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Shandong Medical Journal, 2017, Vol. 57, Iss. 26
Clinical Research

Effect of Speech-Auditory Feedback Training on cognitive dysfunctions in stroke patients

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DOI: 10.3969 / j.issn.1002-266X.2017.26.013
CLC: R743. 3
Document code: B
Article ID: 1002-266X (2017) 26-0044-03
Supported by Hebei Province Science and Technology Infrastructure Program(13277748D)
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Abstract

Objective: This experiment was undertaken to determine the effect of speech-auditory feedback training on cognitive dysfunction in stroke patients.

Methods: 80 stroke patients with cognitive dysfunction were randomly divided into experimental group (n=40) and control group (n= 40). The control group received conventional rehabi1itation, whi1e, additionally, the experimental group also received Forbrain speech-auditory feedback training, 20 minutes per session, 5 sessions per week, for 10 weeks in total. All participants were assessed with Montreal cognitive assessment scale (MoCA) and the Livingston Cognitive Assessment Scale II (LOTCA-II) before and after the intervention.

Results: No difference between scores of the two groups were noted before the experiment (P> 0.05). After the intervention, the total score of MoCA, the scores of attention and concentration, visuospatial construction, language, abstract thinking, memory, orientation of the experimental group were higher than those of the control group; also, the total score of LOTCA-Ⅱ, the score of visual perception, visual movement, thinking operation, attention and concentration increased as compared to those of the control group (P <0.05).

Conclusion: Speech-auditory feedback training can improve cognitive functions of stroke patients.

Key words: Stroke; Cognition Dysfunction; Speech-auditory feedback training, Rehabilitation

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Stroke can cause different degrees of nerve damage, which often gives rise to high disability rates and mortality, and it is one of the leading cause of disability and cognitive impairments [1,2]. It is reported that 75% stroke patients have to live with some degrees of cognitive dysfunction [3], suffering from affected ability to live and work as usual. In the meantime, readmission rate and mortality increase [4]. Therefore, restoration of the cognitive function of stroke patients emerged to be a popular research hotspot. At present, the most commonly chosen clinical rehabilitation methods are motion sensing games, visual training, virtual reality techniques and sensory integration training.

Based on the cognitive neuroscience, Forbrain is a device used for brain cognitive training, integrating visual, auditory and language trainings. It is easy, convenient and safe to administer. Using Forbrain, we applied speech-auditory feedback training to stroke patients, from June 2015 to June 2016, to observe its effect of improving cognitive function.

1 Data Collection and Methods

1.1 Data Collection

The inclusion criteria were: (1) diagnosis of stroke based on the standard established by The 4th Conference of Chinese Cerebrovascular Disease in 1995[5]and confirmed by CT or MRI results; (2) the course of disease being more than one month, stable vital signs and clear consciousness; (3) no moderate or severe encephalatrophy, leukoaraiosis, visual field defect or spatial neglect found through examinations; (4) cognitive dysfunction shown by a MoCA score of less than 26.

Exclusion criteria were: (1) history of mental illness or retardation; (2) severe dysfunction of the heart, liver or kidney, malignant tumors or other critical conditions unsuitable for the training; (3) drug or alcohol abuse; (4) aphasia or dysarthria; (5) hearing-impairment

80 hospitalized stroke patients with cognitive dysfunctions were selected from the Rehabilitation Department in Tangshan Gongren Hospital. The sample was composed of 56 males and 24 females between 45-74. Among all the participants, there were 59 cases of cerebral infarction and 21 cerebral hemorrhage; as to the location of the lesions, 29 were on the left hemisphere, 38 on the right and 13 on both sides.

The patients were randomly and equally divided into the experimental group and control group. There were 27 males and 13 females in the experiment group, with an average age of 58 ± 7, course of disease 68 ± 25 days and education of 9 ± 3 years. There were 29 males and 11 females in the control group, with an average age of 58 ± 6, course of disease 69 ± 26 days and education of 8 ± 3 years. Two groups are statistically comparable. Written informed consent forms were obtained from each patient before participation.

1.2 Intervention

The control group received conventional rehabilitation, including occupational therapy (OT), physical therapy (PT), medication and acupuncture while the experimental group received Forbrain speech-auditory feedback training in addition to conventional rehabilitation and intervention given to the control group.

Operation of Forbrain: Turn on Forbrain. When the blue light is on, instruct the patient to wear the device. The patient can select his favorite material, be it stories, essays, novels, magazines and newspapers, and he needs to read out loud. During the process, instruct the patient to adjust his pronunciation and stress timely according to the sound perceived through bone conduction, in order to optimize the effect of the training. For those who are illiterate or with literacy problems, their family members can initiate conversations for the purpose of training. The training was scheduled for 20 minutes per session, 5 sessions a week, 10 weeks in total.

