

ORIGINAL RESEARCH



Clinical impact of high-potassium and low-sodium dash diet on H-type hypertension and cognitive impairment in cerebral small vessel disease

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Abstract

Objective

To evaluate the effect of a high-potassium, low-sodium Dietary Approaches to Stop Hypertension (DASH) intervention on cognitive impairment (CI) in patients with H-type hypertension (HHTN) complicated with cerebral small vessel disease.

Methods

A total of 112 patients with essential hypertension admitted to our hospital from February 2022 to February 2023 were enrolled and divided into two groups: the non-HHTN group [plasma homocysteine (Hcy) $<15 \mu\text{mol/L}$, $n=46$] and the HHTN group (Hcy $\geq 15 \mu\text{mol/L}$, $n=66$). The HHTN group was randomly assigned to the control group (CG, $n=33$) or the experimental group (EG, $n=33$). The EG received the high-potassium, low-sodium DASH intervention. General clinical data, clinical indicators, cognitive function scores, and nutritional markers were collected and analyzed.

Results

HHTN patients had significantly higher Hcy, lower Montreal Cognitive Assessment (MoCA)/Mini Mental State Examination (MMSE) scores (worse cognition), and higher Activity of Daily Living (ADL) scores (better daily function) than non-HHTN patients. Hcy correlated negatively with MoCA/MMSE and positively with ADL. Post-intervention, both groups improved nutritional markers [albumin (ALB), hemoglobin (HGB), and transferrin (TFN)], but EG improved more. Hcy decreased and MoCA/MMSE increased (improved cognition) significantly more in EG than CG. ADL increased (improved function) more in EG.

Conclusion

Plasma Hcy concentration is negatively correlated with cognitive function in HHTN patients, suggesting it may be crucial for CI occurrence and progression. High-potassium, low-sodium DASH intervention effectively reduces Hcy and delays CI in cerebral small vessel disease patients, worthy of clinical promotion.

Keywords: H-type hypertension; cerebral small vessel disease; cognitive impairment; dietary approaches to stop hypertension; homocysteine

Introduction

Homocysteine (Hcy), a sulfur-containing non-essential amino acid, is an intermediate product in metabolism of methionine and only exists in trace amounts in the body under normal circumstances^{1, 2}. H-type hypertension (HHTN) refers to a type of primary hypertension with elevated blood pressure accompanied by elevated homocysteine level (Hcy $\geq 10 \mu\text{mol/L}$); incidence rate of males exhibits a marked elevation relative to that of females^{3, 4}. Currently, fast-paced lifestyle has changed people's work and rest patterns; environmental pollution, food pollution, bad eating habits, bad living habits, etc. have led to a marked increase in incidence rate of HHTN⁵. Plasma Hcy level $\geq 15 \mu\text{mol/L}$ is referred to as hyperhomocysteinemia (HHcy)⁶. Research has demonstrated that HHcy and hypertension are two independent risk elements for occurrence and development of cerebrovascular diseases, and they exert a strong joint action, which can lead to a much higher risk of vascular diseases relative to risk of HHcy interacting with other risk elements^{7, 8}. Clinical reports have depicted that over half of vascular cognitive impairment (CI) has association with cerebral small vessel disease (CSVD)^{9, 10}. Mild CI refers to a transitional stage between normal aging and dementia, where

memory or cognitive function is mildly impaired, whereas dementia is not manifested, which is early stage of dementia in the elderly¹¹. Currently, diagnosis of CI is difficult and there is a lack of cure drugs. Thus, controlling hypertension while reducing plasma Hcy level may become a new strategy for preventing and treating vascular CI.

Both domestic and international guidelines for prevention and treatment of hypertension emphasize that a reasonable diet is a crucial and effective means of preventing and treating hypertension¹². The dietary approaches to stop hypertension (DASH) with high potassium and low sodium has achieved significant results in prevention and control of salt-sensitive hypertension¹³.

This research attempted to clarify clinical impact of DASH with high potassium and low sodium intervention on CI of patients with HHTN and cerebral small vessel disease, which may provide a theoretical basis for treatment of HHTN patients with vascular CI.

