A Clinical and Haemodynamic Investigation into the Role of Calf Perforating Vein Surgery in Patients with Venous Ulceration and Deep Venous Incompetence


Department of Surgery, University of Leicester, Leicester, U.K.

Objective: To determine the clinical efficacy and local haemodynamic effects of perforating vein surgery in ulcerated limbs with combined deep and perforating vein incompetence.

Design: Prospective, interventional study.

Materials and methods: Seven ulcerated limbs with combined primary deep and perforating vein incompetence were studied. Clinical efficacy was determined by ultimate ulcer healing and reduction in ulcer area, local haemodynamics were assessed at three sites with photoplethysmographic 90% venous refilling times (PPG RT90); both assessments were performed pre- and 1-month postoperatively.

Results: None of the ulcers healed following perforating vein surgery, the median (range) ulcer areas pre- and postoperatively were 31 (7–685) cm² and 35.5 (7–796) cm² (Wilcoxon p = 0.07). Preoperative PPG RT90 demonstrated a global abnormality of venous function at all sites examined that persisted after perforating vein surgery.

Conclusion: In the presence of deep venous incompetence perforating vein surgery had no influence on venous function or ulcer healing. We conclude that perforating vein surgery is not indicated for the treatment of venous ulceration in limbs with primary deep venous incompetence.

Key Words: Venous ulcer; Perforating vein; Surgery.

Introduction

Venous ulcers occur most commonly on the supramalleolar medial aspect of the calf in close proximity to incompetent medial calf perforating veins. This anatomical proximity has led to a pathophysiological association between incompetent perforating veins and venous ulceration, and perforating vein surgery (PVS) has therefore been proposed as a treatment for venous ulceration. However, the role of perforating vein surgery in patients with venous ulceration remains uncertain. This is because the interpretation of previous studies is confounded by a number of factors. Thus, in many studies superficial venous surgery has been combined with PVS and the distribution of venous incompetence in the superficial and deep veins has not been clear. This latter information is particularly important in view of studies showing that in ulcerated limbs with perforator and superficial venous incompetence and normal deep veins, superficial venous surgery alone, without PVS, will lead to ulcer healing in the majority of cases. The interpretation of the role of PVS in ulcer healing is further hampered by additional perioperative procedures, including operating after any ulceration has healed and using prolonged postoperative bed rest elevation and/or compression. The advent of colour duplex scanning has revolutionised the investigation of patients with venous ulceration and it is now possible to rapidly and accurately define the distribution of venous incompetence in affected limbs. The purpose of this study was to investigate the role of PVS in patients with venous ulceration and incompetent deep veins. We purposefully identified limbs that had previously undergone saphenous vein surgery so that the only remaining venous abnormalities were calf perforating vein and deep venous incompetence. The effect of PVS was examined without preoperative ulcer healing and without postoperative bed rest, elevation or compression, thereby allowing the specific role of PVS to be assessed.
Patients and Methods

Study design

Patients with ulcerated limbs and a combination of calf perforating vein incompetence and deep venous incompetence extending from the common femoral vein down into the below-knee popliteal vein were entered into the study. All patients had previously undergone long saphenous vein surgery in an unsuccessful attempt to achieve ulcer healing and were receiving four layer compression bandaging at the time of recruitment. Each limb under investigation had an ABPI >0.8, excluding significant peripheral arterial disease. The effect of PVS was measured by its effect on ulcer healing and in its effect on local venous haemodynamics. Thus, pre- and 1-month postoperatively ulcer areas were measured and photoplethysmography (PPG) performed at three sites on the ulcerated limb. No postoperative compression was applied. If, however, at 1 month there was no evidence of ulcer healing or the ulcer size had increased, then a four layer compression bandage was applied.

Ultrasonography

Colour duplex scanning using either an ATL Ultramark (HDI) (Advanced Technology Laboratories U.K. Ltd.) or a Diasonics Masters (Sonotron Ltd.) machine with linear array 5 MHz and 10 MHz probes to examine the deep and superficial venous systems, respectively. Limbs were examined in the dependent position and venous reflux was defined as reversed blood flow of more than 0.5 s on release of a manual calf squeeze distal to the segment of vein under examination. Colour duplex scanning was used to mark the site of refluxing calf perforating veins preoperatively and to re-examine the operated limb at the follow up visit to assess the completeness of PVS. Perforating veins were defined as possessing reflux if they could be made to exhibit deep to superficial blood flow in response to a manual compression. Post-thrombotic deep vein damage was inferred from the following characteristics on duplex scanning: old intraluminal thrombus (incompressible vein), thickened/scarred vein walls, stenosis of the vein, shrunken and scarred valve cusps.

Ulcer area

Ulcer areas were obtained by computerised planimetry of tracings of the ulcer perimeter taken onto transparent acetate sheets immediately preoperatively and 1-month postoperatively. Ulcer healing was defined as complete re-epithelialisation of the ulcer base determined by inspection.

