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Eversion Carotid Endarterectomy in Patients with Near-Total Internal Carotid Artery Occlusion – Diagnostic Modalities, Indications and Surgical Technique

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1. Introduction

There is a general agreement that symptomatic patients with high-grade stenosis of internal carotid artery (ICA) should be treated with either surgery or percutaneous intervention.[1,2] On the other hand, there is considerable controversy with respect to the approach to the patients with near total ICA occlusion. These patients are considered to be at lower risk for transient ischemic attack (TIA), stroke, and death than patients with a lesser degree of stenosis. [3] There are no prospective randomized clinical trials dealing with this issue, and the available data mostly originate from the post-hoc analysis of the large trials performed in the late 1990s. The results of these studies are conflicting and provide little benefit in clinical decision making. [4,5] Therefore, the aim of the present study was to prospectively evaluate clinical effects of eversion carotid endarterectomy (ECEA) versus best medical treatment of symptomatic patients with near total ICA occlusion.

2. Methods

2.1 Patients

From January 2003 to December 2006, a total of 359 patients with near total ICA occlusion were referred to Dedinje Cardiovascular Institute for evaluation and therapy. Patients were excluded from the study if they were asymptomatic (32 patients), had occlusion of the contralateral ICA (8 patients), or were considered to have unacceptably high surgical risk due to associated comorbidities (10 patients). Therefore, the final study group consisted of 309 patients. Symptoms were identified as TIA and stroke. In order to enter the study patients had to be symptomatic for 12 months or less. Since near total occlusion is not that often seen in our population, randomization was difficult so patients were nonrandomly divided in group A (259 patients), who underwent ECEA surgery, and group B (50 patients), who refused surgery. Inclusion criteria were near total ICA occlusion and previous neurological ischemic events (TIA, stroke...). A high proportion of patients who refused surgery was due to the fact that all patients were thoroughly informed about the conflicting data regarding the potential surgical benefit. Patients in group B received best medical

treatment based on the opinion of the attending vascular surgeon and/or angiologist. This study conforms with the principles outlined in the Declaration of Helsinki and all patients signed a written informed consent. Likewise, this study was approved by institutional review board (IRB).

2.2 Diagnostic techniques

Initial diagnostic technique of choice was Duplex ultrasonographic scan of the carotid arteries. Diagnosis of near total ICA occlusion was made if 95% to 99% stenosis was found and if there was either obvious diameter reduction of ICA compared with opposite ICA, or ICA diameter reduction compared with ipsilateral external carotid artery. (Figure 1) For the ICA stenosis degree assessment we used ECST [1] criteria. Additionally, near total occlusion was diagnosed if peak systolic velocity ICA was greater than 230 cm/s, end-diastolic velocity ICA was greater than 100 cm/s, and ICA/common carotid artery (CCA) ratio was greater than 4. When diagnosis based only on ultrasonography was in question, arterial angiography (9 patients) or 64-slice computer tomography (21 patients) was performed. (Figures 2 and 3) Severity of stenosis of contralateral ICA was also assessed by Duplex scan at the time of the initial examination.

