

# Verification of the Effect of Techniques Used to Prevent Deep-vein Thrombosis

MANABU UCHIDA<sup>1)</sup>, MUNENORI KATOH<sup>2)</sup>

<sup>1)</sup>Health Science University: 7187 Kodachi, Fuji-Kawaguchiko, Minamitsuru, Yamanashi 401-0302, Japan. TEL: +81 555-83-5296, E-mail: uchida7801@kenkoudai.ac.jp

<sup>2)</sup>Ryoutokuji University

**Abstract.** [Purpose] An investigation of the blood flow velocity in the femoral vein was carried out, in order to verify the effectiveness of elastic stockings, and intermittent pneumatic compression, [Subjects] Subjects were 16 healthy males with no past history of vascular lesions. [Methods] A comparative investigation was carried out of the blood flow velocity of the femoral vein, which was measured at rest under three different conditions – at rest, wearing elastic stockings, and with an intermittent pneumatic compression device. [Results] The blood flow velocities in the femoral vein were  $30.7 \pm 5.2$  cm/sec,  $29.1 \pm 6.6$  cm/sec, and  $50.4 \pm 19.3$  cm/sec for at rest, wearing elastic stockings and with the application of intermittent pneumatic compression respectively. No significant differences were observed among any of the conditions. [Conclusion] There were no differences observed in blood-flow velocity between wearing the elastic stockings and the application of intermittent pneumatic compression. This study clarified the effect of passive methods on blood flow velocity in the femoral vein.

**Key words:** Ankle joints, Active movement, Venous blood flow velocity

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## INTRODUCTION

The Pulmonary Embolism/Deep Vein Thrombosis (Arterio-thromboembolism) Prevention Guidelines<sup>1)</sup> were published in February 2004. Following this, from April 2004, hospitals in Japan have been awarded points (305 points) for the prevention and management of pulmonary embolisms by physical management preventive measures, such as use of elastic stockings and intermittent pneumatic compression. This has resulted in the rapid spread of these physical managements in Japan. The reduction in perioperative pulmonary embolisms through the use of these methods was published by the Japanese Society of Anesthesiologists, and Kuroiwa<sup>2)</sup> has reported that there were 4.41 pulmonary embolism(PE) case/10, 000 operation cases in 2002, 4.76 PE case /10, 000 operation cases in 2003, and 3.62 PE case/10, 000 operation cases in 2004. However, he also states that the mortality rate has risen from 17.9% in 2002, 18.9% in 2003, to 21.8% in 2004. In Europe and the United States, the main preventive measures are the use of anticoagulants, and it has been reported<sup>3)</sup> that this reduces the morbidity and mortality rates of this disorder.

In Japan, it is also possible to carry out pre-emptive measures, including drug therapy, to reduce the rate of mortality. However, in the field of physical therapy, though active ankle joint motion, practice in standing up, and gait training are carried out with the aim of early ambulation in the perioperative period, no uniform methods exist in the

conduct of these techniques.

Virchow's triad (slowing of blood flow, vein endothelial disorders, and increased blood coagulation) has been put forward as a factor of vein thrombosis, and in order to prevent these symptoms, interventions such as the wearing of elastic stockings, the use of intermittent pneumatic compression methods, active ankle joint motion and deep breathing are used. It has been reported by Komori et al.<sup>4)</sup> that active ankle joint motion, which is a method that is actively carried out by the patient, increases blood flow velocity. However, no comparative investigations of blood flow velocity at rest while using passive methods such as wearing elastic stockings and intermittent pneumatic compression devices have been carried out. This study aimed to clarify the effect of passive methods to prevent arterial embolisms on blood flow velocity in the femoral artery.

## SUBJECTS AND METHODS

The subjects were 14 healthy males with a mean age of  $27.3 \pm 6.4$  years, mean height of  $168.6 \pm 4.0$  cm and mean weight of  $62.8 \pm 7.4$  kg, the average of girth of thigh lower was  $36.1 \pm 1.3$  cm.

