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Influence of stent-assisted angioplasty on cognitive function and affective disorder in elderly patients with symptomatic vertebrobasilar artery stenosis

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Background: We aimed to investigate cognitive function and affective disorder in elderly patients with symptomatic vertebrobasilar artery stenosis (SVAS) after stent-assisted angioplasty (SAA) and to explore the potential mechanism.

Material/Methods: The study subjects were 26 elderly SVAS patients who were non-responsive to pharmacotherapy and received SAA (study group) and 30 patients receiving intracoronary stent implantation (control group). Montreal cognitive assessment (MoCA), Hamilton depression rating scale (HAMD), and Hamilton anxiety rating scale (HAMA) were used.

Results: The total MoCA score, scores of line connection, copying cube, drawing clock, and delayed recall increased significantly in the study group after surgery ($P<0.05$, $P<0.01$). In addition, the MoCA score increased over time and the total MoCA score at 12 months was markedly higher than that at 1 month ($P<0.05$). The scores of HAMD and HAMA decreased dramatically after surgery compared with before surgery in these patients ($P<0.01$). A comparison at the corresponding period was performed between study group and control group, and it was found that the differences in total MoCA scores and scores of line connection, copying cube, drawing clock, and delayed recall before surgery and at 1 month after surgery were significant ($P<0.05$, $P<0.01$).

Conclusions: SAA may improve the visuospatial/executive abilities and delayed recall, as well as the depression and anxiety in patients with SVAS. Larger and controlled trails are needed to investigate the effect of SAA on cognition and affection in these patients.

MeSH Keywords: Angioplasty • Cognition • Signs and Symptoms • Vertebrobasilar Insufficiency

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Background

The vertebrobasilar system (VBS) mainly supplies blood to the brainstem, cerebellum, and posterior cerebral hemisphere. Atherosclerosis of the VBS may cause stenosis, chronic occlusion, and plaque shedding, which may induce distant embolism, thus it is a major cause of posterior circulation ischemia, may result in severe consequences, and predicts a poor prognosis. Up to 40% of ischemic strokes involve the vertebrobasilar circulation [1]. Atherosclerotic stenosis >50% in the vertebral or basilar artery is found in approximately one-fourth of the patients with vertebrobasilar transient ischemic attack (TIA) or stroke. Patients with symptomatic vertebrobasilar artery stenosis have a higher risk of posterior circulation ischemic stroke than patients without such a stenosis, and have a high risk for early recurrent stroke [2,3]. Early intervention might reduce the risk for recurrent stroke. However, the pharmacotherapy of symptomatic vertebrobasilar artery stenosis (SVAS) in the elderly usually achieves transient effectiveness, and the recurrence rate is high, even after standard pharmacotherapy has been performed, leading to a poor prognosis [2,3]. In recent years, stent-assisted angioplasty (SAA) has been applied in the treatment of cerebrovascular diseases. It may help the revascularization, increase blood flow in the brain, and reduce the recurrence of stroke. To date, SAA has been a safe and effective strategy for the treatment of SVAS in the elderly [4–7].

The improvement of arterial stenosis is not only beneficial for the prevention of stroke, but is also important in elevating cognitive function [8,9]. To date, most studies have focussed on the relationship between carotid stenosis and cognitive function, and results reveal that both carotid endarterectomy and SAA can significantly improve cognitive function [10–12]. However, few studies have investigated the influence of SAA on cognition in SVAS patients. In the present study, 26 elderly SVAS patients, who were non-responsive to pharmacotherapy and received SAA in our department, were recruited and reviewed. Our aim was to investigate the effect of SAA on cognition and affective disorder in these patients.