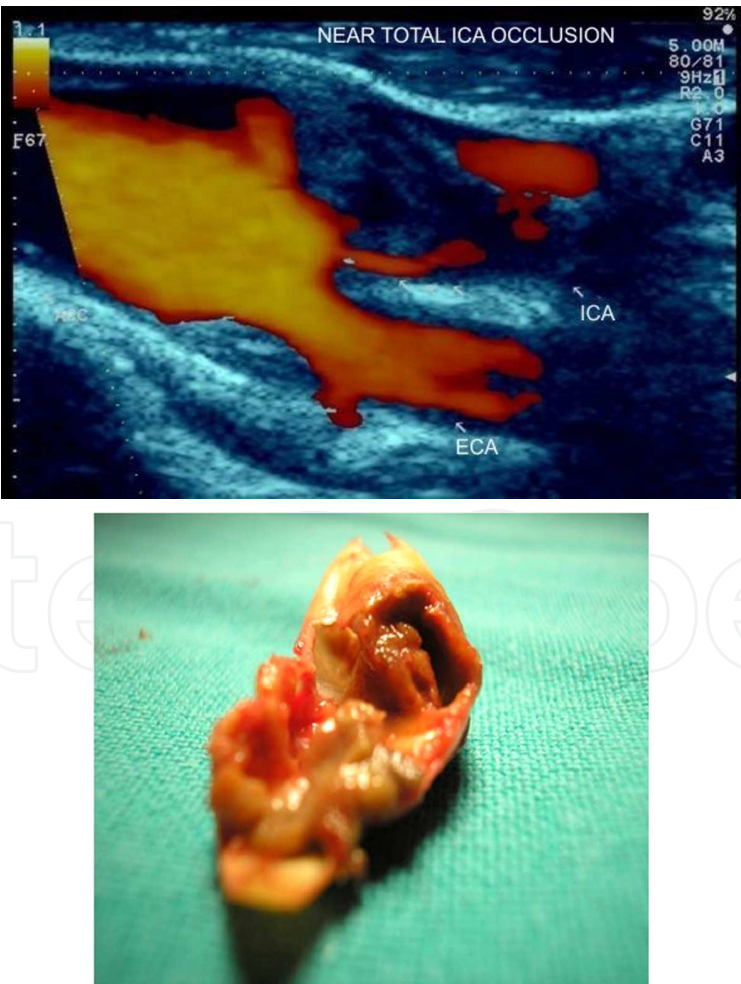


Fig. 1. Ultrasonography of near total ICA occlusion (top) confirmed by intraoperative findings (bottom)

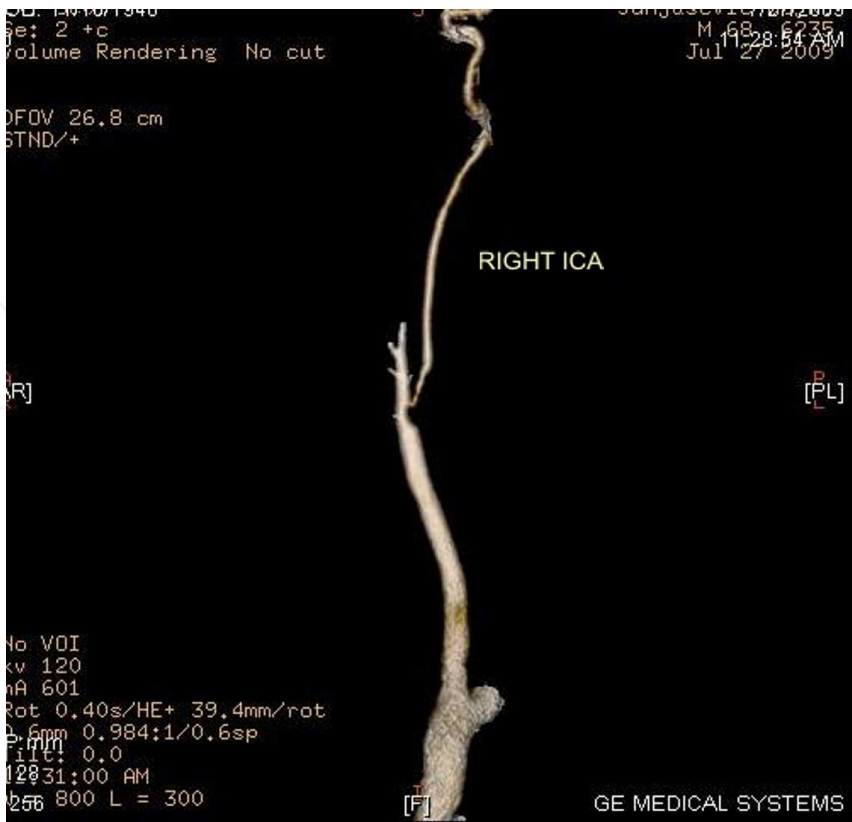


Fig. 2. Multislice CT angiography. Right ICA near total occlusion



Fig. 3. Multislice CT angiography. Near total ICA occlusion

2.3 Eversion carotid endarterectomy and postoperative treatment

Good surgical technique is the determining factor for achieving good quality results of carotid endarterectomy. Any technical error (intimal or medial flap, the stricture of suture line, artery injury following clamping, inadequate resection of carotid artery elongation, thrombosis within arterial wall, intraoperative embolisation or brain ischemia, etc...) may manifest in early and/or late complications. Systemic factors (hipercoagulability, etc...) are rarely to blame for the occurrence of complications. Eversion carotid endarterectomy reduces the possibility of technical errors.

