Evaluating the Effect of Comprehensive Intervention on Cerebro-Vascular Function in Population at High Risk of Stroke

Xiangxiang Liu, MD, Yaohua Gu, MD, Yuting Zhang, MD, Yanan Zhang, MD, and Xiaodong Tan, PhD

Background: Today there exists few intervention researches on cerebro-vascular function in populations at high risk of stroke in China. *Methods:* Patients more than 40 years old, with at least 1 of stroke risk factors were recruited from outpatient department in 3 hospitals. A quasi-experimental design was performed by assigning participants into 3 groups: comprehensive intervention group, health education group, and control group. Participants in the control group received no intervention but were informed of risk factors of stroke. For health education group, a health education class was performed. Except to the health education program, participants in the comprehensive intervention group received an additional health life and behavior guidance. *Results:* After the intervention, the Cerebro-Vascular Function Scores (CVFS) had significant differences among 3 groups ($F = 5.252$, $P < 0.05$). There was a significant increase in CVFS compared to the control group ($P = 0.003$, 95%CI: 1.552-8.493). Significantly changes in obesity were observed in comprehensive intervention group before and after the intervention ($\chi^2 = 9.0747$, $P = 0.0026$). The results of logistic regression showed that comprehensive intervention group had a significant decrease in prevalence of obesity (OR = 0.482, 95% CI: 0.242-0.961) compared to the control group. *Conclusion:* Health education on stroke in a high-risk population combined with guidance on proper health life and behavior can be effective in preventing stroke.

Key Words: Stroke—high-risk population—Cerebro-Vascular Function Scores—intervention—health education

Introduction

Stroke is the second leading cause of death and the leading cause of acquired disability worldwide.[1] In 2013, there were nearly 25.7 million stroke survivors globally, 6.5 million deaths due to stroke, 10.3 million new cases of strokes, and 113 million disability-adjusted life-years lost because of stroke.[2] China is one of the countries with the largest number of stroke cases, with high incident, high recurrence rate, and high mortality. A review reported that the age-sex standardized mortality of stroke was 126.98 per 100,000 person-year; the incidence was from 116 to 219 per 100,000 person-year; the prevalence was from 2.6 to 7.2 per 1000 persons; and the age-sex standardized disability-adjusted life-years lost was 2101.5 per 100,000 person-year.[2] As such, stroke poses a major public health burden in China. Without intervention, the global death toll due to stroke is expected to reach 78 million by 2030.

Epidemiological studies have demonstrated that stroke is a complex, multifactorial disease caused by a combination of cerebro-vascular factors, environmental factors, and hereditary factors.[3] Family history of cardiovascular diseases (CVD) is considered a nonmodifiable, hereditary risk factor for stroke.[4-6] Modifiable risk factors for ischemic stroke include hypertension, diabetes mellitus (DM), dyslipidemia, sleep apnea, obesity[7], and transient ischemic attack (TIA) history.[8-9] Lifestyle modifications, including tobacco cessation, decreased alcohol use,[10] and

From the School of Health sciences, Wuhan University, Wuhan 430071, China.

Received February 26, 2019; revision received May 19, 2019; accepted June 2, 2019.

Financial Support: None.

Conflict of Interest: The authors declare no conflict of interest.

Address correspondence to Xiaodong Tan, School of Health sciences, Wuhan University, No.115 of Donghu Road, Wuhan, China. E-mail: 2016103050004@whu.edu.cn.

1052-3057/$ - see front matter

https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.06.003

increased physical activity,[11-14] are also important in the management of patients with a history of stroke or TIA.[7] Many studies have suggested that comprehensive interventions were urgently needed to control risk factors, reduce the risk of disease, and improve health.[15-17] However, in China, the treatment of stroke mainly based on traditional medical treatment,[18] and the early prevention was insufficient. The disease does not get the attention it deserves, and as such there is an urgent need to develop a comprehensive intervention method for stroke prevention.

Despite the great importance of taking actions to reduce morbidity of stroke, there is currently a lack of relative research in China. The primary purpose of this study was to evaluate the effect of different types of intervention aiming at reducing risk factors of stroke. In this study, we have conducted a comprehensive intervention on stroke patients based on the major known risk factors. This was done by establishing 2 intervention groups and 1 control group. We hope that the knowledge gained from this study will help in development of interventions targeting population at high risk of stroke.

Materials and Methods

Study Design and Participants

This study was conducted at 3 different hospitals in Wuhan, the capitol of Hubei Province, located at the central of China and with a population of roughly 10 million people. Hospital A, a general hospital equipped with 200 ward beds and 500 outpatient visits per day; Hospital B, a general hospital equipped with 100 ward beds and 400 outpatient visits per day, and Hospital C, a general hospital equipped with 120 ward beds and 400 outpatient visits per day. All of the selected hospitals are nonprofit hospitals. The participants of this study are all from high-risk populations and have similar demographic characteristics, such as age, gender, income, marital status, educational background, and occupation ($P > 0.05$). A convenience sample of patients was recruited to complete a questionnaire individually in outpatient department settings. Inclusion criteria were: (1) patients were above 40 years old, (2) had one of following risk factors, including hypertension, diabetes, dyslipidemia, TIA, obesity, smoking, and drinking, (3) had no infectious diseases, (4) no previous stroke, (5) lived in Wuhan city more than 6 months, (6) were able to read, write, and speak Mandarin, and (7) agreed to participate by signing a consent form. Participants who were pregnant women, who had a family history of CVD, who did not complete the intervention measures, who did not return to the hospital to complete the reinvestigation after 12 months, or who were lose to follow-up, were excluded.

Baseline Data Collection

Data on demographic information, lifestyle risk factors, medical history of the participants, history of TIA, and family history of CVD were collected form standard questionnaires written in Chinese. In the baseline questionnaires, the participants were asked whether they smoke, whether they drink alcohol, whether they had a history of TIA, and whether they had family history of CVD. Cigarette smoking was defined as having smoked at least 1 cigarette per day in the past 12 months. Alcohol consumption was defined as consuming any alcoholic beverage containing at least 25 g alcohol once a day on average in the past 12 months. Family history of CVD was defined as having at least 1 person with diagnosed CVD among first-degree relatives, or at least 2 people with diagnosed CVD among second-degree relatives.

