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Original Article

Analysis of cognitive dysfunction-related influencing factors after elderly patients with vertebroarterial-type cervical spondylosis underwent low-temperature plasma ablation of nucleus pulposus

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Abstract: Objective: To analyze cognitive dysfunction-related influencing factors after elderly patients with vertebroarterial-type cervical spondylosis (CSA) undergoing low-temperature plasma ablation of nucleus pulposus. Methods: A total of 111 elderly CSA patients with cognitive dysfunction who received low-temperature plasma ablation of nucleus pulposus and a 3-year follow-up visit were selected in this study. Mini-mental state examination (MMSE), Montreal cognitive assessment (MoCA), clinical dementia rating (CDR) and Wechsler adult intelligence scale-revised in China (WAIS-RC) scoring were conducted in the treatment group before surgery and in 1 month, 6 months, 1 year, 2 years and 3 years after surgery. Logistic regression analysis was used to analyze the correlation between MoCA scores and related factors. Results: This study showed that CDR scores of the patients in the treatment group were above 0.5 point (including 0.5 point) before surgery. The CDR scores were reduced to 0 point in 2 patients in 1 month after surgery and in 6 patients in 6 months after surgery. Such a change was more obvious in 3 years after surgery (up to 11 patients). The number of patients scoring 0.5 point in CDR was increased obviously over time after surgery, and it was increased from 58 patients to 79 patients in the 3rd year after surgery, taking up 71.2%. At the same time when the number of patients scoring 0.5 point in CDR was significantly increased, the number of those scoring 1 point and 2+ points in CDR was also decreased. They were decreased from 31 patients and 22 patients before surgery to 15 patients and 6 patients, respectively and declined by 51.6% and 72.7%, respectively. The WAIS-RC scores of the patients were significantly improved after surgery compared with those before surgery. Such an improvement was particularly prominent in 6 months after surgery, which showed statistical significance ($P<0.01$). As time flied after surgery, the WAIS-RC scores of the patients in the treatment group were improved remarkably. Dependent variables (MoCA scores) of the patients in the treatment group were highly correlated with independent variables (the age of the patients, low education level, hypertension and diabetes), but had no significant correlation with smoking, blood lipids (triglyceride (TG) and total cholesterol (TC)), alcohol consumption and coronary atherosclerotic heart disease. Conclusion: The low-temperature plasma ablation of nucleus pulposus has an effect on improving the cognitive function of the elderly CSA patients with cognitive impairment. Meanwhile, such a protective effect is more significant over time. This study suggested that the cognitive dysfunction of the patients was highly correlated with the age of the patients, low education level, hypertension and diabetes, which indicated that surgical operation is not an independent protective factor for the disease.

Keywords: Elderly cervical spondylosis, low-temperature plasma ablation of nucleus pulposus, cognitive dysfunction, factor analysis

Introduction

Vertebroarterial-type cervical spondylosis (CSA) is closely related to cognitive function, which is more obvious in the onset of the elderly patients [1]. Its main mechanism may be associated with insufficient blood supply of vertebral-basilar artery, thus damaging the neurological function of CSA patients. In clinic, the injury may be transient, and the signs of neuropathy cannot be found. However, this injury can be sustained for a long time, which will

cause a change in the cognitive function, and may eventually develop into vascular dementia and ischemic stroke. Active prevention may be an important method to prevent cerebrovascular disease especially for elderly CSA patients with cognitive dysfunction. In recent years, the use of low-temperature plasma ablation of nucleus pulposus is a new minimally invasive surgical method for CSA. However, the previous studies showed that postoperative cognitive impairment may occur after cardiac surgery and major orthopedic surgery. Its incidence can even be as high as 50% [2, 3]. The impacts of low-temperature plasma ablation of nucleus pulposus on the cognitive function of the elderly CSA patients and its correlated factors need to be further proved and studied. The clinical data of the elderly CSA patients with cognitive dysfunction that underwent low-temperature plasma ablation of nucleus pulposus in our hospital are reported as follows.