Eversion carotid endarterectomy includes:

- carotid artery resection at the bifurcation level
- atherosclerotic plaque removal by eversion technique (Figures 4 and 5)
- anatomic reimplantation of internal carotid artery (Figures 6 and 7)

Advantages of eversion endarterectomy are: shorter clamping time, anatomical reconstruction of carotid bifurcation, shorter and transverse placed suture line. Implantation of foreign material (patch) is not required. Resection of carotid artery elongation (kinking, coiling) is far simpler. However, many vascular surgeons still hesitate to accept this surgical technique and expand the standard repertoire of carotid artery reconstruction. Preoperative diagnosis and indications for eversion carotid endarterectomy are no different than for standard endarterectomy.

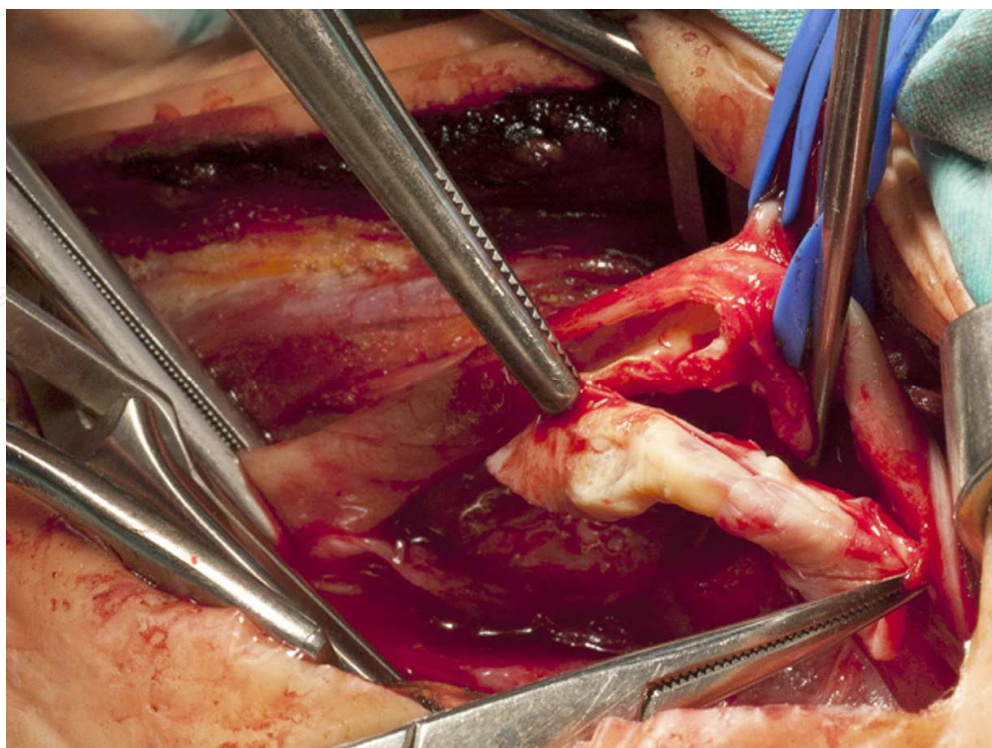


Fig. 4. Atherosclerotic plaque removal by eversion technique

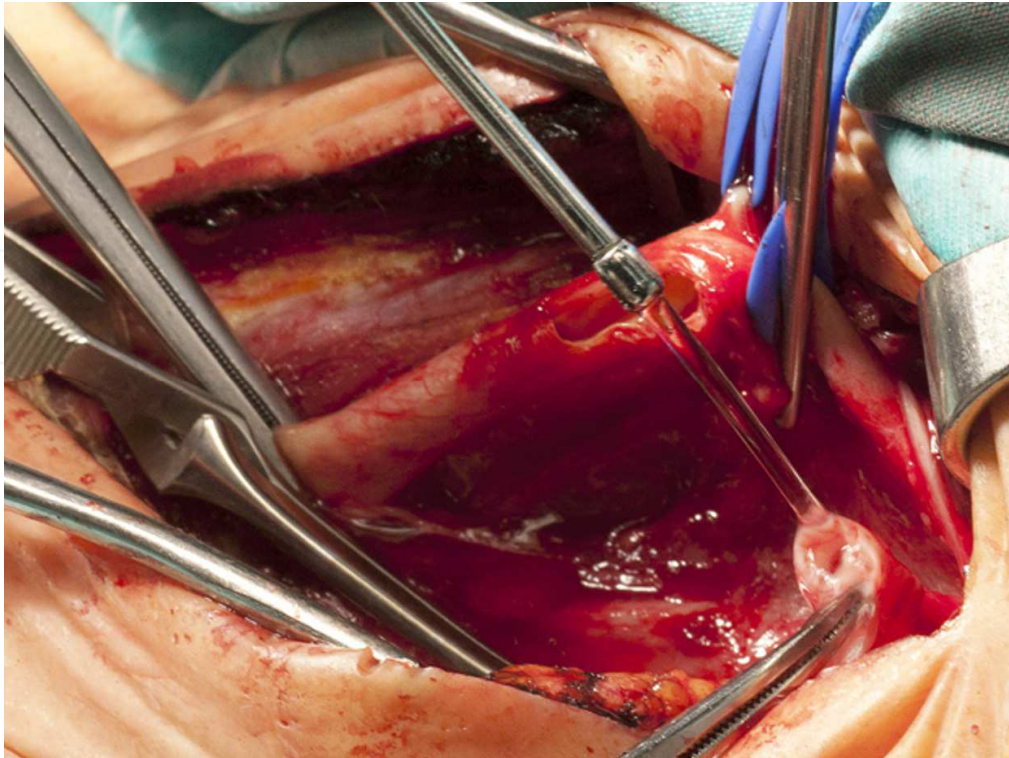


Fig. 5. Distal endarterectomy verification

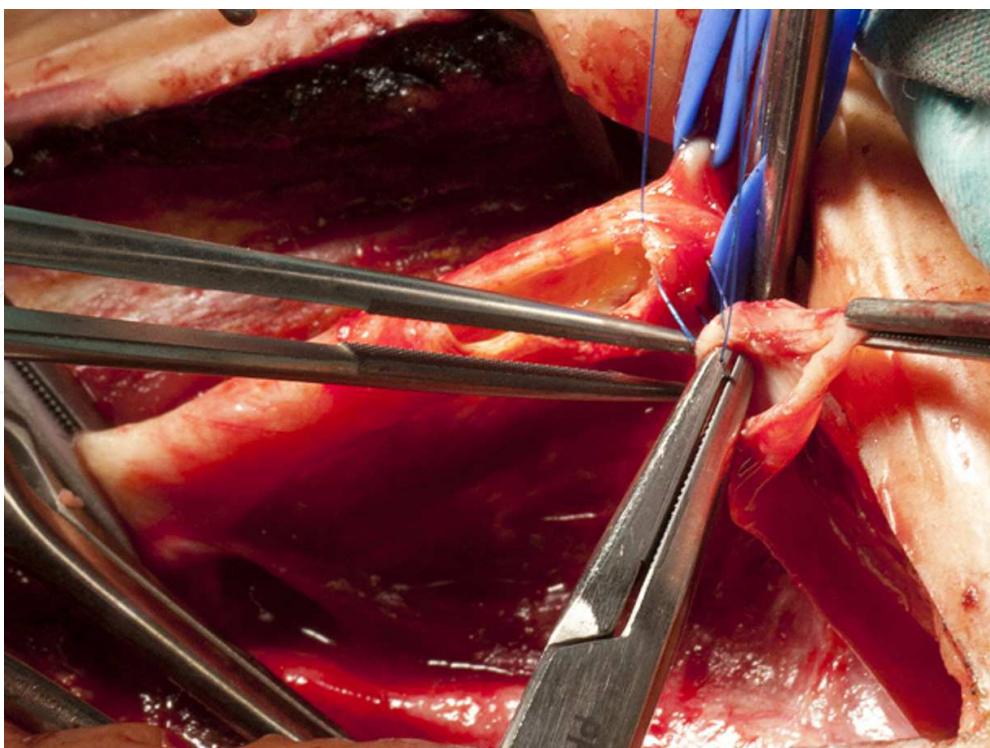


Fig. 6. Beginning of anastomosis creation

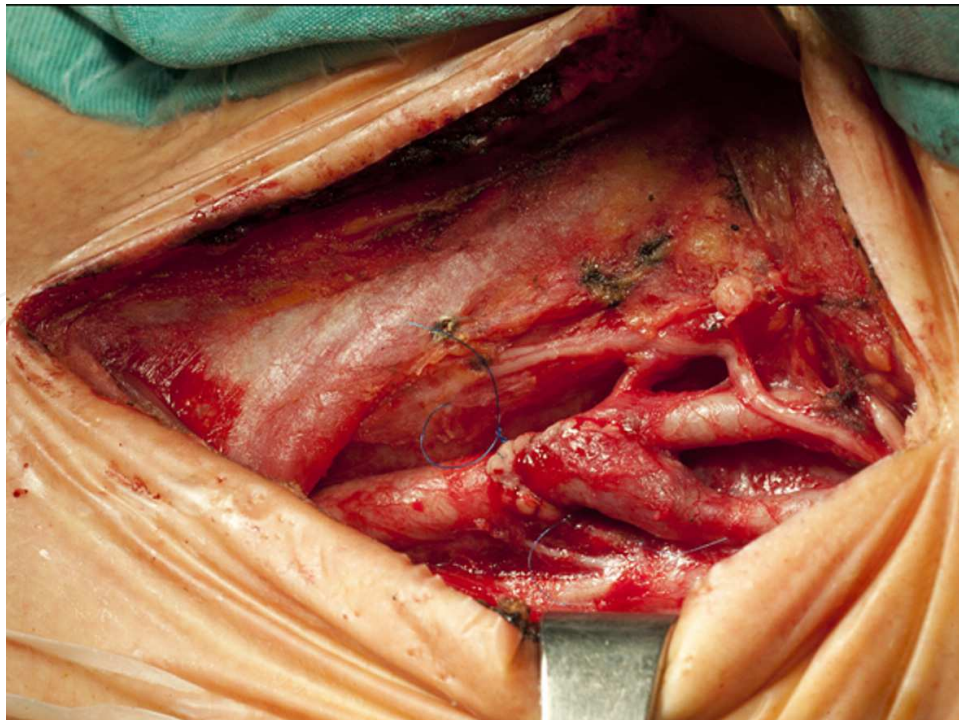