Material and Methods

General information

The indications for SAA in patients with SVAS included: 1) patients aged ≥60 years; 2) patients who have symptoms (transient ischemic attack [TIA] of VBS or nondisabling ischemic stroke), with the digital subtraction angiography (DSA) showing >50% stenosis and contralateral occlusion; 3) symptomatic dominant vertebral artery with >50% stenosis; 4) symptomatic non-dominant vertebral artery with stenosis (the non-dominant vertebral artery connects to the posterior inferior cerebellar artery, and patients develop symptoms due to insufficient blood supply to the region of posterior inferior cerebellar artery); 5) symptomatic basilar artery with >50% stenosis; and 6) informed consent obtained before patients and/or their relatives had had favorable compliance. Contraindications included: 1) patients with severe neurological disorders after stroke; 2) patients with severe concomitant heart, liver, kidney, or lung diseases or failure; 3) the blood vessels are completely occluded; 4) patients with intracranial hemorrhage or visceral bleeding in the past 3 months or who have the bleeding tendency; 5) patients with intracranial aneurysm or arteriovenous malformation which cannot be treated before SAA or simultaneously; and 6) patients with intracranial tumor. Twenty-six elderly SVAS patients who were hospitalized in our department from May 2008 to December 2010 met the above criteria and signed informed consent agreeing to SAA, and then were included in the study group. All procedures were conducted in accordance with the ethics standards of the responsible committee on human experimentation and with the Helsinki Declaration as revised in 1983. All these 26 patients (11 males and 15 females, mean age 72.1±3.9 [65–78] years) received therapy for control of stroke risk factors, anti-platelet aggregation, stabilizing plaque with statin, and other therapies before they were be admitted to hospital. Among them, 12 patients exhibited vertebrobasilar systemic TIA and 14 patients showed posterior circulation cerebral infarction. DSA examination showed stenosis at the opening of the vertebral artery, stenosis of the V_4 segment, and vertebrobasilar artery stenosis in 16, 3, and 7 patients, respectively.

The control group contained 30 patients (13 males and 17 females, mean age 73.2±5.2 [62–82] years) who received intracoronary stent implantation due to attack of coronary atherosclerotic heart disease at the same period, and had no history of stoke or TIA, abnormal changes indicated by head MRI and significant stenosis or stenosis <30% in vertebrobasilar artery shown by vascular examination.

We excluded patients with histories of significant depression, mental disorder, mental retardation, or other mental illness, as well as cognitive impairment due to other causes.

Evaluation of cognitive function

Montreal cognitive assessment (MoCA) [13] was used to evaluate the cognitive function. The MoCA scale includes the domains of visuospatial/executive abilities, naming, memory, attention, language, abstraction, delayed recall, and orientation. A total of 30 items were required to be completed, with a total possible score of 30. A higher the score indicates better cognitive function. A MoCA score of ≥26 was defined as normal cognitive function, and 1 point was added for education years ≤12. The physicians received training and certification, and testing was done under the supervision of neuropsychological experts. The evaluation of cognitive function was done

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Table 1. Characteristics of the patients and the statistical analysis of the results.

Parameter	Study group N=26	Control group N=30	Statistical values
Sex (male/female)-no.	11/15	13/17	x^2=0.006; p=9383
Age (mean ±SD)	72.13.9	73.25.2	t=0.884; p=0.3806
Education (mean ±SD)	6.94.1	7.14.1	t=0.182; p=0.8562
Degree of vertebrobasilar artery stenosis (%, mean ±SD)	81.38.8	5.96.2	t=37.438; p<0.0001
Hypertension (n %)	23 (88.5)	25 (83.3)	x^2=0.299; p=0.5844
Dyslipidemia (n %)	10 (38.5)	13 (43.3)	x^2=0.062; p=0.8029
Smoking (n %)	9 (34.6)	10 (33.3)	x^2=0.010; p=0.9195
Diabetes (n %)	13 (50)	16 (53.3)	x^2=0.062; p=0.8034
Body mass index (kg/m^2, mean ±SD)	26.22.8	25.72.8	t=0.666; p=0.5080

at 1 day before SAA and at 1, 3, 6, and 12 months after surgery. Evaluation was done in the same place by the same physician.

