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Prediction of Post-interventional Outcome in Great Saphenous Vein Incompetence: The Role of Venous Plethysmography with Selective Superficial Vein Occlusion

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WHAT THIS PAPER ADDS

The available methods used in the diagnosis of venous incompetence permit only a limited possibility for quantification of venous function. Failure to identify all segments of venous reflux may lead to ongoing venous incompetence. In this study, a cuff system with strain gauge plethysmography was used, with the possibility of occluding the superficial venous system in a standardized manner. This seems to be a reliable method for identifying significant venous reflux. In addition it may be possible to predict the results of ablation of great saphenous vein reflux.

Objective/Background: To evaluate whether the outcome of radiofrequency ablation (RFA) treatment of great saphenous vein (GSV) incompetence may be predicted using strain-gauge plethysmography (SGP) with selective occlusion of the superficial venous system.

Methods: Seventeen patients (20 limbs) underwent endovenous RFA treatment for GSV incompetence (Clinical Etiology Anatomy Pathophysiology classification C2–C5; "C-group"). Duplex ultrasound (DUS) and SGP were performed with selective occlusion of superficial veins before and after RFA. Selective superficial occlusion was validated, in a control group (C-group) of 12 patients (14 legs), by ascending phlebography. In the RFA group, the time taken to reach 50% and 90% (T_{50}, T_{90}) of maximum venous volume was measured, as well as relative maximal reflux rates (%EV/min). The methodological error and coefficient of variation (CV) were assessed.

Results: Nineteen of 20 legs had complete post-operative GSV obliteration using DUS, and refilling times were improved after RFA (T_{50} 11 $\pm$ 3 vs. 19 $\pm$ 3 s; $p < .001$; T_{90} 27 $\pm$ 5 vs. 47 $\pm$ 6 s; $p < .001$). With SGP, the methodological error and CV for T_{50} were 4 s and 16%, respectively. Equivalence between pre-operative superficial occlusion and post-operative baseline measurements was achieved in 15 of 17 legs for T_{50}, and 12 of 17 for T_{90} (three of the 20 legs were excluded due to treatment failure [$n = 1$], and untreated perforating veins [$n = 2$]). Mean differences (95% confidence interval) were within the equivalence ranges (T_{50} 1 [−1 to 3] seconds; T_{90} −3 [−11 to 4] seconds). In the C-group superficial vein occlusion was possible in 12 of 14 legs. The remaining patient (two legs) showed incomplete superficial vein occlusion at ankle level (lipodermatosclerosis) and complete superficial vein occlusion at calf level.

Conclusion: SGP with standardized superficial venous occlusion seems to be a reliable method for identifying venous reflux and may be useful in predicting the results of successful RFA treatment.

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Keywords: Duplex ultrasound, Radiofrequency ablation, Strain-gauge plethysmography, Venous incompetence

INTRODUCTION

Chronic venous disease has a prevalence of 30–40% in the population, with an even distribution between the sexes.[1,2] Clinical signs range from telangiectasias to varicose veins, which can lead to edema, eczema, lipodermatosclerosis, and ulcers.[1–3] Diagnosis relies on clinical assessment (C of the CEAP classification, "Clinical Etiology Anatomy Pathophysiology"),[4] and duplex ultrasound (DUS) is often used to describe the anatomical distribution of the disease.[3,5,6] Although DUS is useful in assessing reflux in individual vein segments, it does not permit an overall quantification of venous function. Failure to identify all segments of venous reflux using DUS increases the risk of persistent post-interventional venous incompetence.[7–10]

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Strain gauge, photo, and air plethysmography, have been suggested to provide quantitative information about whole limb venous hemodynamics.[11–17] Plethysmographic assessment of venous reflux with tourniquet application has also been used to differentiate superficial from deep venous incompetence.[13,14,16,18] It remains unknown whether the functional parameters derived from plethysmography are able to predict outcome after venous intervention and there is no consensus regarding the use of compression cuffs for selective occlusion of the superficial veins, contributing to conflicting results regarding the utility of compression cuffs in the assessment of venous reflux.[13,16,17,19,20] Zachrisson et al. showed that it is possible to achieve selective occlusion of the superficial veins using a standardized cuff occlusion model, being then able to differentiate between superficial and deep venous reflux.[14]

The high frequency of recurrence of venous incompetence is challenging in the development of non-invasive methods for assessing the hemodynamic significance of venous disease, which is not always possible by DUS alone.

