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CASE REPORT

Extracorporeal Treatment with High Intensity Focused Ultrasound of an Incompetent Perforating Vein in a Patient with Active Venous Ulcers

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Introduction: Endovenous techniques such as ultrasound guided foam sclerotherapy, thermal methods, or glues are generally recommended to occlude incompetent veins. However, these methods can be technically challenging and risky for patients with severe atrophic skin disorders like lipodermatosclerosis or atrophie blanche. High intensity focused ultrasound (HIFU), which has been shown to coagulate and occlude veins successfully, may offer an alternative method. This case report details ultrasound guided HIFU to occlude non-invasively a refluxing perforator vein causing active ulcers.

Report: A 95 year old man presented to the Institute for Functional Phlebology (Melk, Austria) with painful recurrent ulcers in his left medial calf. His limb was scored C2,3,4a, b,6, Ep, Ap, Pr,18 according to the Clinical, Etiology, Anatomic, Pathophysiology (CEAP) classification. Lower limb ultrasound revealed a refluxing posterior tibial perforating vein, measuring 2.7 mm in diameter at the level of the fascia. Extracorporeal HIFU pulses were delivered to this vein with the Sonovein device (Theraclion, Malakoff, France). Sonication was applied for eight seconds at a mean acoustic power of 80 W. The patient was followed up for three months post-treatment and occlusion was evaluated by duplex ultrasound. There were no complications during treatment or follow up. Three months after the treatment, reflux was abolished and the two initially active ulcers had healed.

Discussion: Although this is an early report, this study shows that HIFU can be successful in ablation of incompetent perforator veins in the treatment of venous leg ulcers.

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INTRODUCTION

Current options for the treatment of incompetent perforating veins (IPVs) include minimally invasive techniques like endovenous thermal ablation (EVTA) or surgical options.

Regardless of the technique used, occluding IPVs is technically challenging compared with the ablation of the great saphenous vein (GSV).[1]

While EVTA for GSV incompetence has a success rate of >96%,[1] lower success rates are reported for the ablation of IPVs (59%—90%). These higher perforating vein closure failures are explained by the difficulties cannulating them.[1] Perforating veins are frequently deep, tortuous, and located close to damaged and ulcerated skin.[1] An extracorporeal approach using HIFU to treat an IPV causing active ulcers in an elderly patient is described.

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CASE REPORT

A 95 year old man presented with painful recurrent left leg ulcers after a six year ulcer free period. The patient was in relatively good general health but had a medical history of prior ischaemic stroke and coronary artery disease. In 2012, he had undergone stripping of his left GSV and simultaneous shave therapy with mesh graft transplantation to treat the initial ulcer.

Clinical examination revealed two active ulcers located in an area of severe lipodermatosclerosis in the medial left calf, atrophie blanche, hyperpigmentation, and mild oedema (Fig. 1A). Both ulcers were exuding, with diameters of 10 mm. The Clinical, Etiology, Anatomic, Pathophysiology (CEAP) classification of his left limb was C2,3,4a,b,6,Ep,Ap,Pr,18.

Before treatment, a detailed ultrasound examination of the left limb was performed using a Terason scanner (Burlington, MA, USA).

Examination revealed post-flush ligation and partial stripping of the GSV to knee level without recurrence. No deep venous incompetence was observed. To identify the origin of the venous leg ulcers, a "sourcing" technique