Evaluation of depression and anxiety

The Hamilton depression scale (HAMD) [14] was used to evaluate the degree of depression. The HAMD scale is a 5-point (0–4) scale and the total score ranges from 0 to 68. A higher score indicates more severe depression. The total score of <7 was defined as absence of depression, 7–17 as suspected depression, 18–24 as definite depression, and >24 as severe depression. The Hamilton anxiety rating scale (HAMA) [15] was used to evaluate the degree of anxiety. The HAMA scale is 5-point (0–4) scale, and the total possible scores range from 0 to 56, with a higher score indicating more severe anxiety. A total score <7 was defined as absence of anxiety, 7–13 as mild anxiety, 14–20 as definite anxiety, and >20 as severe anxiety. The evaluation of anxiety and depression was done at 1 day before SAA and at 1, 3, 6, and 12 months after SAA.

Detection of arterial stenosis

Arterial stenosis was determined according to the NASCET criteria [16]. In brief, the diameter of the artery at the narrowest site (D_{sten}) and that of a normal artery distant from the injured site (D_{dist}) were measured and the stenosis was calculated as: Degree of stenosis =$[1–(D_{sten}/D_{dist})] \times 100\%$. Stenosis was evaluated before and after surgery in the DSA. At 7–12 months after surgery, DSA and/or CTA were performed to further evaluate the stenosis.

Blood flow at stenotic artery

Transcranial Doppler (TCD) was used to detect the maximal median velocity (Vm) at the stenotic artery before SAA and at 1, 3, 6, and 12 months after SAA.

Evaluation after stoke recurrence

During the follow-up period, the TIA and stroke attack were monitored, and brain CT/MRI was done to detect recurrent stroke.

Statistical analysis

We used the SPSS l0.0 package for statistical analysis. Measurement data were expressed as x±s, and count data were expressed with constituent ratio of relative number (%). The chi-squared test was used for comparison of count data, and the t test was used for comparison of mean values of the 2 samples, and a 1-way repeated measures ANOVA was used for comparison of mean values of multiple samples. The LSD test was used for pairwise comparison. P<0.05 was considered statistically significant.

Results

Patient characteristics

According to inclusion and exclusion criteria, a total of 56 subjects were enrolled and all received regular follow-up. Of these 56, 26 patients were included in the study group and 30 patients were included in the control group. No significant differences were found in gender, age, education level, hypertension, dyslipidemia, smoking, diabetes, or body mass index, (P>0.05) in addition to vertebrobasilar artery stenosis degree (P<0.0001) (Table 1).

Degree of arterial stenosis and complications after SAA

The surgery was successful in all patients (100% success rate). The mean degree of stenosis was 81.3±8.8% (range: 65–95%).

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Table 2. Comparison of cognitive function scores before surgery and at each time point after surgery between the 2 groups (x±s).