Body weight and height were measured by trained nurses with participants wearing light clothing and without shoes. The body mass index (BMI) was calculated using weight in kilograms divided by the square of the height in meters (kg/m^2). Obesity was defined as BMI > 24 kg/m^2. Blood pressure measurement was taken by trained nurses using a mercury sphygmomanometer after the participants had rested for at least 5 minutes. Hypertension was defined as SBP $\geqq$ 140 mmHg and/or DBP $\geqq$ 90 mmHg and/or use of antihypertensive medication in the last 2 weeks. Fasting blood samples were gathered from all subjects using an automatic biochemical analyzer after at least 8 hours of fasting. Diabetes was defined as fasting blood glucose $\geqq$7.0 mmol/L. Dyslipidemia was diagnosed based on the levels of triglycerides, total cholesterol, and high-density lipoprotein cholesterol, which were assessed enzymatically on a Beckman Synchrony CX5 Delta Clinical System using commercial reagents.

Cerebro-Vascular Function Scores (CVFS) were measured by trained medical technicians using a Cerebro-Vascular Function Testing (CT-300, Shenzhou Gaote Medical Equipment Company, LTD, Shanghai, China). Each subject laid down in bed, and a trained technician measured the bilateral common carotid artery, 10 indexes were measured, including mean blood flow (Qmean), maximum cerebral blood flow velocity (Vmax), minimum cerebral blood flow velocity (Vmin), mean velocity (Vmean), peripheral resistance (Rv), specific impedance (Zev), pulse wave velocity (Wv), dynamic resistance (DR), critical pressure (Cp) and the difference of diastolic blood pressure and the critical pressure (Dp). The indicators of cerebral hemodynamics were scored based on a built-in software of the instrument. Method of score: a score value of 100 points was assigned to each index based on the weight of stroke risk, then the score was deducted according to the weight of each index deviated from the normal reference value. The CVFS were calculated as 100 minus the cumulative deducted score. The score ranged from 0 to 100 points, with 75 as the cut-off point. Individuals with <75 points were at high risk of stroke. The lower the score, the higher risk of stroke.

Ethical Statements

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Wuhan University of ethics committee. Written informed consent was obtained from all subjects/patients.

Intervention Type and Measures

Participating patients were systematically assigned into one of the 3 groups:

Control group: Eligible patients recruited in Hospital C were assigned to this group. Participating patients were informed of risk factors about stroke without any intervention.

Health education intervention group: Eligible patients who saw a doctor in Hospital B were assigned into this group. Participating patients received a three-folded pamphlet about stroke prevention, a cerebro-vascular health management manual, and a standardized educational class about stroke and its prevention and implications during their hospital stay. The three-folded pamphlet included the cover and 5 sections about health management concerning stroke, high-risk population of stroke, CVFS and health registers and health advice, and examples of stroke victims' stories. The manual on cerebro-vascular health management included the contents of three-folded pamphlet, baseline questionnaire, follow-up questionnaire from the first to twelfth visit, and the evaluation questionnaire of intervention effect. The standardized stroke health education class involved in the pathogenesis, risk factors, prevention and intervention of stroke. Each class began at 10:30 am and lasted about 30 minutes. Before the class, the participants were told to register their basic information (eg, name, ID, telephone number, et al) to ensure no one previously received the class by a trained nurse.

Comprehensive intervention group: Eligible patients who went to Hospital A were assigned into this group. Receiving the same education materials as the health education group, however participating patients received an additional guidance regarding health and lifestyle before they left the hospital. The guidance was conducted by a nurse, mainly included daily oil intake, salt intake, dietary pagoda, and exercise intensity. An adult should consume no more than 6 g of salt per day, including sauces, pickles, MSG, and other condiments, and no more than 25 g of oil a day, which includes cooking oil and fats from foods such as pork.

The balanced diet pagoda is launched by the Chinese Nutrition Association, which presents a nutritionally ideal dietary pattern. The balanced diet pagoda consists of 5 layers and contains the main types of food we should eat every day. The location and area in each layer of the pagoda are different, reflecting the status and proportion of various foods in the diet. Cereal is at the bottom. Healthy adults should consume between 250 g and 400 g of cereal per day. Vegetables and fruits are in the second layer. Healthy adults should consume 300-500 g and 200-400 g each day. Fish, poultry, meat, eggs, and other animal food are located in the third layer. Healthy adults should consume 125-225 g of animal food every day (including 50-100 g of fish and shrimp, 50-75 g of livestock and poultry meat, and 25-50 g of eggs). Dairy and soy foods form the fourth group. Healthy adults should consume 300 g of dairy and dairy products and 30-50 g of soy and soy products per day. At the top of the fifth tower are cooking oil and salt.

The exercise intensity is the strength and tension of the body. Appropriate exercise intensity can effectively improve the body function and enhance physical fitness. Excessive exercise will lead to excessive lactic acid material, making the body too much acid, causing acid-base imbalance, damaging body health. A low-intensity exercise, such as shadowboxing, swordplay, run, jog, walk, and dance are good for health. A 30 minutes of shadowboxing per day can significantly improve the level of high-density lipoprotein after a month, which is beneficial to the prevention and treatment of arteriosclerosis and CVD.

Intervention Data Collection and Survey Instruments

At each hospital 3 trained nurses carried out each respective function. One nurse was responsible for recruiting eligible participants, signing informed consent forms, and distributing three-folded brochures and cerebro-vascular health management manuals before the intervention. The second nurse was responsible for collecting baseline data, including name, gender, age, smoking, drinking, history of history, height, weight, BMI, blood pressure, blood glucose, blood lipid, TIA history, and CVFS. Following complete baseline assessment, enrolled participants were then assigned to one of the 3 groups and received the different intervention measures. The last nurse was responsible for carrying out the standardized stroke health education class, and giving health and lifestyle guidance.

Twelve months later, the nurse made telephone to call the participants back for indicators measure and assessment. And the participants who did not go to hospital for review, who did not finish the 12 months follow-up, or who refused to participate in the research were excluded. The study was conducted from December 2016 to January 2018.

The survey instruments at baseline and follow-up were developed by the research team based on the hospital information registration system and the team's previous screening work of stroke. The questions asked included the following 4 parts: CVFS, risky factors, prevention measures and doctor's diagnosis and suggestion.

CVFS: A comprehensive index was used to evaluate cerebral vascular function and stroke risk in a quantitative way. The 10 related indexes, including Qmean, Vmax, Vmin, Vmean, Rv, Zev, Wv, DR, Cp, and Dp which reflected the cerebral blood supply and cerebral vascular elasticity were obtained from the neck detection by using a carotid artery detection which is a noninvasive method. The CVFS were then calculated based on a built-in software integrated in the instrument.

