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Research Article

Effects of Resting in Different Postures and Ankle Pump Movement on Hemodynamics of Deep Venous Blood Flow of Lower Limb

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Abstract

Purpose: The aim of this study was to provide evidence of individualized prevention of deep venous thrombosis (DVT) through evaluating venous hemodynamics of lower limb in response to ankle pump movement in different positions.

Methods: Peak systolic velocity and mean flow velocity of common femoral vein were measured in 10 health volunteers (20 limbs) using color Doppler ultrasound in different positions, including at rest and when ankle pump movement were performed at lower limb elevation of 0, 15, 30, 45 degrees.

Results: In the rest position, there were differences in the peak and mean femoral venous blood velocity among 0°, 15°, 30° and 45° (P=0.00, P=0.00); The Peak velocity of the common femoral venous blood flow was higher in lower limb elevate 30° (35.36±4.97) than 0° (23.38±2.23), 15° (28.45±3.01) and 45° (25.89±5.51). (P<0.05). The mean velocity of the common femoral venous blood flow was higher in lower limb elevate 30° (29.14±7.23) than 0° (20.20±2.51), 15° (23.67±4.52) and 45° (20.37±3.39). (P<0.05). In ankle pump movement position, the Peak velocity of the common femoral venous blood flow was higher in lower limb elevate 0° 47.35(41.35~57.18) than 15° 32.05(28.13~39.20), 30° 43.60(36.33~51.23), and 45° 29.80(27.15~36.08). However, there were no significant differences between either group(P>0.05).

Conclusion: A better individualized prevention of DVT could be achieved through appropriate selection of position and ankle pump movement.

Keywords: Ankle pump movement; Position; Lower extremity; Venae profundae; Hemodynamics

Introduction

Deep venous thrombosis (DVT) is a common complication of trauma, operation and immobility. The incidence of DVT is 80 cases per 100,000, with a prevalence of lower limb DVT of 1case per 1000 population. DVT may cause pulmonary thromboembolism (PTE), even death [1]. The pathophysiological mechanisms of DVT involves damage of the vessel wall, blood flow turbulence and hypercoagulability. Immobility may reduce blood flow, which allows the accumulation of procoagulant factors that may induce thrombosis. The primary goal of pharmacologic DVT prophylaxis is to prevent fatal PE. There are three protocols for the prevention of DVT, which including basic prevention, physical prevention and drug prevention. Early clinical studies in DVT prevention focused on the potential benefit of prophylactic anticoagulation in populations at high risk of DVT. And, anticoagulation is the mainstay of treatment for DVT. It aims to reduce mortality, thrombus extension, recurrence, the risk of post thrombotic syndrome (PTS) and chronic thromboembolic pulmonary hypertension. However, effective anticoagulant also increases the risk of bleeding, and anticoagulant may prevent DVT results in a 50-70% reduction in the rate of DVT [2], there are still about 30-50% patients would suffered DVT. Physical prevention of DVT includes ankle pump exercise and lower limb elevation, which may promote the venous blood return [3].

Physical prevention is one of measures of prevention recommended by guideline and has been used in clinical application. However, there are few studies focus on how much lower limb elevation will promote lower limb return is the best. In this study, we measure the flow the velocity of femoral vein using color Doppler ultrasound in different degrees of lower limb elevation, analysis the effect of elevation of lower limb on blood return. Comparing the velocity of femoral venous blood flow aims to form a suitable plan which provide a theoretical basis for clinical application.

Materials and Methods

Participants

In this study, twenty participants were enrolled form May 2019 to September 2019. Among them, there were 10 females, aged from 20-32 years. Both sides of femoral veins were detected.

Exclusion criteria:

I. Deep venous thrombosis

II. Iliac venous compression syndrome

III. Chronic venous insufficiency

IV. With heart disease.

V. With a history of vascular disease

VI. Operational history or trauma of lower limb

VII. Coagulation disorders

Methods

The participant lies on examination bed, the femoral vein was located inside the femoral artery above the bilateral ilioinguinal ligament. Femoral venous blood flow was detected at 1cm upon the saphenous femoral vein valve. Duplex sonographic measurements were made with a PHILIPS CX50, fitted with a 5.0MHz sonar head. The angle between the probe and the femoral vein was kept at 60°. The trapezoidal position was selected for lower limb elevation. The line between the top of the greater trochanter of femur and the lateral malleolus of femur in the same side was taken, and then the horizontal line between the top of the greater trochanter of femur and the bed surface was taken. The angel of the two lines was the angle of lower limb elevation.