Parameter	Before SAA		1 month		3 months		6 months		12 months	
	Study	Control	Study	Control	Study	Control	Study	Control	Study	Control
MoCA total score	24.92±3.06	27.27±1.34**	26.77±2.20*	27.73±1.60***	27.38±1.77*	27.47±1.28	27.54±1.63*	27.67±1.58	27.85±1.49*,##	27.83±1.60
Line connection test	0.42±0.50	0.70±0.47***	0.69±0.47#	0.73±0.45	0.73±0.45*	0.72±0.46	0.77±0.43*	0.73±0.45	0.77±0.43*	0.74±0.44
Copying cube	0.50±0.51	0.87±0.35**	0.77±0.43#	0.83±0.38	0.81±0.40*	0.80±0.41	0.81±0.40*	0.83±0.38	0.85±0.37*	0.87±0.35
Drawing clock	1.42±0.81	2.13±0.63**	1.85±0.73#	2.17±0.65***	2.04±0.60*	2.23±0.63	2.08±0.69*	2.20±0.66	2.15±0.67*	2.23±0.57
Naming	2.69±0.47	2.80±0.41	2.73±0.45	2.77±0.43	2.77±0.43	2.73±0.45	2.73±0.45	2.67±0.48	2.77±0.43	2.73±0.45
Attention	5.04±0.82	5.27±0.74	5.31±0.79	5.30±0.70	5.35±0.75	5.27±0.69	5.30±0.74	5.33±0.71	5.35±0.69	5.37±0.67
Sentence repeating	1.85±0.37	1.90±0.31	1.88±0.33	1.97±0.18	1.92±0.27	1.93±0.25	1.96±0.20	1.93±0.25	1.96±0.20	1.90±0.30
Language fluency	0.77±0.43	0.83±0.38	0.81±0.40	0.90±0.31	0.85±0.37	0.87±0.35	0.85±0.37	0.93±0.25	0.88±0.33	0.97±0.18
Abstraction	1.81±0.40	1.83±0.38	1.85±0.37	1.87±0.35	1.88±0.33	1.83±0.38	1.92±0.27	1.83±0.38	1.92±0.27	1.90±0.31
Delayed recall	4.00±0.75	4.53±0.51**	4.42±0.76#	4.70±0.47***	4.54±0.65*	4.67±0.48	4.58±0.58*	4.73±0.45	4.58±0.58*	4.63±0.49
Orientation	5.58±0.64	5.63±0.49	5.65±0.56	5.73±0.45	5.69±0.47	5.67±0.48	5.73±0.45	5.70±0.47	5.81±0.40	5.73±0.44

* P<0.01 *vs.* before SAA; # P<0.05 *vs.* before SAA; ## P<0.05 *vs.* 1 month after SAA. Compared with the study group in the same period: *** P<0.05; ** P<0.01.

Table 3. Comparison of HAMD and HAMA scores before surgery and at each time point after surgery between the 2 groups (x±s).

Variables	Before SAA		1 month		3 months		6 months		12 months	
	Study	Control	Study	Control	Study	Control	Study	Control	Study	Control
HAMD	15.12±4.62	14.37±3.74	11.65±4.20*	11.83±4.36	11.85±5.12*	11.53±4.00	11.58±5.46*	11.87±4.27	11.46±6.17*	11.47±3.76
HAMA	16.46±6.88	15.63±5.10	9.77±4.06*	10.50±3.44	9.85±3.91*	10.17±3.06	10.04±4.39*	10.03±2.68	10.88±5.35*	10.33±2.77

* P<0.01 *vs.* before SAA.

Immediately after surgery, the mean degree of stenosis was 3.7±3.6% (range: 0–10%), showing significant improvement of arterial stenosis (P<0.01). Ischemia-related symptoms and deterioration of previous symptoms were not found before discharge, and TIA was also absent. In 1 patient with TIA due to vertebral artery stenosis, the degree of stenosis was 10% after surgery, and TIA was noted at 7 months after SAA, the symptoms of which were similar to those before SAA. Again, DSA showed 10% stenosis. Then, anti-platelet therapy was improved with oral aspirin (100 mg/d) and clopidogrel (75 mg/d) administered for 1 month. Thereafter, oral clopidogrel (75 mg/d) alone was administered, and similar symptoms were not observed in the follow-up. The remaining 25 patients received CTA at 9–12 months after SAA; stent migration, stent fracture, and restenosis were absent, and the forward blood flow was good.

Comparison of MoCA, HAMD, and HAMA scores before and after SAA in the study group

Before surgery, the total MoCA score was 24.92±3.06 and the total MoCA score was <26 in 14 patients (53.8%). The total MoCA score after SAA increased significantly when compared with that before surgery (P<0.01). Of note, the MoCA score increased over time, and the MoCA score at 12 months increased markedly when compared with that at 1 month after SAA (P<0.05). The scores of line connection, copying cube, drawing clock, and delayed recall at 1, 3, 6, and 12 months after SAA increased dramatically when compared with those before SAA (P<0.05 or 0.01). However, there were no marked differences in the scores of line connection, copying cube, drawing clock, and delayed recall at different time points after