The subjects had no past history of disorders that may have affected the blood flow velocity, such as vascular lesions, external injuries, and arteriosclerosis. The physiques of the selected subjects were similar to avoid

physique having an influence on the blood flow velocity. The subjects were given written explanations of the purpose of the study, and they signed an informed consent form before measurements were carried out.

An ultrasound diagnostic imaging device (HD11 from PHILIPS) was used to measure the blood flow velocity in the right femoral vein. Measurements were made: 1) at rest (at rest in the supine position, after 3 minutes of lying down), 2) at rest in the supine position wearing elastic stockings (Fine Support from TOROY), and 3) at rest in the supine position using an intermittent pneumatic compression device (Veno Stream from TERUMO). In each of these conditions, blood flow velocity of the right femoral vein was measured using a pulse Doppler. Although active motion such as planterflexion and dorsiflexion exercise of the ankle joint and deep breathing are often carried out in clinical settings in order to prevent arterial thrombosis, these are active methods, and therefore were excluded them from the measurement conditions, as the aim of this study was to verify the effectiveness of passive techniques. The order of measurement was randomized beforehand using cards to eliminate the influence of order effects. Also, 5 minutes of rest was given between measurements under different conditions, and the next measurement was carried out after visually checking that the blood flow velocity had returned to the rest level on the pulse Doppler. The pressure of the elastic stocking was measured as the Hatra pressure. Which is used for the measurement of elastic stocking pressure.

In the statistical analysis, a one-factor analysis of variance was carried out for the difference in the blood flow velocity in the femoral vein between the different conditions. The significant main effect was investigated using multiple comparison (Tukey test). The significance level was less than 5%. Statistics software Dr SPSS II for Windows was used for the investigation.

## RESULTS

Blood flow velocity in the femoral vein was  $30.7 \pm 5.2$  cm/sec at rest,  $29.1 \pm 6.6$  cm/sec at rest in the supine position wearing elastic stockings, and  $50.4 \pm 19.3$  cm/sec at rest in the supine position with intermittent pneumatic compression. There were no significant differences between any of the conditions ( $p > 0.05$ ).

## DISCUSSION

We investigated the degree of influence of wearing elastic stockings and the use of an intermittent pneumatic

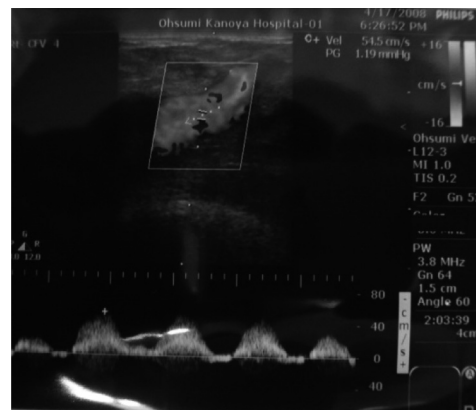


Fig. 1. Femoral vein blood flow velocity pulse Doppler

compression device, which are treatments performed to prevent pulmonary embolisms/deep vein thrombosis, had on the femoral vein blood flow velocity.

The results showed that there were no significant differences between the measurements at rest and those made when wearing elastic stockings or using an intermittent pneumatic compression device.

Slowing of blood flow, venous endothelial disorders and increased blood coagulation are listed in Virchow's Triad as being the main factors contributing to the onset of pulmonary embolism/deep vein thrombosis, and interventions such as wearing of elastic stockings or intermittent pneumatic compression are recommended in the perioperative period to minimize these risk factors.

