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Comparison of Perioperative and Postoperative Results of Three Eversion Techniques in Carotid Endarterectomy: A Single-Center Retrospective Study (Experience of the Vascular Surgery Department, Mohamed V Military Instruction Hospital, Rabat)

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Abstract | **Original Research Article**

Background: Eversion carotid endarterectomy (ECEA) is an established alternative to the standard technique. Several technical variants exist (Etheredge, Van Maele, Chevalier), but few studies have compared their immediate results. ***Objective:*** To compare the perioperative and early postoperative results of the three ECEA techniques. ***Methods:*** Retrospective study including 30 consecutive patients operated on for carotid stenosis >70% (NASCET criteria) between 2013 and 2021. Patients were divided according to the technique used: Etheredge (n=12), Van Maele (n=11), Chevalier (n=7). The primary evaluation criteria were carotid clamping time, intensive care unit (ICU) length of stay, and total length of hospitalization. Secondary criteria included early postoperative complications (stroke, TIA, hematoma, restenosis, mortality). ***Results:*** The mean age was 71.9 years with a male predominance (80%). All patients had cardiovascular risk factors, mainly hypertension (37.9%). The mean clamping time was significantly different between groups: 13.8 min (Etheredge), 15.8 min (Van Maele), and 23.4 min (Chevalier) ($p<0.05$). The mean ICU stay was 26.3h (Etheredge), 29.6h (Van Maele), and 48h (Chevalier). The total length of hospitalization was 3.1, 3.8, and 3.9 days respectively. No postoperative stroke/TIA or death was observed. One case of restenosis and one non-compressive hematoma each occurred in the Etheredge group. ***Conclusion:*** In our series, the Etheredge technique was associated with the shortest clamping times and hospitalization durations, followed by Van Maele then Chevalier. All three techniques demonstrated comparable safety with very low perioperative morbidity. The technical choice can be guided by lesion anatomy and surgeon experience, with a potential intraoperative advantage for the Etheredge technique.

Keywords: Carotid Endarterectomy, Eversion, Etheredge Technique, Van Maele Technique, Chevalier Technique, Surgical Outcomes, Carotid Stenosis.

INTRODUCTION

Extracranial carotid atherosclerosis is a major cause of ischemic stroke [1]. Carotid endarterectomy (CEA) remains the gold standard treatment for selected symptomatic and asymptomatic tight stenoses, as demonstrated by the historical NASCET and ACST trials [2, 3].

Among surgical techniques, eversion carotid endarterectomy (ECEA), initially described by Etheredge, has gained popularity [4]. It involves a transverse section of the common or internal carotid artery, followed by a circumferential detachment of the atheromatous plaque and a termino-terminal reimplantation. Its theoretical advantages include an anastomosis without a patch, preservation of the natural anatomy, and a potentially lower restenosis rate [5]. Three main technical variants are described: section of the common carotid (Etheredge), section of the internal carotid (Van Maele), and a hybrid technique with longitudinal arteriotomy of the bifurcation (Chevalier) [6, 7].

While the superiority of ECEA over the conventional patch technique has been widely studied (EVEREST trial), few studies have compared in detail the results of the different eversion techniques themselves [8]. This single-center retrospective study aims to compare the perioperative and early postoperative results of the three ECEA techniques

(Etheredge, Van Maele, Chevalier) in the surgical management of carotid stenoses.