***Risk factors related behaviors*:** Eight items were included, about patients' blood pressure, blood glucose, blood lipid, BMI, drug treatment, smoking, drinking, and TIA history.

***Prevention measures*:** Three survey items were designed to measure life style (eg, tobacco smoking, alcohol drinking, daily intake of oil and salt, and daily exercise), risky factors treatment (eg, smoking cessation, alcohol cessation, more exercise, low salt, low oil, and low sugar), and pharmacological intervention (if necessary given by a physician based on the severity of patients illness).

Doctor's diagnosis suggestion: All the patients received a doctor's diagnosis and suggestion according to each patient's individual situation and treatment.

Demographic information collected included: Age, gender, income, marital status, educational background, and occupation.

Statistical Analysis

Survey data were entered EpiData version 3.0 for Windows and then analyzed using SPSS version 19.0 (version 20, SPSS Inc., Chicago, IL). All the data were double-entered to ensure quality. The characteristics of participating patients were described using descriptive statistics. The differences in CVFS, risky behaviors, and morbidity of stroke were evaluated before and after the intervention using chi-square tests. Logistic regression was used to assess the effects of different intervention measures on CVFS, risk factors, and related behaviors, using the control group as a reference. The significance level was set at $\alpha = 0.05$ and used the 2-sided test in statistical analysis.

Results

Characteristics of Participating Patients

Four hundred and eighty-four patients in the 3 hospitals were invited to participant in the study. Out of these, 484 patients were enrolled in the study, while 77 were excluded (15 refused to participate in the study, 55 were not eligible, and 7 had incomplete baseline surveys). Of the 407 enrolled patients, 164 were in the comprehensive intervention group, 116 were in the health education group, and 127 were in the control group. Twelve months after the interventions, 153 patients remained in the comprehensive intervention group, 108 in the health education group, and 118 in the control group completed the follow-up surveys. Of the 28 patients who were lost to follow-up, 11 patients were impossible to reach for contact, 9 declined to participate, and 8 did not complete the follow-up survey (see Fig 1).

No significant differences were observed in demographic characteristics among the 3 groups (see Table 1). The average age of patients in the comprehensive intervention group, health education group, and control group were as follow: 60.73 ± 11.456, 62.58 ± 9.924, and 63.55 ± 10.850 years old respectively, with no significant difference ($F = 2.376$, $P = 0.094$). Circa half of the participating patients (51.19%) were male and had only attended primary school or lower education. About 51.98% of patients self-reported that their household income was more than 3000 Yuan per month. More than half (53.29%) of the patients were workers or farmers, and 42.74% of patients worked in enterprises or institutions.

Changes in the CVFS After the Intervention

The CVFS ranged from 0 to 100 points, with 75 as the cut-off point. A scores higher than 75 out of 100 points were defined normal cerebro-vascular function. Scores between 50 and 74 points were defined as moderate damage of cerebro-vascular function. A CVFS between 25 and 49 points were defined as considerable damage of cerebro-vascular function. A CVFS between 0 and 24 points were defined as severe damage of cerebro-vascular function.

Before the intervention, the CVFS in the comprehensive intervention group, the health education group, and the control group were 75.304 ± 17.6771, 78.085 ± 14.2207, 77.473 ± 15.6800 respectively, without statistically significant differences ($F = 2.790$, $P = 0.063$) (see Table 2). After the intervention, the average score of 3 groups were 87.980 ± 12.0051, 85.148 ± 13.9937, 82.958 ± 12.5580, with statistically significant differences ($F = 5.252$, $P = 0.006$) (see Table 2). Afterward a pair-wise comparison was made, using the Dunnett t test, and the results showed that a significant increase in CVFS between the comprehensive intervention group and the control group after the intervention ($P = 0.003$, 95% CI: 1.552-8.493). No differences existed between the control group and the health education group ($P = 0.329$, 95% CI: −1.581 to 5.962) (see Table 3).

Changes in Risky Factors Related Stroke After Intervention

When comparing the changes in risky factors among 3 groups after the intervention, the chi-square was conducted