Materials and methods

General data

The 112 patients with primary hypertension hospitalized at the Affiliated Hospital of Hebei University from February

2022 to February 2023 received selection. All patients met diagnostic criteria recommended in the Guidelines for the Prevention and Treatment of Hypertension in China in 2010. The patients received division into non-HHTN group (Hcy < 15 $\mu\text{mol/L}$) and HHTN group (Hcy $\geq$ 15 $\mu\text{mol/L}$) based on whether to accompany by elevated Hcy level through detection value of plasma Hcy. Non-HHTN group: A total of 46 cases; 26 males and 20 females; mean age was (65.54 ± 3.64) years old; education duration: (8.28 ± 0.94) years. HHTN group: A total of 66 cases; 38 males and 28 females; mean age was (65.92 ± 4.48) years old; education duration: (8.23 ± 0.99) years. Both groups had an education level of junior high school or above, with no marked decline in vision or hearing, and were able to cooperate to complete all scale examinations. According to different nursing intervention models, 66 patients with HHTN received random division into a control group (CG) and an experimental group (EG), with 33 cases each. Exclusion criteria: Those with severe coronary heart disease, atrial fibrillation and cardiac insufficiency, dilated cardiomyopathy, etc.; those with recent manifestations of mental disorders such as anxiety and depression; those with a history of mental illness; anemia, leukemia, hypothyroidism, psoriasis, malignant tumors; those with chronic renal insufficiency who had undergone kidney transplantation surgery; those with a history of a marked decline in liver function due to various reasons; those with a history of addiction to drugs, special drugs, or alcohol dependence; those with a history of traumatic brain injury or stroke; those with a history of coma due to carbon monoxide poisoning or other reasons; those with a history of severe physical diseases such as heart, liver, and kidney; those with other systemic diseases in the body to markedly affect patients' daily life, work, or study; those with a history of taking vitamin B12 or folic acid for various reasons within the past 2 weeks.

Methods

The CG received general nursing, including conventional dietary nursing, and patients maintained their original lifestyle and rest habits, and received conventional dietary guidance. The EG received DASH with high potassium and low sodium intervention, specifically: (1) Adjust intake of major nutrients: Nursing staff should adjust daily intake of major nutrients for patients, with protein ratio adjusted to 18%, carbohydrate ratio adjusted to 55%, and fat ratio adjusted to 27%. Simultaneously, nursing staff should limit daily salt intake of patients to no more than 6 grams per day, and guide patients to consume high potassium and low sodium salts; nursing staff should also limit patients' fat intake to no more than 25 grams per day; nursing staff should guide patients to consume more protein-rich foods, as well as more fruits and vegetables. If patients need to consume 2000 calories of food per day, nursing staff should develop a detailed dietary plan for patients, specifically: A. Patients should consume grains and cereal products 7-8 times per day, with one piece of bread, half a cup of cereal, or half a bowl of rice, noodles, and other cereals. B. Patients should consume low-fat or fat-free dairy products 2-3 times per day, with drinking 230 ml of milk or yogurt or consuming 45 g of cheese each time. C. The patients should consume poultry meat and fish $\leq$ 2 times per day, with a meat intake of 150 g each time. D. Patients should consume vegetables 4-5 times per day, with 170 ml of vegetable juice each time. E. Patients should consume fruits 4-5 times per day, with half a cup of dried fruit, one serving

of raw fruit, 170 ml of fruit juice, or half a cup of fresh (frozen) canned fruit each time. F. Patients should consume half a cup of nuts, 45 g of nuts, 15 g of seeds, or half a cup of dried beans every day. G. Patients should consume low-fat candies 5 times a week, with 1 tablespoon of sugar, jam, or jelly each time, or 15 g of jellybeans each time. H. Patients should consume fat and oil 2-3 times per day, with 1 teaspoon of soft margarine, low-fat mayonnaise or vegetable oil. (2) Dietary health education: When providing DASH interventions for patients, nursing staff should pay attention to providing dietary health education to patients and inform them of importance of dietary treatment for hypertension. Nursing staff should develop a food ingredient content table for patients, indicating energy reference values of fat, carbohydrates, and protein content in each type of food, such as vegetables, cereal products, fish, fruits, skimmed milk, meat, nuts and dried beans, desserts, etc., so that patients and their families can reasonably match their diets according to food ingredient content table. (3) Change dietary structure and habits: In process of implementing DASH intervention, nursing staff should pay attention to improving patients' dietary structure and habits; nursing staff should first eliminate patients' resistance to improving dietary structure and habits, inform patients that establishing a good dietary structure is of great significance for treatment of their own diseases, and arrange for people with rich dietary knowledge and good communication skills to persuade patients, so that patients can consciously improve their own unhealthy dietary structure and habits.

Observation indicators and evaluation criteria

(1) General data: all patients were collected clinical information at admission, such as name, gender, age, height, weight, smoking history, drinking history, coronary heart disease history, hyperlipidemia history, diabetes history, education level, etc. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) received measurement after patients' resting calmly for 20 min.

