHESIA

All patients were operated under general anesthesia. Systolic blood pressure was maintained at 100-140 mmHg until the end of the surgery. We administered 8 mg dexamethasone before the application and after the removal of the cross clamp. The stump pressure was not measured and neuromonitoring was not performed in any of the patients during the surgery.

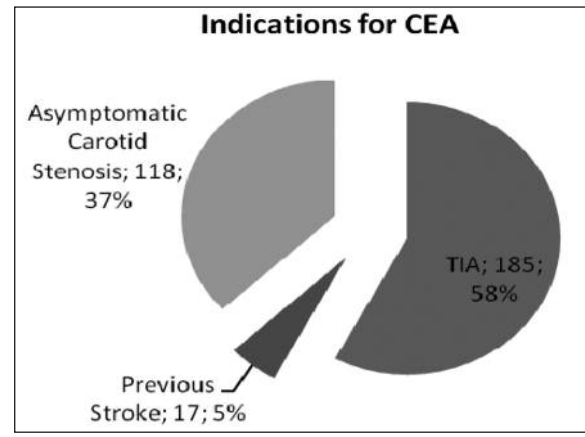

FIGURE 1: Indications for carotid endarterectomy operations
TIA: Transient ischemic attacks.

TABLE 2: Accompanying cardiac diseases which required surgical therapy in carotid endarterectomy patients.

Evidences of cardiac diseases	n=133
CAD (Required CABG)	127 (95.4%)
Mitral Valve Surgery+CAD	2 (1.5%)
Ascending Aortic Aneurysm+CAD	3 (2.2%)
Ascending Aortic Aneurysm+Aortic Stenosis+CAD	1 (0.7%)

CAD: Coronary artery disease; CABG: Coronary artery bypass grafting.

TABLE 3: Rate of stenosis in the contralateral carotid artery.

Rate of Stenosis in the Contralateral Carotid Artery (%)	N
0	68
20–49	190
50–69	42
70 and more	29
Complete occlusion	23

SURGICAL TECHNIQUE

The carotid arteries were explored through a longitudinal incision parallel to the medial aspect of the sternocleidomastoid muscle. The carotid arterial tree was completely freed, and the internal carotid artery (ICA) was explored. Special attention was paid to find a region without atherosclerotic plaques, particularly at the distal 0.5 cm of the ICA. Next, the common carotid artery (CCA) was encircled with tape, and silk or elastic slings were placed around the internal and external carotid arteries and the other territories. Following the intravenous administration of 200 unit/kg heparin, the slings were tightened to stop blood flow, and attached to the surgical wraps. Than the CCA was clamped using a suitable sized vessel clamp. In this way, a large working area was provided by reducing the number of clamps in the field (Figure 2). Arteriotomy was extended from the common carotid artery to the external carotid artery (Figure 3).

After that, the CCA and the segment with plaque extending to the external carotid artery (ECA) were separated. Then, the plaque segment extending to the ICA was removed from the arterial wall using circular motions. During that time, the occlusive slings were released to reduce the tension on the artery. Care was taken to maintain the integrity of the plaque while performing arteriotomy. In this way, we think that the plaque is removed as an entire unit in a better way (Figure 4). To prevent air and debris embolism, first the ICA then the ECA was allowed to bleed and the vascular bed was flushed with heparinized saline. The arteriotomy was primarily closed using 6/0 propylene sutures. In order to avoid the risk of particle and air embolism, the ICA was occluded at the carotid bifurcation for 5 seconds while removing the cross-clamp from the CCA. The heparin was then neutralized with protamine, and the patients were transferred to the intensive care unit (ICU), intubated, and followed up.

It was not possible to reach the distal part of the atherosclerotic plaque in the ICA in 9 patients; therefore, the arteriotomy was extended to the ICA and closed with a 0.6 mm thick polytetrafluoroethylene (PTFE) patch following the endarterectomy in these patients.

Antiplatelet therapy was given during preoperative and postoperative periods, and all of the patients were prescribed acetylsalicylic acid (150 mg oral/daily).

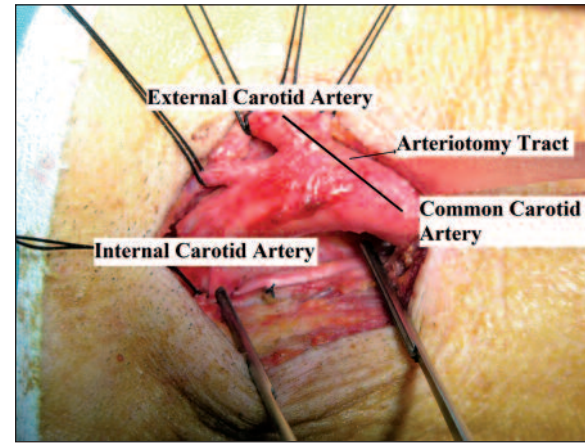

FIGURE 2: The common carotid artery and its branches were clamped and suspended with elastic slings.
(See color figure at http://tipbilimleri.turkiyeklinikleri.com/)