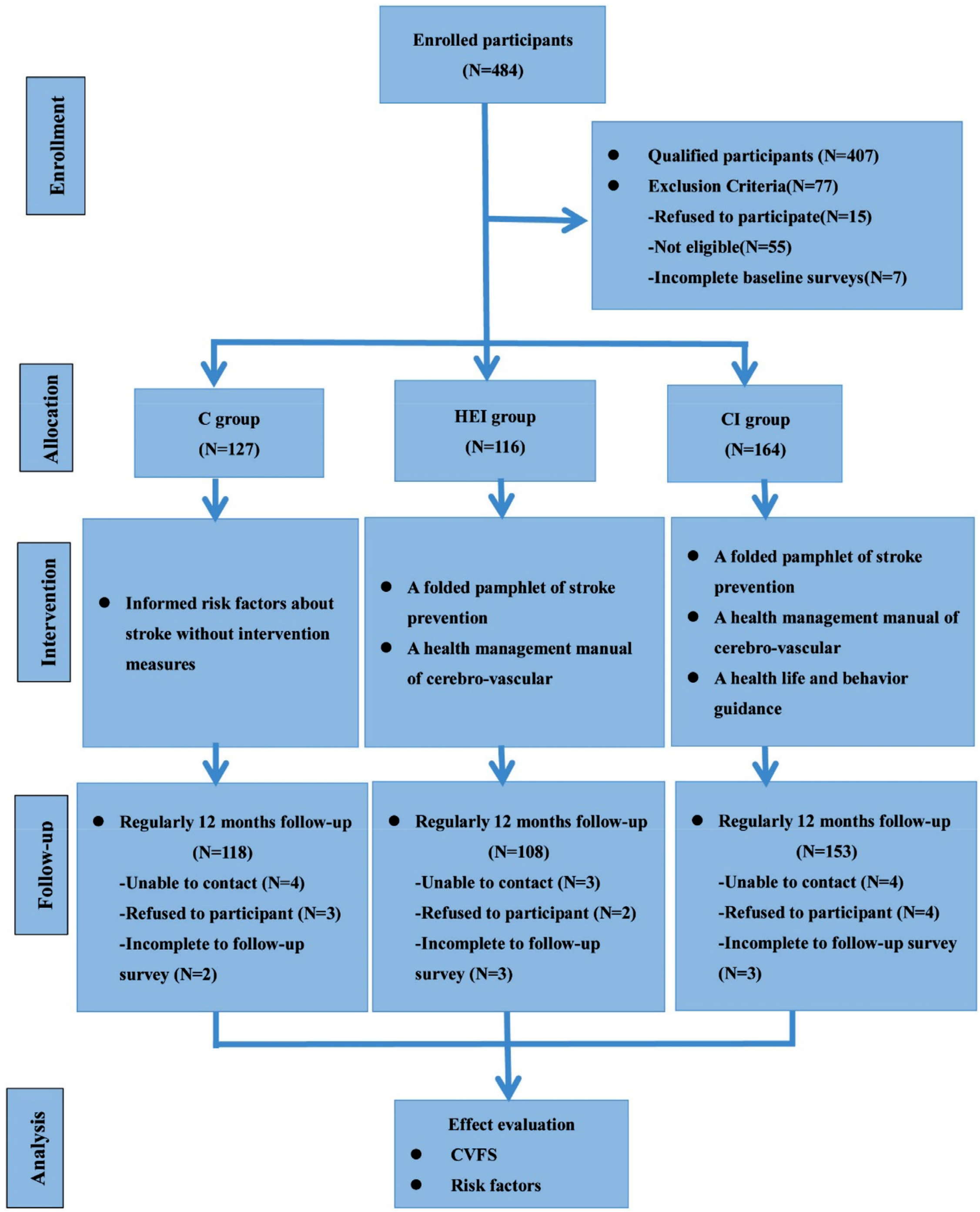

Figure 1. *The procedures of study.*

by SPSS 19.0 software, and the results showed statistically significant differences in obesity among 3 groups ($\chi^2 = 8.944$, $P = 0.011$). Further pairwise-comparisons were made to determine which 2 groups were different, using adjusted for the Alpha value (according to the calibration standard formula $\boldsymbol{\alpha}' = \boldsymbol{\alpha}/2(\boldsymbol{\kappa} - 1)$, where α was 0.05; and κ was the number of groups, $\alpha' = 0.05/2\ (3 - 1) = 0.0125$. We found a statistical difference between the comprehensive intervention group and the control group ($\chi^2 = 8.1438$, $P = 0.0043$). However, differences between the health education group and the control group were not significant ($\chi^2 = 0.5416$, $P = 0.4618$), neither between the comprehensive intervention group and education intervention group ($\chi^2 = 4.5689$, $P = 0.0326$). The results suggest that the health education intervention alone did not have significant effect in changing the risk factors related to stroke. However,

Table 1. *Demographic characteristics of surveyed patients among 3 groups*

Items	CI group		HEI group		C group		χ2	*P* value
	N	R (%)	N	R (%)	N	R (%)		
Gender							0.262	0.877
Male	76	49.67	57	52.78	61	51.69		
Female	77	50.33	51	47.22	57	48.31		
Age								
40-49	30	19.61	10	9.26	13	11.02	9.294	0.054
50-59	46	30.07	28	25.93	31	26.27		
≥60	77	50.33	70	64.81	74	62.71		
Marital status								
Married	145	94.77	101	93.52	111	94.07	0.187	0.911
Unmarried and others	8	5.23	7	6.48	7	5.93		
Degree of education								
University or above	6	3.92	5	4.63	4	3.39	9.360	0.053
High school	101	66.01	56	51.85	59	50.00		
Primary school or below	46	30.07	47	43.52	55	46.61		
Profession								
Enterprise and institution	62	40.52	49	45.37	51	43.22	0.944	0.918
Workers or farmers	85	56.21	54	50	63	53.39		
Other	6	3.27	5	4.63	4	3.39		
Household per capita income								
<¥3000	71	46.41	59	54.63	52	44.07	2.788	0.248
≥¥3000	82	53.59	49	45.37	66	55.93		

C, Control; CI, Comprehensive Intervention; HEI, Health Education Intervention.

when the health education intervention was combined with a lifestyle and behavior guidance, it had a significant effect on stroke prevention.

Significantly changes in risk factors relating to stroke after the intervention was observed in the comprehensive intervention group, regarding the hypertension ($\chi^2 = 5.8824$, $P = 0.0153$) and obesity ($\chi^2 = 9.0747$, $P = 0.0026$). But no significantly changes in dyslipidemia ($\chi^2 = 0.8559$, $P = 0.3549$), diabetes ($\chi^2 = 0.0956$, $P = 0.7571$), smoking ($\chi^2 = 0.0756$, $P = 0.7833$), alcohol drinking ($\chi^2 = 0.0829$, $P = 0.7734$), drug treatment ($\chi^2 = 0.6513$, $P = 0.4196$) and TIA history ($\chi^2 = 0.4416$, $P = 0.5064$) (see Table 3). No significantly changes in risky factors related to stroke after the intervention was observed in the health education intervention group, regarding the hypertension ($\chi^2 = 1.2843$, $P = 0.2571$), diabetes ($\chi^2 = 0.0452$, $P = 0.8316$), dyslipidemia ($\chi^2 = 0.2204$,$P = 0.6387$), obesity ($\chi^2 = 0.1277$, $P = 0.7208$), drug treatment ($\chi^2 = 0.4071$, $P = 0.5234$), smoking ($\chi^2 = 0.1142$, $P = 0.7355$), alcohol drinking ($\chi^2 = 0.1548$, $P = 0.6940$), and TIA history($\chi^2 = 0.1227$, $P = 0.7261$). There was also no significantly changes in risky factors related to stroke at follow-up was observed in the control group, regarding the hypertension ($\chi^2 = 0.6586$, $P = 0.4171$), diabetes ($\chi^2 = 0.0000$,$P = 1.0000$), dyslipidemia ($\chi^2 = 0.0482$, $P = 0.8263$), obesity ($\chi^2 = 2.0978$, $P = 0.1475$), drug treatment ($\chi^2 = 01621$, $P = 0.6872$, smoking ($\chi^2 = 0.1528$, $P = 0.6959$), alcohol drinking ($\chi^2 = 0.0352$, $P = 0.8511$), and TIA history ($\chi^2 = 0.3576$, $P = 0.5499$). The results were showed in Table 4.