Quiescent condition: the ankle actively dorsiflexes 20° and then plantarflexes 45°, the frequency was 30-40 times/min. The velocities of femoral venous blood flow were detected at horizontal position, lower limb elevation 15, 30 and 45° (Figure 1). All detections were operated by same ultrasonologist, each position would detect 3 times. The participant would rest 10min before detection.

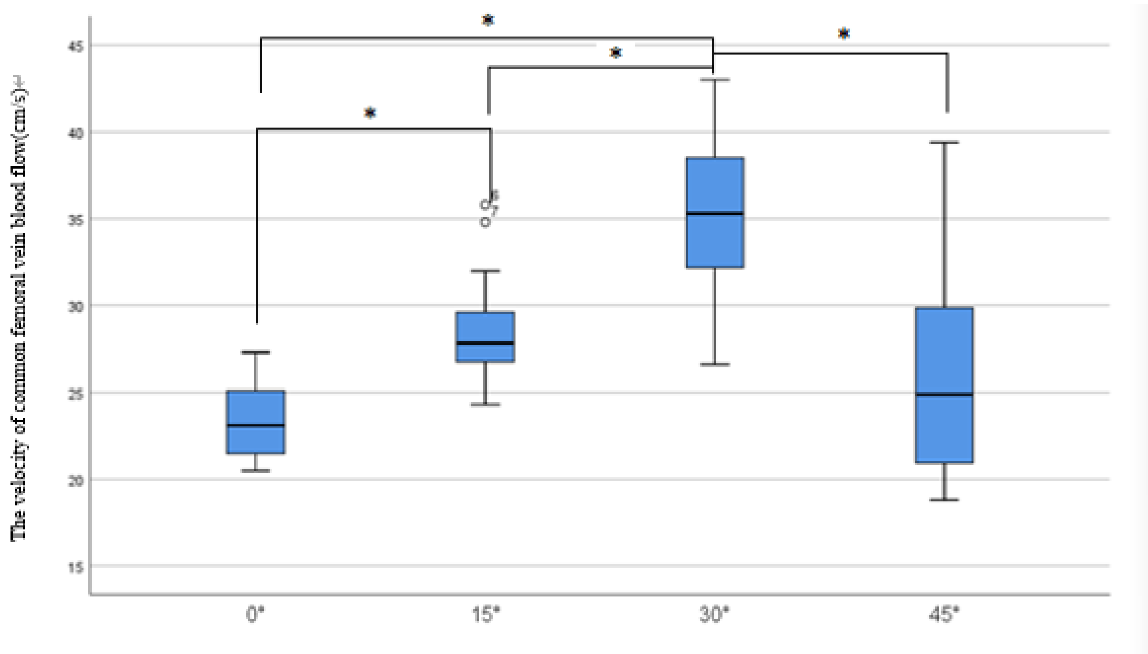

Figure 1: In the rest position, peak systolic velocity of common femoral venous blood flow at different levels of lower limb elevation. *P<0.05.

Statistical Analysis

SPSS 22.0 software was used for the statistical analysis. The date presented is regarded as being normal distribution and the results are presented as mean ± SD (χ±s). The date presented is regarded as being abnormal distribution and the results are presented as medians and interquartile range. A paired t-test was used to analyze the both side of femoral venous blood flow. The variance analysis of repeated measurement was performed for different groups. Significance was set at P<0.05.

Results

The flow velocity of both femoral venous blood flow at rest

In the rest position, there was no difference between right and left femoral venous blood flow velocity at different limb elevation degrees(P>0.05) (Table 1).

Table 1: The peak and mean flow of right and left femoral venous blood flow.