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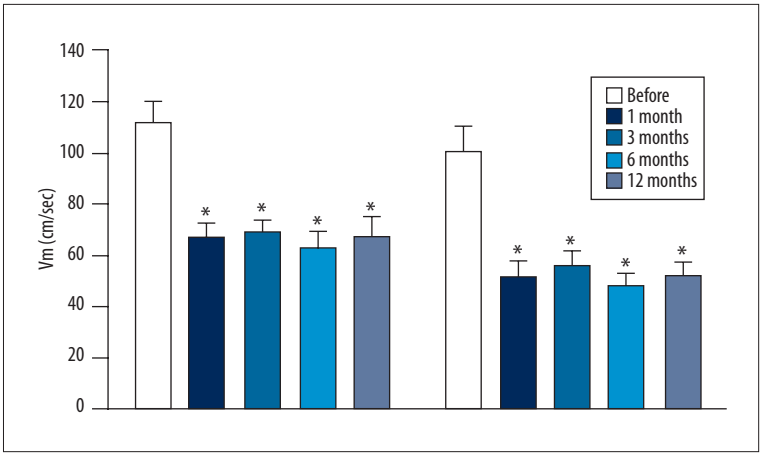

Figure 1. Blood velocity (Vm) of basilar and vertebral arteries before SAA and at 1, 3, 6, and 12 months after SAA (cm/sec) means ±SD. * P<0.01 *vs.* before SAA.

SAA (P>0.05). The scores of naming, attention, sentence repeating, language fluency, abstraction, and orientation before SAA were comparable to those after surgery at different time points (P>0.05) (Table 2).

Before SAA, the mean scores of HAMD and HAMA were 15.12±4.62 and 16.46±6.88, respectively. Six patients had HAMD scores of >18 and 14 had HAMA scores of >14. The incidences of depression and anxiety were 23.1% and 53.8%, respectively, before surgery. At different time points after surgery, the scores of HAMD and HAMA reduced markedly when compared with those before surgery (P<0.01). However, no marked differences were noted in the scores of HAMD and HAMA at different time points after surgery (P>0.05) (Table 3).

The 26 patients in the study group were divided into 2 sub-groups: 12 TIA patients were included in the TIA sub-group, and 14 patients with posterior circulation cerebral infarction were included in the cerebral infarction sub-group. No statistical differences were found in age, gender, education level, or concomitant diseases between the 2 sub-groups, but these parameters were comparable. No statistically significant differences were found in MoCA, HAMD, and HAMA scores before surgery and at 1, 3, 6, and 12 months after surgery between the 2 sub-groups (P>0.05).

Comparison of MoCA, HAMD and HAMA scores before and after stent implantation in control group

No significant differences were found in total MoCA scores and scores of each subtest in each time interval during follow-up period in the control group (P>0.05). The preoperative HAMD and HAMA scores were 14.37±3.74 and 15.63±5.10, respectively, in which 8 patients had HAMD scores >18 and 17 patients had HAMA scores >14 before surgery. The incidences of preoperative depression and anxiety were 26.7% and 56.7%, respectively. HAMD and HAMA scores clearly decreased at each time point after surgery compared with those before surgery, and the differences were significant (P<0.01). The differences were not statistically significant in HAMD and HAMA scores among the different time points after surgery (P>0.05) (Tables 2 and 3).

Comparison of MoCA, HAMD, and HAMA scores between study group and control group

There were significant differences in total MoCA scores and scores of line connection, copying cube, drawing clock, and delayed recall before surgery and at 1 month after surgery between the 2 groups (P<0.05 and P<0.01, respectively) and no differences were found in these parameters at 3, 6, and 12 months after surgery between the 2 groups (P>0.05). The differences in HAMD and HAMA scores among different time points before and after surgery were not significant (P>0.05) (Tables 2 and 3).