Effects of the Intervention on Comprehensive Measures

The results of logistic regression showed that comprehensive intervention group had a significant decrease in prevalence of obesity (odds ratio = 0.482, 95% confidence

Table 2. *The pre- and postintervention comparative results on Cerebro-Vascular Function Scores (CVFS) among 3 groups*

Scores	Group	SS_{total}	*df*	*MS*	*F*	*P* value
Prointervention CVFS	Between group	1358.858	2	679.429	2.790	0.063
	Within group	91576.590	376	243.555		
	Total	92935.448	378			
Postintervention CVFS	Between group	1712.847	2	856.423	5.252	0.006
	Within group	61310.859	376	163.061		
	Total	63023.706	378			

Table 3. *The pairwise comparative on CVFS among 3 groups after the intervention*

Groups	Mean difference	SE	*P* value	95%CI	
CI vs C	5.0228	1.5645	0.003	1.552	8.493
HEI vs C	2.1905	1.7005	0.329	−1.581	5.962

C, Control; CI, Comprehensive Intervention; HEI, Health Education Intervention.
*Dunnett test, $\alpha = 0.05$.

interval, CI: 0.242-0.961) compared to the control group. While the health education group had no statistically decrease in any risk factors as compared to the control group (see Table 5). The results suggested that the comprehensive intervention measures had an effect on obesity.

According to results, the changes of CVFS and obesity had statistically significant in the comprehensive intervention group. Thus, we compared the relationship between BMI and CVFS, and the results showed that there was an increased risk of stroke on obese population. Figure 2 shows the CVFS estimates from the nonlinear does-response analysis for selected BMI values. The CVFS was not less than 75 points at the low BMI range (<24 kg/m^2), but was less than 75 points at the high BMI range (>25 kg/m^2). In the comprehensive intervention group, the CVFS increased apparent after intervention, and the interval increased most of BMI was from 27.34 kg/m^2 to 29.39 kg/m^2 (see Fig 3). In the education intervention group, CVFS slightly increased after intervention (see Fig 4). In the control group, there was little difference in CVFS before and after intervention (see Fig 5).

Discussion

At present, most of the screening methods for stroke revolve around imaging processing, of which Cerebro-Vascular Function Testing is widely used,[19-21] and has been used as a reference for screening high-risk population. Compared with digital subtraction angiography, it has the advantages of being noninvasive, radiation-free and simple operation, and is more acceptable by patients and clinicians.[21] We measured 10 different indexes including blood flow and blood direction measurements, and finally a comprehensive index called cerebral hemodynamics was scored based on a built-in software integrated into the instrument. Existing research shows that the sensitivity, specificity and area under ROC curve of CVFS used an early warning signal for stroke were 80.8%, 67.6%, and 0.81 respectively, indicating that cerebral hemodynamic function score was a sensitive method to assess the risk of stroke.[22]

As an effect of the population growing older, the incidence of stroke is increasing year by year, which puts a great burden to individuals, families, and society as whole.[23] It is easy to be ignored by medical staff and patients at its early stage, but once stoke occurs the consequences might be very severe. Stroke is a disease which heavily depends on a patient's behavior, whose occurrence and outcome are related to patients' awareness of the disease, lifestyle, and self-management consciousness.[14] On the basis of education intervention, such as changing bad behavior, controlling and treating risk factors, it is of great significance to further adopt and develop simple, noninvasive and economically sound means to screen high-risk individual for stroke at an early stage and conduct targeted interventions to reduce the incidence and mortality of stroke.[21]

This study evaluated the effect of comprehensive intervention (health education plus health life and behavior guidance intervention) strategies to improve CVFS and reduce the prevalence of stroke among a high-risk population in one of 3 hospitals. The results showed that comprehensive intervention was effective in improving CVFS

Table 4. *The pre- and postintervention comparative results on risk factors among 3 groups**

Risk factors	CI group		*P* value	HEI group		*P* value	C group		*P* value
	pre	post		pre	post		pre	post	
Hypertension	61	41	0.0153	43	35	0.2571	46	40	0.4171
Dyslipidemia	8	12	0.3549	9	11	0.6387	11	12	0.8263
Diabetes	24	26	0.7571	12	13	0.8316	12	12	1.0000
Obesity	33	14	0.0026	18	20	0.7208	14	22	0.1475
Pharmacotherapy	20	25	0.4196	11	14	0.5234	13	15	0.6872
TIA history	19	23	0.5064	19	21	0.7261	28	32	0.5499
Smoking history	35	33	0.0756	21	23	0.7355	14	16	0.6959
Alcohol drinking history	31	29	0.7734	16	14	0.6940	16	17	0.8511

*C, Control; CI, Comprehensive Interention; HEI, Health Education Intervention

Table 5. *The Results of Binomial Logistic Regression on risk factors**

Risk factors	Group†	*β*	*OR*	*95%CI*		*χ2*	*P* value
Hypertension	CI	0.337	1.401	0.831	2.363	1.597	0.405
	HEI	0.067	1.070	0.614	1.863	0.057	0.812
Dyslipidemia	CI	0.285	1.330	0.575	3.078	0.444	0.505
	HEI	−0.002	0.997	0.421	2.367	0.000	0.997
Diabetes	CI	−0.592	0.553	0.266	1.149	2.523	0.112
	HEI	−0.190	0.827	0.360	1.901	0.199	0.655
Obesity	CI	−0.729	0.482	0.242	0.961	4.293	0.038
	HEI	−0.063	0.939	0.482	1.827	0.035	0.852
Pharmacotherapy	CI	−0.294	0.746	0.374	1.488	0.694	0.405
	HEI	−0.022	0.978	0.448	2.133	0.003	0.955
TIA history	CI	0.743	2.103	1.153	3.836	5.887	0.015
	HEI	0.433	1.542	0.824	2.883	1.836	0.175
Smoking history	CI	−0.561	0.570	0.297	1.096	2.841	0.092
	HEI	−0.545	0.580	0.288	1.167	2.331	0.127
Alcohol drinking history	CI	−0.329	0.720	0.374	1.384	0.972	0.324
	HEI	0.122	1.130	0.528	2.419	0.099	0.753

*Consider the control group as reference group;
†CI, Education Plus Free CSS; HEI, Health Education Intervention.

and reducing the prevalence of stroke measured 12 months after the intervention. Specifically, in the comprehensive intervention group, the risk factor (obesity) decreased and CVFS increased significantly after the intervention. At the 12-month follow-up, the prevalence of stroke in the comprehensive intervention group was significantly lower than prevalence in the health education only group and control group. These findings have demonstrated that education about stroke prevention and management coupled with lifestyle and behavior guidance was effective in improving CVFS and reducing the risk factors of stroke.

