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Clinical Study

Retinal embolization after carotid endarterectomy and stenting for carotid artery stenosis

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ABSTRACT

To compare the incidence of retinal arterial embolism after carotid endarterectomy (CEA) or carotid artery stenting (CAS) as a treatment for carotid artery stenosis and to determine the risk factors for retinal artery embolization, this study included all consecutive severe carotid artery stenosis patients (70–99%), diagnosed by digital subtraction angiography, who underwent CEA or CAS between February 2014 and July 2014. The study included 61 patients in the CEA group and 71 patients in the CAS group. None of the patients developed a stroke or myocardial infarction or died within 7 days of the surgery. A total of 15 patients exhibited retinal embolization including three patients who underwent CEA. None of these emboli caused symptoms. After undergoing CAS, 12 patients exhibited retinal embolization and one of the 12 patients suffered a decrease in visual acuity and visual field after CAS. The retinal embolization rate was 4.9% in the CEA group which was lower than the 16.9% rate in the CAS group ($p = 0.031$). In addition, the retinal embolization rate in the ulcerated plaque group was higher than that in the non-ulcerated plaque group ($p = 0.007$). Ulcerated plaques (odds ratio [OR] 5.043; 95% confidence interval [CI] 1.476–17.225; $p = 0.010$) and CAS (OR 4.248; 95% CI 1.104–16.343; $p = 0.035$) were independent predictors of retinal embolization. Although retinal embolization during CEA and CAS is common at our center, symptomatic embolization is not. The presence of ulcerated plaques and CAS were independent predictors of retinal embolization.

1. Introduction

The reconstruction methods for carotid artery stenosis include carotid endarterectomy (CEA) and carotid artery stenting (CAS). Recently, the international carotid stenting study (ICSS) was completed which was a randomized study of patients with symptomatic carotid stenosis after CAS or CEA. Approximately three times as many patients in the CAS group than the CEA group showed new ischemic lesions on diffusion-weighted imaging (DWI) on post treatment scans [1]. A significant number of embolic episodes during CEA and CAS have been reported [2]. The majority of studies that have examined CAS and CEA have concentrated on cerebral emboli. Retinal embolization is also a potential complication after CEA and CAS and this complication can be visualized on fundal photographs. A 4–15% rate of retinal embolization has been reported to occur after CAS [3]. However, sufficient data describing new embolism in the retinal artery after CEA and CAS for carotid artery stenosis are lacking and the risk factors for retinal artery embolization have not been reported.

The aims of this study were to investigate the incidence of new embolism in the retinal artery after CEA and CAS for carotid artery stenosis using fundal photographs, compare the difference in retinal embolization after the reconstruction of carotid artery stenosis, and determine the risk factors for retinal artery embolization.

2. Methods

A prospective, non-randomized study was performed. The procedures were approved by our Institutional Ethics Committee and all patients signed consent forms. The study included 132 consecutive patients with severe carotid artery stenosis (70–99%) diagnosed by digital subtraction angiography (DSA) during the study period from February 2014 to July 2014 and who underwent either CEA or CAS. The degree of stenosis diagnosed by DSA was characterized according to the same criteria used in the North American symptomatic carotid endarterectomy trial (NASCET) [4]. For this study, the patients underwent a unilateral procedure without

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other simultaneous cerebrovascular procedures. The demographics and baseline patient characteristics are shown in Table 1.

2.1. CAS procedure

Before undergoing CAS, the absence of new cerebral infarction within 3 weeks of the surgery was confirmed by DWI. CAS was performed in all patients based on the identification of carotid artery stenosis by duplex ultrasound (DUS) and DSA. Aspirin (100 mg) and clopidogrel (75 mg) were administered for 3 days preoperatively. The procedures were performed under local anesthesia. Throughout the procedure, the heart rate and blood pressure were monitored. A sheath was introduced into the common femoral artery after successful percutaneous DSA was performed to confirm the diagnosis. Then, a guiding catheter was placed in the common carotid artery. The use of embolic protection devices (EPD) was required. The choice of stent type was dependent on operator preference. A heparin bolus (5000–10,000 IU) was administered during the procedure.

2.2. CEA procedure

Before CEA, the absence of new cerebral infarction within 3 weeks of the surgery was confirmed by DWI. Aspirin (100 mg) or clopidogrel (75 mg) was administered preoperatively for 3 days. All of the procedures were performed under general anesthesia. A skin incision was made along the anterior border of the sternocleidomastoid muscle and a ventrojugular approach to the carotid bifurcation was used. Before cross clamping, a 5000 IU heparin bolus was administered. In all patients, a microsurgical procedure was performed with a surgical microscope (OPMI Pentero, Carl Zeiss Meditec, Jena, Thuringia, Germany) to remove the plaque. The method of carotid closure was a primary closure.