Blood flow at stenotic artery

Favorable blood flow signals were found in the vertebral artery and basilar artery in all 26 patients after surgery. Figure 1 shows Vm at 1, 3, 6, and 12 months after surgery. Vm at the stenotic artery was at a high level before surgery; after SAA, the Vm decreased significantly at different time points when compared with that before surgery (P<0.01), and it was within normal range. However, the Vm at different time points after SAA was comparable (P>0.05).

Recurrence of post-operative stroke

One patient with TIA due to vertebral artery stenosis presented with TIA once at 7 months after surgery, but stroke-related symptoms were not observed in any other patients. All patients received brain MRI at 12 months after surgery. One patient was diagnosed with a new asymptomatic lacunar infarct and the lesion was located at the region supplied by the VBS.

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Discussion

Cerebral artery stenosis is not only an important risk factor for ischemic cerebrovascular diseases, but is also closely related to cognitive disorders [17,18]. There is evidence [19] that cerebral artery stenosis is a major cause of chronic hypoperfusion. In chronic hypoperfusion state, the neurons in the region with hypoperfusion may get insufficient blood and oxygen, which then inhibits the cellular aerobic metabolism and compensates by activating anaerobic glycolysis. Under this condition, the neurons have low energy production. In addition, in the absence of collateral circulation, the brain is in a hypoperfusion state, which may cause ischemia in the region supplied by the deep perforating artery, inducing oxidative stress, inflammatory reaction, increased phagocytosis of oligodendrocytes, and metalloproteinase activation [20], which may reduce cognitive function. Patients with cerebral artery stenosis develop cognitive dysfunction to various degrees [21,22]. When the stenosis is improved and the perfusion increases, the cellular metabolism also improves [23]. In the present study, 26 elderly patients with SVAS were recruited, and the total MoCA score was 24.92±3.06, which was lower than the normal lower limit (a score of 26). Of these patients, 14 were diagnosed with mild cognitive disorder. Thus, cognition must be borne in mind when VAS is treated.

Traditionally, SVAS can be treated with conservative therapy and surgical intervention. However, patients usually have high risk for stroke recurrence, even after routine pharmacotherapy, and often have a poor prognosis [2,3]. In addition, surgical procedures are usually complex and have potential complications, which significantly limit the wide application of surgical intervention. In recent years, with the development in the intervention therapy and related materials, SAA has become an effective strategy for the treatment of SVAS, due to its minimal invasiveness and clear effectiveness [5–7]. In the present study, 26 SVAS patients received SAA, with a success rate of 100%. Both clinical symptoms and cognitive function significantly improved in these patients. Moreover, the post-operative MoCA score increased dramatically ($P<0.01$), characterized by improvement in visuospatial/executive abilities and delayed recall ($P<0.05$ and $P<0.01$). The MoCA score increased gradually over time, and significant differences in the MoCA score were noted at 1 and 12 months after SAA ($P<0.01$), suggesting that the therapeutic efficacy increases over time.

Studies have shown that patients can present with improved executive ability, memory, language, visuospatial ability, and attention after treatment of carotid stenosis [24,25]. The improvement of cognitive function after carotid artery stenosis removal is different from that after vertebrobasilar artery stenosis removal, which may be the potential difference in cognitive improvement of different blood supply systems. The vertebral-basilar artery is also known as posterior circulation and mainly supplies blood to the back of the brain, especially the temporal lobe, hippocampus, thalamus, and cerebellum. The carotid artery system is also known as anterior circulation and mainly supplies blood to the eye, the front of the cerebral hemisphere, frontal lobe, temporal lobe, parietal lobe, and basal ganglia. After a comparison between the TIA group (12 TIA patients) and the infarction group (14 patients with posterior circulation infarction), we found no significant differences in each score before and after surgery between the 2 groups ($P>0.05$), which may be related to the same mechanism of cognition and affective disorder caused by the similar pathogenesis (atherosclerosis) and the same blood supply system.