Materials and methods

Data

A total of 111 CSA patients (>60 years old) with cognitive dysfunction were received and treated with low-temperature plasma ablation of nucleus pulposus in the Orthopedics Department of Shanghai Fengxian District Central Hospital from January 2012 to November 2014. They were followed up for 3 years after treatment. CSA was diagnosed according to the diagnostic criteria in The Second Session of the National Symposium on Cervical Spondylosis: (1) patients with the history of chronic strain, which is commonly observed in the working with head lowering or long-term bending over a desk; (2) patients with neck soreness and tension of neck muscle with tenderness by pressing, which is mainly observed in the middle and upper part of the neck; (3) patients with chronic or paroxysmal headache, dizziness, blurred vision, swallowing difficulties; (4) patients with limited neck movement and positive results of revolve-cervix test.

Criteria for cognitive function were as follows. (1) Detection of cognitive function with Montreal cognitive assessment (MoCA): Patients receiving 0-12 years' education will get 1 point. The highest score of this item is 30 points. Patients with the final score >26 points are regarded to have normal cognitive function, and those with the final score <26 points are considered to have cognitive dysfunction. (2) Detection of cognitive function with mini-mental state examination (MMSE): Patients receiving 4-year-education will get 2 points, and those receiving 4-8 years' education will get 1 point. The highest score is 30 points. Patients with the final score within 25-30 points are considered to have normal cognitive function, and those with the final score ≤24 points are regarded to have cognitive dysfunction. (3) Clinical dementia rating (CDR): It is evaluated as per each function of the patient. There are 6 items in total. Each aspect of each function is assessed in five levels, from no damage to severe impairment, namely normal, suspicious, mild, moderate and severe, and the score of each function is not allowed to be superimposed. Finally, the six functional scores are combined into one total score according to the overall rating criteria, which are expressed as 0, 0.5, 1, 2 and 3, respectively. (4) Wechsler adult intelligence scale-revised in China (WAIS-RC): It is composed of the detection of operation intelligence quotient (IQ), speech IQ and full scale IQ. Patients meeting the criteria for CSA and cognitive dysfunction were included in this data as the treatment group.

Methods

Low-temperature plasma ablation of nucleus pulposus: The patients lay in a supine position with a soft pillow under their shoulders which drooped as much as possible. Their heads and necks lay in the central position and stretched backward. The assistant performed C-type arm positioning (TOSHIBA) on the intervertebral discs to be ablated and marked it with a marker. Conventional disinfection with iodophor was conducted on the site, then deiodination with alcohol and draping were carried out. About 10 mL of 1% lidocaine hydrochloride was used for local anesthesia. A full set of electrocardiogram monitoring was given for elderly patients. The ablation of the cervical 4-5 disc was taken as an example. The cervical 4-5 disc was determined under C-type arm fluoroscopy. The surgeon, located at the side of the patient's head, pulled the trachea and esophagus to the left with his/her left hand, and hold the puncture needle with his/her right hand to puncture it into the cervical 4-5 disc under the guidance of C-type arm. After the position was confirmed to be correct by anterioposterior and lateral X-ray

of the cervical vertebra, the puncture needle was withdrawn, and cervical plasma blade was placed. It was confirmed once again that the blade lay in 1/3 after the middle of the intervertebral disc. Once the blade moved forward, the ablation mode was used, and the energy was set to the second gear. The thermal coagulation mode at a speed of about 5 mm/s was used when the blade was withdrawn. Meanwhile, the patients were asked whether they suffered from obvious pain and other uncomfortable symptoms. If the answer was yes, the surgical operation was stopped temporarily. When punching was started, the white line at the end of the blade was aimed at the direction of 12 o'clock. The ablation pedal was stepped, and the blade was pushed from the starting point to the farthest point. Then the thermocoagulation pedal was stepped to return the blade from the farthest point to the starting point at a speed of 5 mm/s. When next hole was punctured, the white line was turned to the direction of 2 o'clock, and punching was conducted continuously. The aforementioned steps were repeated. The punching was conducted at the direction of 4, 6, 8 and 10 o'clock until 6 holes were completed. After surgery, the plasma blade and the puncture needles were extracted. The sites were suppressed with sterile dressings for 10min until there was no bleeding, and they were covered with plasters.

