Neurología. 2010;**25(8)**:485-490

NEUROLOGÍA

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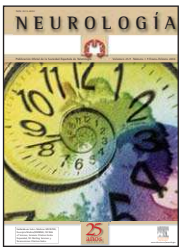

ORIGINAL ARTICLE

Carotid revascularisation using angioplasty and stent in 134 consecutive cases in a reference hospital: A risky technique?

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Received on 17th December 2009; accepted on 10th May 2010

KEYWORDS
Carotid revascularisation;
Angioplasty;
Stent

Abstract
Introduction: Carotid revascularisation (CR) using angioplasty and stent (ASC) is an effective procedure in the prevention of ischaemic stroke, but with a controversial morbidity and mortality in the different studies conducted in this field.
Methods: The results of the ASCs performed in the Virgen de la Arrixaca University Hospital (Murcia) between January 2006 and April 2009 were analysed (epidemiology, indication, grade of residual stenosis and procedure complications). All patients subjected to ASC were pre-selected and followed up by neurologists, and they followed a strict medical protocol for performing the procedure. All ASCs were performed by a team consisting of two surgeons, an anaesthetist and a nurse.
Results: A total of 134 ASC were performed. The mean age of our patients was 72.7 years, with the large majority (75%) being male. The most prevalent diseases were, high blood pressure (81%), smoking (66.4%), and diabetes (38.1%). The most common indications for CR were symptomatic carotid stenosis with a level of stenosis of 75-99%, either in the left (33.6%) or right (32.1%), followed by asymptomatic stenosis combined with risk factors (11.2% in the left side and 10.4% in the right side). A level of stenosis less than 30% was achieved in 132 of the 134 ASC (98.5%). performed. Five patients (3.7%) had complications associated with the procedure, of which four were different clinical presentations of a re-perfusion syndrome and one an asymptomatic thrombosis of the stent.
Conclusions: ASC is a complex technique that must be performed by appropriately trained specialists. The performing a minimum number of procedures per year and an admission

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protocol controlled by Neurology are essential conditions for a low rate of complications. Under these conditions, the morbidity and mortality of the technique is no higher than that of endarterectomy.

PALABRAS CLAVE
Revascularización carotídea;
Angioplastia;
Stent

134 casos consecutivos de revascularización carotídea mediante angioplastia y stent en un centro de referencia: ¿una técnica de riesgo?

Resumen
Introducción: La revascularización carotídea mediante angioplastia y stent (ASC) es un procedimiento eficaz en la prevención del ictus isquémico, pero con una morbimortalidad periprocedimiento muy discutida en los diferentes estudios realizados al respecto.
Métodos: Se analizan los resultados (epidemiología, tipo de indicación, grado de estenosis residual y complicaciones periprocedimiento) de las ASC realizadas en el Hospital Universitario Virgen de la Arrixaca entre enero de 2006 y abril de 2009. Todos los pacientes sometidos a ASC fueron preseleccionados y seguidos por neurólogos, y siguieron un protocolo médico estricto para la realización del procedimiento. Todas las ASC fueron llevadas a cabo por un equipo formado por dos intervencionistas, un anestesista y un enfermero.
Resultados: Se realizaron 134 ASC. La edad media de nuestros pacientes fue de 72,7 años, con predominio del sexo masculino (75%). Las patologías más prevalentes fueron la hipertensión arterial (81%), el tabaquismo (66,4%), y la diabetes (38,1%). La indicación de RC más frecuente fue la estenosis carotídea sintomática con grado de estenosis 75-99%, tanto izquierda (33,6%) como derecha (32,1%), seguida de las estenosis asintomáticas asociadas a factores de riesgo (11,2%en el lado izquierdo y 10,4%en el lado derecho). En 132 de las 134 ASC (98,5%) se consiguió un grado de estenosis residual menor al 30%. Cinco pacientes (3,7%) presentaron complicaciones relacionadas con el procedimiento, de las cuales cuatro correspondieron a diferentes presentaciones clínicas del síndrome de reperfusión y una, a una trombosis asintomática del stent.
Conclusiones: La ASC es una técnica compleja que debe ser llevada a cabo por especialistas con una capacitación adecuada. La realización de un número mínimo de procedimientos al año, y la existencia de un protocolo de ingreso controlado por Neurología son condiciones imprescindibles para una tasa de complicaciones. En estas circunstancias, la morbimortalidad de la técnica no es superior a la de la endarterectomía.