While the health education group did not show a significant change in CVFS and risk factors after the intervention; the CVFS did increase from 78.085 ± 14.2207 to 855.148 ± 13.9937. Moreover, when compared to

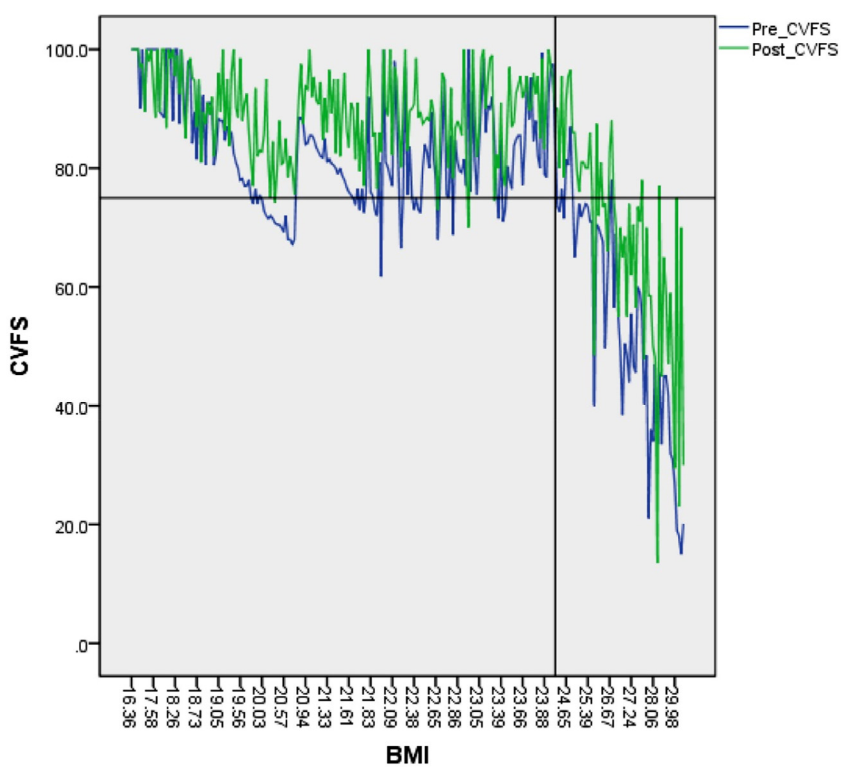

Figure 2. *The relationship between CVFS and BMI in pre- and postintervention among 3 groups. CVFS, Cerebro-Vascular Function Scores.*

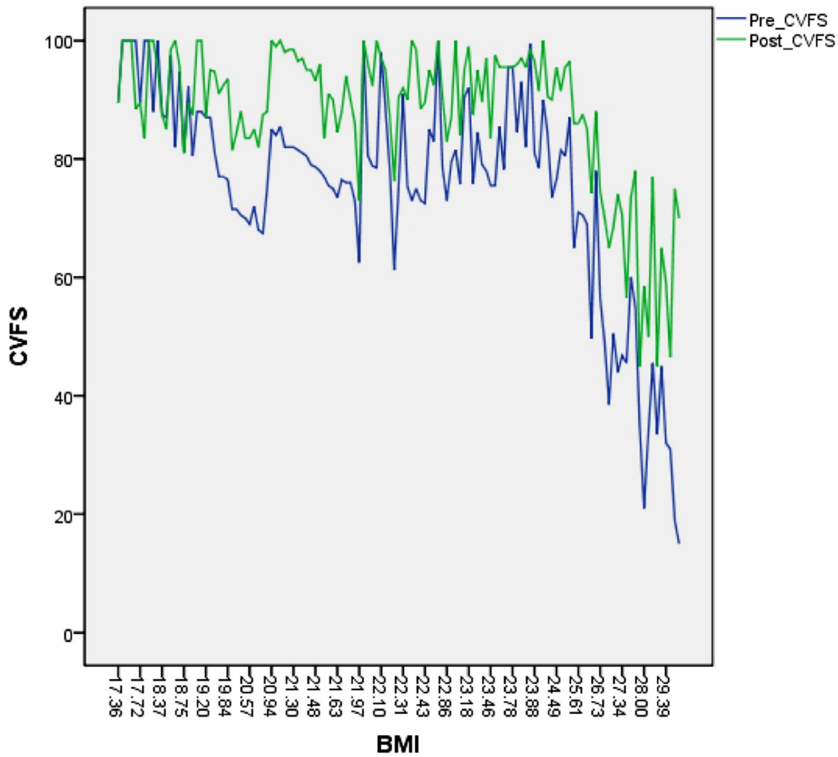

Figure 3. *The relationship between CVFS and BMI in pre- and postintervention in the CI group. CI, Comprehensive Intervention; CVFS, Cerebro-Vascular Function Scores.*

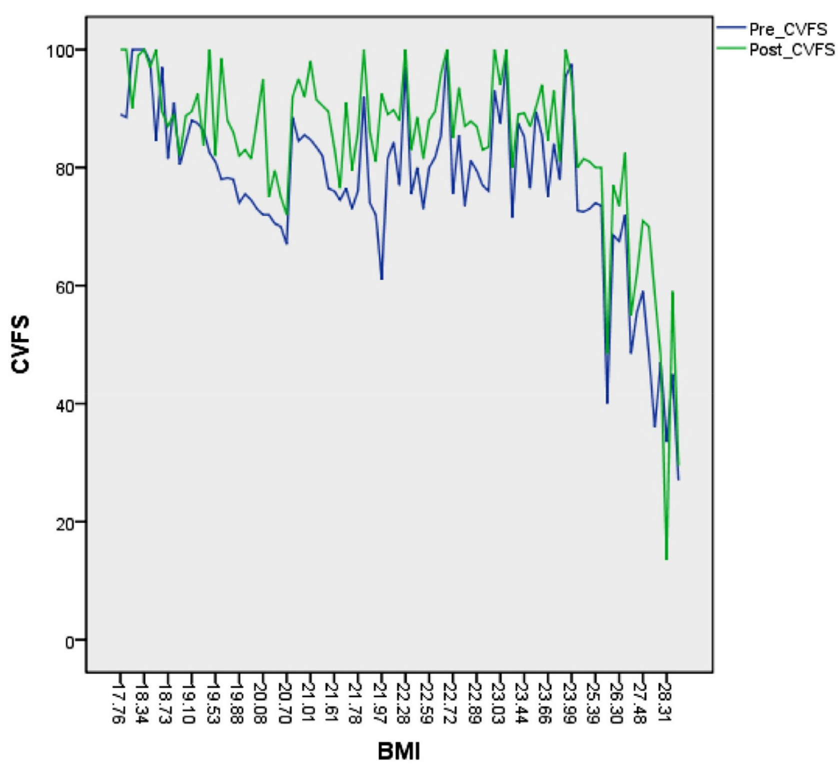

Figure 4. *The relationship between CVFS and BMI in pre- and postintervention in the HEI group. CVFS, Cerebro-Vascular Function Scores; HEI, Health Education Intervention.*

