Eur J Vasc Endovasc Surg **22**, 306–309 (2001)
doi:10.1053/ejvs.2001.1473, available online at http://www.idealibrary.com on IDEAL®

External Carotid Artery Shunting During Carotid Endarterectomy: An Alternative for Cerebral Protection?

P. Belardi*, **C. Finocchi, G. Lucertini, A. Viacava and G. Simoni**

Section of Vascular Surgery and Department of Neurological Science and Neurological Rehabilitation (Dr Cinzia Finocchi), University of Genova

Objectives: *to assess the application of external carotid artery (ECA) shunting in cerebral protection during carotid endarterectomy (CEA).*
Design: *prospective study.*
Materials and Methods: *the study comprised 137 consecutive patients who underwent CEA under locoregional anaesthesia. Transcranial Doppler was used to monitor the mean velocity of the middle cerebral artery (mv-MCA): (1) before carotid clamping; (2) after clamping both the common and external carotid arteries; (3) after clamping the internal carotid artery alone ("ECA test"). The decision to shunt was based on the occurrence of neurological deficit during carotid clamping. If the ECA test revealed mv-MCA approaching the pre-clamping values ECA shunting was used, whereas the remaining patients in need of a shunt had a standard internal carotid artery (ICA) shunt.*
Results: *shunting was necessary in 12/137 cases (9%). The ECA test indicated that in four cases – 3% of the whole series or 33% of the shunted cases. In these four patients ECA shunting reversed the neurological deficit, and CEA was successfully performed without any complications.*
Conclusions: *ECA shunting could be considered as an alternative to standard ICA shunting. Suitable cases can be identified on the basis of the ECA test.*

Key Words: Carotid endarterectomy; Shunting; External carotid artery.

Introduction

The relevance of cerebral protection during carotid endarterectomy (CEA) is well known.

Selective shunting is the preferred procedure for cerebral protection.[1–8]

Nevertheless, shunting in the internal carotid artery (ICA) may lead to complications (dissection, microembolism, and thrombosis) and has technical limitations (difficulty in shunt insertion and poor revision of distal flaps).[5,9]

On the basis of these considerations, Machleder *et al.*,[10] and Faraglia *et al.*[11] claimed that in some circumstances the external carotid artery (ECA) might provide efficient collateral supply that would allow safe cerebral perfusion during temporary ICA occlusion. Therefore, these authors have demonstrated the efficacy of shunting through the ECA during CEA, but say that due to their limited series further studies are needed to clarify the range of application of this technique.

The aim of this study was to assess the application of ECA shunting in cerebral protection during CEA.

Materials and Methods

Between October 1998 and January 2000, a prospective study on 137 consecutive cases of CEA was performed. Indication to surgery was severe carotid stenosis (equal to or greater than 70%, graded according to haemodynamic criteria[12]) in 132 patients (five were operated upon bilaterally). There were 101 males (74%) and 31 females (26%) ranging in age from 46 to 80 years (median 71).

Stenoses were asymptomatic in 66 (48%) cases on the clinical basis and symptomatic in 71 (52%) due to previous TIA (44 cases, 32%), amaurosis fugax (11 cases, 8%) or stroke (16 cases, 12%).

Preoperative evaluation included clinical examination, ultrasound examination using duplex scanning of the extracranial arteries (including ophthalmic

* Please address all correspondence to: P. Belardi, Cattedra di Chirurgia Vascolare, Università di Genova, Largo Rosanna Benzi, 8, 16132 Genova, Italy.

1078–5884/01/100306+04 $35.00/0

test) and transcranial Doppler (TCD), cerebral computed tomography, subtractive digital angiography, and assessment of blood, cardiac, respiratory, hepatic and renal conditions.

TCD examination was possible in all 137 cases due to the presence of an acoustic temporal window. The surgical procedure was carried out under locoregional anaesthesia. Systemic arterial pressure of the patient was maintained stable during carotid endarterectomy. Neurological events (unconsciousness or focal neurological deficit) were assessed each minute during the surgical procedure.

Furthermore, the mean velocity of the ipsilateral middle cerebral artery (mv-MCA) was monitored by TCD (EME TC2-64, Uberlingen, Germany) throughout the surgical procedure with the patient's head steadily immobilised and was carefully evaluated before carotid clamping, after both common (CCA) and external (ECA) carotid clamping, and after internal carotid artery (ICA) clamping alone (the so-called "ECA test").

To protect the cerebral parenchyma, the shunt was used when neurological event was observed and its function was checked by neurological evaluation (obtaining reversion of unconsciousness or focal neurological deficit) and TCD monitoring (observing an increase of mv-MCA to a level close to the pre-clamping value).

ECA shunting was performed in cases with neurological event presenting a drop in the mv-MCA after CCA and ECA clamping followed by an increase back to values close to the pre-clamping ones upon ECA test.