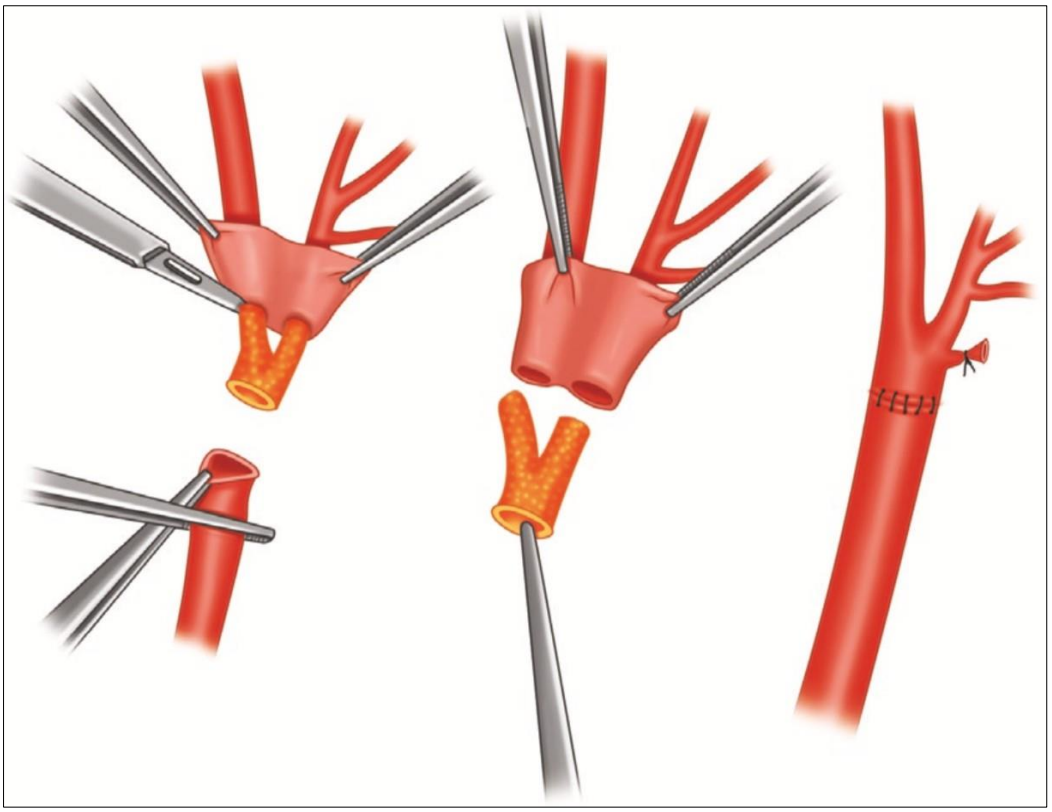

Figure 1: Etheredge technique showing the section of the common carotid artery and the eversion of the internal and external carotid arteries