Photoplethysmography

Local venous haemodynamics were assessed by photoplethysmography (PPG). In order to detect any localised abnormality in venous haemodynamics 90% refill times (RT90) were measured at three sites in the lower limb: the dorsum of the foot (5 cm distal to the ankle joint crease), the medial and lateral gaiter regions 5 cm proximal to the tip of the respective maleolus. If the preferred sites of RT90 measurement were involved in ulceration, extensive lipodermatosclerosis or atrophic blanche then the nearest area of skin to the preferred site was used to obtain the measurements. PPG measurements were made using a Scimed PVL-50 photoplethysmograph (Scimed, Bristol, U.K.) with the subject seated with the legs dependent. The knees were relaxed and flexed to 90 degrees and the knee joints were clear of the edge of the couch to ensure the popliteal vein was not compressed. Recordings were made after a stable resting reading was obtained by the PPG and the subject was asked to perform five dorsiflexions of the ankle whilst keeping the knee relaxed and flexed. The dorsiflexions were made at 1 s intervals and thereafter the knee and ankle joints were left fully relaxed and dangling free until the tracing returned to the pre-exercise baseline reading. If the pre-exercise level was not regained then the post-exercise level was used as the baseline for the whole investigation and all measurements of RT90 were made with reference to this level.

Surgery

Perforating vein surgery was performed in one of three ways; via individual 2–3 cm skin incisions at the preoperatively marked sites, subfascial endoscopic perforating surgery (SEPS), or coil embolisation. Postoperatively limbs were dressed with NA dressings (Johnson and Johnson Ltd.) sterile gauze and a graduated Tubigrip (Seton) to keep the dressings in place.

Data analysis

Photoplethysmography data were analysed using ANOVA techniques to test for site dependent variations in RT90. Thus, if reflexing medial calf perforating veins do give rise to venous abnormalities in
their immediate vicinity then one would expect to find an abnormally rapid RT90 in association with the medial perforating veins and more normal RT90s at the pedal and lateral gaiter sites studied. If, however, there is no local venous abnormality then no such site dependent abnormality in RT90 will be detected. All limbs were examined in this manner preoperatively and 1 month postoperatively. If PVS does alter local venous haemodynamics then one would expect the postoperative RT90 to show a prolongation at the medial site compared to the other two points. Data were not examined in a paired pre-/postoperative manner because temporal variations in skin perfusion do not allow valid comparisons to be made in this way.\(^{19,20}\)

**Results**

**Patients, limbs and ulcers**

Seven patients with seven ulcerated limbs were investigated, four were male and the median (range) age was 70 (36–90) years. All seven limbs had previously undergone formal saphenofemoral disconnection with long saphenous vein stripping to the knee at least 12 months prior to entry into this study. None of the limbs had undergone short saphenous vein surgery and none had short saphenous vein reflux. Only one patient gave a history of having had a previous deep vein thrombosis (DVT) and this was the only limb with duplex evidence of a DVT, the remaining six limbs had neither a history nor evidence of previous DVT. No limb studied possessed any duplex detectable deep venous valves. Five limbs had medial ulcers (all with refluxing medial perforating veins only), one had a lateral ulcer (with reflux in four medial and one lateral perforating vein and duplex evidence of a previous DVT) and one limb had medial and lateral ulcers (refluxing medial perforating veins only). The median (range) ulcer duration prior to surgery was 2 (0.5–6) years with a preoperative median (range) area of 31 (7–685) cm\(^2\). Preoperative colour duplex scanning identified a median (range) of 2 (1–5) perforators per limb that were disconnected as follows: direct open division five limbs, SEPS one limb, coil embolisation one limb.

At operation there was complete agreement between the preoperative duplex identification of perforating veins and the operative findings. This was corroborated by the postoperative duplex scanning that confirmed the absence of persisting refluxing perforating veins in any of the limbs studied.

One month postoperatively none of the ulcers had begun to heal and the median (range) ulcer area had increased to 35.5 (7–796) cm\(^2\) (Wilcoxon matched-pairs testing \(p=0.07\)) and consequently all seven limbs were treated by four layer compression bandaging thereafter.

**Venous haemodynamics**

Figure 1 demonstrates the duration of the preoperative RT90 for all seven limbs at the three sites. All three sites in all seven limbs demonstrated a more rapid RT90 than normal (20 s).\(^2\) Interestingly, one limb with a medial ulcer (refluxing medial perforators) displayed a more rapid RT90 in the lateral gaiter area (4.0 s) compared to the pedal (8.8 s) and medial gaiter areas (6.4 s), the limb with a lateral ulcer (four medial and one lateral perforators) had a medial RT90 of 2.5 s and pedal and lateral RT90 of 4.9 s and 6 s, respectively. The five remaining limbs, four with medial ulcers and one with a medial and lateral ulcer (all with refluxing medial perforating veins) demonstrated no meaningful pattern to the distribution of RT90. Repeated measures ANOVA found no site dependent variation in RT90 (\(F=0.57, \text{d.f.}=2, p=0.58\)).