1.3 Assessment

Both groups were assessed by MoCA and LOTCA- Ⅱ before the experiment and after the 10-week intervention.

[1] MoCA [6] includes 11 indexes covering 8 cognitive aspects: concentration, executive function, memory, language, visuospatial construction, abstract thinking, calculation and orientation. The total score is 30 and 26 is set as the baseline for normal cognition. A score less than 26 is indicative of impaired cognitive function and 1 point would be added to the score if the subject received less than 12 years of education.

[2] LOTCA- Ⅱ [7] assesses 26 items of 6 aspects including orientation, visual perception, spatial perception, movement, visual movement organization and thinking operation. Additional items are attention and concentration. The total score is 115, and attention and concentration worth 4 points. The higher the score, the better the cognitive functions.

1.4 Statistical Analysis

Statistical software SPSS17.0 was used. Comparison between enumeration data were shown by x^2 test and measurement data were compared using *t* test. The level of significance was set a priori at *P* =

0.05.

2 Results

No difference between scores of the two groups were noted before the experiment (P> 0.05).

After the intervention, the total score of MoCA, the scores of attention and concentration, visuospatial construction, language, abstract thinking, memory, orientation of the experimental group were higher than those of the control group (P <0.05)。

Also, the total score of MoCA, the scores of attention and concentration, visuospatial construction, executive skills, language, abstract thinking, memory, orientation of the experimental group showed significant improvement as compared to the data gathered at baseline (P <0.05).

As to the control group, after the intervention, the total score of MoCA, the score of visuospatial construction, executive skills, language and abstract thinking also increased greatly (P <0.05).See Table 1.

Moreover, the total score of LOTCA-Ⅱ, the score of visual perception, visual movement, thinking operation, attention and concentration of the experimental group increased as compared to those of the control group after intervention (P <0.05). In the experimental group, there was significant increase in the total score of LOTCA-Ⅱ, the score of orientation, visual perception, movement, visual movement, thinking operation, attention and concentration after treatment (P <0.05). Similarly, in the control group, the total score of LOTCA-Ⅱ, the score of orientation, visual perception, movement, visual movement also showed major increase after the experiment (P <0.05). See Table 2

Table 1 MoCA Scores of 2 groups before and after intervention ($\bar{x} \pm s$)

	visuospatial construction	executive skills	attention and concentration	language	calculation	abstract thinking	memory	orientation	total
Experimental group									
before	1.53 ± 0.55	2.00 ± 0.45	1.75 ± 0.43	1.43 ± 0.50	1.53 ± 0.93	1.18 ± 0.55	1.60 ± 0.74	4.05 ± 0.39	15.80 ± 2.24
after	2.05 ± 0.50*#	2.30 ± 0.51#	2.15 ± 0.36*#	2.03 ± 0.48*#	1.65 ± 0.95	1.50 ± 0.51*#	2.18 ± 0.59*#	4.15 ± 0.43*#	18.75 ± 2.05*#
Control group									
before	1.63 ± 0.59	2.03 ± 0.57	1.80 ± 0.40	1.60 ± 0.49	1.83 ± 1.04	1.13 ± 0.56	1.63 ± 0.59	3.90 ± 0.44	16.30 ± 2.73
after	1.78 ± 0.53#	2.28 ± 0.45#	1.85 ± 0.36	1.70 ± 0.46#	1.90 ± 1.01	1.25 ± 0.44#	1.70 ± 0.56	3.95 ± 0.39	17.18 ± 2.37#

Note: *: P＜0.05 when compared with the control group; #: p＜0.05 when compared within the same group

Table 2 LOTCA-Ⅱ Scores of 2 groups before and after intervention (x ± s)

	orientation	visual perception	spatial perception	movement	Visual movement	Thinking operation	Attention and concentration	Total

Experimental group								
before	9.30 ± 1.36	12.10 ± 1.69	9.13 ± 1.31	9.68 ± 1.46	17.65 ± 3.07	17.48 ± 3.09	2.80 ± 0.52	75.33 ± 8.45
after	10.05 ± 1.32#	13.48 ± 1.45*#	9.68 ± 1.42	10.65 ± 1.08#	20.03 ± 2.35*#	20.03 ± 2.35*#	3.43 ± 0.50*#	84.18 ± 6.16*#
Control group								
before	9.20 ± 1.32	11.98 ± 1.66	9.15 ± 1.29	9.65 ± 1.44	18.08 ± 2.62	17.83 ± 2.57	2.65 ± 0.48	75.88 ± 7.34
after	9.83 ± 1.24#	12.60 ± 1.46#	9.43 ± 1.38	10.08 ± 1.29#	19.15 ± 1.97#	18.90 ± 2.05	3.00 ± 0.51	79.98 ± 6.07#

Note: *: $P<0.05$ when compared with the control group; #: $p<0.05$ when compared within the same group

3 Discussion

Stroke damages the ability to perceive and adapt to the external environment, and it also adds to the incidence of dementia [8]. It has been found that early cognitive training of patients after stroke can accelerate cognitive function recovery, facilitating reorganization of the neural network and re-integration of the brain function [9].

