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*Original Article*

# Intermittent pneumatic compression (IPC) combined with an electric stimulator in the prevention of venous thromboembolism in stroke patients

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**Abstract:** Objective: To explore the clinical value of intermittent pneumatic compression (IPC) combined with an electric stimulator in the prevention of venous thromboembolism in stroke patients. Methods: 58 stroke patients with hemiplegia admitted to the Department of Neurology in our hospital were recruited as the study cohort and randomly placed into a control group or an observation group, with 29 patients in each group. The control group was administered routine care and IPC, and the observation group was administered electric stimulation in addition to the treatment administered to the control group. We conducted a comparison and an analysis of the occurrences of thrombosis, the blood rheology indexes, the femoral vein flow rates, and the nursing satisfaction levels in the two groups. The circumferences of the hemiplegia patients' lower extremities were measured and recorded, and the circumferences of the healthy sides and the affected limbs were compared. Results: On the 7th day after the intervention, the observation group had a higher incidence of deep vein thrombosis (DVT) than the control group (6.90% vs. 31.03%, P<0.05). The hemorheology indexes were lower after the treatment, and the hemorheology indexes in the observation group were higher compared with the control group (P<0.05). The observation group had a higher femoral vein flow velocity than the control group (P<0.05). On the 7th and 14th days after the intervention, the peak flow and average flow velocities in the observation group exceeded those of the control group (P<0.05). The nursing satisfaction rate in the observation group was higher than it was in the control group (96.55% vs. 82.76%, P<0.05). After 7 and 14 days of treatment, smaller changes in the hemiplegic limbs of the observation group were observed, compared to the control group (P<0.05). Conclusion: IPC combined with an electrical stimulator can enhance the patients' blood hypercoagulability, effectively prevent the occurrence of DVT, and improve the nursing satisfaction levels.

**Keywords:** DVT, electric stimulator, IPC, nursing, stroke

## Introduction

Stroke is a common neurological disease characterized by high morbidity, disability, and mortality. The latest epidemiological results show that there are about 2.4 million new stroke patients in China every year, and the number of people who die from stroke every year reaches 1 million [1]. DVT, a serious stroke complication [2], jeopardizes stroke patients with high mortality and disability rates [3]. Different incidences of stroke combined with DVT, ranging from 22% to 75% have been reported in numerous studies [4], which consequently, indicates the importance of preventing DVT. Among the commonly used prevention methods at present, the mechanical methods include body position placement, physical function exercises, decompression elastic stockings, intermittent airbag compression, and flat pumps. The drug prevention methods include aspirin, warfarin, the injection of low-molecular-weight heparin sodium and the like [2]. However, it is indispensable and significant to find a safe, effective, convenient, economical, and practical method, as the decline of multiple organ functions in stroke patients is quite frequent and high-dose anticoagulants are prone to cause bleeding complications [5]. Studies have shown [6] that both IPC and electric stimulation can effectively prevent

DVT. Therefore, this study aims to explore the clinical value of IPC combined with electric stimulation in preventing venous thromboembolism in stroke patients. The report is as follows.

## Materials and methods

### *General data*

29 stroke patients with hemiplegia admitted to the Department of Neurology in our hospital were randomly placed into the observation group, and 60 stroke patients with hemiplegia were placed in the control group. Logistic regression was used to determine the propensity matching scores, the propensity scores were calculated, and patients with similar scores were matched. Among the 60 patients in the control group, 29 patients matching the observation group were selected. The two groups' basic information included gender, age, drug treatment, and other factors. The two groups were used as 1/0 binary processing indicators, gender, age, drug treatment and other factors were used as co-variables, and the propensity score matching standard (the caliper value) was set to 0.02, and a logistic regression formula was used to determine the propensity matching scores. The matching ratio was 1:1, the propensity score was calculated, and the patients with similar scores were matched. Inclusion criteria [7]: (1) Patients who met the diagnostic criteria for stroke established by the Fourth National Cerebrovascular Disease Conference, diagnosed as the first episode by CT or MRI, and who had limb dysfunction after the onset. (2) Patients who had no clinical symptoms or signs of DVT, and no DVT was apparent in a b-ultrasonic examination. (3) Patients who participated in the study voluntarily and who signed the informed consent.

Exclusion criteria: (1) Patients who were pregnant. (2) Patients who were lactating women. (3) Patients with primary serious diseases such as liver, kidney, heart, circulator system diseases, or mental illness. (4) Patients without complete medical data.