Introduction

Carotid revascularization (CR) is a procedure that has proven effective for primary and secondary prevention of strokes in multiple studies. It is routinely performed at many healthcare centres. The 2 most common techniques are carotid endarterectomy (CE) through direct exposure of the carotid at cervical level, and carotid angioplasty and stenting (CAS), which is usually performed through a percutaneous endovascular path.

Since the publication of the NASCET study[1] in 1991 to the present time, both techniques have conclusively proven their effectiveness and safety in different studies, although there has been a certain controversy about which technique is superior. This discussion has recently come up again in recent years after the publication of various randomized studies (EVA 3S, SPACE, CREST)[2-4] suggested a significantly superior percentage of periprocedural complications after CAS. Their inclusion criteria, degree of experience at the centres, technical aspects, premedication protocols and procedures, among other aspects, have been strongly criticised. One critical review of these studies has been published recently.[5]

In this article, we analyse the epidemiological aspects, indications, morbidity and mortality associated to the procedure in a series of cases consisting of the last 135 CAS performed at the Hospital Universitario Virgen de la Arrixaca (HUVA). This hospital is the reference centre in the Region de Murcia for neurointerventional techniques. Subsequently, the results are discussed in the context of the current debate about different CR techniques, and some conclusions are proposed.

Patients and methods

Patients

This study analysed those CR performed through CAS between January 2006 and April 2009. Patients were selected for this procedure by neurologists specialised in cerebrovascular diseases based on the most reputed current indications for CR: 1) symptomatic stenosis between 75%-99% (NASCET measurement), 2) symptomatic stenosis between 50%-74% or 3) asymptomatic stenosis 75%-99% with associated risk factors (contralateral carotid occlusion, upcoming high risk cardiovascular surgery/bypass, very high risk angiographic plaque). In our hospital, the Cardiovascular Surgery Service does not usually perform CE, which is why patients are directly remitted to CAS when they are considered subsidiary of CR.

Protocol for admission and performance of carotid angioplasty and stenting (CAS)

All patients subjected to CAS followed a procedure protocol that is routine at our hospital for this technique. It includes: 1) dual preprocedural antiplatelet therapy (75mg of clopidogrel daily and 300mg of ASA every day from at least 5 days before the procedure); 2) admission on the day before the angioplasty; 3) urgent laboratory tests (biochemistry, blood count and coagulation), ECG and radiograph of the thorax; 4) the CAS; 5) observation at the hospital for 2 days after the procedure, with the first 24 hours in the stroke unit (except for patients who were admitted before its inauguration, in which case they went directly to the service); 6) discharge; 7) maintenance of the dual antiplatelet therapy for 1 month, followed by simple antiplatelet therapy for an undefined length of time; and 8) clinical and radiological follow-up at external consultation, with an initial review after 1 month, another one after 6 months and annual follow-up visits after that.

Procedure

Carotid revascularization technique by angioplasty and placement of stenting

Once the patient is in the Interventional Neuroradiology Ward, the standard CAS procedure is carried out, following these steps:

1. Femoral pathway approach.
2. Angiographic confirmation of the degree of stenosis and selection of the best radiological projection for treatment.
3. Placement of a long sheath in the common carotid, at a distance of 1-2cm from the start of the stenosis.
4. Positioning and deployment of the protection filter.
5. Balloon pre-dilatation.
6. Passage and deployment of the stent over the stenosis.
7. Balloon post-dilatation.
8. Filter collection.
9. Angiographic controls of stenosis and intracranial circulation. The choice of appropriate material for each procedure, including sheath, catheters, filters, balloons and stents is performed prior to the procedure.

Staff

All of the CAS procedures are always performed by two interventional neuroradiologists, one with experience in this technique and the other in the process of learning it. There is always an anaesthetist present; the help of two nurses is also necessary, one as a direct intervention assistant in sterile conditions and another to prepare and help with the material. Throughout the procedure, EEG monitoring is performed using bilateral monitoring with 4 channels (2 per side).

Medication

As was described earlier, patients subjected to CAS must be premedicated with 2 antiplatelet agents before the procedure. During the procedure, once the femoral approach has been carried out and the sheath has been placed, the next step is to anticoagulate with an intravenous heparin bolus (dose of 1mg/kg, usually between 5000-7000 international units) to minimise the potential risk of thromboembolic complications. Atropine is administered (dose of 0.6-1mg in a bolus) prior to the carotid dilation manoeuvres (with balloons or with the stent itself) to avoid the possible consequences of vagal stimulation (bradycardia, hypotension, asystolia). These atropine doses can be repeated according to the criteria of the anaesthetist if too much time has passed between the different dilatations, or if the doses were insufficient.