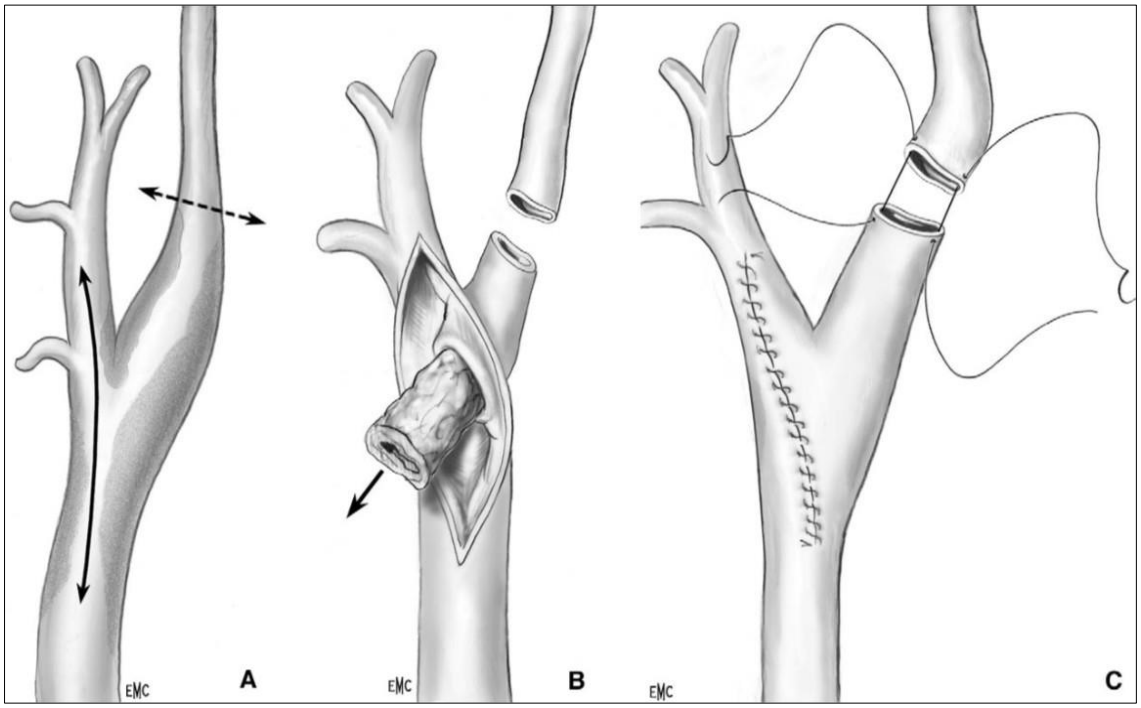

Figure 2: Chevalier technique showing the distal section of the internal carotid artery. A. Incision at the bifurcation and section of the ICA. B. Eversion in a glove-like fashion showing the atherosclerotic plaque. C. Restoration of anatomical continuity.