Higashino et al.<sup>5)</sup> state that the wearing of elastic stockings, and the use of intermittent pneumatic compression devices increases blood flow velocity in the deep veins by compressing the lower limbs, and thereby reduces venous endothelial injury caused by venous congestion and dilation in the lower limbs. For these reasons, such measures are used for perioperative patients in many medical institutions. However, according to the guidelines issued at/by the 6th ACCP, the preventive effects of elastic stockings on deep vein thrombosis are 23% in THA and 6% in TKA in terms of relative risk reduction, which shows that the preventive effects of elastic stockings themselves are relatively small. In the present study, the wearing of elastic stockings and the use of an intermittent pneumatic compression device had no effect difference when compared with the condition at rest. According to these results, the blood flow velocity was less when wearing elastic stockings than in the condition at rest. Although prior

Table 1. Femoral vein blood flow velocity under each condition

Condition	Blood flow velocity in right femoral vein	Significant difference
At rest	$30.7 \pm 5.2$ cm/sec	
Wearing elastic stockings	$29.1 \pm 6.6$ cm/sec	
Intermittent pneumatic compression	$50.4 \pm 19.3$ cm/sec	
(Mean $\pm$ SD)		(n = 14)

studies have investigated the morbidity of deep vein thrombosis when wearing elastic stockings, since there has been no comparison carried out with other conditions, the effectiveness of wearing elastic stockings in terms of blood flow velocity has not been verified.

When using elastic stockings, the recommended pressure around the ankles is 16–20 mmHg, with a pressure ratio of the ankle to the lower thigh and to the proximal femur of 10: 7: 4. This is a relatively high pressure, and it is thought that the blood flow in the surface layer capillaries at the point where the pressure is applied is restricted, and if we hypothesize that the systemic circulation volume is fixed, it can be speculated that the internal lumen diameter in deep veins is increased to compensate for the return volume. If this is the case, the increase in the internal diameter of the deep vein lumen causes a decrease in blood flow velocity. External factors, such as elastic stockings and the intermittent pneumatic compression device, did not result in increases in blood flow velocity. As this study investigated the effectiveness of passive intervention, the effectiveness of muscle pump effects, such as planterflexion and dorsiflexion exercises of the ankle joint, have not been verified. However, in active motion, the promotion of voluntary muscle contraction causes a muscle pump effect in the capillaries inside the muscles and in the deep veins. Therefore it is expected that such exercises would have the effect of increasing blood flow. Komori et al.<sup>8)</sup> investigated the change in blood flow velocity in the femoral vein in relation to the speed of active motion, and reported that the blood flow velocity in the femoral vein does not change with slow performance of planterflexion and dorsiflexion exercises of the ankle joint, but that rapid movement (80 times per minute) induced a significant increase. The function of the veins is to store blood and 75% of circulating blood volume is contained in them. In limb veins with a diameter of 1 mm or higher, there are bicuspid valves which prevent the backflow of blood, as well as preventing hyperextension of the venous wall. Blood that has accumulated and has made the venous wall in the lower limbs swell, is squeezed out by the contraction of the surrounding skeletal muscle, and flows only in the direction towards the heart due to the functioning of the valves. We were unable to form an opinion on this from the results of the present study, however, it is necessary to consider conducting further investigations that include active motion.

For many patients in the perioperative period, elastic stockings and intermittent pneumatic compression devices are used to prevent pulmonary embolisms/deep vein thrombosis. As seen in the statements by Akagi et al.<sup>10)</sup>,

which argue that the wearing of stockings plays an important role in increasing the motivation of patients and co-medicals for the prevention of thromboses, there is an impression that direct preventative effects may not be expected from such methods.

In the present study, we demonstrated that the wearing of elastic stockings or the use of intermittent pneumatic compression devices, which are used to prevent slowing of blood flow, venous endothelial disorders, and increases in blood coagulation, in order to prevent pulmonary embolisms/deep vein thrombosis, have little effect in achieving such aims. However, those who use elastic stockings or intermittent pneumatic compression devices are often elderly people.

In elderly people, blood vessel elasticity declines with age, and they also have a tendency to have factors which have a direct impact on blood flow velocity, such as complications of life style diseases and/or a history of vascular lesions. Instead of using healthy subjects, it will be necessary to carry out clinical studies with elderly people as subjects. We consider that the present study has made clear that the wearing of elastic stockings or the use of intermittent pneumatic compression devices does not eliminate the risk of vascular disorders.

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