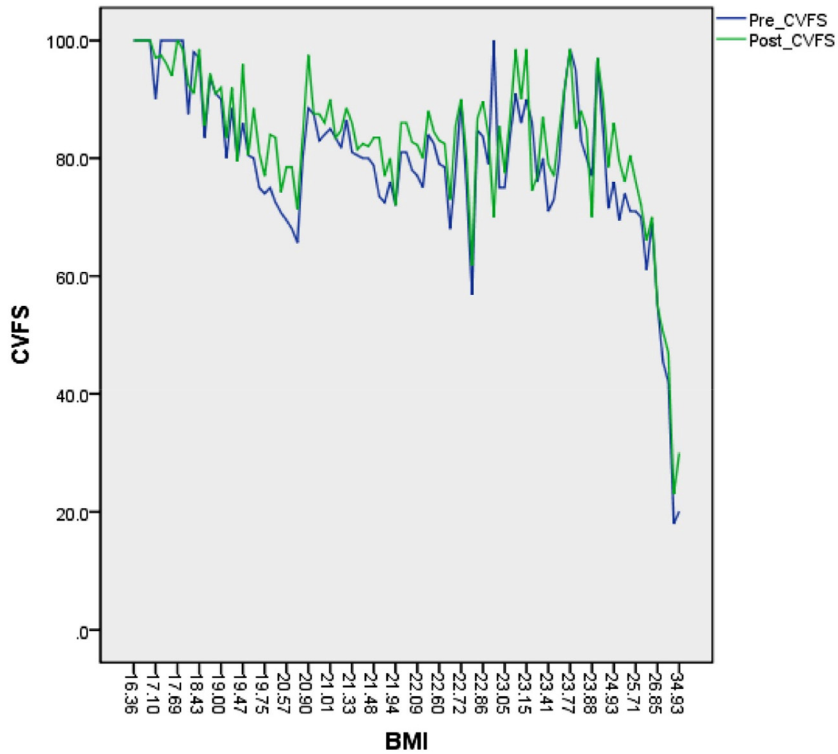

Figure 5. *The relationship between CVFS and BMI in pre- and postintervention in the C group. CVFS, Cerebro-Vascular Function Scores.*

participants in the comprehensive intervention group (in which CVFS increased from 75.304 ± 17.6771 to 87.980 ± 12.0051), the effect in the education intervention group were shown to be smaller. These findings suggested that education without lifestyle and behavior guidance might be insufficient in improving CVFS of high-risk population.

Existed evidence have shown that obesity, measured as BMI, is an independent risk factor for stroke.[24-27] Our results suggest that the BMI has a nonlinear does-response relationship with CVFS. The risk was not increased when BMI was less than 24 kg/m^2, while was increased when BMI was more than 25 kg/m^2. This result was similar with Ji Wan Park' s study in Korean.[28] The pathogenesis of obesity may be: (1) obesity leads to hypertension, hyperlipidemia, and hyperglycemia, (2) adipose tissue is an endocrine organ that can release a variety of inflammatory mediators that promote atherosclerosis and alter the coagulation and fibrinolysis systems. Inflammatory mediators such as free fatty acids of obesity and tumor necrosis factor α (TNF α) induce continuous stress in the endoplasmic reticulum, leading to insulin resistance, which can lead to atherosclerosis and affect CVFS. Even if obesity is related to DM, it is well known that it takes years to reduce cardiovascular risks by controlling DM. However, this study did not find changes in DM before and after intervention statistically, which may be related to the low number of diabetic patients or the short intervention time.

Obesity is recognized as an important risk factor for primary stroke in the general population and treatment for obesity is recommended as stroke prevention by American Heart Association and the American Stroke Association.[25] In our study, an intervention combining health education and lifestyle and behavior guidance was effective in losing weight, especially in an obese population whose BMI was between 27 kg/m^{2}and 29 kg/m^2. Thus, the intervention measures in comprehensive group might be extended to future researches related to weight loss.

Our results also indicates a lack of knowledge of risk factors in a high-risk population in China. Before the intervention, even though 70 (18.67%) of the participants knew tobacco smoking was harmful for their health, they were still tobacco users. Of 375 participants, 331 (88.27%) potential patients reported they had not received pharmacotherapy even though they had hypertension, dyslipidemia, or diabetes. After the intervention, even though the risk factors of stroke had decreased, nearly 19.2% of patients still were smoking tobacco and 85.6% of the participants still had not received pharmacotherapy; and most of them had not received a high school education. Health education plays a key role in improving people's knowledge, which in turn is a predisposing factor for lifestyle and behavioral change. Our results showed that health education only was not as effective as education plus lifestyle and behavior guidance in reducing risk factors of stroke. Thus, we suggested that comprehensive education programs be developed implemented widely in the future.

Limitations

There are 3 limitations in our study. First, we have a selection bias since the study used convenience sampling to recruit participants. The sample population also only represented the patients in Wuhan, mainly patients above 40 years old who had no infectious diseases. This can not be generalized to all patients in China. To obtain a better representation of the population, a larger scale intervention study among patients in communities is recommended for future study. Second, the long-term effect of the intervention cannot be measured in this short-term study. The effects were measured 12 months after the intervention, which might be too early to evaluate the true effect of the intervention. Chronic diseases, such as hypertension and diabetes, traditionally need to be observed over a long time and treated over many years. Finally, a total of 407 patients completed the intervention, but only 379 parents completed the 12-month follow-up, with the rate of loss to follow-up being 7% (28/407). The reasons for loss to follow-up included no answer, unfinished questionnaire, and refusal to participate. The attrition rate may lead to distortion of the study results. Without the data of participants who did not complete the 12-month follow-up, the effect of intervention measures might be overestimated. Additional steps to reduce loss to follow-up should be included in future studies.