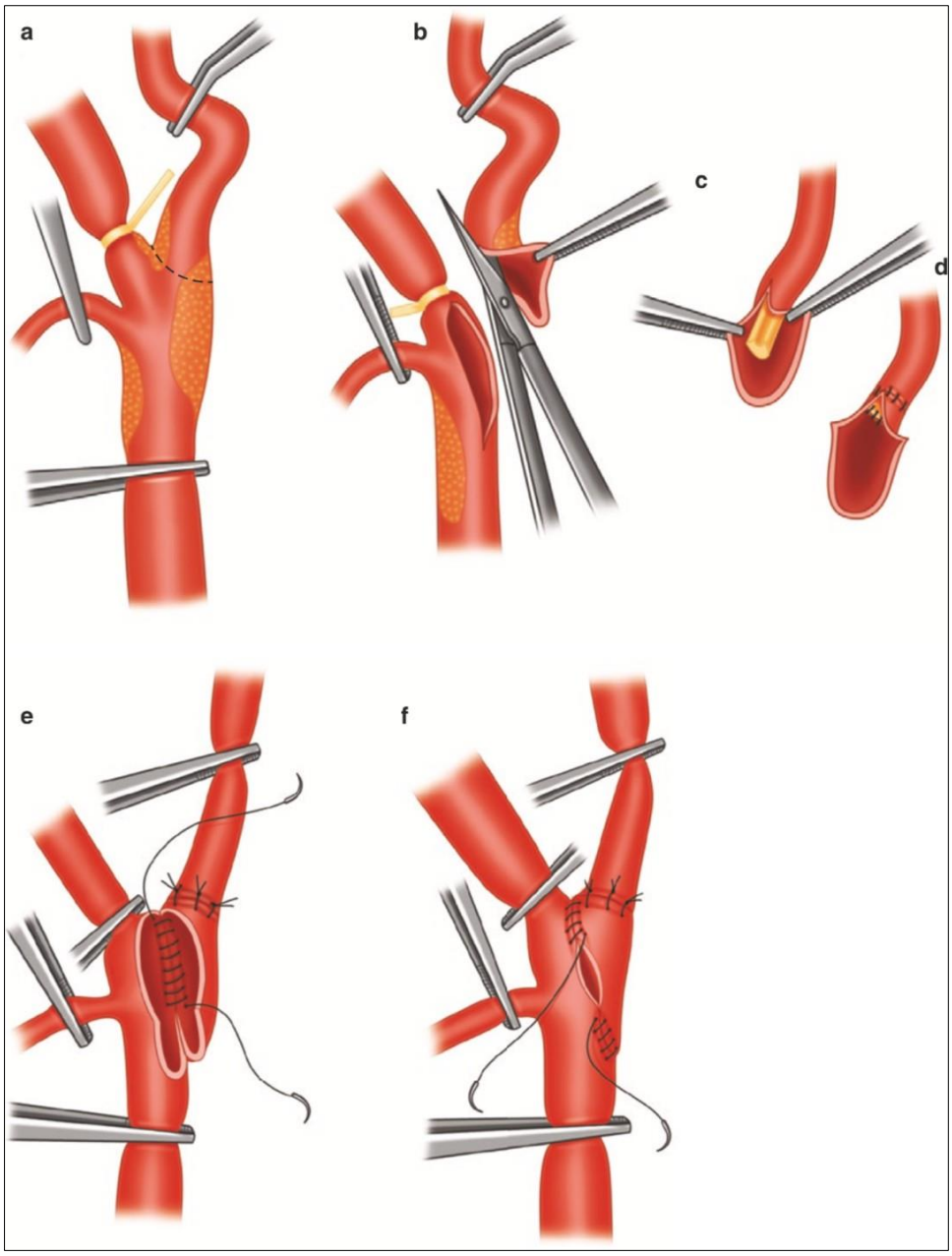

Figure 3: Steps for performing an eversion endarterectomy according to the Van Maele method

METHODS

Study Design and Population

This is a retrospective observational study conducted in the vascular surgery department of the Mohammed V Military Instruction Hospital in Rabat. All records of patients who underwent ECEA for internal carotid artery stenosis between January 2013 and December 2021 were analyzed. Inclusion criteria were: stenosis ≥70% measured according to NASCET criteria by Doppler ultrasound and MRI angiography, treatment by ECEA (Etheredge, Van Maele, or Chevalier technique), and a complete medical record. Exclusion criteria were patch endarterectomies, reinterventions, and incomplete records.

Thirty patients were included. The choice of surgical technique was left to the discretion of the senior surgeon, based on the anatomy of the bifurcation, the extent of the plaque, and their experience.

Variables Studied and Definitions

Demographic data, cardiovascular risk factors (hypertension, diabetes, dyslipidemia, smoking), and symptomatic status (completed stroke, transient ischemic attack - TIA, asymptomatic) were collected.

The studied intraoperative parameters were: surgical technique, carotid clamping time (in minutes), and the use of a carotid shunt.

The postoperative outcome measures were: length of stay in the intensive care unit (ICU, in hours), total length of hospitalization (in days), and the occurrence of complications within 30 days (ipsilateral

stroke/TIA, compressive cervical hematoma requiring surgical revision, myocardial infarction, cranial nerve palsy, all-cause mortality). One-year follow-up also noted the occurrence of restenosis (>50%) detected by Doppler ultrasound.

Statistical Analysis

Data are presented as means (± standard deviation) for quantitative variables and counts (percentages) for qualitative variables. Comparison of means between the three groups was performed using a one-way analysis of variance (ANOVA), with a significance level set at $p<0.05$. Analyses were performed using SPSS software version 26.0.

RESULTS

Population Characteristics

The mean age of the 30 patients was 71.9 years (range: 58-86 years). There was a clear male predominance (24 men, 80%). The most frequent risk factors were hypertension (37.9%), diabetes (20.7%), and smoking (19.0%). Fifteen patients (50%) were symptomatic before surgery (9 completed strokes, 6 TIAs), while 14 (46.7%) were asymptomatic and one patient (3.3%) was discovered incidentally.

Intraoperative Data

The distribution of techniques was as follows: Etheredge (n=12, 40%), Van Maele (n=11, 36.7%), Chevalier (n=7, 23.3%). No carotid shunt was used in this series.

The mean clamping time differed significantly between the three techniques ($p<0.001$): 13.8 ± 3.2 minutes for Etheredge, 15.8 ± 1.7 minutes for Van Maele, and 23.4 ± 2.1 minutes for Chevalier. The shortest clamping time was observed in the Etheredge group.

