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Embolism to the brain during carotid stenting

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Aim. **Stenting of carotid arteries is at risk for embolic complication with cerebral ischemia. The aim of this study was to assess the prevalence, quality and clinical relevance of microembolism in 50 unselected patients with hemodynamic lesions of carotid bifurcations (>70% stenosis) submitted to 50 carotid artery stenting (CAS) from January 2005 to January 2006.**
Methods. **High-resolution color-flow mapping (CFM), transcranial Doppler (TCD), cerebral computed tomography (CT) or magnetic resonance (MR) and 4 psychometric tests were carried out in the preoperative study in all the patients. Local anesthesia, 3 different carotid stents and 3 temporary distal filter protection devices, without predilatation, were employed. TCD monitoring was used intra- and 6 h postoperatively to evaluate the presence and the number of microembolic signals (MES) and to investigate the effectiveness of neuroprotective filter devices. The efficacy of the in situ opened filter was judged evaluating the decrease of mean blood velocity in ipsilateral middle cerebral artery (MCA) and the reduction rate of microembolic events. Diffusion-weighted magnetic resonance imaging (DWI) of the brain was obtained within 24 to 48 h after the procedures to detect new ischemic brain lesions. Psychometric tests were repeated before patient's discharge and after 2 months to evaluate cognitive faculties.**
Results. **During postoperative period (30 days) and follow-up, no death or major strokes procedure-related occurred; 2 regressive minor strokes intraoperatively were recorded (4%). TCD monitoring showed MES (60 events mean) in all the CASs (100%). A 10-30% decrease of mean blood velocity basal value was recorded in ipsilateral MCA when filter device was opened; mean 70% reduction of MES was also detected for the time in which the cerebral protection system was working. In 5 patients repeated microemboli occurred during 1 h postoperative TCD control (10%). Postoperative DWI detected new focal ischemic lesions in 22 patients (44%), 5 ipsi- and/or contralateral lesions mean. Cognitive capability worsened in 18 patients (36%).**
Conclusion. **Isolated corpuscolated emboli were detected during cannulation of common carotid and internal carotid artery, introduction and withdrawal of protection device and during stenting and ballooning. The use of a protection device seems to be able to sensibly reduce the number of embolic event. New asymptomatic lesions were detected in the brain by DWI in the postoperative period with a weighty deterioration of cognitive capability in 1/3 of patients.**

KEY WORDS: Carotid artery stenosis - Stenting - Transcranial Doppler - Micro embolic signals - Diffusion-weighted magnetic resonance imaging.

A large body of evidence is now available on evaluation and management of patients with cerebrovascular disease. Two prospective randomized trials, one in North America (NASCET) [1] and one in Europe (ECST),[2] have begun to provide definitive data on which to base decisions about carotid endarterectomy (CEA). The greatest beneficial results of surgery were found for those patients with recent symptoms and with the highest degrees of stenosis. In the last

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Figure 1.—TCD evaluation of MBV in MCA while the in situ opened filter is working. In the circle the neuroprotective filter device is visible.

10 years carotid artery stenting (CAS) has been introduced to take the place of surgery in this field: mortality and morbidity rates of patients submitted to this treatment are superimposed to results obtained by CEA in a large number of experiences.[3-5] Conversely, few news are reported about microembolic events during CAS and its implications in cerebral function, cognitive capability and quality of life of those patients.[6-8] During the last 9 years transcranial Doppler (TCD) has been successfully used by us during CEA to monitor carotid cross clamping, the efficacy of indwelling shunt, and the microembolic signals (MES).[9] To assess the prevalence, quality and clinical relevance of microembolism in patients submitted to CAS we have employed TDC monitoring, diffusion-weighted magnetic resonance imaging (DWI) [10, 11] and psychometric test [12] pre, intra and post those endovascular procedures.

Materials and methods

From January 2005 to January 2006, 50 patients (36 males and 14 females), with age ranging between 62 and 81 years, underwent CAS in our Institution for hemodynamic lesion of carotid bifurcation (more than 70% stenosis evaluated by ECST method). Other 57 patients were previously submitted to carotid stenting by us, but those cases are not included in this study. In this group of patients the choice for the endovascular approach was carried out only on the basis of a good temporal window which is needed for TCD monitoring of intracranial vessels. Clinical neurological examination was done pre and after treatment by the same neurologist: 28 patients were judged asymptomatic (58% of cases). All patients were studied preoperatively by high-resolution color-flow mapping (CFM) to evaluate the site and the morphological findings of the carotid arteries and by cerebral computed tomography (CT) or magnetic resonance (MR) scan to detect nonvascular (tumors, subdural hematoma), vascular lesions (aneurysms and arterio-venous malformations) and hypodensities suggestive of brain infarction. Four psychometric test (Mini mental state, Beck depression inventory, Zung anxiety inventory, SF-12) were carried out in the preoperative study to evaluate cognitive capability, depression, anxiety level and general health state. TCD (10-12 mm sample volume, 128 FTT resolution, >6 dB threshold, 5-10 kHz PRF, 100-250 mW power and software for the recognition and the count of MES) has been employed before the treatment to monitor MES under basal conditions (continuous monitoring for 60 min). During the endovascular procedure TCD monitoring was carried out from the percutaneous puncture of femoral artery until 30 min after the procedure end. TCD monitoring was obtained using a bilateral insonation of the middle cerebral artery (MCA) and fixing the probes to temporal bone, at the level of middle temporal acoustic window, by a helmet: mitral balloon valvotomy, possible blood flow asymmetry between 2 sides and MES were recorded.