(2) Clinical indicators: After fasting for 8 h, upper limb venous blood received collection in the morning on the second day of admission. The plasma Hcy, plasma homocysteine, triglycerides (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDLC), high-density lipoprotein cholesterol (HDLC) and other related biochemical indicators received measurement.

(3) Cognitive function scores: All selected patients received evaluation for cognitive function using the Mini Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA) Chinese version, and Activity of Daily Living (ADL) scale. The diagnosis of mild CI is based on commonly applied clinical aMCI diagnostic criteria 14. MMSE scores $\geq$ 26 points and ADL $\leq$ 16 points are classified as normal cognitive function. 24 points < MMSE scores < 26 points and 16 points < ADL $\leq$ 22 points are classified as mild CI. MMSE scores $\leq$ 24 points (secondary school or above education, education years > 6 years); MMSE scores $\leq$ 20 points (primary school education, education years $\leq$ 6 years); MMSE scores $\leq$ 17 points (illiterate and uneducated) and/or ADL > 22 points are classified as CI.

(4) Nutritional indicators: The automatic biochemical analyzer detects the levels of albumin (ALB), hemoglobin (HGB), and transferrin (TFN) in patients with HHTN.

Statistical analysis

SPSS 27.0 software received application to process data. Quantitative data that conformed to normal distribution and homogeneity of variance received expression as ($\bar{x} \pm s$), followed by independent sample t-test for intergroup comparisons. Count data received expression in %, followed by χ^2 test for intergroup comparisons. The correlation between two variables received analysis using Person correlation analysis. $P < 0.05$ indicated statistically significant difference.

Results

Comparison of general data between non-HHTN group and HHTN group

No statistical significance in general data such as gender, age, and years of education exhibited between non-HHTN group and HHTN group ($P > 0.05$; Table 1), indicating comparability.

Comparison of clinical indicators between non-HHTN group and HHTN group

No statistical significance in clinical indicators such as TC, TG, LDLC and HDLC levels, SBP, and DBP exhibited between non-HHTN group and HHTN group ($P > 0.05$). The plasma Hcy level in HHTN group exhibited elevation relative to that in non-HHTN group, indicating statistical significance ($P < 0.05$; Table 2).

Table 1 General data in both groups

Groups	N	Gender (male/female)	Age (years)	Education (years)
Non-HHTN group	46	26/20	65.54 $\pm$ 3.64	8.28 $\pm$ 0.94
HHTN group	66	38/28	65.92 $\pm$ 4.48	8.23 $\pm$ 0.99
χ^2/t		0.012	0.477	0.298
P		0.912	0.634	0.766

Table 2 Clinical indicators in both groups

Groups	Non-HHTN group	HHTN group	t	P
N	46	66		
TC (mmol/L)	5.46 $\pm$ 0.93	5.65 $\pm$ 0.77	1.186	0.238
TG (mmol/L)	1.37 $\pm$ 0.34	1.32 $\pm$ 0.26	0.769	0.443
LDLC (mmol/L)	3.41 $\pm$ 0.47	3.53 $\pm$ 0.51	1.277	0.204
HDLC (mmol/L)	1.20 $\pm$ 0.33	1.17 $\pm$ 0.32	0.565	0.573
SBP (mmHg)	157.00 $\pm$ 5.00	156.00 $\pm$ 6.00	1.017	0.311
DBP (mmHg)	88.00 $\pm$ 8.00	90.00 $\pm$ 5.00	1.935	0.056
Hcy (μ mol/L)	10.27 $\pm$ 1.47	18.40 $\pm$ 1.42	29.401	<0.001

Table 3 Cognitive function scores in both groups

Groups	Non-HHTN group	HHTN group	t	P
N	46	66		
MMSE scores (points)	27.43 $\pm$ 1.57	25.24 $\pm$ 1.16	8.477	<0.001
MoCA scores (points)	25.87 $\pm$ 1.54	22.48 $\pm$ 1.63	11.051	<0.001
ADL scores (points)	21.28 $\pm$ 1.15	24.00 $\pm$ 1.41	10.784	<0.001

Comparison of cognitive function scores between non-HHTN group and HHTN group

The MoCA scores and MMSE scores in HHTN group exhibited depletion relative to those in non-HHTN group, indicating statistical significance ($P < 0.05$). The ADL scores in HHTN group exhibited elevation relative to those in non-HHTN group, indicating statistical significance ($P < 0.05$; Table 3).