Fig. 7. Preserved morphological and hemodynamic characteristics after anatomical reimplantation of internal carotid artery

All patients who were surgically treated underwent ECEA under general anesthesia, without shunting and without intraoperative monitoring of cerebral functions. If postoperative course was uneventful, patients were discharged from hospital by the third postoperative day.

2.4 Medications

Patients who were taking standard antiplatelet therapy (aspirin and/or clopidogrel) were taken off these drugs at least 2 days before the operation, as this is a routine practice in our institution to minimize operative and perioperative bleeding. All patients were discharged on either aspirin or clopidogrel or both medications. These drugs were continued upon discharge. Other cardiovascular medications (β -blockers, inhibitors of angiotensin-converting enzyme, angiotensin receptor blockers, diuretics, and/or statins) in both groups of patients were prescribed if clinically indicated.

2.5 Follow-up

Follow-up consisted of detailed history and physical examination at 1, 3, 6, and 12 months. Patients were followed for ipsilateral stroke, TIA, and neurologic mortality. Duplex ultrasonographic scan of the carotid arteries was repeated at 12 months. After this period patients were sent for regular control examinations to the competent surgeon.

2.6 Statistical analysis

All data were collected prospectively as a part of our institution's database. Data are expressed as mean $\pm$ standard deviation. T-Test and chi-squared tests were used for

comparisons between the subgroups for continuous and categorical variables, respectively (a probability value of $p<0.05$ was considered significant). Kaplan-Meier analysis was performed to assess differences in event-free survival between the groups.

3. Results

	Group A (n=259)	Group B (n=50)	<i>p</i> value
Sex (male)	184 (71%)	34 (68%)	0.79
Age (yr), mean±SD	64 ± 8	65 ± 10	0.44
Stroke	100 (39%)	17 (34%)	0.64
TIA	159 (61%)	33 (66%)	0.64
Hypertension	199 (76%)	40 (80%)	0.76
Hyperlipoproteinaemia	144 (55%)	36 (72%)	0.049
Diabetes	68 (26%)	15 (30%)	0.70
Smoking	77 (30%)	34 (68%)	<0.001
CAD	50 (19%)	11 (22%)	0.80
PVD	61 (23%)	12 (24%)	0.90

CAD - coronary artery disease; PVD - peripheral vascular disease; TIA - transitory ischemic attack.