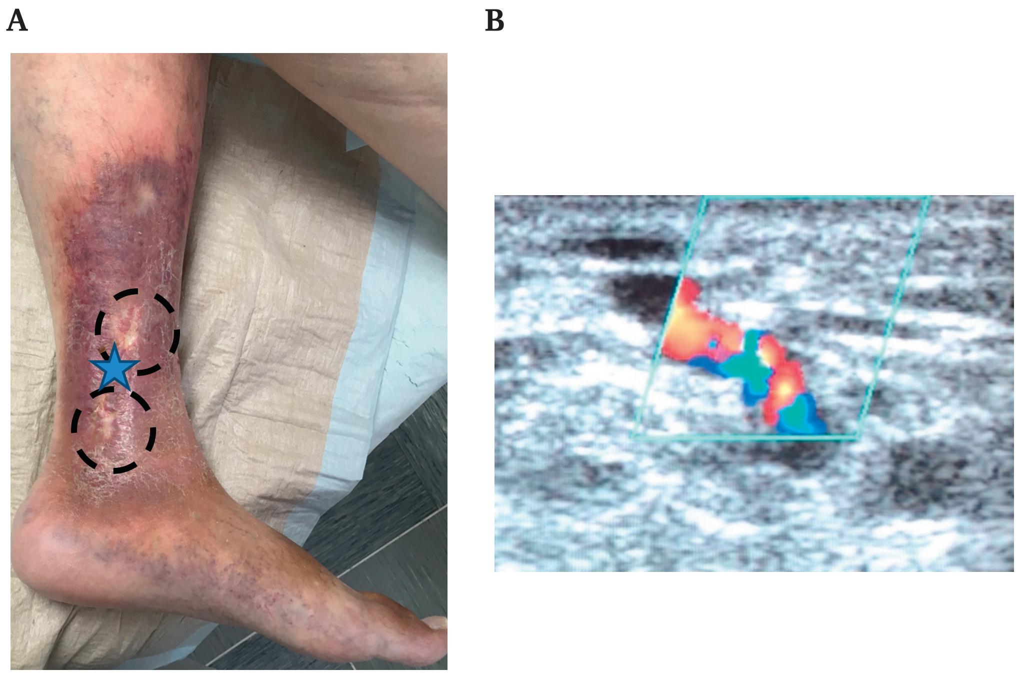

Figure 1. (A) Left calf showing two exuding ulcers (dark dotted circles). Location of the incompetent perforating vein is indicated by the blue star. (B) Colour Doppler image of the incompetent perforating vein showing outward flow ("blow out").

described by Obermayer and Garzon was performed.[2] This technique, carried out with the patient standing, involved gently compressing and releasing the ulcerated area and investigating the routes of venous reflux penetrating into the ulcer area with duplex ultrasound.

A refluxing posterior tibial perforating vein 18 cm from the floor and with a systolic and diastolic outward flow >1.5 seconds was identified as the source of the local venous hypertension (Fig. 1B, C) feeding superficial varicose veins. A diameter of 2.7 mm was measured at the level of the fascia.

The patient was placed in the Trendelenburg position and was treated in an outpatient setting.

A Sonovein device was used for the treatment. This ultrasound guided device encompasses a motorised treatment head mounted on an articulated arm. The treatment head (Fig. 2, right) is a removable part incorporating both an imaging transducer (7.5 MHz, 128 elements) and a therapy transducer (3 MHz, single element, diameter 56 mm, −6 dB focal spot width 0.5 mm) that can treat target tissues located at least 10 mm under the skin.

The system operates in conjunction with a single use disposable kit called EPack (Fig. 3). A fluid filled balloon was fixed to the transducer to ensure acoustic coupling between the transducer and the target. The coupling liquid was continuously circulated and cooled at 10°C to prevent skin burns.

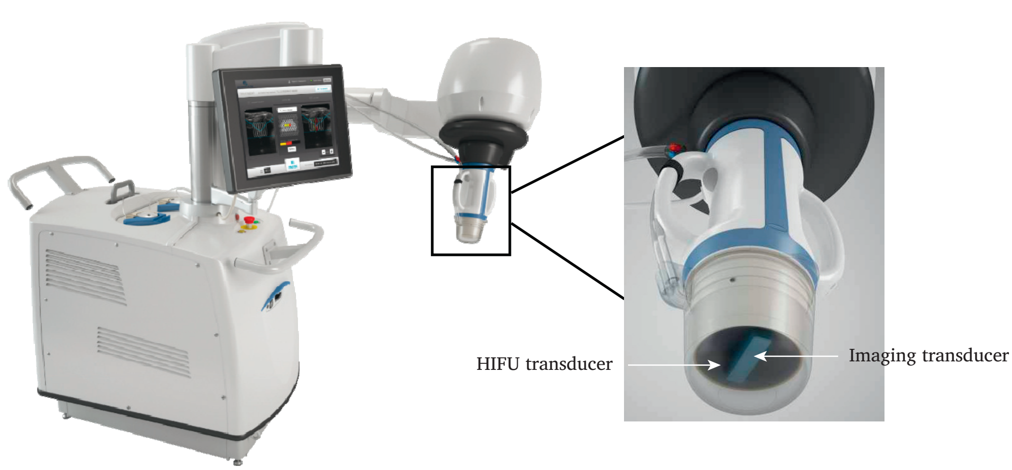

Figure 2. Sonovein high intensity focused ultrasound (HIFU) device.

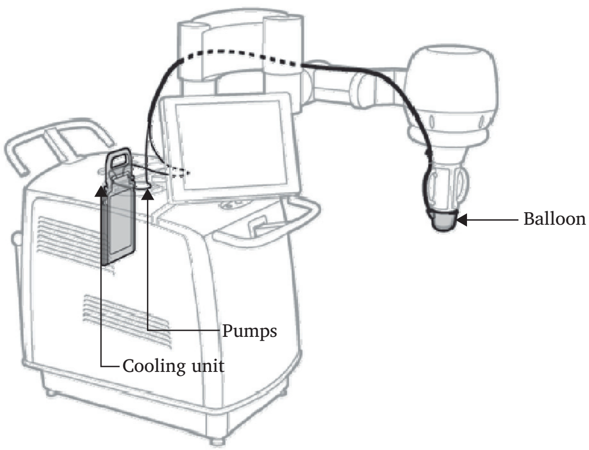

Figure 3. EPack. The kit comprises a prefilled pouch of degassed liquid, a balloon, and tubes to connect the balloon to the pouch. The pouch is incorporated in a dedicated bracket and placed in the cooling unit to cool the liquid; the balloon is mounted on the transducer; and the tubes are placed in the pumps, which allow the circulation of the liquid from the pouch to the balloon and back.