The double-blind method was used. 58 hospitalized stroke patients with hemiplegia were randomly assigned into a control group or an observation group, with 29 cases in each group. The two groups did not differ in terms of their general data or drug treatment ($P>0.05$). The present study was approved by our hospital's ethics committee.

### *Methods*

The control group was administered routine nursing. (1) Psychological intervention: The nurses conducted appropriate communication with the patients and their families, informed the patients of the relevant knowledge, and helped them gain confidence. (2) Exercise: The nurses encouraged the patients to exercise properly and provided guidance. (3) Diet instruction: According to the nutritional needs of the patients before and after the surgery, appropriate dietary instructions were provided by the nurses. (4) The nurses were well prepared for the perioperative period.

In addition to the treatment administered to the control group, the observation group was administered IPC combined with electric stimulation for the nursing. From the first day of the hospitalization, an electric stimulator (produced by Suzhou Medical Products Factory Co., Ltd.) was used for the treatment, after 30 minutes of treatment with an IPC device. Electrodes were attached to the Zusanli, Taichong, Sanyinjiao, and Yinlingquan acupuncture points of both lower limbs. At the same time, density wave stimulation (frequency 30/100 Hz) was administered at an intensity of 20 to 30 minutes with slight bulges observed over the stimulated body parts. Both groups were treated for 10 consecutive days.

### *Observation indexes and evaluation criteria*

The incidence of DVT, the coagulation function, the hematocrit (HCT) (%), the erythrocyte aggregation rate (%), and the fibrin (FIB) (g/L) and d-Dimer (ug/mL) levels 7 days after the intervention in the two groups were recorded. 7 days after the intervention, Color Doppler Ultrasound was performed to measure the average flow and peak flow velocities of the femoral vein blood before and after the intervention. And the patients' nursing satisfaction levels were also compared.

### *Leg circumference measurement*

During the hospitalization, each patient was required to lay on his back at a fixed time every

**Table 1.** Comparison of the incidences of DVT in the two groups

| Groups | n | DVT | Incidence (%) |
|---|---|---|---|
| Observation group | 29 | 2 | 6.90 |
| Control group | 29 | 9 | 31.03 |
| $\chi^2$ | | | 4.238 |
| P | | | 0.038 |

day, and the circumference of the patient's hemiplegic lower extremity was measured with a soft tape 15 cm from the upper edge of the patella and recorded, and the circumferences of the healthy side and the affected limb were compared.

*Statistical processing*

SPSS 23.0 software (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) was used for the data processing. The measurement data were expressed as the mean ± standard deviation, and t-tests were performed for the comparison between the groups. The count data were expressed as (%), and chi-square tests were performed for the comparisons between groups. A difference was considered statistically significant when P<0.05. GraphPad Prism 8 software was used to plot the graphics.

## Results

*Comparison of the incidence of DVT in the two groups*

In the observation group, there were 2 patients with DVT, with an incidence rate of 6.90%. In the control group, there were 9 patients with DVT, with an incidence rate of 31.03%. A significantly lower incidence of DVT in the observation group than the control group was observed (P<0.05), see **Table 1**.

*Hemorheology indexes of the two groups*

No evidence of any statistical differences in terms of the HCT, the erythrocyte aggregation rates, or the Fib and d-Dimer levels between the two groups before the treatment were found (P<0.05). After the treatment, the hemorheological indexes in both groups were decreased (P<0.05), and the group with electric stimulator intervention observed a greater decline than the other one (P<0.05). See **Table 2**.

*Comparison of the femoral vein blood flow velocity after the intervention between the two groups*

The femoral venous blood flow velocities in the two groups rose sharply after the treatment (P<0.05). With regard to the 7 day peak flow velocity, the 7 day average flow velocity, the 14 day peak velocity, and the 14 day average velocity, the observation group had higher results in contrast with the control group (P<0.05). See **Table 3**.

*Comparison of the nursing satisfaction between the two groups*

In the observation group, there were 21 patients who were very satisfied, 7 patients who were satisfied, and 1 patient who was unsatisfied, for a total satisfied rate of 96.5%. In the control group, there were 8 patients who were very satisfied, 16 patients who were satisfied, and 5 patients who were unsatisfied, for a total satisfied rate of 82.76%, which was lower than the observation group (P<0.05). See **Table 4**.