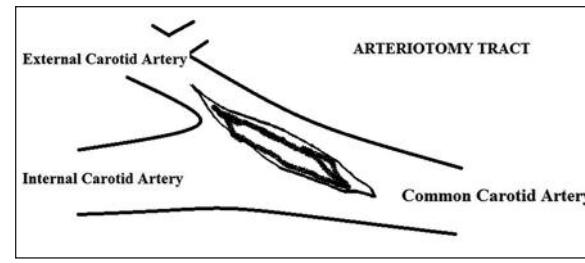

FIGURE 3: Longitudinal arteriotomy started on the common carotid artery and purposely skewed towards the origin of the external carotid artery.

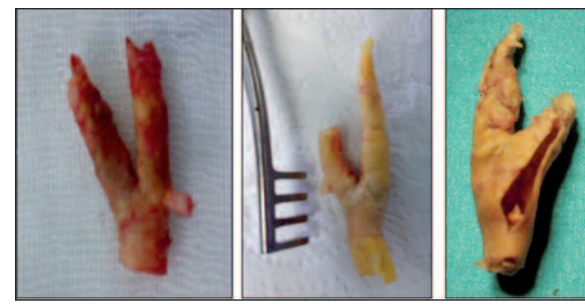

FIGURE 4: Specimens of removed atherosclerotic plaques. Incision line is extended from common carotid artery to the external carotid artery. The plaques were kept intact to remove them easily.
(See color figure at http://tipbilimleri.turkiyeklinikleri.com/)

RESULTS

The early (within 30 days) postoperative outcome of the cases is summarized in Table 4. There was one case of postoperative mortality (0.28%) and one (0.28%) case of permanent neurologic deficit. Transient neurological attacks were observed in four patients (1.1%), and a temporary peripheral nerve injury (ipsilateral facial asymmetry, lingual deviation, or difficulty in swallowing) was observed in 27 (7.67%) cases.

Furthermore, neurocognitive impairments were observed in three patients (0.85%), three other (0,85%) cases developed hoarseness, and one developed hematoma in the surgical area. However, none of the patients had signs of infection, bleeding or airway compression. The mean cross-clamp time was 12±4.62 minutes in our study.

DISCUSSION

In the postoperative period, the patients were evaluated by the cardiovascular surgeon who performed the operation, and a neurologist examined the patients when any neurologic deficit was detected. This was a limitation of the study. Because of this, we could have overlooked minor neurologic deficits.

In this series in which patients underwent a technically modified CEA without a shunt, mortality rate was 0.28% and permanent neurologic deficit rate was 0.28%. This outcome is better than most other series in which patients underwent carotid endarterectomy with or without a shunt.[9,12,20,21]

These results provide clinical evidence that collateral circulation from the contralateral carotid artery and vertebral system apparently provides adequate perfusion to sustain basal cerebral viability during carotid clamping in these patients.[9,21] Because of this, we tried to maintain the systolic blood pressure at 100-140 mmHg until the end of the surgery.

Arterial dissection, bleeding, thrombosis or air embolism can be seen due to the use of a shunt.[11] Furthermore, the flow rate of the blood flowing through the shunt may not be able to maintain the necessary blood flow rate in the brain.[22] Studies undertaken on the use of shunt suggests selective use of shunts due to complications related to their use.[23] However, several studies have indicated that the use of a shunt did not have a significant influence on reducing stroke rates and 30-day-mortality.[10,11,24]

Several studies which indicated that carotid artery surgery could be performed safely without using a shunt reported successful outcomes despite the presence of contralateral carotid artery lesions and low stump pressure.[9,25-27]

Most of the clinics performing CEA on awake patients prefer this method to determine an indication for using a shunt based on the outcome of brain monitoring and the patient's conscious state. However in previous studies, general anesthesia has been shown to have a protective effect for cerebral hypoxia.[28,29] We preferred general anesthesia since cerebral protection is provided in together with a comfortable environment for both the pa-

TABLE 4: Early (30 days) postoperative complications of carotid endarterectomy without a shunt in 352 procedures.

		Symptomatic		Asymptomatic	
Complications	**Total**	**Unilateral**	**Bilateral**	**Unilateral**	**Bilateral**
Death	1 (0.28%)	1	--	--	--
Permanent Neurologic deficit	1 (0.28%)	1	--	--	--
Myocardial infarction	1 (0.28%)	--	--	1	--
Temporary peripheral nerve injury	27 (7.67%)	6	10	2	9
Transient neurologic attack	4 (1.1%)	2	--	2	--
Wound hematoma, infection	1 (0.28%)	--	--	1	--
Hoarseness	3 (0.85%)	--	2	--	1
Neurocognitive impairments	3 (0.85%)	--	2	--	1

tient and the surgeon.