2.3. DUS

Before undergoing CEA or CAS, the patients underwent a DUS clinical evaluation. DUS (Ultramark IU-22 and HDI 5000 ATL; Philips Healthcare, Andover, MA, USA) was performed before the CEA or CAS by two trained sonographers who were blinded to the treatment. The sonographic diagnostic criteria for plaque ulcers, proposed in 1997 by de Bray et al., were used and stipulate that plaques must be at least 2 mm in depth and 2 mm in length with a well-defined back wall at the base and an area of reversed flow (no aliasing) within the recess or a zone of low flow signal at the level of the recess [5].

Table 1
Demographic and clinical characteristics of carotid artery stenosis patients

Characteristics	Patients
Age (years), mean ± SD	64.6 ± 7.8
Sex, n (%)	
Male	109 (82.6)
Female	23 (17.4)
Medical history and comorbidities, n (%)	
Hypertension	87 (65.9)
Hyperlipidemia	34 (25.8)
Diabetes	34 (25.8)
Coronary artery disease	28 (21.2)
Smoking	67 (50.8)
Presentation, n (%)	
Asymptomatic	75 (56.8)
Symptomatic	57 (43.2)
Operated artery, n (%)	
Left	50 (37.9)
Right	82 (62.1)

SD = standard deviation.

2.4. DWI

In all patients, DWI scans using a 3.0 T scanner were obtained 1 to 3 days preoperatively and 1 to 3 days postoperatively. The DWI scans were independently read by two neuroradiologists who were blinded to the treatment. An acute ischemic lesion was diagnosed after identification on the DWI images. All of the new DWI lesions were described by their number, location and maximal diameter and were then classified as <1 cm, 1–2 cm, or >2 cm.

2.5. Ophthalmic examination

The fundal photographs, visual acuity and visual fields were examined for all of the patients 1 day preoperatively and 1 day postoperatively by two ophthalmologists who were blinded to the clinical data. Any new retinal emboli were recorded.

2.6. Statistical analysis

SPSS statistical software (version 19.0; IBM Corporation, Armonk, NY, USA) was used. Mean ± standard deviation was calculated for the continuous variables. Pearson's chi-squared test or Fisher's exact test was used for the comparisons between categorical variables. Univariate analyses were compared with Pearson's chi-squared test or Fisher's exact test. All tests were two-tailed and the level of significance was set at $p < 0.05$. Multivariate logistic regression was conducted to assess the risk factors for postoperative retinal embolization for all of the patients. The preoperative variables were entered into the multivariate regression analysis. Then, a stepwise selection was used in the regression analysis to identify the variables that remained in the final model. The odds ratio (OR) and 95% confidence interval (CI) were calculated for retinal embolization.

This study is a substudy of the Revascularization of Extracranial Carotid Artery Stenosis (RECAS) registered trial. The registration number at www.clinicaltrials.gov is BCT01994187.

3. Results

From February 2014 to July 2014, a total of 132 consecutive patients were treated with CEA or CAS at our center. Within this series, data from 61 CEA and 71 CAS patients were analyzed. The demographic and clinical characteristics of the patients are summarized in Table 1. The study cohort had a mean age of 64.6 ± 7.8 years (range: 45–85). There were 109 male patients, and 65.9% had hypertension, 25.8% had hyperlipidemia, 25.8% had diabetes, 21.2% had coronary artery disease and 50.8% were smokers. A total of 43.2% were symptomatic and presented with amaurosis, TIA or stroke. In addition, 37.9% of the arteries that underwent surgical procedures were on the left side.

In this study, no strokes, myocardial infarctions or deaths occurred in the 132 patients within 7 days of CEA or CAS. A total of 15 patients exhibited retinal embolization including three patients who underwent CEA. None of these emboli caused symptoms. There were 12 patients who showed retinal embolization after CAS, and one of the 12 patients suffered decrease in visual acuity and visual field after CAS. The rate of decrease in visual acuity and visual field was 1/15 (6.7%). The fundal photographs showed that 10 of the 15 patients who developed retinal embolization had a single embolus, three of 15 had two emboli, one of 15 had three emboli, and one of 15 had seven emboli. The patient who had seven emboli developed visual acuity and visual field