*Comparison of the circumferences of the hemiplegic limbs between the two groups*

7 days after the intervention, the thigh circumference differences between the control group and the observation group were (0.98±0.51) cm and (0.83±0.41) cm, smaller in the observation group (t=2.048, P=0.002). 14 days after the intervention, the thigh circumference differences between the control group and the observation group were (1.24±0.61) cm and (1.02±0.41) cm, smaller in the observation group (t=2.635, P=0.001), see **Tables 5** and **6**.

## Discussion

Stroke is a disease with a high incidence and disability rate in China [8], with its most frequent clinical manifestation being hemiplegia. DVT of the lower extremities in hemiplegic patients is an important complication that causes aggravation, disability, and even death in stroke patients [9]. Therefore, the prevention of DVT in stroke patients with hemiplegia has always been a concern. Blood stasis, vascular wall damage, and high blood coagulation are the three major factors of DVT. Stroke patients with hemiplegia are at high risk of DVT [10], a consequence of long-term bed rest. The

**Table 2.** The hemorheology indexes of the two groups

| Groups | n | HCT (%) | | Erythrocyte aggregation rate (%) | | Fib (g/L) | | d-Dimer (ug/mL) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Before treatment | After treatment | Before treatment | After treatment | Before treatment | After treatment | Before treatment | After treatment |
| Observation group | 29 | 49.11±2.13 | 40.17±2.06 | 19.76±3.28 | 16.37±0.19 | 3.67±0.74 | 2.13±0.21 | 1122.67±43.81 | 452.83±39.62 |
| Control group | 29 | 48.92±2.73 | 44.37±2.67 | 20.03±2.19 | 18.83±0.13 | 3.59±0.52 | 3.17±0.25 | 1137.28±49.26 | 857.29±42.18 |
| T | | 1.548 | -9.452 | 1.891 | -4.971 | 1.153 | -10.262 | 1.835 | -22.258 |
| P | | 0.115 | <0.001 | 0.077 | <0.001 | 0.241 | <0.001 | 0.176 | <0.001 |

**Table 3.** Comparison of femoral vein blood flow velocities after the intervention between the two groups (cm/s)

| Groups | n | Before intervention | | 7 d after intervention | | 14 d after intervention | |
|---|---|---|---|---|---|---|---|
| | | Peak velocity | Average velocity | Peak velocity | Average velocity | Peak velocity | Average velocity |
| Observation group | 29 | 23.25±2.96 | 15.06±3.03 | 52.77±5.18 | 36.24±4.15 | 53.62±5.26 | 36.24±4.15 |
| Control group | 29 | 22.95±2.84 | 14.94±3.12 | 42.70±4.55 | 27.87±4.28 | 42.91±5.13 | 28.73±4.17 |
| T | | 1.548 | -9.452 | 1.891 | -4.971 | 1.153 | -5.217 |
| P | | 0.115 | <0.001 | 0.077 | <0.001 | 0.241 | <0.001 |

**Table 4.** Comparison of nursing satisfaction rates between the two groups

| Groups | n | Very satisfied | Satisfied | Unsatisfied | Satisfaction rate (%) |
|---|---|---|---|---|---|
| Observation group | 29 | 21 | 7 | 1 | 28 (96.55) |
| Control group | 29 | 8 | 16 | 5 | 24 (82.76) |
| $X^2$ | | | | | 3.671 |
| P | | | | | 0.039 |

**Table 5.** Comparison of the differences in the thigh circumferences between the two groups of patients with hemiplegia (cm, x±s)

| Group | n | 1 d | 7 d | 14 d |
|---|---|---|---|---|
| Control group | 29 | 0 | 0.98±0.51 | 1.24±0.61 |
| observation group | 29 | 0 | 0.83±0.41 | 1.02±0.41 |
| t | | | 2.048 | 2.635 |
| P | | | 0.002 | 0.001 |