Table 1. Baseline demographic and clinical data

Table 1 depicts basic demographic and clinical data. Briefly, there was no difference between the groups with respect to age, sex, symptoms, and risk factors for atherosclerosis except for the smoking and hyperlipoproteinemia. Importantly, there was also no difference in incidence of peripheral vascular and coronary artery disease between the groups. There were no intra- and perioperative deaths and strokes in patients who were subjected to surgery. TIA was noted in 4 (1.5%) of these patients. There were no differences between the groups with respect to medications on discharge. The majority of patients were on aspirin and statins, but clopidogrel was prescribed rarely (Table 2).

	Group A (n=259)	Group B (n=50)	<i>p</i> value
B-blockers	160 (61%)	28 (56%)	0.54
ACEi/ARB	201 (77%)	36 (72%)	0.49
Statins	212 (81%)	40 (80%)	0.91
Aspirin	245 (94%)	46 (92%)	0.69
Clopidogrel	20 (7%)	5 (10%)	0.76

ACEI - angiotensin-converting enzyme inhibitor; ARB - angiotensin receptor blocker.

Table 2. Medications on discharge

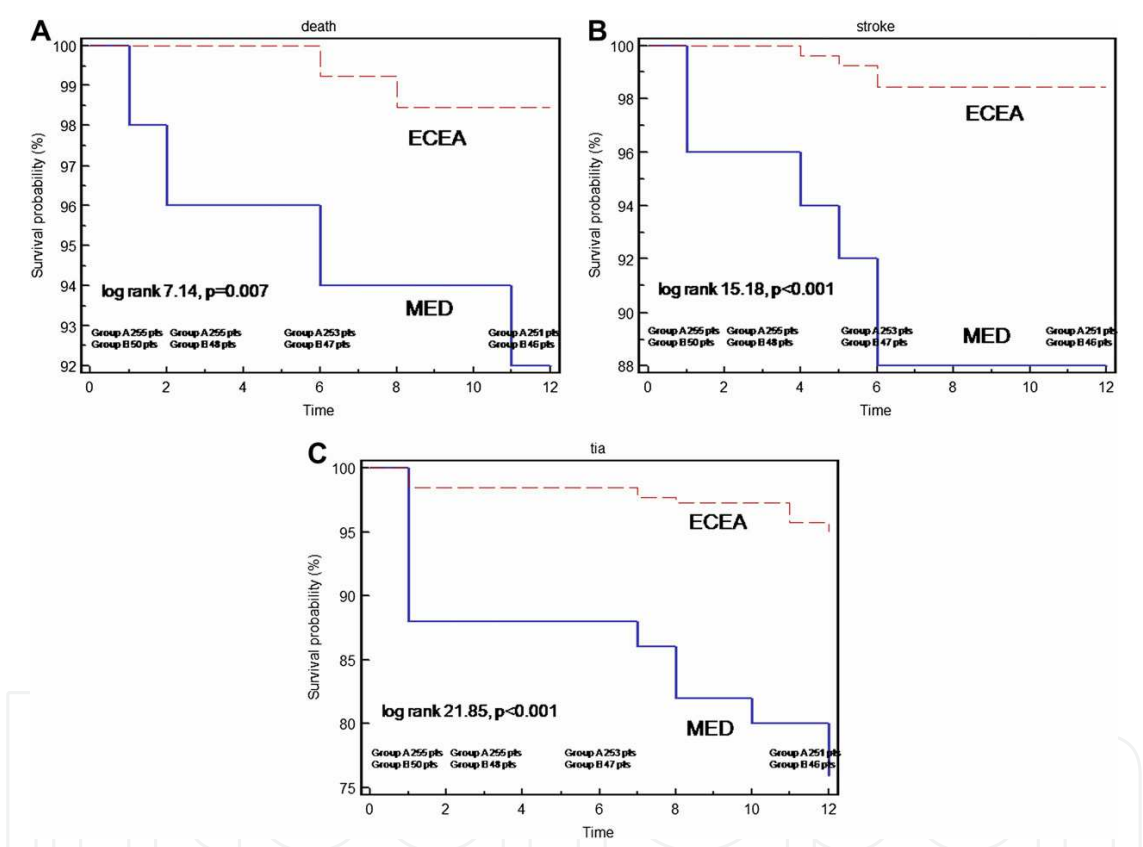
Cumulative 12-month incidence of TIA, ipsilateral stroke, and neurologic mortality in both groups is shown in Table 3.