TABLE I.—*Correlation between MES and phases of procedure.*

Patients (n=50)	Patients with MES		Mainly bubbles		Isolate corpuscolated emboli	
	No.	%	No.	%	No.	%
Cannulation plus withdrawal	27	54	5	18.5	22	81.5
Angiography	50	100	50	100	—	—
Stenting and ballooning	45	90	31	68.9	14	31.1

MES: microembolic signals

MES were judged air bubbles if were registered as clusters of emboli with a frequency above 60 dB and corpuscolated or formed elements if the emboli were isolated and with a frequency below 60 dB. In only 2 patients a predilatation of the severe stenotic lesions was carried out before filter deployment. Three different cerebral protection devices (Angioguard-Cordis, Accunet-Guidant, Filterwire-EZ, Boston Scientific), were routinely used by transfemoral approach in all cases. The efficacy of the in situ opened filter was judged evaluating the decrease of MBV in ipsilateral MCA and the reduction rate of microembolic events (number of microemboli detected during the entire procedure/number of microemboli detected during the filter positioning) (Figure 1). Three different carotid stents (Precise-Cordis, Acculink-Guidant and Carotid Wallstent, Boston Scientific) were used. Post-treatment angiography was obtained to control the correct stent delivery and the patency of distal arterial tree. DWI of the brain was obtained within 24 to 48 h after the procedures, to detect new ischemic brain lesions. Blood flow velocity and hemodynamics across the stented vessel were also investigated by CFM before the discharge, likewise psychometric test. Those tests were repeated after 2 months to evaluate the changes in the cognitive capability.

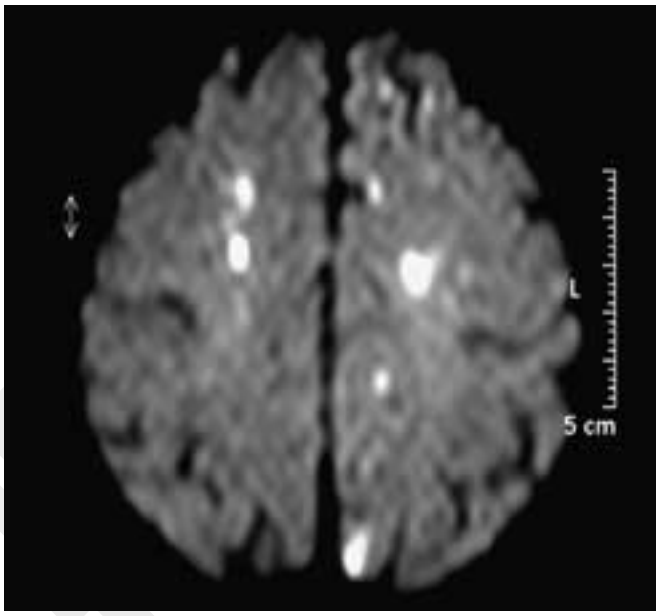

Figure 2.—Forty-eight hours DWI imaging after CAS; bilateral new ischemic brain lesions are present. During the entire procedure 180 MES were detected in this asymptomatic patient.

Results

TCD monitoring carried out in basal conditions before endovascular treatment recorded 2 isolated MES only in 1 patient with a severe hypoechoic stenosis of the internal carotid artery. All the endovascular procedures were performed without discomfort for the patients or technical problems. During the procedures TCD monitoring detected MES in all cases (from 35 to 250 events, 60 means) as showed in Table I: when angiography was performed a lot of clusters of bubbles were detected in all cases: it was not possible to recognize if corpuscolated emboli were superimposed. The highest incidence of isolated MES was recorded during catheter introduction and retraction through the operated vessel, and during stent delivery. A 10-30% decrease of MBV basal value was recorded in ipsilateral MCA when filter device was opened, relating to the type of filter employed. A mean 70% reduction of MES was also detected for the time in which the cerebral protection system was working. Two minor strokes occurred after stenting (4%), with complete remittance of symptoms within 7 days. In 5 patients 1 h TCD control performed within 6 h after the procedure showed repeated MES (10%). An immediate CFM control revealed in 2 of those cases 1 incomplete covering of carotid plaque and 1 incomplete adhesion of stent to the carotid wall, due to the calcification of plaque. In both those cases anticoagulant therapy was sudden begun. During postoperative period (30 days) and follow-up no death or major strokes procedure-related were recorded in this small series of patients. Postoperative DWI detected new focal ischemic lesions in 22 patients (44%): those lesions were 5 on an average and were detected not only on the ipsilateral hemisphere, but also on the contralateral ones (Figure 2). Cognitive capability worsened in 18 out of 22 patients (36%), even if a remarkable improvement was found in 1 patient after 2 months.