Our results showed the cognitive function of patients with SVAS was improved after SAA, which was characterized by increase in the scores of visuospatial/executive abilities and delayed recall and the total MoCA score. This may be due to improved cerebral hypoperfusion and reduced incidence of asymptomatic cerebral infarction. The cerebral hypoperfusion is improved and some studies have confirmed that hypoperfusion is related to the cognitive impairment [21,26,27]. In the present study, SAA was performed in patients with SVAS for reconstructing cerebral blood vessels, improving cerebral blood flow, and increasing cerebral perfusion. In our study, the degree of stenosis was 81.3±8.8% before surgery and 3.7±3.6% after surgery. TCD revealed that the hemodynamics improved significantly after surgery, and the normal post-operative hemodynamics was consistent with previous reports [28]. The reduced incidence of asymptomatic cerebral infarction to >50% arterial stenosis is an independent predictor of cerebral infarction. Severe arterial stenosis is usually accompanied by microembolism, resulting in formation of multiple small infarcts [29]. Improvement of arterial stenosis to increase the cerebral blood flow may also effectively prevent the shedding of plaques due to the support by the stents, which further reduce the risk for recurrent stroke [6], decrease the incidence of cerebral infarction, and attenuate the deterioration of cognitive dysfunction due to cerebral infarction. In the present study, 26 patients with SVAS received SAA. Follow-up showed that 1 patient presented with TIA once at 7 months after surgery, and brain MRI at 12 months revealed a new asymptomatic infarct in 1 patient, which suggest a low recurrence rate of post-operative stroke (7.7%; 2/26).

In our study, the MoCA scale was used to evaluate cognition. The MoCA scale includes several domains that comprehensively evaluate cognition. The MoCA scale has been widely used to rapidly screen for mild cognitive impairment [13]. Previous studies have confirmed that MoCA has better sensitivity than the mini-mental state examination (MMSE) in the evaluation of mild cognitive impairment of any cause [30]. Many previous studies on the relationship between SAA and cognitive function used the cognition changes of the patients before

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and after surgery as the self-control. In the present study, 30 patients receiving intracoronary stent implantation were included in the control group, and the general condition of the control group and the study group had a better match, effectively avoiding the influence of anesthesia, perioperative surgery, and subjective factors of the patients.

Patients have a poor understanding of the method and precautions of this treatment because, compared with other treatments, SAA is invasive. Moreover, as an "operation", it is considered to be a stressful event, more or less affecting the patients' emotion and psychology. Anxiety and depression are the most common negative emotions caused by psychological stress. In the 26 patients of the study group, the incidences of preoperative depression and anxiety were 23.1% and 53.8%, respectively. In the 30 patients of the control group, the incidences of preoperative depression and anxiety were 26.7% and 56.7%, respectively. No significant differences were found in the incidences between the 2 groups. HAMD and HAMA scores at each time point after surgery had significantly reduced compared with those before surgery ($p<0.01$), while the scores among different time points after surgery did not obviously change. This suggests that SAA can produce a negative emotional reaction as a stress event, and the negative emotion can be corrected after SAA, which may be the improvement of affective disorder in patients caused by removal of stress response, improvement of clinical symptoms, lower stroke recurrence rate, and other factors.

There were limitations in our study. The sample size was small. MoCA, HAMD, and HAMA scales were used to evaluate cognition and affective disorders of the patients, but testing with each scale is a learning process due to specific features of the scale test, and after multiple tests, the wrong answers to some questions may be corrected gradually to change the scores. In addition, the cerebral blood flow was evaluated with Doppler ultrasound, which has lower sensitivity than positron emission computed tomography (PET). Although there were limitations, our findings may provide theoretical evidence for the improvement of cognition and affective disorder by SAA in elderly patients with SVAS. Of note, more multicenter studies with a larger sample size are needed as well as controlled trails to investigate the effects of SAA on cognition and affective disorder.

Conclusions

SAA may improve the visuospatial/executive abilities and delayed recall, as well as depression and anxiety in patients with SVAS. Further larger, controlled trails were needed to investigate the effect of SAA on the cognition and affection in these patients.

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