Previous studies indicated a higher incidence of electroencephalography (EEG) changes and shunt use in patients with contralateral carotid artery occlusion or critical stenosis.[30] It is very clear that brain protection under general anesthesia is very important in this patient group. It is known that thiopental use provides a safe cross-clamp time.[28-33] Therefore, we have chosen to use this anesthetic in our general practice.

There was one postoperative mortality (0.28%). This death occurred because of myocardial infarction in the third day of CEA. This case was a candidate for CABG procedure after CEA because of concomitant coronary artery disease. In addition, one (0.28%) case of permanent neurological deficit had a diseased symptomatic unilateral carotid artery and diffuse atherosclerosis which could not be reached to the non-atherosclerotic area on the ICA, therefore a patch had to be used to close the arteriotomy. That patient suffered from contralateral cerebral ischemic event after 15th postoperative day of the CEA.

Thirty-three cases developed temporary lingual deviation to the ipsilateral side and various degrees of facial asymmetry, which were considered to be due to hypoglossal nerve damage. This might have been due to our attempts to reach to the 0.5 cm distal part of the atherosclerotic plaque. These patients with peripheral neural damage improved completely after treatment with non-steroidal anti-inflammatory drugs (NSAIDs) (indomethacin 50 mg oral/daily) and, if there was no response in five days, methyl prednisolone (4 mg oral/daily) was given.

Neurocognitive impairments similar to post perfusion syndrome, which may be seen following open-heart surgery, were observed in three of the CEA patients who were over 70 years old, but no motor skill deficiency was evident. Clinical improvement for these patients was achieved within 3 -10 days haloperidol (3 mg oral/daily) treatment was.

In the three cases that developed hoarseness, unilateral vocal cord paralysis was confirmed by an indirect laryngoscopy. This may have been due to recurrent nerve damage or endotracheal intubation. All of the cases with hoarseness had undergone bilateral CEA surgery.

Initially, the first 120 patients were awakened and extubated immediately after the surgery. However, because of the high incidence of hypertension (72% of first 120 patients), we began to transfer the patients to the ICU before extubation, and the patients were extubated in the ICU following hemodynamic stabilization. There was no correlation between hypertension and postoperative complications, but hemodynamic control was much easier in intubated cases especially at the first hours of the postoperative period.

Any complications that developed were not related to the cross-clamp time. In patients with neurocognitive impairments, the cross-clamp time was 12-28 minutes. Although cross clamp time exceeded 40 minutes in two patients (42 and 44 minutes), none of these patients showed signs of cerebral ischemia or any other complications.

Using no shunt and performing no incision in the ICA are two of the most beneficial characteristics of the modified technique that was utilized in this study. The present study introduced postoperative 30-day mortality and morbidity outcomes and investigated the present technique, as well as the results without using shunt.

During the preparation stage of the surgery, the point that the atherosclerotic plaque ended was certainly reached before cross-clamping and carotid artery system was released up to 0.5 cm distal from this point. However, we also have to mention about the difficulty in applying this technique in the presence of atherosclerotic plaques extending to the quite high levels in the ICA. When this procedure failed (9 out of 352 cases), arteriotomy and patch plasty were performed in the internal carotid arteries via the conventional incision method due to above-mentioned reason. Therefore, these nine patients who underwent patch plasty were also included in the study in order to show that applying this technique in certain patients is not always easy.

We think that the removal of the plaque totally without any atherosclerotic remnant is the

key to success of CEAs. In fact, this is even more important than cross clamp time.

It is known that eversion CEA has a lower restenosis rate than conventional CEA closure techniques and thus superior long-term durability.[34] On the other hand, a circular suture line is required for the closure of arteriotomy in the eversion technique. In the technique defined here, primary closure can be performed on a straight line beginning from the main carotid artery extending to the external carotid artery without performing patch plasty, as is shown in Figure 3.

CONCLUSION

The present study have discussed mainly two subjects: one of them is shunt usage in CEA and the other one is a technical modification, which has been newly defined here.

In this series, the outcomes of 352 CEAs without using a shunt were presented, and our experience proves that this type of procedure can be performed safely. Brain protection, surgeon and patient comfort provided by the general anesthesia, and the experience of surgical team have important roles in achieving success. Even in patients with contralateral carotid artery occlusion or stenosis, successful outcomes were obtained without using a shunt.

The new technique described is a technical modification of CEA. Nevertheless, we think that both the type of arteriotomy and a non-circular suture line not extending to the ICA would be advantageous.

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