In all cases, after exposing the carotid arteries and intravenously administering 5000 IU of heparin, a longitudinal arteriotomy in the CCA and ICA was performed and endarterectomy, involving CCA, ICA and proximal ECA, was carried out.

In the non-shunted subgroup CEA was carried out quickly and completed immediately. In the shunted subgroup endarterectomy was carried out quickly before shunt insertion. The shunt was inserted within a few minutes after the onset of neurological deficit. Three cms. of its distal end (in ICA or ECA) was first inserted then allowed to fill with blood, after which the proximal end (in CCA) was inserted. CEA was accurately completed after shunt insertion. The Pruitt–Inahara shunt model 400-40-8F (Ideas for Medicine, St Petersburg, U.S.A.) with an inner diameter of 2.7 mm was used.

After completing endarterectomy, arteriotomy was closed by using a pre-coated Dacron patch (Ultra-Thin HemaCarotid Patch knitted, InterVascular, La Ciotat, France) interposition in 119/137 cases (87%) when the preoperative arteriographic diameter of ICA over the distal limit of carotid stenosis was equal to or less than 4 mm, and by primary closure in the other 18/137 (13%).

We evaluated the frequency of application for ECA shunting, the effectiveness of this procedure, and its complications.

Results

Altogether a shunt was used in 12/137 cases (9%). In this subgroup mv-MCA decreased after clamping of the CCA and ECA in all cases. mv-MCA remained the same during ECA test as well as after clamping of the CCA and ECA in eight cases. These eight cases received an ICA shunt. In four cases (33% of the shunted subgroup of 12 cases, and 3% of the whole series of 137 CEAs) mv-MCA dropped to either 0 or 8 cm/s after CCA and ECA clamping, whereas during ECA test it increased to values close to the pre-clamping ones. In these four cases ECA shunting was used. During ECA shunting, followed by reversion of neurological deficit, mv-MCA increased to values close to the ECA test ones (Fig. 1).

Table 1 shows mv-MCA in the subgroups of ECA shunting, ICA shunting and nonshunted cases. Findings of the ophthalmic test are shown in Table 2.

ECA shunting did not require any changes in the surgical procedure. ECA shunting facilitated the surgical procedure and did not lead to any complications. Lastly, CEA was successful in all four cases. Surgical mortality was 1% (1/137), due to cerebral ischaemia caused by thrombosis of the operated ICA in a patient in the ICA shunted subgroup. Neurological morbidity was 3% (4/137), due to minor stroke in four cases (Table 3).

Clamping times were 16–52 min (median 24) in the whole series of 137 CEAs, 30–50 min (median 34) in the shunted subgroup (12/137) and 34–48 min (median 33) in the subgroup of ECA shunting (4/137).

Discussion

In the present study ECA played a significant role in cerebral perfusion in four of the 137 cases (3%), which we were able to use for shunting. This confirms the results of previous studies on the feasibility and effectiveness of this procedure.[10–13]

However, we must emphasise the importance of intraoperative evaluation by means of the ECA test

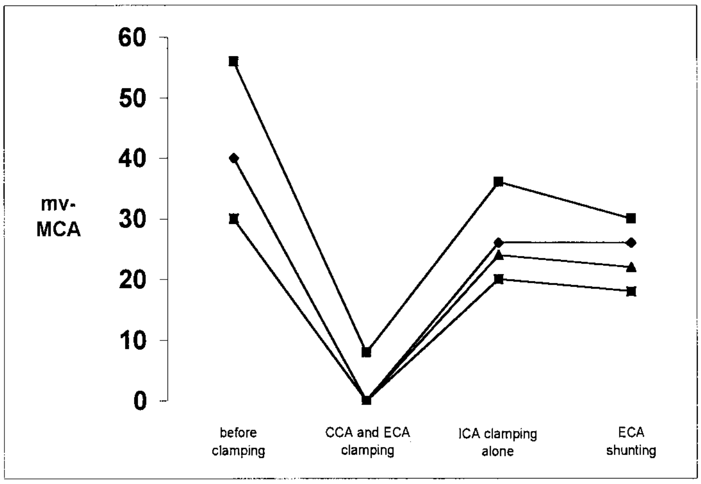

Fig. 1. Mean velocities of the middle cerebral artery (mv-MCA) before clamping of the carotid arteries, after clamping of the common (CCA) and external (ECA) carotid arteries, after clamping of the internal carotid artery (ICA) alone, and during external carotid artery (ECA) shunting for the four cases undergoing external carotid artery shunting.

