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Original contribution

Blood flow velocity of the femoral vein with foot exercise compared to pneumatic foot compression

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Abstract
Study objective: To compare the effects of foot exercise with an intermittent pneumatic foot compression (IPC) device on blood flow velocity of the femoral veins.
Design: Prospective, controlled study.
Setting: General intensive care unit of a university hospital.
Patients: 20 patients on bed rest in the intensive care unit.
Interventions: Patients were divided into 2 groups: group A, foot exercise (n = 10); and group B, IPC device (n = 10). The foot exercise was done once by a nurse for 5 minutes with the dorsiflexion of the ankle (15 times per minute) in group A patients. The IPC device (A-V Impulse System, compression setting: 130 mm Hg for 3 seconds followed by a resting period of 60 seconds) was used for 2 hours in group B.
Measurements: Peak blood flow velocity of the femoral vein was measured using the ultrasound unit with a 7.5-MHz linear array probe (ALOKA SSD-5500) at 0, 5, 15, 30, 60, and 120 minutes.
Main results: Peak blood flow velocities in both groups increased significantly vs the control values during the study. At 5 minutes, group A showed a significant increase in the peak blood flow velocity compared with group B.
Conclusions: Foot exercise by a nurse for 5 minutes was equally or more effective compared with the IPC device in increasing peak blood flow velocity of the femoral vein. The effect of the 5-minute foot exercise lasted for 2 hours.
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1. Introduction

Deep vein thrombosis (DVT) is a major contributor to pulmonary embolism. Blood flow in the deep veins is thought to be one of the important factors of DVT [1].

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	Group A (n = 10)	Group B (n = 10)
Sex (M/F)	3/7	6/4
Age (y)	72 ± 8	71 ± 8
Height (cm)	156 ± 11	154 ± 9
Weight (kg)	54 ± 15	55 ± 13
Preoperative anticoagulant use (Yes/no)	2/8	0/10
Coronary artery disease (Yes/no)	2/8	2/8
Previous thromboembolic event (Yes/no)	1/9	0/10
Diabetes mellitus (Yes/no)	2/8	3/7
Smoking (Yes/no)	8/2	7/3

Data are means ± SD. Group A received foot exercise, and group B received IPC.

Recently, an intermittent pneumatic foot compression (IPC) device [2-4], graduated compression stockings [5], and active and/or passive foot exercise [6,7] were used to increase blood flow in the deep veins. Foot exercise in particular is easily available. However, until recently, the effect of foot exercise has not been well known [8]. In this study, we compared in the intensive care unit (ICU) setting the effects of the IPC with single foot exercise performed by a nurse for 5 minutes on peak blood flow velocity of the femoral vein in the legs that received exercise.

2. Materials and methods

After the written, informed consent from patients and Kochi Medical School institutional approval were obtained, 20 patients on bed rest in the ICU and who had undergone elective gastrectomy, colectomy, pancreaticoduodenectomy, esophagectomy, or nephrectomy were enrolled in this study. All patients were sedated with midazolam 0.1 mg/kg per hour and buprenorphine 0.3 μg/kg per hour, and all received mechanical ventilation. The attending physician adjusted the vasopressor drug (dopamine) and vasodilator drugs (nitroglycerine and/or prostagrandin E_1) to maintain mean arterial pressure (MAP) between 60 and 80 mm Hg. The ventilator setting was adjusted to maintain oxygen saturation between 98% and 100% (BIPAP Pins 10-20 mbar, positive end-expiratory 5 mbar, tidal volume 7 mL/kg; Evita 2 or 4, Dräger, Lübeck, Germany). Respiratory rate (RR) was adjusted to maintain end-tidal CO_2 between 35 and 40 mm Hg. Patients were randomly divided into 2 groups before starting the surgery: group A (n = 10) received foot exercise, and group B (n = 10) received the IPC (A-V Impulse System, Novamedix, Andovor, UK). The foot exercise was performed on one foot only and only once by a nurse for 5 minutes (15 times per minute) with dorsiflexion of the ankle in which any intravenous catheter was placed. The IPC was used continuously for 2 hours. The IPC setting was a compression with 130 mm Hg for 3 seconds followed by a resting period of 60 seconds. We measured peak blood flow velocity at the common femoral vein 1 cm above the saphenofemoral vein junction using the ultrasound unit with

a 7.5-MHz linear array probe (ALOKA SSD-5500, ALOKA, Tokyo, Japan). Peak blood flow velocity was measured by the staff technicians who were blinded to the details of the study protocol. Blood pressure (BP), heart rate (HR), and central venous pressure (CVP) were also measured. Measurements were started 3 hours after admission to the ICU, and done at 0, 5, 15, 30, 60, and 120 minutes after starting the IPC or after the foot exercise.

2.1. Statistical analysis

Student t test was used for age, height, weight, and percent increase in peak blood flow velocity at each point from 5 to 120 minutes. Other demographic data were analyzed by χ^2 test. One-way repeated measures analysis of variance (ANOVA) with Bonferroni correction was
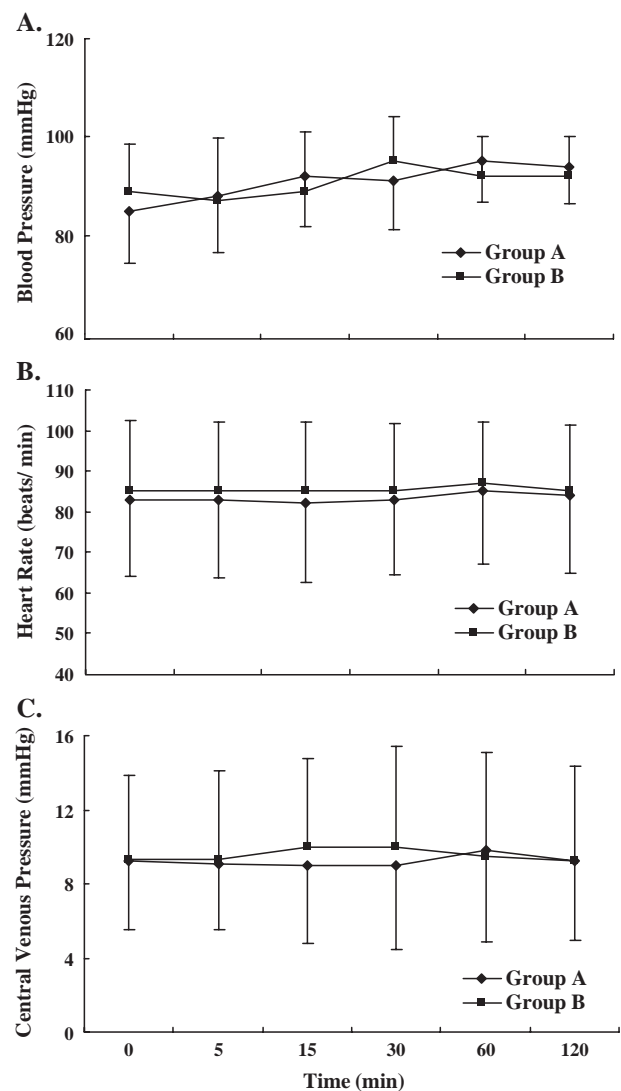

Fig. 1 A, Mean blood pressure. B, Heart rate. C, Central venous pressure. Values are means ± SD. Asterisk indicates $P < .05$ vs control values. Group A received foot exercise; group B received IPC.