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Venous pressure gradients in patients with chronic venous disease

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Summary

Venous pressure was measured simultaneously in a vein of the calf and the foot in five healthy controls and 10 patients with superficial chronic venous insufficiency (CVI). In both groups ambulatory venous pressure decreased more in the foot veins than in the calf veins. In patients with CVI the mean difference in foot and calf ambulatory venous pressure reduction (AVPR) was 25.5 mmHg, as was found in the controls (24.6 mmHg). During compression of superficial veins the difference in AVPR was reduced in patients but not in controls (11.6 *vs* 27.0 mmHg, respectively). About 50% of this difference in AVPR could be ascribed to the difference in cannulation height (except for the meaurement with superficial compression in patients where the whole difference in AVPR could be ascribed to the difference in cannulation height). Pressure changes during ambulation in the dorsal foot vein and calf veins may differ considerably, dependent on the existance of a specific foot vein pump and sufficiency of venous valves at the level of the ankle. Therefore, veins proximal to the ankle should be used for pressure recordings in the evaluation of chronic venous insufficiency in the calf.

Keywords: venous pressure, chronic venous disease.

Introduction

Measurements of venous blood pressure during exercise are used to investigate chronic venous insufficiency (CVI)[1]. Venous pressure measurements in the lower limb are often performed by cannulation of a dorsal foot vein[2,3]. However, pressure changes in the dorsal foot veins during exercise do not necessarily reflect alterations in venous pressure at calf level. This hypothesis is supported by the clinical observation that skin changes due to venous hypertension are most commonly seen at the distal part of the leg and not on the foot where the venous pressure supposedly is highest. An explanation may be that patients with chronic venous insufficiency have normal venous values in the foot.

The aim of the present investigation was to study venous pressure in the foot and the calf at rest and during ambulation.

Materials and methods

The study included two groups. Group I consisted of five healthy controls (three males and two females) without varicose veins; mean age 37 years (28-67). Group II comprised ten patients (three males and seven females) with varicose veins of the great saphenous system without leg ulcers) mean age 55 years (21-70).

Following informed consent a dorsal foot vein and a calf vein (great saphenous vein or a major tributary) were cannulated (Fig. 1). Venous pressure at these levels was recorded simultaneously with two Statham pressure transducers (P 23 Db) connected to a pressure monitor and a Watanabe linear recorder. The gradient between the pressures was measured by means of a differential amplifier. The pressure gradient caused by the difference in cannulation height was 'zeroed' at upright position. The pressure difference then recorded during ambulation (after zeroing) was termed Δgradient. Venous pressure measurements were performed in the erect position at rest and during ambulation with and without manual superficial venous compression at knee level (Fig. 2).

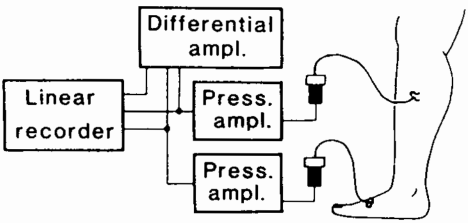

Fig. 1. *Schematic illustration of the experimental set-up.* Venous pressures were obtained at the foot and calf. A pressure monitoring system containing two pressure amplifiers and a differential amplifier was developed for the study.

The results were analyzed with Student's *t*-test for paired and unpaired data, with 5% as the level of significance.

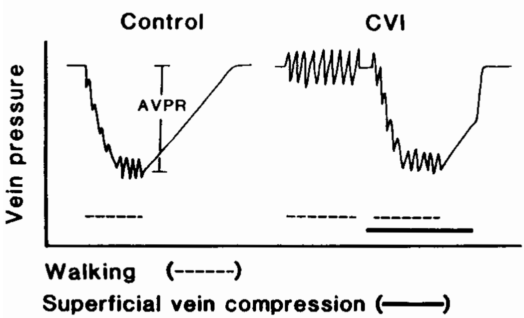

Fig. 2. *Schematic ambulatory venous pressure curves of a control person and a patient with a chronic venous insufficiency (CVI).* In this example the insufficiency is located in the superficial veins because there is normal ambulatory venous pressure reduction (AVPR) after compression of the superficial veins.