Collected data

A series of data was collected and included in a database for each CAS procedure carried out for study purposes: 1) epidemiological data, including gender, age, arterial hypertension, diabetes mellitus, hypercholesterolemia, ischemic heart disease, peripheral arterial disease, smoking and alcohol consumption; 2) type of CR indication: symptomatic stenosis 75%-99%, symptomatic stenosis 50%-74%, and asymptomatic stenosis 75%-99% with associated risk factors (contralateral carotid occlusion, upcoming high risk cardiovascular surgery/bypass, very high risk angiographic plaque); 3) degree of postprocedural stenosis, above or below 30% (the percentage usually considered as successful in this technique); and 4) complications related to the procedure: thromboembolic events (transient ischemic attack or stroke) and cerebral hyperperfusion syndrome in its different clinical presentations (non-specific neurological symptoms, cerebral oedema, parenchymal or subarachnoid haemorrhage). This list of complications was collected while the patients were admitted and during a clinical control on an outpatient basis one month after the procedure was carried out.

Results

A total of 134 CAS interventions were carried out at our centre between January 2006 and April 2009, with the following results.

Table 1 Epidemiological data

	No. of patients (%)
Mean age (72.7 years)	
Gender	
Male	102 (76.1)
Female	32 (23.9)
Medical History	
Arterial hypertension	110 (81)
Smoking	89 (66.4)
Diabetes mellitus	51 (38.1)
Ischemic cardiopathy	38 (28.4)
Peripheral arteriopathy	35 (26.1)
Drinking	17 (12.7)

Epidemiology (table 1)

The average age of our patients was 72.7 years, with a predominance of males (3 out of every 4 patients). The most prevalent diseases were arterial hypertension (81%), smoking (66.4%) and diabetes (38.1%).

Indications (table 2)

The most common indicator for CR in our series was symptomatic carotid stenosis with a degree of stenosis of 75%-99%, both left (33.6%) and right (32.1%). This was followed by asymptomatic stenosis associated with risk factors (11.2% on the left side and 10.4% on the right side).

Table 2 Indications for carotid revascularization

Type of indication	No. of patients (%)
Symptomatic LICA stenosis 70-99%	45 (33.6)
Symptomatic LICA stenosis 50-69%	9 (6.7)
Symptomatic RICA stenosis 70-99%	43 (32.1)
Symptomatic RICA stenosis 50-69%	4 (3)
Asymptomatic LICA stenosis	15 (11.2)
Contralateral occlusion	9
Next cardiovascular surgery	5
Ulcerated and irregular plaque	1
Asymptomatic RICA stenosis	14 (10.4)
Contralateral occlusion	7
Next cardiovascular surgery	6
Ulcerated and irregular plaque	1
Bilateral and clinical stenosis of low cerebral expense	4 (2.9)

LICA: left internal carotid artery; RICA: right internal carotid artery.

Table 3 Morbidity-mortality associated to the procedure (0-30 days)

Complications	No. of patients (%)
Thromboembolic complications	1 (0.7)
Asymptomatic stent thrombosis	1
Ischemic stroke	0
Reperfusion syndrome	4 (2.9)
Parenchymatous haemorrhage	1
Cerebral oedema	3
Benign development	2
Haemorrhagic transformation	1

Degree of stenosis after angioplasty and placement of stents

A degree of residual stenosis lower than 30% was achieved in 132 of the 134 CAS (98.5%).

Periprocedural morbidity and mortality (table 3)

Five patients (3.7%) presented different complications related to the procedure. Of these, 4 corresponded to different clinical presentations of reperfusion syndrome and 1 to a thromboembolic event.

The thromboembolic complication consisted of an asymptomatic thrombosis of the stent, which was discovered incidentally in a patient treated for a symptomatic stenosis of the right ICA. This patient was readmitted one month after the intervention due to an episode of acute pulmonary oedema and underwent a control CT angiogram of the supra-aortic trunks.