	Group A (n=259)	Group B (n=50)	RR (95% CI)	p value
TIA	13 (5%)	12 (24%)	1.14 (1.02-1.18)	<0.001
Stroke	4 (1.5%)	7 (14%)	1.24 (1.06-1.46)	<0.001
Death	4 (1.5%)	4 (8%)	.07 (0.98-1.16)	0.034

CI - confidence interval; RR - risk reduction; TIA - transitory ischemic attack.

Table 3. Cumulative incidence of TIA, ipsilateral stroke, and neurologic mortality at 12 months

It is evident that patients who underwent ECEA had lower incidence of all three events at 12 months than did patients who received medical therapy. Follow-up data were available for 255 (98%) of surgically treated and 50 (100%) for medically treated patients.



ECEA - eversion carotid endarterectomy; MED - medical treatment; TIA - transient ischemic attack.

Fig. 8. Kaplan-Meier curves for (A) neurologic death, (B) ipsilateral stroke, and (C) TIA for surgically and medically treated patients.

Figures 8, A-C depict Kaplan-Meier curves for death, ipsilateral stroke, and TIA for surgically and medically treated patients, respectively, which demonstrate better 12-month outcome for surgically patients with respect to all three variables.

Duplex ultrasonographic scan of the carotid arteries was performed after 12 months in 220 (84%) patients in group A and 40 (80%) patients in group B. Restenosis of the operated ICA was noted in 7 (3%) patients, and progression of near to total occlusion was seen in 15 (37%)

patients in group B. Stroke/TIA was noted in 12 patients in group B who progressed to total occlusion; conversely, stroke/TIA was also noted in 2 patients who did not progress to total occlusion.

4. Discussion

Since 1991, when first ECEA was performed at our institution, this surgical technique gradually replaced longitudinal arteriotomy as the treatment of choice in patients with carotid atherosclerosis. [6-8] One of the major reasons why ECEA is a technique of choice at our institution is shorter clamping time (12.4 ± 3.1 min). [7,9] This fact made shunting unnecessary, which resulted in nearly total abandoning of shunt use in recent years (0.5% of all patients). [7] The choice of anesthetic management for carotid surgery is still controversial. [10-12] The vast majority of operations in our series were performed under general anesthesia, whereby we have not registered disadvantages of this procedure in relation to the outcome.

Eversion carotid endarterectomy showed satisfactory results in near total ICA occlusion treatment as well. Our data indicate that recently (within 12 months) symptomatic patients with near total ICA occlusion who underwent ECEA have better prognosis over 12-month follow-up compared with medically treated patients in terms of increased neurologic mortality and morbidity. The prevalence of near total occlusion is uncertain and it has been estimated in the range of 0.5-10% of all patients undergoing surgery. [13] The issue of management of patients with near total ICA occlusion is highly controversial as it has been suggested that patients with reduced ICA lumen diameter distal to severe symptomatic stenosis are at low risk of ischemic stroke. [14] Currently, there are no randomized clinical trials that would address this important problem.

Data that are currently available mostly originate from post-hoc analysis of NASCET and ESCT studies. [15,16] For the problem to be worse, these post-hoc analyses produced conflicting results. Analysis from the NASCET trial identified 106 symptomatic patients with near total occlusion of ICA and concluded that carotid endarterectomy is beneficial and not more dangerous than in patients with 70-94% stenosis, provided that the procedure is performed by experienced surgeons with low complication rate.