Elevation Degree	Peak systolic velocity of right femoral venous blood flow (X±S)	Peak systolic velocity of left femoral venous blood flow (X±S)	t	P	Mean flow velocity of right common femoral venous blood flow (X±S)	Mean flow velocity of left common femoral venous blood flow (X±S)	t	P
0	23.25±2.24	23.51±2.12	-0.40	0.701	20.20±2.21	20.19±2.90	0.014	0.99
15	29.35±3.80	27.55±1.93	2.09	0.07	24.49±4.75	22.84±4.36	1.81	0.10
30	35.36±5.65	35.35±4.49	0.007	0.99	29.11±7.55	29.16±7.30	-0.035	0.97
45	25.85±6.34	25.92±4.88	-0.05	0.96	20.12±3.28	20.62±3.66	-0.44	0.67

Effects of lower limb elevation on the velocity of common femoral venous blood flow at rest

In the rest position, there were differences in the peak and mean femoral venous blood velocity among 0°, 15°, 30° and 45° (P=0.00, P=0.00); The Peak velocity of the common femoral venous blood flow was higher in lower limb elevate 30° (35.36±4.97) than 0° (23.38±2.23), 15° (28.45±3.01) and 45° (25.89±5.51). (P<0.05). The mean velocity of the common femoral venous blood flow was higher in lower limb elevate 30° (29.14±7.23) than 0° (20.20±2.51), 15° (23.67±4.52) and 45° (20.37±3.39). (P<0.05) (Figures 1&2).

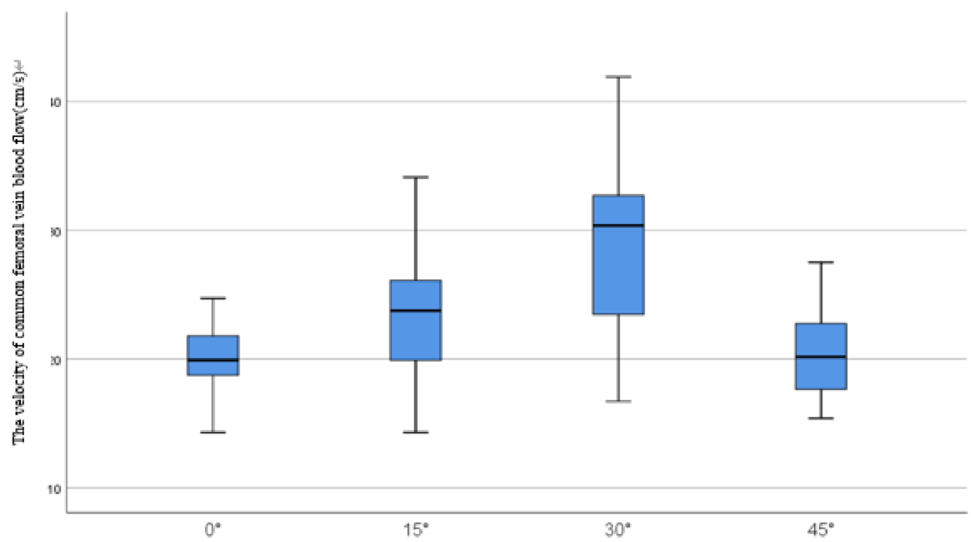

Figure 2: In the rest position, mean velocity of common femoral venous blood flow at different levels of lower limb elevation. There were differences in mean femoral venous blood flow velocity between different lower limb elevations(P<0.05).

The flow velocity of both femoral venous blood flow at ankle pump movement

In ankle pump movement position, there was no difference between right and left femoral venous flow velocity at different limb elevation degrees(P>0.05) (Table 2).

Effects of lower limb elevation on the velocity of common femoral venous blood flow at ankle pump movement.

Table 2: The peak and mean flow of right and left femoral venous blood flow.

Elevation Degree	Peak systolic velocity of right femoral venous blood flow M(P25~P45)	Peak systolic velocity of left femoral venous blood flow M(P25~P45)	t	P	Mean flow velocity of right common femoral venous blood flow M(P25~P45)	Mean flow velocity of left common femoral venous blood flow M(P25~P45)	t	P
0	45.20(41.45~58.05)	50.65(41.28~55.95)	-0.627	0.55	31.20(27.73~37.47)	33.00(28.03~47.47)	-1.18	0.27
15	44.20(35.80~52.95)	42.50(36.15~53.45)	-0.07	0.944	28.95(26.48~32.15)	30.90(28.18~41.53)	-1.359	0.21
30	44.70(41.45~50.33)	45.80(40.80~58.33)	-0.186	0.86	28.85(25.50~35.40)	32.30(29.20~37.55)	0.988	0.08
45	41.00(30.08~55.22)	37.20(34.22~46.08)	1.371	0.2	23.75(20.08~41.15)	25.50(20.18~33.50)	0.926	0.38

