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Case study

Staged carotid artery stenting in patients with severe carotid stenosis: Multicenter experience

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ABSTRACT

Cerebral hyperperfusion syndrome (CHS) is serious complication after carotid artery stenting (CAS) caused by decreased cerebral vasoreactivity (CVR) due to long standing hypoperfusion of the brain. We hypothesized that partial dilatation of carotid stenosis would allow the recovery of CVR, and prevent CHS when definitive angioplasty with stent is performed afterward. In this study, we aimed to evaluate the safety and efficacy of staged CAS in patients with severe carotid artery stenosis with evident hemodynamic compromise in regard to preventing hyperperfusion syndrome. From January 2005 to February 2016, 53 patients with 55 severe carotid artery stenosis lesions showing decreased CVR and/or cerebral basal flow at the perfusion studies underwent staged CAS in three institutes. The procedure consisted of initial partial balloon angioplasty (BA), recovery period, and delayed definitive stenting (DS). We analyzed immediate results, complications, recoil and CHS related to staged CAS. We experienced no symptomatic manifestation of CHS except self-limited headache after the procedures. The median of intervals between BA and DS stages were 10 days. There was no case of severe recoil during the interval between BA and DS stage. Where perfusion imaging data was available, hyperperfusion was present in three and one patients after BA and DS stage, respectively, with no clinical symptom of CHS. In conclusion, staged CAS was feasible in patients with severe carotid artery stenosis and hemodynamic compromise, without inducing severe complication of CHS such as intracranial hemorrhage.

1. Introduction

Cerebral hyperperfusion syndrome (CHS) is one of uncommon but critical complications after carotid artery stenting (CAS) with incidences ranging from 1.1% to 14.9% [1–5]. Decreased cerebral vasoreactivity (CVR) and loss of autoregulatory function due to long standing hypoperfusion of the brain is the probable mechanism contributing to CHS after CAS [6]. The symptoms of CHS are variable including ipsilateral throbbing headache, vomiting, focal neurologic deficits, confusion and seizure [6]. Intracranial hemorrhage (ICH), which is the most severe manifestation of the syndrome, may lead to profound morbidity and mortality with reported incidences of around 1% [1–3,7,8]. The risk factors associated with CHS or ICH after CAS include advanced patients' age, decreased cerebrovascular reserve, severe degree of stenosis, contralateral carotid stenosis more than 80% and presence of symptom [2,8,9].

Staged CAS has been introduced in an effort to prevent CHS and ICH in high-risk patients. The procedure consists of two sessions. First, balloon angioplasty (BA) is performed with an undersized balloon to partially restore cerebral blood flow and CVR. It is then followed by delayed stenting (DS). A previous study reported decreased hyperperfusion phenomenon on single-photon emission computed tomography (SPECT) after using a similar procedural technique and protocol [10]. Our study, conducted on larger number of patients, describes experience with staged CAS to evaluate its feasibility and safety.

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2. Methods

This study was approved by the local ethics review board and written informed consent was waived due to the retrospective nature of the study.

We conducted a retrospective multicenter study of all patients who received staged CAS between January 2005 and February 2016. Eligibility for staged CAS was decided based on findings of digital subtraction angiography (DSA) and perfusion imaging studies (using CT and/or MRI and/or SPECT). Patients with severe carotid artery stenosis showing decreased CVR and/or cerebral basal flow (CBF) at the perfusion studies were included, considering other factors such as slow distal run-off and poor collateral flow at the cerebral DSA. Dual antiplatelet medication with aspirin (100 mg/day) and clopidogrel (75 mg/day) was started at least 1 week prior to the BA stage of the procedure. Loading doses of aspirin and clopidogrel were administered if the pre-procedural regimen could not be given for 1 week in cases of urgent procedure. The dual antiplatelet medication was continued until the DS stage of the procedure, and maintained for three months followed by a life-long aspirin (100 mg/day) monotherapy.

Both BA and DS procedures were performed under systemic heparinization. In the BA stage, 6-French long sheath was inserted via the femoral artery and placed at the common carotid artery. Any embolic protection device was not used at this stage. A microguidewire was navigated distal to the carotid stenosis and angioplasty was performed with a semicompliant balloon of 2–4 mm. After the balloon angioplasty, 10-minute delayed DSA was performed to evaluate whether significant recoil or dissection occurred. Intracranial projection of common carotid DSA was performed to assess improvement in cerebral perfusion. During the recovery period, the patients were closely observed. Any symptoms suggesting cerebral hyperperfusion were documented. Follow-up perfusion studies were performed during this period. In DS stage, a protective distal filter device was deployed at the distal cervical ICA, followed by conventional CAS procedure; predilation with a semicompliant balloon, deployment of self-expanding nitinol stents with diameters ranging from 5 to 10 mm, then post-stenting balloon angioplasty when necessary.