The treatment head was first manually positioned in the region of interest and then the precise position was adjusted robotically (Fig. 4). To ensure the targeted vein was located at least 10 mm below the skin, 8 mL 0.1% lidocaine was injected subcutaneously under ultrasound guidance. This local anaesthesia was also performed to prevent pain and to compress the vein mechanically, which increases energy deposition on the vein wall.[3–5] Owing to the fragility of the skin and to avoid an infection, the injection was performed with a 21 G needle (0.80 × 120 mm; B Braun, Melsungen, Germany) inserted from the dorsal side, outside the lesion.

Thirty-one eight second pulses were delivered to the IPV at a mean ± standard deviation acoustic power 80 ± 21 W. Acoustic power was adjusted during the treatment according to the appearance of hyperechoic regions on the ultrasound image.[5] A minimum pause time of 30 seconds was observed between each pulse to allow the skin to cool down.

After the procedure, a compression bandage was applied for seven days and the patient returned to his normal activities.

Clinical follow up appointments were scheduled seven days and three months post-treatment.

A visual analogue pain score (from 0 to 10) was given to the patient before treatment, at day seven post-treatment, and at three months. A patient satisfaction questionnaire was also completed at the last clinical visit.

The patient initially reported a pain score of 3 before treatment and 0 on day seven and three months post-treatment.

Seven days post-operatively, the vein was not occluded and the ulcers were still active, but at three months the vein was occluded and the ulcers were healed (Fig. 5B). The patient scored the treatment as very satisfactory. No complications occurred during treatment or follow up.

Approval was obtained to publish this case.

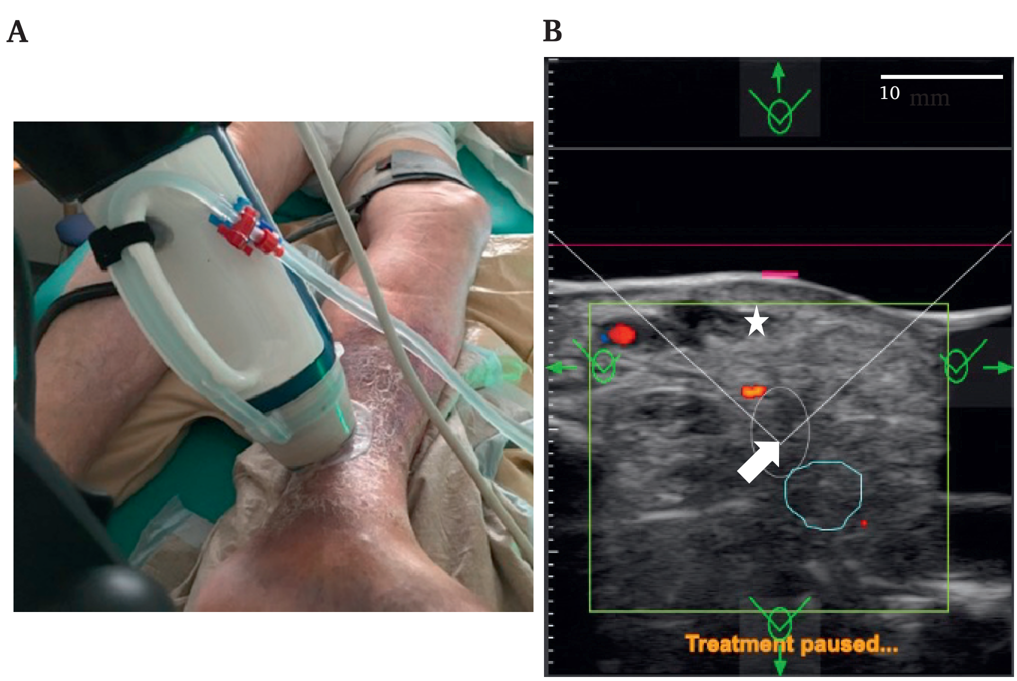

Figure 4. (A) Positioning of the high intensity focused ultrasound transducer on the calf. (B) Robotic adjustment on the treatment screen of the therapy transducer position. To be properly centred on the targeted vein (white arrow), the focal point position is adjusted with the green directional command arrows. Note here the presence of the subcutaneous infiltration (white star) creating depth between the skin (pink line) and the anterior vein wall.