Of the 4 reperfusion syndromes, 3 occurred in patients with contralateral carotid occlusion. One was an immediate post-CAS cerebral haemorrhage that caused patient death, and the remaining 3 appeared as post-CAS cerebral oedema. Out of these, 2 presented a benign evolution, with a progressive and total resolution of the oedema, and 1 presented a late haemorrhagic transformation that led to death. These cases have been described in great detail in another publication by our group.[6]

Discussion

Our series of 134 patients treated using CAS shows a periprocedural morbidity and mortality of 3.7%, which is within the recommended 6% for this procedure.[7] This figure is comperable to that of previous studies like SAPPHIRE,[7] the global registry of angioplasties[8,9] or recent series of cases with more than 100 patients.[10] However, it is lower than that found in recent studies (such as EVA 3S, SPACE or CREST).[2-4] These studies have contributed to recreating an uncertainty regarding the periprocedural safety of this technique.

Our results corroborate the fact that CAS is a safe technique, as suggested by earlier reviews,[11] as long as it is

performed under "minimum conditions" regarding the degree of experience of the interventionists, anaesthetic and operation room conditions and the existence of protocols for admission and performance of this technique. Morbidity and mortality rates close to 10%, as those found in the previously mentioned studies, can be explained through non-compliance with these minimal conditions.

Regarding the degree of experience, there is an average of 50-60 CAS every year at the HUVA, which are always performed by a neurointerventionist with experience in this technique, aided by another one in training. Once the second doctor has been sufficiently trained, he begins to train a third one, who then takes his place. With this method, the presence of someone with experience in this technique is always guaranteed during the intervention. The number of necessary interventions to consider someone capable of performing it has been discussed, but will always be far from what was accepted in studies like EVA 3S, where anyone who had participated in 5 carotid artery procedures was considered as a qualified interventionist (as long as they had performed 35 stents in other supra-aortic trunks), 12 carotid stents during their career, or simply if they were tutored by someone who met these requirements. The same is true with the minimum number of annual interventions per hospital, which is sure to be far from the average of centres included in the EVA 3S study (1.6 CAS per year).

The presence of an anaesthetist is necessary in CAS interventions, as they make it possible to sedate the patient when needed, control the vagal phenomena that occur in relation to the inflation of angioplasty balloons and stent deployment (bradycardia, hypotension, asystole) and to treat other possible complications that may appear during the procedure in these multipathological patients, such as arrhythmias, chest pain, hypertensive crisis, etc.[12] In studies such as EVA 3S, the presence of an anaesthetist was not a requirement.

An admission protocol supervised by neurologists ensures correct indication of CR, and is essential in starting the appropriate premedication and performing an adequate follow-up during admission and on an outpatient basis. The EVA 3S study does not specify this, but clinical control was probably carried out by the vascular surgeons who designed the study and who presumably did not have much experience in detecting and diagnosing cerebrovascular events. As an example, it would be interesting to know what percentage of patients followed appropriate treatment with statins or inhibitors of the angiotensin conversion enzyme as part of the management of their coronary heart disease, or what percentage of them underwent a preprocedural brain imaging test to assess the ischemic lesion load and the associated reperfusion risk.

Performing this technique in a systematic, routine way (in our case, an average of 1 or 2 weekly interventions) makes the appearance of complications less likely because it is a technique with which everyone is familiar. The use of distal protection filters,[13,14] dual antiplatelet therapy and intraprocedural anticoagulation make the appearance of thromboembolic complications during the technique less likely (none in our series). In the EVA 3S study, the mean number of CAS interventions was 1.6 per year (50-60 per year in our case); 15%-20% of patients did not have dual antiplatelet therapy and protective filters were not used.

Summing up, our series corroborates the fact that CAS is not a trivial procedure, but rather a technique that can be complex and must be carried out by specialists with adequate training, clearly superior to that required in studies like EVA 3S. Our study also emphasises that the performance of a minimum number of yearly interventions is critical, as is the existence of an admission protocol controlled by the Neurology service that includes the optimisation of medical treatment, tracking and monitoring at the stroke unit and early discharge. The best measure of the efficiency of these points and the limitations of the inclusion criteria used in the EVA 3S or SPACE studies is the disparity of results obtained in these different studies.

At the same time, our results also suggest that the conditions of the hospital must be taken into account when deciding which CR technique is optimal. The struggle to establish which technique is better does not make sense when studies have proven that morbidity and mortality rates vary according to the conditions and experience at every centre. Moreover, this conflict can make us forget the key to both techniques, which is that under specific conditions both techniques are safe and effective for the treatment of carotid disease.

Conflict of interest

The authors declare no conflict of interest.

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