Observation indicators and judgment criteria

The information, including the age, gender, fasting blood glucose before meals, blood lipids (total cholesterol (TC) and triglyceride (TG)), blood pressure (systolic and diastolic pressure), the level of education, underlying diseases (such as hypertension, coronary atherosclerotic heart disease and diabetes) and bad habits (such as smoking and alcohol abuse), of all the patients enrolled was collected. The level of education ≤12 years was defined as low education level. Diabetes and hypertension were diagnosed according to corresponding diagnostic criteria.

Psychological and neurological tests: The patients were evaluated according to the following four measurement scales: MMSE, MoCA, CDR, and WAIS-RC.

The above measurement scales were all completed by the deputy chief physician or above, and two measurement scales for the same patient were completed at an interval of more than 1 hour.

Follow-up visits

All the patients were followed up through subsequent visits in the Outpatient Department. Patients in the treatment group were evaluated using the above four measurement scales before surgery (on admission) and in 1 month, 6 months, 1 year, 2 years and 3 years after surgery.

Statistical analysis

Statistical Product and Service Solutions 17.0 software was used in this study for data analysis. The measurement data were expressed as mean ± standard deviation ($\bar{x}\pm$sd), and the enumeration data were expressed as frequency. Two independent samples t-test and repeated-measures analysis of variance were adopted for the measurement data, and Fisher's exact probability test or χ^2 test was performed for the enumeration data. Binary logistic regression analysis was adopted for the correlation analysis of multiple potential independent risk factors. $P<0.05$ indicated that the difference was statistical significant.

Results

Comparison of the two groups' general data

A total of 111 patients were included in this group, including 64 males and 47 females aged 61-85 years old (mean age of 65.17±9.45). There were 77 patients aged between 61-70 years old, and 34 elderly patients aged above 70 years old. The course of the disease was 3 months to 5 years with an average of 1.45±0.64 years. The years of education were 11.04±3.01 years. The level of fasting blood glucose was 7.22±2.18 mmol/L. The level of TC and TG was 6.17±1.67 mmol/L and 2.04±0.85 mmol/L, respectively. The average systolic pressure was 148.46±21.75 mmHg, and the average diastolic pressure was 84.56±11.48 mmHg. Sixteen patients were combined with diabetes (14.4%), 18 patients with coronary heart disease (16.2%), 21 patients with hypertension (18.9%), 23 patients with the bad habit of drinking (20.7%) and 26 patients with the bad habit of smoking (23.4%). The cerebral blood flow was

Table 1. Comparison of two groups' general data

Item	
Case (n)	111
Male (n, %)	64 (57.7)
Female (n, %)	47 (42.3)
Age (year old)	65.17±9.45
Years of education	11.04±3.01
Fasting blood glucose (mmol/L)	7.22±2.18
Total cholesterol (mmol/L)	6.17±1.67
Triglyceride (mmol/L)	2.04±0.85
Average systolic pressure (mmHg)	148.46±21.75
Average diastolic pressure (mmHg)	84.56±11.48
Diabetes (n, %)	16 (14.4)
Coronary heart disease (n, %)	18 (16.2)
Hypertension (n, %)	21 (18.9)
Dringking (n, %)	23 (20.7)
Smoking (n, %)	26 (23.4)
Cerebral blood flow (mL/min)	39.48±10.64
The lesion in segment (n, %)	
3-4	31 (27.9)
4-5	77 (69.4)
5-6	64 (57.7)
6-7	52 (46.8)
No. lesion in segment (n, %)	
1 segment	16 (14.4)
2 segment	77 (69.4)
3 segments	18 (16.2)