Table 1. Range (median) of the middle cerebral artery mean velocities (mv-MCA) before clamping of the carotid arteries, after clamping of the common (CCA) and external (ECA) carotid arteries, after clamping of the internal carotid artery (ICA) alone, and during shunting for the subgroups of external carotid artery (ECA) shunting, internal carotid artery (ICA) shunting and nonshunted cases

mv-MCA (cm/sec)	Before carotid clamping	After CCA and ECA clamping	After ICA clamping alone	During shunting
ECA shunting (four cases)	30–56 (35)	0–8 (0)	20–36 (25)	18–30 (24)
ICA shunting (eight cases)	19–44 (31)	0–25 (12)	0–28 (14)	18–44 (28)
Non-shunted (125 cases)	16–66 (44)	0–50 (28)	0–50 (28)	—

Table 2. Findings of the ophthalmic test on the basis of ultrasound examination in the non-shunted, ICA shunted, and ECA shunted groups

	Non-shunted group	ICA shunted group	ECA shunted group
Normal flow (negative ophthalmic test)	113/125	4/8	1/4
Reversed flow (positive ophthalmic test)	12/125	4/8	3/4

Table 3. Neurological complications after carotid endarterectomy for the subgroups of external carotid artery (ECA) shunting, internal carotid artery (ICA) shunting and non-shunted cases

Postoperative neurological deficit	*n*	%
ECA shunting	0/4	0
ICA shunting	1/8	12
Non-shunted	3/125	2

which provides exact information on the possible application of ECA shunting.

Based on our experience, inserting a shunt into the ECA requires no change in the surgical technique and no prolongation of clamping time. It is important for shunt insertion to be limited to the first 3 cm of the ECA in order to guarantee perfusion of proximal ECA branches.

Neurological monitoring can be used to verify whether perfusion through the ECA is adequate. ECA shunt may avoid the technical problems and neurological complications associated with ICA shunting.[5,9,14–16]

References

1 Sundt TM. The ischemic tolerance of neural tissue and the need for monitoring and selective shunting during carotid endarterectomy. Stroke 1983; **14**: 93–98.

2 Cho I, Smullens SN, Streletz LJ, Fariello RG. The value of intraoperative EEG monitoring during carotid endarterectomy. Ann Neurol 1986; **20**: 508–512.

3 Archie JP. Technique and clinical results of carotid stump backpressure to determine selective shunting during carotid endarterectomy. J Vasc Surg 1991; **13**: 319–327.

4 Giannoni MF, Sbarigia E, Panico MA *et al.* Intraoperative transcranial Doppler sonography monitoring during carotid surgery under locoregional anaesthesia. Eur J Vasc Endovasc Surg 1996; **12**: 407–411.

5 Plestis KA, Loubser P, Mizrahi EM *et al.* Continuous electroencephalographic monitoring and selective shunting reduces neurological morbidity rates in carotid endarterectomy. J Vasc Surg 1997; **25**: 620–628.
6 Cao P, Giordano G, Zannetti S *et al.* Transcranial Doppler monitoring during carotid endarterectomy: is it appropriate for selecting patients in need of a shunt? J Vasc Surg 1997; **26**: 973–980.
7 Salvian AJ, Taylor DC, Hsiang YN *et al.* Selective shunting with EEG monitoring is safer than routine shunting for carotid endarterectomy. Cardiovasc Surg 1997; **5**: 481–485.
8 Finocchi C, Gandolfo C, Carissimi T, Del Sette M, Bertoglio C. Role of transcranial Doppler and stump pressure during carotid endarterectomy. Stroke 1997; **28**: 2448–2452.
9 Frawley JE, Hicks RG, Beaudoin M, Woodey R. Hemodynamic ischemic stroke during carotid endarterectomy: an appraisal of risk and cerebral protection. J Vasc Surg 1997; **25**: 611–619.
10 Machleder HI, Barker WF. External carotid artery shunting during carotid endarterectomy. Arch Surg 1974; **108**: 785–788.
11 Faraglia V, Sbarigia E, Speziale F *et al.* An external carotid artery shunt to prevent cerebral ischaemia during carotid surgery. Eur J Vasc Surg 1990; **4**: 385–389.
12 Hood DB, Mattos MA, Mansour A *et al.* Prospective evaluation of new duplex criteria to identify 70% internal carotid artery stenosis. J Vasc Surg 1996; **23**: 254–262.
13 Connolly JE, Kwaan JHM, Stemmer EA. Improved results with carotid endarterectomy. *Ann Surg* 1977; **186**: 334–342.
14 Mackey WC, O'Donnel TF, Callow AD. Carotid endarterectomy contralateral to an occluded carotid artery: perioperative risk and late results. J Vasc Surg 1990; **11**: 778–783.
15 Perler BA, Burdick GF. Does contralateral internal carotid artery occlusion increase the risk of carotid endarterectomy? J Vasc Surg 1992; **16**: 347–353.
16 Davies MJ, Mooney PH, Scott DA, Silbert BS, Cook RJ. Neurologic changes during carotid endarterectomy under cervical block predict a high risk of postoperative stroke. Anesthesiology 1993; **78**: 829–833.

Accepted date 2 July 2001