Results

A recording of the venous pressures in a patient with chronic venous insufficiency is shown in Fig. 3. The difference in pressure curves obtained

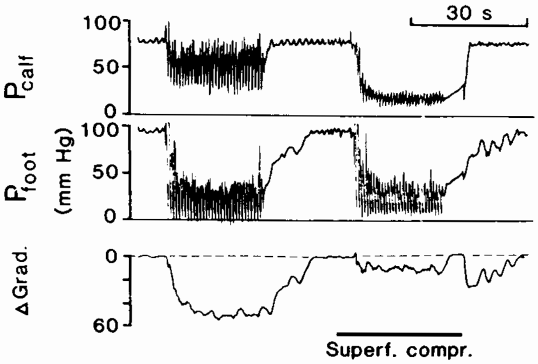

Fig. 3. *Venous pressure recording of a patient with superficial venous insufficiency.* Note the normal ambulatory pressure reduction in the foot and the abnormal in the calf, leading to a large Δ gradient (Δ Grad.). During superficial venous compression the calf ambulatory venous pressure is normalized, leading to a considerable reduction in Δ gradient.

in foot and calf veins caused a considerable Δgradient. The Δgradient decreased after superficial venous compression.

Controls as well as patients had a greater ambulatory venous pressure reduction (AVPR) in the foot than the calf veins (Fig. 4). Controls had Δgradients ranging between 17–30 mmHg (mean 24.6 mmHg). After manual superficial venous compression Δgradients of 12–40 mmHg with unaltered mean value (27.0 mmHg) was observed ($P > 0.05$).

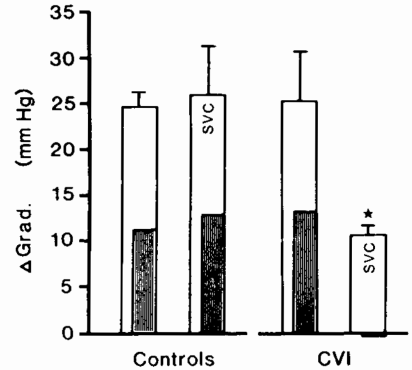

Fig. 4. *Difference in pressure reduction during ambulation (Δ Grad.) between foot and calf in controls and patients with chronic venous insufficiency (CVI).* The inner bars represent Δ gradient when difference in cannulation level is corrected for, and thus indicate the difference in vein pump capacity between the two levels. SVC, superficial vein compression; mean values ± SEM; $*P < 0.05$.

Patients had Δgradients of 10–65 mmHg before and 3–25 mmHg after superficial venous compression ($P < 0.005$, Fig. 4). All deep veins were patent. In one case the Δgradient was negligible in both superficial and deep venous system. This was the only patient who had varicose veins in the foot as well as in the calf.

Discussion

Venous pressure decreases in the deep and superficial venous system during ambulation if venous valves are competent. Ambulatory venous hypertension occurs in patients with incompetent valves[1]. In dysfunction of the saphenous system distal vein pressure decreases following manual compression of the superficial veins. In patients with deep venous insufficiency ambulatory hypertension persists during this procedure. Findings in the present study indicate that recording of these phenomena may depend on the level of measurement, and should be interpreted with care.

The finding of a greater AVPR in the foot than in the calf veins may to some extent be explained by the higher column of blood between heart and measuring level in the former. If the vein pressure during ambulation is reduced to the same value, AVPR in foot has to be larger than in calf and causes thereby a Δgradient. When differences in hydrostatic pressure in upright position are maximally compensated for, the Δgradient is reduced by 54% in controls and by 52% in patients (without superficial compression in patients). The remainder represents real differences in vein pump function. By using video-phlebography Gardner and Fox[4] have discovered a vein pump mechanism in the sole of the human foot which could explain the difference in vein pump function observed in our study. The foot vein pump was able to return blood from the foot into the abdomen without assistance from calf muscular action. By compressing the soft tissue when weight bearing, blood was forced in proximal direction.

All of the Δgradients in patients during superficial compression could be ascribed to the difference in blood column between foot and calf (Fig. 4).

The finding of the present study may explain the poor correlation between vein pressure recordings and degree of CVI which has been reported[5], because pressures have been measured in dorsal foot veins.

Conclusions about venous function in the lower limb should preferably be based on venous pressure measurements performed at the level of the calf since there is a discrepancy between pressure measurements at calf and foot levels. This discrepancy is probably caused by a difference in vein pump function and patent venous valves between the sites of measurements.

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