39.48±10.64 mL/min. All the patients received magnetic resonance imaging (MRI) after admission to our hospital. All the included 111 CSA patients received plain radiography and MRI of the cervical spine before surgery. The results showed that 31 patients were observed with the lesion in segment 3-4 of the cervical spine, 77 patients with the lesion in segment 4-5, 64 patients with the lesion in segment 5-6, and 52 patients with the lesion in segment 6-7. There were 16 patients with the lesion involving in only 1 segment, 77 patients with the lesion involving in 2 segments and 18 patients with the lesion involving in 3 segments. See **Table 1**.

Comparison of MoCA and MMSE scores of subjects in different periods

MoCA and MMSE scores of the patients were elevated obviously in 6 months, 1 year, 2 years and 3 years after surgery compared with those before surgery, which showed statistical significance (P<0.05 or P<0.01, **Table 2**).

Comparison of CDR scores of the treatment group before and after surgery

CDR scores of the patients in the treatment group were above 0.5 point (including 0.5 point) before surgery. The CDR scores were reduced to 0 point in 2 patients in 1 month after surgery and in 6 patients in 6 months after surgery. Such a change was more obvious in 3 years after surgery (up to 11 patients). However, the number of patients scoring 0.5 point in CDR was increased obviously over time after surgery, and it was increased from 58 patients to 79 patients in the 3rd year after surgery, taking up 71.2%. At the same time when the number of patients scoring 0.5 point in CDR was significantly increased, the number of those scoring 1 point and 2+ points in CDR was also decreased. They were decreased from 31 patients and 22 patients before surgery to 15 patients and 6 patients, respectively, and declined by 51.6% and 72.7%, respectively (**Table 3**).

Comparison of WAIS-RC scores of the treatment group before and after surgery

The WAIS-RC scores of the patients were significantly improved after surgery compared with those before surgery. Such an improvement was particularly prominent in 6 months after surgery, which showed statistical significance (P<0.01). As time flied after surgery, the WAIS-RC scores of the patients in the treatment group were improved remarkably (**Table 4**).

Multivariate analysis of the MoCA scores of the patients in the treatment group during the 3-year follow-up visit

Stepwise logistic regression analysis was performed with the MoCA scores of the patients in the treatment group in the 3 years after surgery as the dependent variables and relevant factors (including years of education, 11.04±3.01 years; the level of fasting blood glucose, 7.22±2.18 mmol/L; TC, 6.17±1.67 mmol/L; TG, 2.04±0.85 mmol/L; average systolic pressure, 148.46±21.75 mmHg; average diastolic pressure, 84.56±11.48 mmHg; diabetes, 16 patients (14.4%); coronary heart disease, 18 patients (16.2%); hypertension, 21 patients (18.9%); bad habit of drinking, 23 patients

Table 2. Comparison of MoCA and MMSE scores of subjects in different periods

Item		MMSE	MoCA
Treatment group (n=111)	Before surgery	27.16±2.13	19.81±2.04
	1 month after surgery	27.26±2.27	19.91±2.06
	6 months after surgery	28.46±2.46[a]	21.56±2.19[a]
	1 year after surgery	28.64±2.25[a]	20.94±2.07[a]
	2 years after surgery	28.47±2.14[a]	21.16±2.56[a]
	3 years after surgery	28.74±1.96[a]	21.46±1.95[a]

Note: [a]P<0.01, in comparison with those before surgery. MMSE, mini-mental state examination; MoCA, montreal cognitive assessment.

Table 3. Comparison of CDR scores of the treatment group before and after surgery

Item		CDR score			
		0	0.5	1	2+
Treatment group (n=111)	Before surgery	0	58	31	22
	1 month after surgery	2	63	27	19
	6 months after surgery	6	67	26	12
	1 year after surgery	8	72	21	10
	2 years after surgery	9	75	19	8
	3 years after surgery	11	79	15	6

Note: CDR, clinical dementia rating.