In ankle pump movement position, there were differences in the peak and mean femoral venous blood velocity among 0°, 15°, 30° and 45° (P=0.02), however, there were no differences in the mean femoral venous blood velocity among 0°, 15°, 30° and 45° (P=0.10); The Peak velocity of the common femoral venous blood flow was higher in lower limb elevate 0° 47.35(41.35~57.18) than 15° 32.05(28.13~39.20), 30° 43.60(36.33~51.23), and 45° 29.80(27.15~36.08). However, there were no significant differences between either group(P>0.05). The mean velocity of the common femoral venous blood flow was higher in lower limb elevate 0° 45.50(41.35~55.18) than 15° 31.65(26.70~35.40), 30° 38.35(34.08~49.60) and 45° 24.60(20.53~34.50). However, there were no significant differences between either group (P>0.05) (Figures 3&4).

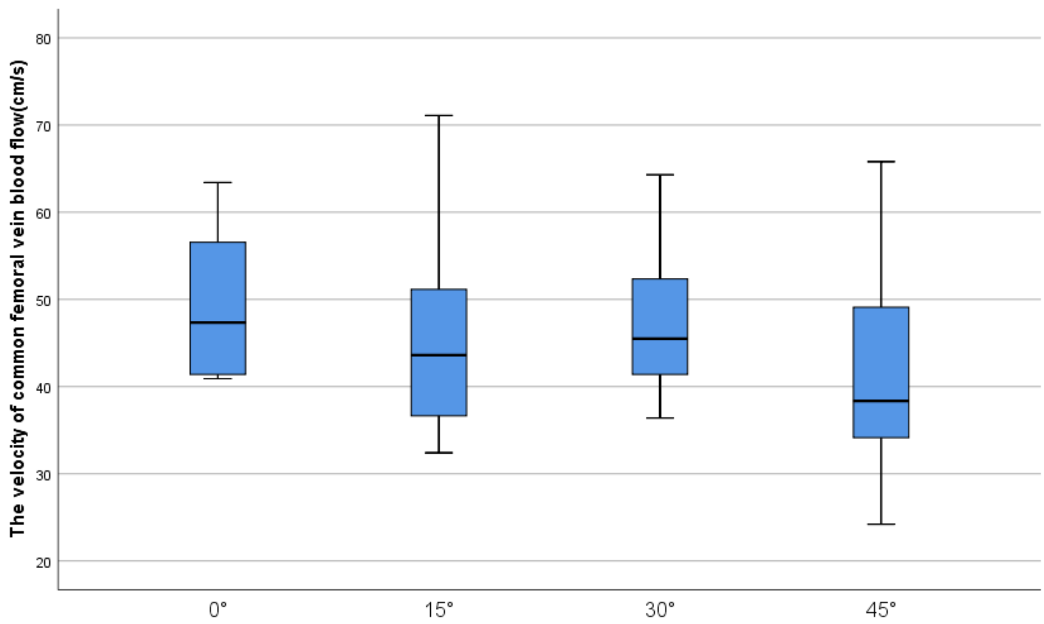

Figure 3: In ankle pump movement position, the Peak velocity of the common femoral venous blood flow was higher in lower limb elevate 0° 47.35(41.35~57.18) than 15° 32.05(28.13~39.20), 30° 43.60(36.33~51.23), and 45° 29.80(27.15~36.08). However, there were no significant differences between either group(P>0.05).

Discussion

Venous stasis is one of the major components of Virchow's triad [4]. Improving the blood return of lower limb is an effective method to prevent DVT [5]. Both lower limb elevation and ankle pump movement are use full for blood return of lower limb [3,6-8].

