

# Improvement of Cognitive Function after Carotid Endarterectomy—A New Strategy for the Evaluation of Cognitive Function

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Significant carotid stenosis is known to cause ischemic stroke and cognitive impairment. However, it remains controversial whether carotid endarterectomy (CEA) can improve cognitive function in patients with carotid stenosis. We used the Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE) to compare cognitive function between before and after CEA. Patients were prospectively registered to evaluate cognitive function from October 2011 to December 2012 after we determined them to have significant carotid stenosis. Patients were examined by 3-dimensional computed tomographic angiography or digital subtraction angiography. Although symptomatic cases were included, their modified Rankin Scale was grade 0 or 1 before CEA. All CEA procedures were performed by the same neurosurgical team. Cognitive function was evaluated by MoCA and MMSE performed before and after surgery. Data were analyzed statistically using the Wilcoxon signed rank test. Thirty-six patients were included in this study. The MoCA score after surgery, whereas the MMSE score was not. After surgery, the MoCA score improved in patients who were 73 years or younger, who underwent CEA in the left side of their carotid lesion, who had severe carotid stenosis of more than 80%, who had bilateral lesion, who did not have abnormal lesion on diffusion-weighted imaging after surgery, or who had cerebral blood flow of pre-CEA over 34.5 mL. In conclusion, MoCA was feasible in patients soon after undergoing CEA. Using MoCA not MMSE, CEA may improve cognitive function in patients with significant carotid stenosis. **Key Words:** Cognitive function—carotid stenosis—carotid endarterectomy—Montreal cognitive assessment.

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## Introduction

Significant carotid stenosis is known to cause ischemic stroke and cognitive impairment. Although carotid endarterectomy (CEA) is effective for preventing future risk of stroke,<sup>1,2</sup> it remains controversial whether CEA can improve cognitive function in patients with carotid stenosis. Various neuropsychological tests have been used to evaluate change of cognitive function after CEA. To precisely evaluate cognitive function, the cognitive examination must be performed using a variety of tests. However, soon after CEA, measurement of cognitive function is often difficult using complicated tests as the patients can exhibit difficulties in concentration.

Therefore, a battery is required that is both accurate and simple to examine cognitive function.

The Montreal Cognitive Assessment (MoCA) has been developed as a 10-minute cognitive screening for detecting mild cognitive impairment.<sup>3</sup> A number of reports have indicated that MoCA can identify patients with reduced cognitive status in subjects with cerebrovascular disease.<sup>4,6</sup> However, it remains uncertain whether MoCA is feasible in patients with carotid stenosis soon after undergoing CEA.

In the present study, we hypothesized that MoCA is feasible for use in patients with carotid stenosis soon after CEA. Furthermore, we hypothesized that CEA can improve cognitive function in patients with significant carotid stenosis and examined for particular characteristics in patients whose cognitive function improved after CEA. For this, we used MoCA and Mini-Mental State Examination (MMSE) and compared cognitive function evaluated by MoCA with that by MMSE before and after CEA.

## Patients and Methods

Patients were prospectively registered to evaluate cognitive function from October 2011 to December 2012, when they were suspected to have significant carotid stenosis in the Department of Neurosurgery, Fukuoka University Hospital. If a patient was screened with ultrasound and was suspected to have carotid stenosis, further evaluation such as 3-dimensional computed tomographic angiography or digital subtraction angiography was conducted. The degree of stenosis was measured by The North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria.<sup>1</sup> Cerebral perfusion was measured by Tc-99m ethyl cysteinate dimer single-photon emission computed tomography (ECD SPECT). The SPECT scan was started 5 minutes after the administration of 600 MBq of Tc-99m ECD, and data were collected for 20 minutes using a 3-head gamma camera. The inclusion criteria of CEA are as we previously reported.<sup>2</sup> Although symptomatic cases were included, their modified Rankin scale was grade 0 to 1 before undergoing CEA. The study protocol was approved by the Ethics Committee of Fukuoka University Hospital. Informed consent was obtained from all patients.

### *Carotid Surgery*

All CEA procedures were performed by the same neurosurgical team (O.H., M.N., H.A., and T.I.). Endarterectomy was performed using a microscope. After CEA, propofol sedation was continued until the next morning. Blood pressure was maintained at 150 mm Hg systolic and 90 mm Hg diastolic in all patients using nitroglycerin and/or diltiazem until 7 days after CEA. Diffusion-weighted images were taken at approximately 7 days after surgery in patients who did not have any contraindication of magnetic resonance imaging.

### *Assessment of Cognitive Function*

Cognitive function was evaluated when each patient's carotid lesion was evaluated and between 7 and 14 days after surgery (median 7 days). MoCA and MMSE were used for the assessment of cognitive function on the same day. Evaluation was performed by a doctor or a speech-language-hearing therapist. The median period between before and after surgery was 21 days. MoCA is a 10-minute cognitive screening tool used to detect mild cognitive impairment. The MoCA scores range from 0 to 30 and are divided into 8 subscores: visuospatial/executive (5 points), naming (3 points), attention (3 points), calculation (3 points), language (3 points), abstraction (2 points), memory (5 points), orientation (6 points), and an additional 1 point is given to each subject who has educational experience of 12 years or less.<sup>3</sup> The Japanese version was used for the evaluation of MoCA and MMSE.<sup>7</sup>

### *Statistical Analysis*

Patients were divided by gender, side of operation, the presence or absence of contralateral carotid lesion, tandem lesion, neurologic symptoms within 120 days before surgery, and diffusion-weighted imaging (DWI) abnormality after surgery. Patients were also categorized into 2 groups by the median age (73 years), degree of stenosis (80%), and cerebral blood flow (34.5 mL/100 g/min).

First, the scores of MoCA and MMSE were compared between before and after surgery in all patients. The Wilcoxon signed rank test was used for the assessment of cognitive function after the scores of both MoCA and MMSE were confirmed to be not normally distributed (Shapiro-Wilk test). Second, the MoCA and MMSE scores were divided by patient age, gender, side of operation, degree of stenosis, unilateral or bilateral, with or without tandem lesion, asymptomatic or symptomatic in 120 days, DWI abnormality after surgery, and cerebral blood flow and were compared in the same manner. A *P* value of .05 was considered to indicate statistical significance. Data were analyzed using SPSS version 16.0 (IBM, Somers, NY).

## Results

### *Patients*

From October 2011 to December 2012, carotid stenosis was screened in 110 patients, of whom 39 patients underwent CEA (Fig 1). Tracheotomy was performed in 1 patient, and hyperperfusion syndrome occurred in another patient after surgery. One patient refused the cognitive function examinations. Thus, a final 36 patients were included in this study (mean age, 72.3 ± 7.7 years; 33 men, 3 women; Table 1). One patient had been taking an antedementia drug throughout the evaluation period. The median educational experience was 12 years.

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