Conclusions

This study evaluated the effects of comprehensive intervention, and compared it to the effects of only health education on improving the CVFS and decreasing the risk factors of stroke. An intervention combining health education and lifestyle and behavior guidance was effective in preventing cerebral stroke on a population with high risk of stroke. This study's findings indicate that more studies with large sample sizes and longer follow-up are needed to determine the long-term effect of the intervention.

Acknowledgments: The authors would like to thank the patients who participated in the study. We are also very grateful to the wonderful at the 3 participants hospitals.

Author Contributions

Conceptualization, Xiangxiang Liu and Xiaodong Tan; Data curation, Xiangxiang Liu; Formal analysis, Xiangxiang Liu; Investigation, Yuting Zhang and Yanan Zhang; Methodology, Xiangxiang Liu; Software, Xiangxiang Liu; Supervision, Xiaodong Tan; Validation, Yaohua Gu and Yanan Zhang; Visualization, Yuting Zhang; Writing – original draft, Xiangxiang Liu; Writing – review & editing, Yaohua Gu and Xiaodong Tan.

References

1. Zhu ZB, Huangfu CK, Zhong XF, et al. Combined effects of family history of cardiovascular disease and serum c-reactive protein level on the risk of stroke: a 9.2-year prospective study among Mongolians in China. Biomed Environ Sci BES 2017;30:632-640.
2. Venketasubramanian N, Yoon BW, Pandian J, et al. Stroke epidemiology in South, East, and South-East Asia: a review. J Stroke 2017;19:286-294.
3. Della-Morte D, Guadagni F, Palmirotta R, et al. Genetics of ischemic stroke, stroke-related risk factors, stroke precursors and treatments. Future Med 2012;13:595-613.
4. Ebell MH. Predicting short-term risk of stroke after TIA. Am Family Physician 2006;74:1001-1002.
5. Uittenbogaart SB, Lucassen WAM, van Etten-Jamaludin FS, et al. Burden of atrial high-rate episodes and risk of stroke: a systematic review. Europace 2018;20:1420-1427.
6. Tian Y, Jia H, Li S, et al. The associations of stroke, transient ischemic attack, and/or stroke-related recurrent vascular events with Lipoprotein-associated phospholipase A2: A systematic review and meta-analysis. Medicine 2017;96:e9413.
7. Oza R, Rundell K, Garcellano M. Recurrent ischemic stroke: strategies for prevention. Am Family Physician 2017;96:436-440.
8. Bender M, Jusufovic E, Railic V, et al. High burden of stroke risk factors in developing country: the case study of Bosnia-Herzegovina. Materia Socio-Medica 2017;29: 277-279.
9. Kleindorfer D, Panagos P, Pancioli A, et al. Incidence and short-term prognosis of transient ischemic attack in a population-based study. Stroke J Cereb Circ 2005;36: 720-723.
10. Parikh S, George P, Wilson K, et al. Alcohol use and hospital readmissions following stroke: A safety net hospital experience. J Neurol Sci 2018;385:83-86.
11. Mohammadi H, Jayedi A, Ghaedi E, et al. Dietary poultry intake and the risk of stroke: A dose-response meta-analysis of prospective cohort studies. Clin Nutr ESPEN 2018;23:25-33.
12. Ilunga Tshiswaka D, Seals SR, Raghavan P. Correlates of physical function among stroke survivors: an examination of the 2015 BRFSS. Public Health 2018;155:17-22.
13. Sato A, Fujita T, Yamamoto Y. Activities of daily living independence level for home discharge in stroke patients based on number of caregivers: an analysis of the Japan Rehabilitation Database. Phys Ther Res 2017;20:23-27.
14. Mury P, Faes C, Millon A, et al. Higher daily physical activity level is associated with lower RBC aggregation in carotid artery disease patients at high risk of stroke. Front Physiol 2017;8:1043.
15. Prabhakaran S, Ruff I, Bernstein RA. Acute stroke intervention: a systematic review. JAMA 2015;313:1451-1462.
16. Lip GYH, Lane DA, Sarwar S. Streamlining primary and secondary care management pathways for stroke prevention in atrial fibrillation. Eur Heart J 2017;38: 2980-2982.
17. Atzema CL. Stroke prevention for high-risk atrial fibrillation in the emergency setting: the emergency physician perspective. Can J Cardiol 2018;34:125-131.
18. Yang XY, Wang LQ, Li JG, et al. Chinese herbal medicine Dengzhan Shengmai capsule as adjunctive treatment for ischemic stroke: a systematic review and meta-analysis of randomized clinical trials. Complement Ther Med 2018;36:82-89.

19. Huang JY, Wang GQ, Yang YJ, et al. Cerebral vascular hemodynamic examination in patients with hypertension and before and after stroke. Chin J Geriatr Cardiovasc Cerebrovasc Dis 2003;5:43-46.
20. Huang J, Guo Z, Shen F, et al. Study on a test of screening to predict stroke using cerebral vascular hemodynamic indexes. China Jf Epidemiol 2002;23:383-386.
21. Li XM, Wang Y, Ye YZ, et al. Effectiveness of application of cerebro-vascular function testing in early screening for cerebro-vascular diseases. Clin Imaging Technol 2015;30:40-43.
22. Zheng Z, Deng J, He C. Study on the effect of screening and intervention management for stroke high-risk individuals. J Mod Med Health 2018;34:2692-2695.
23. Mihejeva I, Vetra A, Berzina G. Factors associated with long-term mortality for stroke unit patients in Latvia. Brain Behav 2018;8:e01152.
24. Liu X, Zhang D, Liu Y, et al. A J-shaped relation of BMI and stroke: systematic review and dose-response meta-analysis of 4.43 million participants. Nutr Metab Cardiovasc Dis 2018;28:1092-1099.
25. Barba R, Marco J, Ruiz J, et al. The obesity paradox in stroke: impact on mortality and short-term readmission. J Stroke Cerebrovasc Dis 2015;24:766-770.
26. Huang K, Liu F, Han X, et al. Association of BMI with total mortality and recurrent stroke among stroke patients: a meta-analysis of cohort studies. Atherosclerosis 2016;253:94-101.
27. Andersen KK, Olsen TS. Body mass index and stroke: overweight and obesity less often associated with stroke recurrence. J Stroke Cerebrovasc Dis 2013;22:e576-e581.
28. Park JW, Lee SY, Kim SY, et al. BMI and stroke risk in Korean women. Obesity (Silver Spring) 2008;16:396-401.