In this study, by analyzing the effects of lower limb elevation on the femoral venous blood flow. In the rest position, the femoral venous blood flow with lower limb elevation of 30° had the faster blood flow. The reason may be that: the venous return is affected by negative pressure which produced by diastolic heart and inspiratory movement [9]. In additional, hydrostatic pressure of lower limb vein may also affect the venous return. Elevate lower limb may increase the hydrostatic pressure, which may promote the venous return. However, when the lower limb is raised more than 45°, the peak velocity and mean velocity of femoral venous blood flow were not significantly increased compared with the rest position. The reasons may be related to the following factors:

(1) with elevation of lower limb, the curvature of the femoral and popliteal vein increased, which causing to swirl of blood flow. Swirly status will reduce the velocity of blood flow. (2) Popliteal vein may be compressed by knee flexion, which lead to reduction of venous blood flow. Similarly, the return of femoral vein will reduce when the hip is bent [7,10]. In this study, we verified that the peak and mean velocity of femoral vein was the highest at 30° of lower limb elevation in rest position. In ankle pump movement position, the femoral vein velocity was the highest in 0°of lower limb elevation. This result provides scientific basis of the suitable potion for venous return in the resting state.

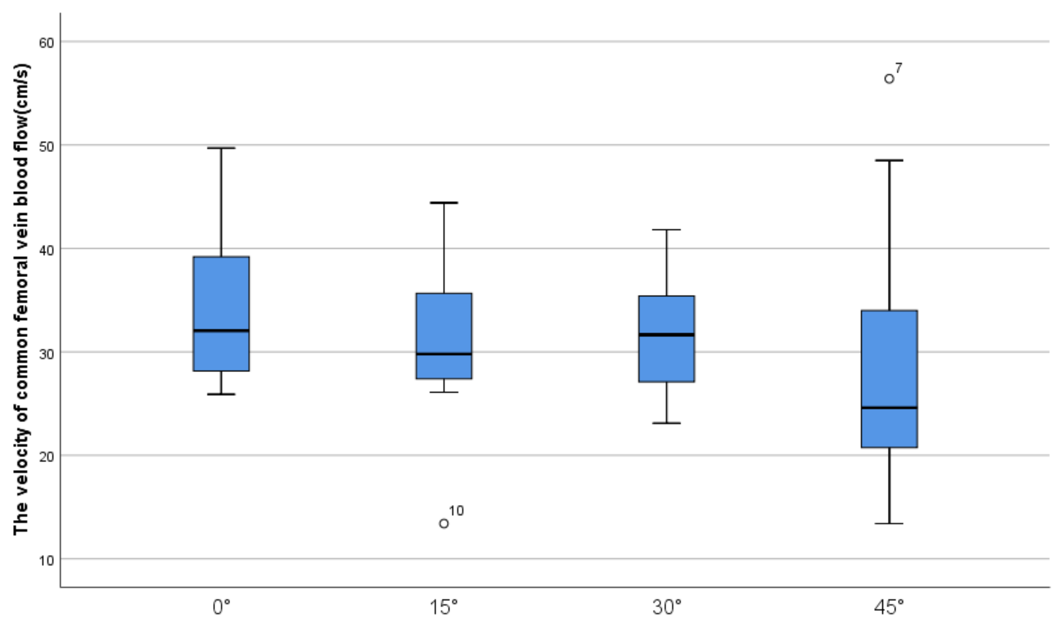

Figure 4: In ankle pump movement position, the mean velocity of the common femoral venous blood flow was higher in lower limb elevate 0° 45.50(41.35~55.18) than 15° 31.65(26.70~35.40), 30° 38.35(34.08~49.60) and 45° 24.60(20.53~34.50). However, there were no significant differences between either group (P>0.05).

According to our research, we have provided scientific guidance for the prevention of DVT in clinical work for patients with different diseased. For the patients with normal lower limb function, elevate 30° of lower limb, when occurred fatigue or discomfort, changed to ankle pump movement at horizontal position, which would be the best scheme for prevention of DVT. For patients with dysfunction of lower limb, elevate 30° of lower limb, intermittently lower elevation angle, which may be the best scheme.

Conclusion

In conclusion, the effects of rest and ankle pump movement on deep venous blood flow dynamics of lower limb are different at different position of lower limb elevation. Personalized prevention scheme is needed for prevention of DVT on different patients.

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Conflict of Interest

The authors have no conflict of interest to disclose.

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