Discussion

TCD monitoring during CAS allows to register a great number of MES due to catheter introduction and retraction through the vessels, stent delivery and ballooning; the in situ opened filter sensibly reduces the

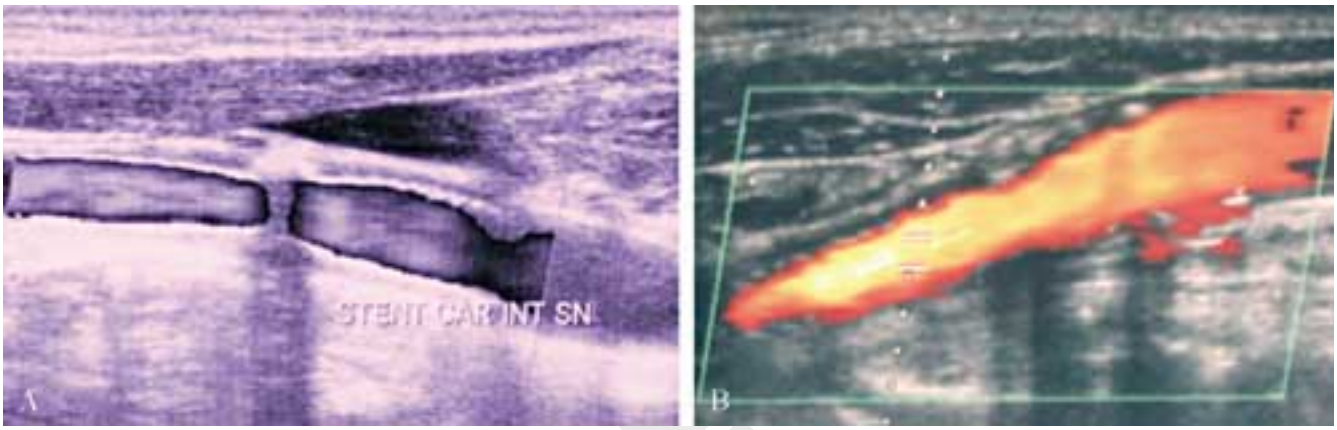

Figure 3.—CFM imaging in patients with MES detected by TCD after CAS: A) the carotid lesion is incomplete covered by stent. B) An incomplete adhesion of stent to the carotid wall, due to the calcification of plaquer, is present.

number of MES, while it is employed. The high incidence of MES is not related to the incidence of neurological deficit, so that CAS mortality and morbidity rates may superimpose to CEA results. These disappointing data suggest that the greatest number of MES is due to air bubbles and it should be supposed that the air bubbles are not able to cause neurological deficit in the majority of cases. Otherwise clinically evident neurological deficit may be due to formed elements, above all if repeated and with rapid sequence. DWI study in post-treatment period has showed hypodensities suggestive of micro brain infarction, also in 20 asymptomatic patients: the high number of those lesions (5 means), in addition in contralateral hemisphere, explains the deterioration of cognitive capability in such subjects.

It should be emphasized that a strict selection of patients, based on a morpho-functional characterization of carotid plaque and a complete study of aortic arch, the use of an adequate and effective cerebral protection device together with a correctly performed endovascular procedure may reduce the incidence of corpuscolated emboli and consequently the number of brain lesions, even if asymptomatic.

Our experience once again underlines that TCD monitoring is very helpful in the study of patient, during endovascular treatment and after the procedure: 1 h pretreatment monitoring points out the lesions at risk of embolic events; the reduction of MBV in MCA and of number of MES suggests a good position of the protection device and its effectiveness; the detection of new MES after CAS reveals an incorrect deployment of stent (Figure 3).

Conclusions

TCD monitoring detects a great number of embolic events during CAS: above all clusters of air bubbles during contrast injection and isolated corpuscolated emboli during vessels cannulation, introduction and withdrawal of catheters and protection device and during stenting and ballooning. The use of a protection device sensibly reduces the number of emboli, while it is employed. New lesions were detected in the brain by DWI in the postoperative period also in asymptomatic patients, with a weighty deterioration of cognitive capability in 1/3 of patients. The use of TCD should be mandatory for the CAS to obtain a better selection of patients, a correct evaluation of protection device effectiveness and a good control of the stent delivery.

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