Analysis on correlation of plasma Hcy level and cognitive function scores in primary hypertension patients

Pearson correlation analysis depicted that MoCA scores and MMSE scores presented negative correlation with plasma Hcy level in primary hypertension patients, while ADL scores presented positive correlation with plasma Hcy level in primary hypertension patients (Figure 1).

Comparison of nutritional indicators between CG and EG before and after intervention

Before intervention, no statistical significance in ALB, HGB, and TFN levels exhibited between CG and EG ($P > 0.05$). After intervention, ALB, HGB, and TFN levels in CG and EG exhibited elevation relative to those before intervention, and EG exhibited elevation relative to CG, indicating statistical significance ($P < 0.05$; Figure 2).

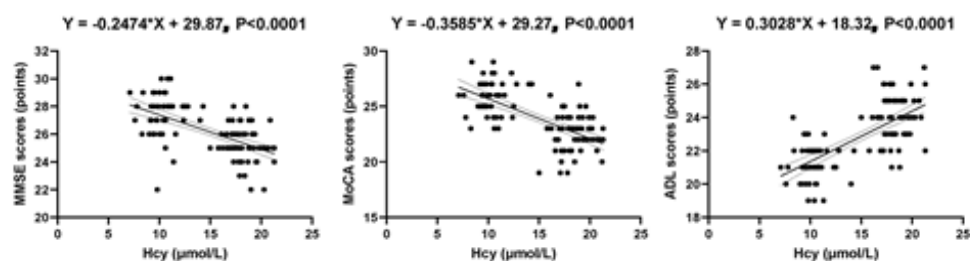


Figure 1. Correlation of plasma Hcy level and cognitive function scores in primary hypertension patients

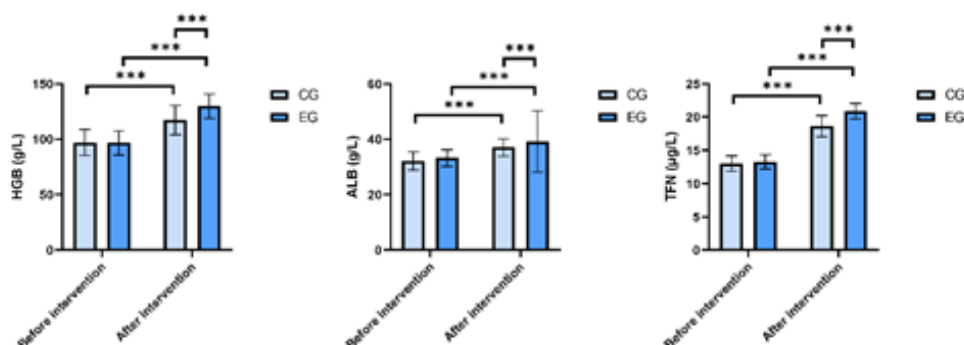


Figure 2. Nutritional indicators in both groups before and after intervention

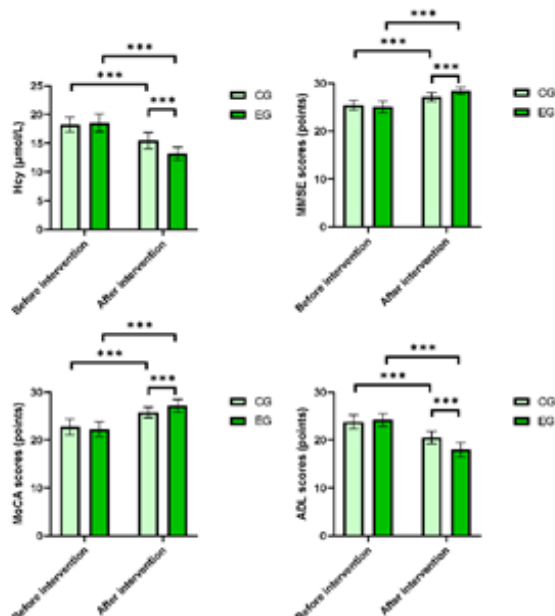


Figure 3. Plasma Hcy level and cognitive function scores in both groups before and after

Comparison of plasma Hcy level and cognitive function scores between CG and EG before and after intervention

Before intervention, no statistical significance in plasma Hcy level, MoCA scores, MMSE scores, and ADL scores exhibited between CG and EG ($P > 0.05$). After intervention, plasma Hcy level, MoCA scores, and MMSE scores in CG and EG exhibited depletion relative to those before intervention, and EG exhibited depletion relative to CG, indicating statistical significance ($P < 0.05$). After intervention, ADL scores in CG and EG exhibited elevation relative to those before intervention, and EG exhibited elevation relative to CG, indicating statistical significance ($P < 0.05$; Figure 3).