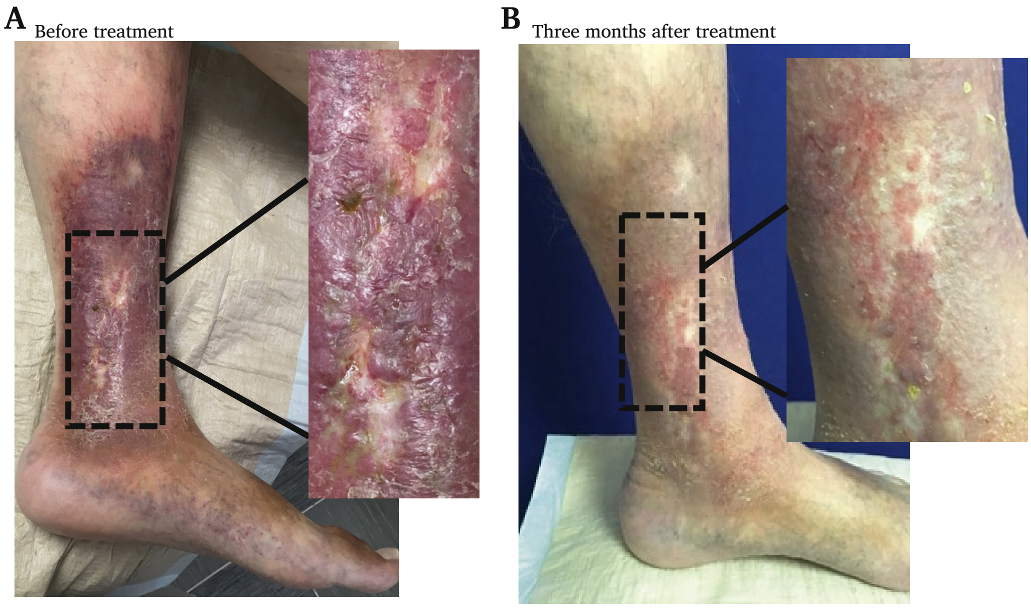

Figure 5. Appearance of the left calf (A) before treatment and (B) three months after treatment.

DISCUSSION

This article describes the first results of IPV treatment with HIFU.

This technique, currently used for many clinical applications like the treatment of benign and malignant solid tumours,[6] uses high intensity focused beams to concentrate acoustic energy into a small soft tissue volume. The focusing of a high power acoustic beam allows induction of high temperatures locally at the focus (approaching 100°C) producing localised tissue ablation.

Owing to the heat and for patient comfort, a small amount (8 mL) of anaesthetic was injected before sonication. The volume used was considerably less than the amount of tumescent anaesthesia infiltrated around truncal veins during EVTA (>250 mL).

The use of HIFU to occlude veins has been investigated in preclinical studies.[3,7] In particular, the ability of occluding veins of similar size (mean diameters of 2.0—4.8 mm) has been demonstrated with the same device.[3—5] Dedicated chronic *in vivo* experiments were performed in a sheep model to assess the long term efficacy and safety of the procedure.[4] Eighteen saphenous veins (mean diameter 3.2 mm) were exposed to pulses similar to those delivered here (mean 84 W, eight seconds). Animals were followed up to 90 days post-treatment and after completion of the follow up vein segments were harvested and assessed microscopically. Histological findings revealed vein wall changes similar to those reported after EVTA (vein wall coagulation and fibrosis). In a human study with a six week follow up, Whiteley[8] reported that the closure rates observed in five patients treated with the Sonovein appeared to be as good as those after EVTA in the same short time with the major advantage of being non-invasive. In the same study, HIFU was delivered to treat varicose veins, venous leg ulcers, and other manifestations of venous reflux disease.[8] The mechanisms through which HIFU produces vascular occlusion are discussed in Barnat.[5] Vascular occlusion is thought to occur as a result of numerous contributing factors, including vein wall collagen coagulation and endothelial damage. Transmural death of the cells in the vein wall may lead to permanent closure of the targeted vein by fibrosis.[8] Although EVTA has proven to be effective, these methods can be arduous and risky as vein wall perforation may occur.[9] With HIFU, as nothing is inserted into the vein, infection and bleeding risks are minimal. HIFU can be particularly interesting for patients with a risk of bleeding.[8] Unlike EVTA methods, the occlusion does not seem to occur immediately but rather after a short delay (here seven days).

This initial experience suggests that the Sonovein may be useful for ablation of refluxing veins.

Although this technique is new, early results are encouraging, as illustrated by the present case.

FUNDING

Research grant.

CONFLICTS OF INTEREST

Nesrine Barnat is an employee of Theraclion.

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