(20.7%); bad habit of smoking, 26 patients (23.4%)) as the independent variables. Upon research and analysis, the dependent variables (MoCA scores) of the patients in the treatment group were highly correlated with the independent variables, including the age of the patients (odds ratio (OR) =4.956; 95% confidence interval (CI): 1.598-14.965; P=0.008), low education level (OR=2.245; 95% CI: 0.846-6.854; P=0.042), hypertension (OR=1.647; 95% CI: 1.125-2.148; P=0.019) and diabetes (OR=2.594; 95% CI: 1.046-6.015; P=0.049), but had no significant correlation with smoking, blood lipids (TG and TC), alcohol consumption and coronary atherosclerotic heart disease. Surgical operation (OR=2.247; 95% CI: 0.805-6.754; P=0.078) was not an independent protective factor for the disease (**Table 5**).

Discussion

CSA can cause insufficient blood supply of vertebral-basilar artery under the influence of various related factors. Long-term lack of blood supply makes the cerebral blood vessels lie in a chronic low perfusion state. Meanwhile, the elderly patients have high blood viscosity and slow blood flow. Ischemic damage to the periventricular and deep brain white matter is resulted from the aforementioned series of actions [4]. Co-rtical degeneration of the brain white matter mainly damages U-type fiber, and influences the cortical energy metabolism, eventually leading to cortical atrophy, decreased brain capacity, and dependent cognitive dysfunction in the specific region of the brain [5-7]. Studies have shown that cortical degeneration of the brain white matter is closely related to the impairment of single cognitive domain (such as memory work) [8-10]. Stenosis or occlusion of cerebral blood vessels can occur in case of long-term chronic ischemia or severe acute ischemia, which can cause chronic brain ischemia, and finally become one of the main causes for the degeneration of brain white matter. More and more studies have confirmed that the degeneration of brain white matter is the main mechanism leading to cognitive dysfunction [11-14]. The use of MMSE in the selected patients is easy to operate and master. It is especially suitable for elderly patients. The measurement scale has the advantage of low false negative rate in evaluating moderate and severe cognitive dysfunction. Moreover, the results of previous studies showed that MoCA has a higher evaluating sensitivity than MMSE. Therefore, MoCA is more suitable for early or mild cognitive impairment, and for Chinese population [15-17]. CDR is widely used in the assessment of dementia segmentation, and its evaluation on the severity of dementia is more accurate [18]. WAIS-RC is used in the evaluation of cognitive and neuropsychiatric symptoms in patients with brain disorders [19]. In this study, it was used to evaluate the degeneration of brain white matter in patients with insufficient blood supply of vertebral artery.

Table 4. Comparison of WAIS-RC scores of the treatment group before and after surgery

Item		Full scale IQ	Speech IQ	Operation IQ
Treatment group (n=111)	Before surgery	84.3±12.8	95.1±17.1	86.9±8.5
	1 month after surgery	86.7±13.2[a]	97.1±16.1[b]	90.2±9.4[a]
	6 months after surgery	91.6±13.4[a]	100.6±16.4[a]	97.1±9.3[a]
	1 year after surgery	95.7±14.1[a]	103.7±16.9[a]	100.2±9.9[a]
	2 years after surgery	99.4±11.9[a]	104.5±17.1[a]	103.1±12.3[a]
	3 years after surgery	103.7±14.2[a]	104.1±17.8[a]	105.7±13.2[a]

Note: [a]P<0.01 and [b]P<0.05 in comparison with those before surgery. WAIS-RC, Wechsler adult intelligence scale-revised in China; IQ, intelligence quotient.