Discussion

Epidemiological survey depicts that there are different characteristics in incidence of cardiovascular and cerebrovascular diseases between China and the United

States; the United States is dominated by coronary atherosclerotic heart disease, while China is dominated by stroke. Further research has demonstrated that plasma Hcy level of hypertensive populations in China are approximately 50% higher relative to those in the United States, suggesting that joint action of the two may be one of the mechanisms facilitating high incidence of stroke in China¹⁵. Recent reports have revealed that HHcy is also an independent risk element for CI^{16,17}. The severity and extent of periventricular white matter damage presents a remarkable correlation with Hcy level¹⁸. Previous studies on clinical impact of HHTN on brain function have majorly focused on its impact on cerebrovascular diseases¹⁹, with less attention paid to its role underlying cognitive function.

Currently, multiple reports have depicted that plasma HHcy level is an independent risk element for CI²⁰. HHcy can directly damage endothelial cells, leading to dysfunction of endothelial function. Normal endothelial cells can secrete various vasoactive substances, which are crucial for maintaining vascular tension, and HHcy can cause abnormal secretion of these vasoactive substances, leading to small vessel lesions; it can also repress vasodilation function of blood vessels through facilitating generation of intracellular reactive oxygen species²¹. According to reports, HHcy in the brain exerts a direct influence on cognitive function and neurological damage²². Herein, plasma Hcy level in HHTN group exhibited elevation relative to that in non-HHTN group; MoCA scores and MMSE scores in HHTN group exhibited depletion relative to those in non-HHTN group, and ADL scores in HHTN group exhibited elevation relative to those in non-HHTN group. Furthermore, MoCA scores and MMSE scores presented negative correlation with plasma Hcy level in primary hypertension patients, while ADL scores presented positive correlation with plasma Hcy level in primary hypertension patients. This indicates that patients with HHTN are more prone to CI, and degree of CI may have positive correlation with plasma Hcy level.

Long term drug therapy is not the most effective treatment for hypertension, as long-term use of antihypertensive drugs can easily result in various adverse reactions and further

elevate patients' economic burden. Nonpharmacological therapy for hypertension has become a crucial development trend. The common nonpharmacological therapies for hypertension in the past were majorly diet control, weight control, potassium supplementation, limiting alcohol consumption, etc.²³. DASH with high potassium and low sodium was first proposed in 1997, and initial purpose of this treatment model was to effectively improve public health status. Research has demonstrated that after application of DASH intervention, there was a marked hypertension control on hypertensive patients²⁴. Potassium is the cation with the highest intracellular content, while sodium is the cation with the highest extracellular content in human body. The balance between potassium and sodium maintains normal functioning of cells in the body. It has been previously depicted that relative to diets with K⁺ and Na⁺ intake of 1.7 g/d and 3.0 g/d, respectively, DASH (a high potassium and low sodium diet dominated by fruits and vegetables) can respectively decrease systolic and diastolic blood pressure by 5.5 mmHg and 3.0 mmHg in healthy adults²⁵. Our research implemented DASH with high potassium and low sodium nursing intervention for patients with HHTN. Herein, after intervention, ALB, HGB, and TFN levels in EG exhibited elevation relative to those in CG, indicating that DASH with high potassium and low sodium nursing intervention effectively ameliorates nutritional status of patients with HHTN. Moreover, after intervention, plasma Hcy level, MoCA scores, and MMSE scores in EG exhibited depletion relative to those in CG, and ADL scores in EG exhibited elevation relative to those in CG. This indicates that DASH with high potassium and low sodium nursing intervention effectively reduce Hcy level in patients with HHTN, thereby markedly alleviating CI in patients with HHTN.

Conclusion

There is a negative association between plasma Hcy concentration and cognitive function level in patients with HHTN, suggesting that plasma Hcy level may be a vital factor in facilitating and exacerbating CI. DASH with high potassium and low sodium nursing interventions can effectively attenuate Hcy level in patients with HHTN, delay occurrence or development of CI in patients with CSVD, which is worthy of clinical promotion.

Declares

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

LZ contributed to the conceptualization, data curation, formal analysis, and wrote the original draft. DZ performed investigation, interpreted the data. Wei Qin supervised the study. All authors reviewed and approved the final manuscript.

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None.

Data Availability Statement

Data supporting this study's findings may be obtained from the corresponding author upon reasonable request.

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