Early Postoperative Data (Table 1)

The mean ICU stay was 26.3 hours for Etheredge, 29.6 hours for Van Maele, and 48 hours for Chevalier.

The total length of hospitalization was 3.1 ± 0.7 days (Etheredge), 3.8 ± 0.8 days (Van Maele), and 3.9 ± 0.9 days (Chevalier).

No stroke, TIA, myocardial infarction, or death occurred perioperatively. One complication was noted: a non-compressive cervical hematoma in the Etheredge group, resolved with medical treatment.

One-Year Follow-up

During the one-year Doppler ultrasound follow-up, one case of non-significant restenosis (<50%) was detected in the Etheredge group. The patient was treated medically. No restenosis was observed in the other groups.

Table 1: Comparison of Operative Parameters and Results According to Eversion Technique

Parameter	Etheredge (n=12)	Van Maele (n=11)	Chevalier (n=7)	p-value
Clamping Time (min)	13.8 ± 3.2	15.8 ± 1.7	23.4 ± 2.1	<0.001
ICU Stay (hours)	26.3	29.6	48.0	-
Hospitalization (days)	3.1 ± 0.7	3.8 ± 0.8	3.9 ± 0.9	0.08
Complications (n)	2*	0	0	-
Mortality (n)	0	0	0	-

*Caption: * 1 non-compressive hematoma and 1 restenosis at 1 year.*

DISCUSSION

This retrospective study, although with a small sample size, offers a rare comparison of the three ECEA techniques. The main finding is the significant difference observed in clamping times, with an advantage for the Etheredge technique, followed by Van Maele, the Chevalier technique being the longest.

This hierarchy can be explained by the intrinsic technical complexity. The Etheredge technique, by sectioning the common carotid, allows easier and often faster plaque detachment in both axes (internal and external) [4]. The Chevalier technique, combining a longitudinal arteriotomy and reimplantation, is mechanically more delicate and time-consuming, which is corroborated by our series [7]. Van Maele, by sectioning the internal carotid, represents a compromise [6].

Our clamping times are overall lower than those reported in the literature for ECEA, where they usually range between 25 and 35 minutes [8]. This could be related to the surgical team's experience. A shorter clamping time is theoretically associated with a reduced risk of cerebral ischemia, although no neurological events occurred in our series, including in the Chevalier group. The non-use of a shunt, possible due to adequate hemodynamic tolerance and/or intraoperative monitoring, may also have contributed to the speed of execution.

Regarding postoperative outcomes, the slightly shorter length of hospitalization in the Etheredge group, although not statistically significant, points towards a faster recovery. Morbidity was very low and comparable between groups, with only two minor events in the Etheredge group. This is consistent with the literature reporting major complication (stroke/death) rates below 3% for ECEA in experienced centers [5-8].

The limitations of this study are its retrospective nature, the absence of randomization (risk of selection bias), the small sample size per group, and the limited follow-up. Since the choice of technique was based on intraoperative anatomical criteria, it is likely that more complex or extensive lesions were treated with Chevalier or Van Maele, which could bias the comparison of operative times.

CONCLUSION

In our experience, the three eversion carotid endarterectomy techniques are safe and effective. The Etheredge technique seems to offer the advantage of a significantly shorter clamping time, potentially associated with reduced hospitalization. The Van Maele technique constitutes an excellent alternative, particularly for lesions with internal extension. The Chevalier technique, more complex and longer, remains indicated for particular anatomical situations. A prospective randomized study with a larger number of patients and long-term follow-up would be necessary to confirm these trends and evaluate the impact on late restenosis.

DECLARATIONS

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Conflicts of Interest: The authors declare no conflict of interest.

Ethical Approval: The study was approved by the local ethics committee of the institution.

Consent: General informed consent was obtained for the use of data for research purposes.

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