Table 5. Multivariate analysis of the MoCA scores of the patients in the treatment group during the 3-year follow-up visit

Variable	Beta coefficient	Standard error	Wald χ^2	df	P	OR	95% CI	
							Lower limit	Upper limit
Age (over 65)	1.523	0.589	8.269	1	0.008	4.956	1.598	14.965
Low education level	0.784	0.452	2.254	1	0.042	2.254	0.846	6.854
Hypertension	0.469	0.354	8.054	1	0.019	1.647	1.125	2.148
Diabetes	0.945	0.321	4.358	1	0.049	2.594	1.046	6.015
Surgical operation	0.823	0.403	2.272	1	0.078	2.247	0.805	6.754
Coronary heart disease	0.885	0.425	2.368	1	0.083	8.438	0.823	6.832
Smoking	0.912	0.365	4.128	1	0.064	9.487	0.983	6.258
Alcohol consumption	0.923	0.398	4.274	1	0.071	9.367	0.846	6.358
TG	0.812	0.426	2.347	1	0.081	8.587	0.836	6.634
TC	0.895	0.474	2.368	1	0.086	8.561	0.874	6.563

Note: MoCA, montreal cognitive assessment; df, degree of freedom, TG, triglyceride; TC, total cholesterol; OR, odds ratio; CI, confidence interval.

It was concluded in previous studies that the conclusions of the change in cognitive function are different after the patients underwent surgical treatment, some of which are even contradictory and have not yet been finally confirmed [20-26]. In this study, elderly CSA patients with cognitive dysfunction were selected as the objects of the study. This study showed that CDR scores of the patients in the treatment group were above 0.5 point (including 0.5 point) before surgery. The CDR scores were reduced to 0 point in 2 patients in 1 month after surgery and in 6 patients in 6 months after surgery. Such a change was more obvious in 3 years after surgery (up to 11 patients). The number of patients scoring 0.5 point in CDR was increased obviously over time after surgery, and it was increased from 58 patients to 79 patients in the 3rd year after surgery, taking up 71.2%. At the same time when the number of patients scoring 0.5 point in CDR was significantly increased, the number of those scoring 1 point and 2+ points in CDR was also decreased. They were decreased from 31 patients and 22 patients before surgery to 15 patients and 6 patients, respectively and declined by 51.6% and 72.7%, respectively. The WAIS-RC scores of the patients were significantly improved after surgery compared with those before surgery. Such an improvement was particularly prominent in 6 months after surgery, which showed statistical significance (P<0.01). WAIS-RC scores of the patients in the treatment group were improved obviously over time after surgery. In this study, the cognitive function of the patients was systematically evaluated using the above-mentioned multiple measurement scales before surgery and in the 3-year follow-up visit after surgery. The scores of cognitive function of the patients after surgery were significantly lower than those before surgery.

Some studies suggested that the gender, age, and education level of the patients are inde-

pendent risk factors for the change in cognitive function [27-30]. These results are consistent with those reported in previous relevant literatures [31-34]. At present, it is considered that a variety of risk factors (such as diabetes, hypertension, smoking and lipid metabolism) may be related to the occurrence of cognitive impairment [35-37]. The results of this study showed that dependent variables (MoCA scores) of the patients in the treatment group were highly correlated with independent variables (the age of the patients, low education level, hypertension and diabetes), but had no significant correlation with smoking, blood lipids (TG and TC), alcohol consumption and coronary atherosclerotic heart disease. Therefore, the positive control of vascular risk factors and the strict control of blood pressure and blood glucose in the treatment of these patients are of great benefits for the prognosis of the disease. This study also showed that the cognitive function of the elderly CSA patients with cognitive impairment was improved after surgery, but surgical operation is not an independent protective factor for the disease.

In conclusion, low-temperature plasma ablation of nucleus pulposus has an effect on improving the cognitive function of elderly CSA patients. Meanwhile, such a protective effect is more significant over time. This study suggested that the cognitive dysfunction of the patients is highly correlated with the age of the patients, low education level, hypertension and diabetes.

Disclosure of conflict of interest

None.

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