lower limb venous blood is in a state of low shear speed and low flow velocity, and the application of large doses of dehydrating agents causes hypercoagulability of the blood. Most patients with limb stroke have complications caused by vascular sclerosis factors such as hypertension, diabetes, hyperlipidemia, slow venous blood return, venous congestion, and the accumulation of a large number of white blood cells, causing intimal damage and activating the clotting process. These are attributable to the high incidence of DVT [11]. Chinese medicine refers to DVT as "Mai Bi" (vessel bi-disease). It is believed that the disease is caused by the stagnation of qi and blood stasis in the vessels, or by dampness, the accumulation of phlegm, phlegm and heat stasis, and impassability in the vessels [12]. Inappropriate or delayed treatment may result in the occurrence of thrombotic sequelae in half of the patients after the onset of the disease, which will take a toll on the patients' quality of life, and even cause serious consequences such as pulmonary embolisms [13]. The traditional prevention methods are mainly conventional drug treatment, training for preventing lower limbs DVT, and prevention and control through the use of stretch hoses, foot pumps, compression therapy, etc. In this study, IPC combined with electric stimulators was used to prevent venous thrombosis in stroke patients, and through physical methods, the purpose of improving the blood circulation of the patients' lower limbs was achieved [14].

Some scholars have pointed out [15] that IPC has been predominantly used to prevent the occurrence of DVT after stroke. The mechanism of IPC to prevent DVT is that the pulsating blood

**Table 6.** Comparison of the thigh circumference differences in the two groups of patients with hemiplegia (cm, x±s)

| Group | n | Before intervention | 7 d after intervention | 14 d after intervention |
|---|---|---|---|---|
| Control group | 29 | 2.62±0.24 | 1.84±0.34 | 0.93±0.14 |
| observation group | 29 | 2.59±0.32 | 1.47±0.42 | 0.69±0.17 |
| t | | 0.404 | 3.687 | 5.869 |
| P | | 0.688 | <0.001 | <0.001 |

flows produced by the mechanical action of periodic compression and decompression can promote the emptying of the venous congestion of the lower extremities, accelerate the flow of venous blood, elevate the venous congestion, and achieve the purpose of mechanical physical therapy [16]. The results of this study showed that after 7 days of preventive care and IPC treatment, the two groups of patients' D-dimer levels and other hemorheological indicators were significantly improved, and the blood flow in the femoral vein of the lower limbs was accelerated ($P<0.05$), which is in conformity with the aforementioned concepts. Acupuncture point electric stimulation is one of the common physical preventive measures for DVT in clinical practice [17]. It has garnered promising results after PICC surgery in elderly patients with gastrointestinal tumors and in the perioperative period of intertrochanteric fractures [18]. The mechanism involves the use of a certain low-frequency pulse current to stimulate the nerves and muscles to contract the muscles, thereby optimizing local blood circulation and promoting the recovery of the damaged muscles. Electrodes used for electric stimulation are usually placed on acupuncture points or exercise points, and these special areas are stimulated by currents of specific waveforms. Compared with traditional acupuncture techniques, a longer effect and more stable stimulation parameters are guaranteed. Acupuncture points on both sides of Sanyinjiao, Yinlingquan, Zusanli, and Taichong were chosen, among which Sanyinjiao and Yinlingquan are the acupoints of the Zutaiyin Spleen Meridian. Sanyinjiao and Yinlingquan can stimulate the physiological functions of the spleen and stomach and achieve the effects of replenishing qi, invigorating the spleen, promoting blood circulation and dredging collaterals. Zusanli is an important acupoint in the Zuyangming Stomach Meridian. Yangming is the qi and blood meridian. It plays a positive role in stimulating blood and qi. Taichong is an acupuncture point on the Zujueyin Liver Meridian, yielding a favorable outcome of lowering the blood pressure, soothing the liver, and regulating qi, dispelling stagnation, promoting blood circulation and removing blood stasis. Additionally, it can stimulate the expansion of local venules, lower blood pressure, improve blood hypercoagulability, and relieve headaches. The combination of various points plays a positive role in nourishing qi and nourishing the blood, removing blood stasis and dredging collaterals [19].

The author found that the efficacy of IPC is considered far too mediocre. Therefore, this study was designed to add acupuncture point electric stimulation in the observation group to enhance the efficacy. In comparison with the control group, the results showed an evidently lower incidence of DVT ($P<0.05$) and a higher nursing satisfaction rate ($P<0.05$) in the observation group, thus achieving a desirable outcome. In summary, acupoint electric stimulation combined with IPC can significantly improve blood circulation in the lower limbs of stroke patients and can prevent DVT, so it is conducive to patient recovery. However, one issue involving this study is the small size of the study cohort. Therefore, the accuracy of the treatment effectiveness needs to be further confirmed by expanding the size of the study cohort.

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## Disclosure of conflict of interest

None.

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