The stenosis degree was measured using the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria before the procedure, after the BA stage, and after the DS stage. When available, we compared post-procedural DSA image of BA stage and pre-procedural DSA image of DS stage, thereby evaluating the presence and degree of recoil at the balloon dilated carotid stenosis lesion during the interval. The findings were classified into 4 categories; severe recoil, mild recoil, no recoil, and improvement. Perfusion imaging study results before and after the procedures were compared to evaluate improvement of CBF and/or CVR and presence of hyperperfusion. Medical records were reviewed to assess clinical outcomes. Symptoms of CHS, such as headache, seizure, and other neurologic deficits were recorded. Any evidence of immediate and delayed thromboembolic or hemorrhagic complications were assessed.

3. Results

3.1. Study population and lesion characteristics

A total of 1,004 patients with 1,042 carotid stenosis lesions were treated by CAS procedure during the study period in the three institutions. Of those, 57 lesions (5.5%) were planned for staged CAS. Severe recoil despite repeated balloon angioplasty or significant dissection occurred on BA stage in two patients. For them, stent placement was done immediately as in conventional CAS, and these two patients were excluded from this study. As a result, a total of 53 patients with 55 lesions (including two patients with bilateral lesions) underwent staged CAS in this cohort. Of the 51 symptomatic patients, 18 patients presented with recurrent transient ischemic attack, while multifocal embolic infarction, border-zone infarction and territorial infarction was present on MR image in 20, 10 and 3 patients, respectively. The initial balloon diameter used for BA stage was typically 3 mm (42 lesions; 74%), and ranged from 2 mm to 4 mm. The intervals between BA and DS stages ranged from 2 to 193 days (mean: 16.8, median: 10), and were within 7 days in 20 lesions and within 2 weeks in 43 (78%). A representative case is demonstrated in Fig. 1. Additional procedures performed on the same session (either BA or DS stage) included contralateral CAS in 5 patients, vertebral artery stenting in 4, ipsilateral cavernous internal carotid artery (ICA) angioplasty in one, and contralateral middle cerebral artery stenting in one. Table 1 summarizes the baseline characteristics of the patients and lesions.

3.2. Procedural outcome

Immediate complications directly related to the procedure occurred in two patients. One patient showed thrombus formation at the stenotic site after BA. Intra-arterial tirofiban infusion was done, which resulted in thrombus migration to the angular artery. The patient suffered transient naming difficulty for three days. In another patient, an event of thromboembolism resulted in dysarthria after DS stage, which resolved completely by the fourth day after the procedure. Other immediate complications included puncture site infection (n = 1), puncture site occlusion after hemostasis with a closure device (n = 1), and fatal subarachnoid hemorrhage related to contralateral middle cerebral artery stenting (n = 1). Mean stenosis degrees improved after each stage of the procedure; from 90.9% to 70.5% after BA, and to 16.1% after DS stage. Among 38 lesions where data were available, the majority (87%) demonstrated improvement of stenosis degree or no recoil during the interval. The others (13%) revealed mild recoil only. Procedural and clinical outcome data are summarized in Table 2.

Of 51 patients in whom 6-month follow-up data were available, later clinical course was uneventful in 47 patients. 4 patients presented with delayed cerebral infarction. One event was directly related to the staged angioplasty procedure; this patient became drowsy with left side weakness after DS, and the angiography showed in-stent thrombosis. Emergent intra-arterial thrombectomy was performed, but there was residual middle cerebral artery superior division occlusion, and neurologic deficit ensued. Another patient suffered cerebral infarction at the contralateral side where carotid stenosis lesion had been managed with conventional one stage CAS. In the remaining two patients, cerebral infarction occurred when they quit antiplatelet medication arbitrarily. In these patients, the final modified Rankin scale scores were 2 in one patient, 4 in two, and 5 in one.

3.3. Cerebral hyperperfusion syndrome

There was no occurrence of other manifestation of CHS except for headache. Fifteen patients (28%) complained of headache after either BA (n = 6) or DS (n = 9). The onset of headache was on the day of the procedure in 8 patients, and within three days after the procedure in remaining 7. The headache was self-limited and durations of the symptom ranged from one to three days (mean 1.5 days). Among them, 10 patients underwent cerebral perfusion studies, which did not demonstrated hyperperfusion.

On pre-procedural perfusion study, decreased CBF was observed in 47 lesions (85.5%) while decreased CVR was observed in 32 lesions (58.2%). Perfusion studies were performed in 42

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