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Short communications

Changes in femoral vein blood flow velocity by intermittent pneumatic compression: calf compression device versus plantar-calf sequential compression device

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Abstract
Intermittent pneumatic compression has become widely used to prevent deep venous thrombosis potentially causing fatal pulmonary embolism. Although uniform compression has been commonly applied, a new method of sequential compression from plantar to calf has recently been developed. In this report, changes in maximum blood flow velocity in the femoral vein were compared with compression of only the calf uniformly and compression from plantar to calf sequentially in 10 healthy adult volunteers. A compression pressure of 60 mm Hg was applied for 5 min, and the velocity was measured before and after this treatment by ultrasound echography. There was no statistically significant difference in the change in maximum velocity between calf compression and plantar-calf sequential compression. The maximum velocity increased significantly with both compressions. However, plantar-calf sequential compression tended to have a greater effect. Although the results did not demonstrate an advantage of plantar-calf sequential compression compared with calf compression only, if the former compression is applied for a long time, it may have a greater effect.

Key words Intermittent pneumatic device · Calf compression · Plantar-calf compression · Blood flow velocity · Femoral vein

The intermittent pneumatic compression (IPC) device has been widely used to prevent deep venous thrombosis followed by pulmonary embolism [1,2]. There are several types of compression device, such as plantar, calf, and calf-thigh, which use uniform compression with a single chamber. Although the best compression site remains unclear, one report showed that plantar compression is less effective than calf-thigh compression for the prevention of deep venous thrombosis [3]. Recently, a new IPC device has been developed that compresses several parts of the lower extremities sequentially. Theoretically, applying compression further up the leg from the plantar to the thigh sequentially may be most effective [2]. In this report, we compared the blood flow velocity in the femoral vein with use of the calf compression device and the plantar-calf sequential compression device.

After approval of the institutional committee of our hospital, 10 healthy adult male volunteers who had no history of disease and who were not taking medications were studied. Their age, height, and weight were 35 ± 9 (22–47) years, 172 ± 6 (160–180) cm, and 69 ± 12 (56–92) kg [mean ± SD (range)]. The volunteer was placed in a supine position for 30 min. A calf-length garment with a single chamber and a plantar-calf-length garment with four chambers were randomly assigned to be placed onto the two legs, and were connected to two types of IPC device (Flowtron DVT, Huntleigh Healthcare, Manalapan, NJ, USA; and Phlebo Press DVT, Mego Afek, Kibbutz Afek, Israel), respectively. The former device compresses the calf uniformly with a compression/decompression time cycle of 10/50 s, and the latter device compresses further up the plantar to calf gradually by inflating four chambers with a time cycle of about 20/50 s. The compression pressure was set at 60 mm Hg for both devices. The blood flow velocity in the femoral vein was measured by ultrasound echography (SONOS-5500, Hewlett-Packard, Andover, MA, USA), in which the proximal site of the femoral vein at the branch point of the great saphenous vein was detected in the color Doppler mode by a linear probe, followed by measurement of the maximum velocity in the pulsed wave Doppler mode. In our observations, the blood flow velocity increased gradually after initiation of compression, reached a maximum level before release of compression, and returned to the control level with no compression. Before use of the IPC devices was initiated, the maximum velocity in the

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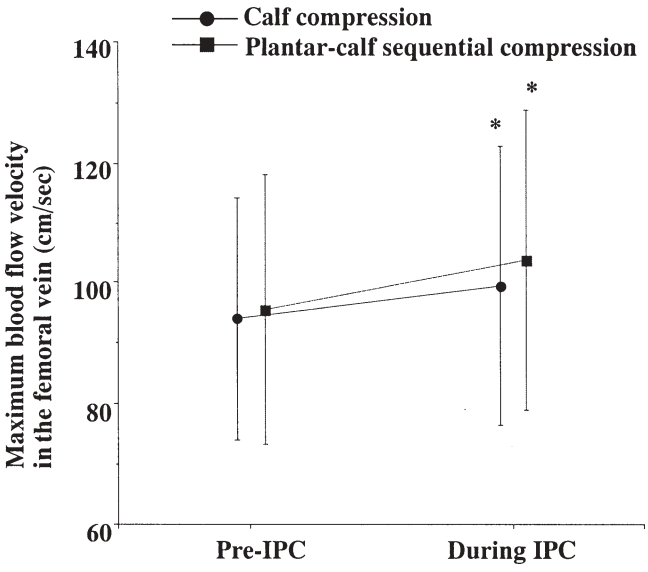

Fig 1. Change in maximum blood flow velocity of the femoral vein with calf compression or plantar-calf sequential compression. The velocity was measured by ultrasound echography. *IPC*, intermittent pneumatic compression. Values are mean ± SD. $*P < 0.05$ vs pre-IPC value

femoral vein was measured on both sides. Subsequently, use of both of the IPC devices was initiated, and the maximum velocities in both femoral veins were measured again 5 min later. On a different day, the same measurements were obtained from the volunteer with the position of the IPC devices switched. Changes in the maximum blood flow velocity in the femoral vein with the calf compression and plantar-calf sequential compression were compared statistically by repeated-measures analysis of variance. Change in the maximum velocity in each compression was analyzed by the paired *t*-test. $P < 0.05$ was considered to indicate statistical significance.

There was no statistically significant difference in the change of the maximum blood flow velocity in the femoral vein between the calf compression and plantar-calf sequential compression. The maximum velocity increased significantly with both the IPC compressions (Fig. 1).

In this study, we used a compression pressure of 60 mm Hg. Although this pressure seems high, it has been shown that this pressure has a greater effect than a standard pressure of around 40 mm Hg [4]. In our hospital, 60 mm Hg has recently become a routine pressure level. The results obtained here showed that both the calf compression and plantar-calf sequential compression IPC devices have similar increasing effects on the maximum blood flow velocity in the femoral vein, whereas the latter device tends to have a greater effect. Because the plantar venous plexus has a great reservoir of venous blood [5], this plantar-calf sequential IPC device may theoretically be more effective. If measurement of the blood flow velocity had been continued repeatedly for a longer time, a difference might have been obtained. The plantar compression IPC device was operated at around 100 mm Hg in some reports [6], suggesting that a pressure of 60 mm Hg on the plantar was insufficient. However, because some reports indicate complications such as skin necrosis with use of the IPC device [7,8], setting a higher pressure may be harmful. We consider that compression pressures up to 60 mm Hg may be appropriate and safe for clinical use.

In conclusion, the present study did not demonstrate an advantage of the plantar-calf sequential compression IPC device in increasing the femoral vein blood flow velocity compared with the traditional IPC device that compresses only the calf uniformly, using nonanesthetized volunteers with 5 min of compression.

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