Forbrain speech-auditory feedback training [10] is developed based on the fact that human perceive sound through two channels, bone conduction and air conduction. When a person makes a sound, the vocal cord vibrates, and the vibration is transmitted firstly through bone conduction and secondly through air conduction via the tympanic membrane.

The purpose of speech-auditory feedback training is to enhance sound transmission through bone conduction. With a bone-conduction headset equipped with a highly sensitive microphone, patients’ perception of their own voice during reading out loud is strengthened, making it easier to perceive and analyze the information. Therefore, the frontal and temporal lobe of the cerebral cortex are efficiently stimulated.

Placed below the temple, the device would not block the channel of air conduction, and patients are trained to focus on their own voice with the presence of interfering sound from the surrounding. In this way, the ability to concentrate only on relevant information is enhanced.

During the training, dynamic filter installed on the device can block the noise from the surrounding environment, highlighting the user’s own voice, inducing enough stimulation and training to the nervous system and brain.

The perception and adjustment of their own voice can stimulate the frontal cortex of the brain, enhance transmission of high-frequency sounds, uncheck the ear canal which is in charge of movements, and improve the entire vestibular system. Thereby, language ability can be trained and enhanced through the auditory feedback and highlighted perception of auditory information, optimizing speech-auditory feedback loop [10].

MoCA was designed by a team led by Nasreddine [11], and it was translated into Chinese by Wang Wei et al [6] in 2007. The scale covers a wide range of cognitive function, and it takes only a relatively short period (about 10 min) to finish, serving as a time-efficient screen of impaired cognitive functions. Currently, it is mainly used for evaluation of stroke patients and senior citizens.

LOTCA-Ⅱ, translated into Chinese by Zhang Shangang et al in 2004, is one of the most systematic and comprehensive evaluations, with high reliability and validity, of cognitive function at present [7].

In this study, Forbrain speech-auditory feedback training was added to conventional intervention in patients with cognitive dysfunctions after stroke, and the result showed that after the intervention, the total score of MoCA, the scores of attention and concentration, visuospatial construction, language, abstract thinking, memory, orientation of the experimental group were higher than those of the control group; also, the total score of LOTCA-Ⅱ, the score of visual perception, visual movement, thinking operation, attention and concentration increased as compared to those of the control group. It can be inferred that auditory feedback training can effectively improve the cognitive function of stroke patients.

As to the control group, after the intervention, the total score of MoCA, the score of visuospatial construction, executive skills, language and abstract thinking, the total score of LOTCA-Ⅱ, the score of orientation, visual perception, movement, visual movement also showed major increase after the experiment, meaning that conventional rehabilitation and care are effective in improving cognitive functions of stroke patients.

The mechanism of the effects of auditory feedback training with Forbrain on cognitive functions might be:

[1] The temporal lobe, pre-motor area, inferior frontal gyri and primary motor cortex are associated with language ability, as it is reported [12]. This study required patients to read aloud, and their voice was collected by microphones. During the process, patients' perception of the sound was enhanced and at the same time, the corresponding regions of the brain such as temporal lobe and primary motor cortex were stimulated to contribute to better language and executive functions. At the same time, tissues and cells would resonate with the acoustic vibration generated by air and bone conduction, resulting in a massage-like effect on cells. As a result, brain-derived neurotrophic factors in the brain and serum would increase in number, thereby improving cognitive function [13].

[2] Attention is the prerequisite of the cognitive process [14]. During the training, dynamic filter installed on the device can block the noise from the surrounding environment, highlighting the perception of the user's own voice. In this way, the part of the cerebral cortex in charge of attention would be activated and trained. In addition, by trying to identify difference in one's voice, a patient's ability to pay attention is

improved.

[3] Patients were asked to read repeatedly, and such repetitive training would bring about repeated stimulation. Consequently, nerve cells would recover from the damage, marginal zones would compensate for the loss caused by stroke, and new neural pathways would establish, improving cognitive function in total [15,16].

[4] During the training, the noise from the surrounding was block while the user's own voice was highlighted. In this way, the nervous system at the brain would be activated and trained. Also, the patient perceived difference in his voice, stimulating the frontal lobe, parietal lobe as well as other part of the brain relevant to attention. Therefore, cognitive functions gradually recovered.

In summary, speech-auditory feedback training can effectively improve the cognitive functions of stroke patients. It is simple to apply and guarantees high patient compliance, serving as a great intervention modality for rehabilitation of cognitive functions in patients with stroke.

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(Received on 2017-03-16)