The aim of this study was to evaluate strain gauge plethysmography (SGP) with standardized selective occlusion as a complement to DUS in the assessment of superficial venous incompetence, and to investigate whether the results of radiofrequency ablation (RFA) can be predicted.

PATIENTS AND METHODS

Seventeen patients were included (three men, 14 women [20 legs]; mean age 55 years [range 31–73 years]) all of whom underwent RFA for great saphenous vein (GSV) incompetence. All patients were investigated with DUS before admission, according to local routines. Only patients without any previous venous intervention in the studied leg were enrolled. Disease severity was C2–C5, according to CEAP classification (Table 1).[4] DUS and SGP were performed before and after treatment. SGP was performed a median of 1 month post-operatively (range 1–2 months); DUS was performed a median of 2 months post-operatively (range 1–14 months). The study was approved by the regional ethical review boards in Linköping and Gothenburg, Sweden, and written informed consent was provided by each participant.

Table 1. Demographic and clinical data.

Patients (*n*)	17
Legs (*n*)	20
Mean (range) age, y	55 (31–73)
Women	14 (82)
BMI (kg/m^2)	28.5 ± 2.1
Median (range) thigh-level GSV diameter (mm) Length of great saphenous vein reflux (from saphenofemoral junction)	7.2 (4.2–13)
Knee	2 (10)
Mid-calf	7 (35)
Foot	11 (55)
CEAP	
Class 2	5 (25)
Class 3	9 (45)
Class 4	4 (20)
Class 5	2 (10)

Note. Venous reflux was evaluated by duplex ultrasound. Data are *n* (%) unless otherwise indicated. BMI = body mass index; GSV = great saphenous vein; CEAP = Clinical Etiology Anatomy Pathophysiology classification.

Ascending phlebography

Ascending phlebography was performed to validate selective occlusion of superficial veins in a separate control group (C-group) of 12 patients (seven men, five women [14 legs]; mean age 51 years [range 30–79 years]) with a similar C distribution (CEAP classification) as in the patient group.[21] The rationale for the inflated cuff pressures for selective vein occlusion has been described elsewhere.[14]

During ascending phlebography compensation for the hydrostatic pressure was performed (semi-erect position [60°]). Images were acquired in two planes after fractionated injections of contrast medium (Omnipaque; Nycomed) into a dorsal foot vein. Pressures of 60 mmHg (calf) and 30 mmHg (ankle) (added to the hydrostatic column from 30 cm above heart level to the position of phlebography) were used to induce selective superficial vein occlusion without affecting the deep veins.[14]

DUS

DUS examinations were performed with an ACUSON S2000 ultrasound system (Siemens Medical Solutions, Malvern, PA, USA) with 9 and 18 MHz transducers. The 9 MHz transducer was used for assessment of reflux. Both the 18 and 9 MHz transducer were used to exclude wall changes in the superficial and deep veins. A standardized protocol to assess reflux was used, including superficial veins (saphenous veins and tributaries), perforator veins, and deep veins (femoral, common femoral, deep femoral, popliteal, and calf veins).[18] A standardized cuff unit (Ekman Biomedical Data AB, Gothenburg, Sweden) was used with a distal cuff pressure of 100 mmHg for distal compression and rapid release. Presence of normal phasic flow during breathing in the common femoral vein was mandatory, in order to exclude significant central obstruction. GSV incompetence was classified by the initial reflux flow and graded as severe (> 100 mL/minute during the first second after release of the distal compression, and/or a maximal flow velocity of > 30 cm/second) or moderate (50–100 mL/minute and/or < 30 cm/second) measured in the proximal and mid-part of the GSV. This classification system concerning volume flow is used at the authors' institution and is based on unpublished data that correlate with the peak flow velocity mentioned above.[22]

SGP

SGP was performed with the same cuff occlusion model as used in the ascending phlebography section. A strain gauge was placed around the forefoot to register the refilling curve (Fig. 1A).[14] An ankle compression cuff (3 × 30 cm) was applied just above the malleoli and a calf cuff (3 × 40 cm) just below the tibial condyles using a cuff inflator (Bergenheim, Elektromedicin, Gothenburg, Sweden).