Of the 48 patients with near occlusion treated with CEA, 3 (6.3%) had perioperative strokes, and only 1 of 58 patients (1.7%) with near occlusion treated medically had a stroke in the first month. For medically treated patients with near occlusion, the 1-year stroke risk was 11.1%. A comparison of treatment differences indicated that surgery reduces the risk of stroke at 1 year by approximately one-half ($p < 0.001$) in patients with near ICA occlusion. [4]

In contrast, a report after reanalysis of the final results of the ECST trial concluded that surgery was of little benefit in symptomatic patients with near total occlusion. This study included 125 patients with near occlusion, of whom 78 were treated surgically and 47 medically. Perioperative stroke was noted in 3 (3.8%) patients, and there were no perioperative deaths. [5] Finally, when these patients were pooled together, 3-year risks of ipsilateral stroke for 114 medically treated patients with near occlusion was 15.1% versus 10.9% for 148 surgically treated (absolute risk reduction 4.2%; $p < 0.33$), indicating no clear benefit of surgery for near total occlusion. [17]

Since the incidences of stroke and death in medically treated patients were similar in our patients as in previously reported trials, it can be assumed that the difference in the outcome was drawn from low perioperative and 12-month mortality and morbidity in our group of surgically treated patients. To our knowledge, this is the largest reported group of operated patients with near total ICA occlusion.

It is not entirely clear why the outcome in our patients was more favorable than in NASCET and ESCT trials but the following may be operative. All patients were operated in one center using ECEA technique. It is noteworthy that all of our surgeons, both senior and junior, are dedicated vascular surgeons with comprehensive training in ECEA.

Furthermore, our center is a high-volume center for ECEA, with over 700 surgeries per year. [6-8] This surely contributes to good surgical results, as it has been shown that high-volume surgeons (more than 60 surgeries per year) have fewer surgical complications [18] and that the results of carotid endarterectomy are better if performed exclusively by vascular surgeons. [19] Furthermore, it appears that the choice of surgical technique may also play a role as it has been suggested that ECEA may be associated with lower risk of arterial occlusion and restenosis than longitudinal arteriotomy. [20]

NASCET and ESCT trials were done more than 15 years ago in an era when the concomitant use of vasculoprotective medications was less well established. Therefore, it can also be assumed that the widespread use of statins, antiplatelet therapy, and angiotensin-converting enzyme inhibitors/angiotensin receptor blockers had modulated atherosclerotic process in our patients. Since the use of medication was similar between the groups, it can be postulated that improved hemodynamics and lower baseline incidence of smoking and hyperlipoproteinemia in medically treated patients may also play a role. Patient population between our and previous trials was also somewhat different, as our study included only recently (within 12 months) symptomatic patients who are regarded to be at higher risk for future neurologic events. [1,2] This may further emphasize the need for surgery and/or tailored medical treatment in high-risk patient population.

Diagnosis of near total ICA occlusion can be challenging, but our experience is in keeping with previous reports that Duplex ultrasonography should be the initial diagnostic test, which can be supplemented by other imaging techniques when the diagnosis is in doubt. [21] The major drawback of our study is that this is a nonrandomized trial. The general policy in our institution is that all symptomatic patients with significant carotid atherosclerotic disease should be operated on, and it was deemed unethical to refuse surgery to a significant number of patients despite conflicting prior evidence.

All patients were thoroughly informed about the potential surgical risk and benefits and the final decision was made according to their preferences. However, two groups were well matched with respect to sex, age, symptoms, and demographic characteristics and we believe that valid comparisons can be made.

The other potential drawback is that we did not assess the presence of collateral circulation, since it has been shown that the 2-year risk of TIAs, hemispheric stroke, and disabling or fatal strokes was reduced in the presence of collaterals on cerebral angiography in medically treated patients, [22] which can further refine risk stratification in patients with near total ICA occlusion.

5. Conclusion

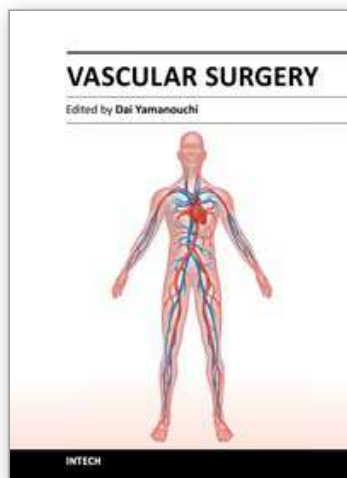
Our data indicate that recently (within 12 months) symptomatic patients with near total ICA occlusion who underwent ECEA have lower incidence of TIA, ipsilateral stroke, and neurologic death during follow-up than medically treated patients. It appears that, at least in high-volume centers, ECEA should be favored over medical treatment for the management of these patients.

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