Postoperatively (Fig. 2) the RT90s remained abnormal in all three sites in all seven limbs and there was no site dependent variation in RT90 within any of the limbs examined (\(F=1.57, \text{d.f.}=2, p=0.27\)). In particular, of those limbs with medial ulcers and medial refluxing perforating veins there was no prolongation of RT90 at the medial site compared with the pedal and lateral sites.
Calf Perforating Vein Surgery

Preoperatively the predominant pattern of perforating vein reflux was medial with only one lateral refluxing perforator identified. Of the limbs with medial perforating vein reflux only, five limbs had a medial ulcer and one limb had medial and lateral ulcers implying that ulceration can occur at sites on the leg distant from any refluxing perforating veins. Likewise, the limb with a combination of four medial and one lateral perforator had a lateral ulcer despite a predominantly medial perforator abnormality. These findings suggest a global abnormality of venous function in the ulcerated limb rather than more pronounced abnormalities at the sites of perforating vein reflux.

Ambulatory venous pressures reflect the venous function of the entire limb and cannot, therefore, be used to detect localised venous abnormalities. Photo-plethysmography was chosen to assess venous haemodynamics because it allows cutaneous venous reflux to be assessed locally. Although PPG is an indirect measure of venous function RT90 times correlate well with AVP refill times in the sitting position. The preoperative PPG studies (Fig. 1) demonstrated a global abnormality of venous function and did not show that the medial gaiter area was any worse than the other two sites. At the postoperative examinations (Fig. 2) the RT90s still remained globally abnormal and in particular the medial RT90s had not lengthened when compared to the other two sites. This finding shows that PVS does not improve the local venous haemodynamics in limbs with coexisting deep venous reflux.

The role of perforating vein surgery needs careful appraisal, highlighted recently by the advent of SEPS. There appears to be no indication for perforating vein surgery in the presence of normal deep veins and saphenous vein reflux: Bjordal, 25 in 1972, demonstrated that in this situation ambulatory venous pressures were normalised by proximal saphenous occlusion and that perforating vein reflux had no influence on venous pressure. Subsequently, Sethia and Darke 15 have clearly demonstrated both clinical healing and venous haemodynamic improvement in limbs undergoing saphenous ligation alone (without PVS) in limbs with saphenous and perforating vein reflux but normal deep veins. Furthermore, it has recently been demonstrated that incompetent perforating veins can regain competence after saphenous veins surgery in limbs with normal deep veins.

Likewise, the role of PVS in limbs with superficial and deep reflux combined is difficult to justify. Burnand has demonstrated that perforating vein surgery can neither prevent ulcer recurrence nor improve ambulatory venous pressures in limbs with post-thrombotic deep

Fig. 2. Postoperative PPG RT90 refill times for the seven limbs studied.

Discussion

This study was designed to investigate the role of calf perforating vein surgery in ulcerated limbs with combined deep and perforating vein incompetence and to document any local venous abnormality associated with incompetent perforating veins that may implicate them in the pathogenesis of venous ulceration. In order to assess the role of calf PVS in isolation we purposefully selected limbs with perforating and deep venous reflux only, thereby avoiding the complicating factor of saphenous reflux. Limbs that fall into this category are relatively uncommon (7/239 in this series) and we do not anticipate seeing any more patients in our own practice because we no longer perform saphenous surgery in the presence of deep venous incompetence extending from the common femoral into the below-knee popliteal vein. We feel, however, that although there were only seven patients in the study, if PVS was of any clinical or haemodynamic benefit then this should have been apparent.

To put these seven patients into context, they represent a select group of 239 consecutive patients with ulcerated limbs examined over a 2-year period. Of these 239 patients perforating vein reflux was present in combination with deep and superficial reflux in a further seven limbs and in combination with superficial reflux alone in a further 21 limbs. In three limbs perforating vein reflux was the only detectable venous abnormality and two limbs exhibited perforator and deep reflux only. As indicated above, we no longer offer surgery to patients with ulcerated limbs possessing superficial, deep and perforating vein reflux in combination.
venous reflux. This has been supported more recently by Stacey,10 Akeesson29 and Bradbury.11,29 One surgical option remaining in this situation is deep venous valve repair30 if any detectable valves are present or valve transplantation/transposition,11,29 if no deep venous valves are suitable for repair. Since reflux of the popliteal venous segment is pivotal in the development of venous ulceration29 we feel this is an important area for future investigation.

In summary, the laterality of calf perforating vein incompetence does not dictate the location of venous ulceration in the presence of below-knee deep venous incompetence and PPG confirmed a global abnormality of venous reflux in the calf extending onto the clinically normal dorsal foot skin. Following calf PVS, none of the ulcers began to heal and indeed the ulcer areas enlarged, PPG RT90s failed to return towards normal at any site, remaining globally abnormal with no preferential improvement at the medial gaiter site. Calf perforating vein surgery has previously been shown to be ineffective in limbs with post-thrombotic deep venous incompetence and in limbs with superficial venous incompetence perforating vein surgery is unnecessary to achieve ulcer healing. Here we have demonstrated similar findings in limbs with primary deep venous incompetence. We conclude that perforating vein surgery has no role in the management of such ulcerated limbs.

References


Accepted 24 March 1998