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An Overview of the Surgical Aspects of Lower Limb Venous Disease

CN Parnaby, GH Welch, WP Stuart

Department of Surgery, Southern General Hospital, Glasgow

Correspondence to

Mr WP Stuart, Department of Surgery, Southern General Hospital, Glasgow
Tel. 0141 423 9327 Email: wesley.stuart@sgh.scot.nhs.uk craigparnaby@aol.com

Summary Points

Lower limb venous disease encompasses a wide spectrum of pathology, the importance of which relates to high prevalence rather than mortality. The complications of chronic venous insufficiency (CVI), namely lipodermatosclerosis and chronic venous ulceration, represent a major burden to healthcare providers and a high degree of personal morbidity for patients.

Management is based upon accurate clinical diagnosis supported by non-invasive imaging. Open surgical and minimally invasive techniques are used to treat varicose veins. Chronic skin complications of CVI require a multi-disciplinary approach.

Introduction

Lower limb venous disease encompasses a wide spectrum of pathology ranging from minor reticular veins and common asymptomatic varicose veins to chronic venous ulceration. There are also several rare conditions. Venous disease derives a significant importance from the number of surgical procedures performed for reasons of cosmesis and minor symptoms and from the huge resource burden associated with the care of patients with end-stage chronic venous insufficiency (CVI), chronic venous ulceration (CVU).[1]

It is beyond the scope of a short general overview to deal with the full spectrum of venous pathology. However common conditions will be dealt with, and a pragmatic management approach presented.

Epidemiology

Until relatively recently data regarding the epidemiology of varicose veins was heavily skewed by a paucity of good studies on a typical western-world population. Arguably, the first paper examining the prevalence of venous pathology in a random population sample was the Edinburgh Vein Study.[2] This was a cross-sectional survey of a population aged 18-64 years living in Edinburgh. In 1566 invited participants (53.8% response rate), the prevalence of varicose veins and chronic venous insufficiency was 35% and 7% respectively. The prevalence of venous disease increased with age.

Previously published work was based upon inappropriate sample populations, with inadequate assessment and therefore unreliable conclusions. Franks et al used a postal questionnaire to assess the presence of varicose veins, therefore relying on the subject's own observation, which may be unreliable.[3] Other studies used highly selected groups such as hospital or clinic patients.[4,5] Personal series in the literature were also heavily biased by the nature of the patient population referred for assessment and surgery. This was due to referral bias leading to an under-estimation of varicose veins in male and older patient groups.[6]

Gross Anatomy

The infra-inguinal venous system can be considered in three parts, the superficial, the deep and the perforating veins.

The superficial veins lie in the subcutaneous layer and comprise the long and short saphenous veins and their tributaries. The long saphenous vein starts as a continuation of the medial marginal vein of the foot, passes anterior to the medial malleolus, passes a hand's breadth posterior to the medial border of the patella and terminates in the common femoral vein (Figure 1). The short saphenous vein starts as a continuation of the lateral marginal vein, passes posterior to the lateral malleolus and terminates in the popliteal vein in the popliteal fossa (Figure 2).

The deep veins accompany the arteries and their branches and are located beneath the deep fascia.[7] The names correspond to the arterial counterparts and therefore, somewhat confusingly, the superficial femoral vein is part of the deep system.

Perforating veins can be considered to be those connecting the deep and superficial venous systems, aside from the sapheno-femoral and sapheno-popliteal junctions. Various perforating vessels have been described and are typically located in the mid-thigh, just below the knee and on the medial aspect of the calf.[8]

Normal Venous Physiology

The calf muscle pump is the principle component of venous return from the lower limbs. Contraction of the skeletal muscle compresses both the deep veins and the venous sinusoids within the muscles themselves. The venous valves prevent reverse flow, directing blood cephalad with minimal distal reflux (< 0.5 seconds on Doppler testing).[9] This action is measurable as a reduction in pressure in a cannulated superficial vein at the

Figure 1: Great (Long) Saphenous Vein

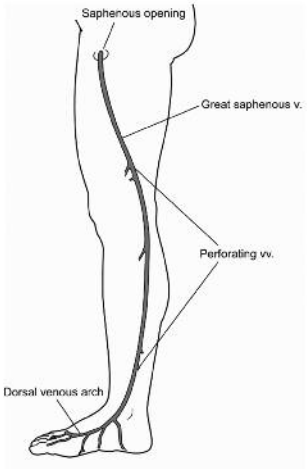
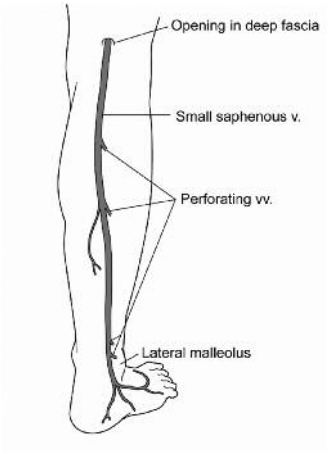


Figure 2: Small (Short) Saphenous Vein



ankle level, from about 90mmHg after a few minutes standing stationary, to less than 30mmHg after a few ankle flexion movements.[10] This forms the basis of ambulatory venous pressure testing.

Venous Pathology and the Classification of Venous Disease

The common venous pathologies of the lower limb can be considered in two broad groups, venous reflux disease and much less commonly venous obstruction. Disease of the superficial system is almost exclusively venous reflux disease, resulting in dilated, tortuous, elongated and incompetent vessels, varicose veins. Within the deep system obstructive pathology is relatively more common. However in most published series of venous ulceration, reflux is still, by some way, the predominant problem (Table I).

Table I: The Distribution of Reflux in Patients with Venous Ulceration by Duplex Ultrasonography

Author	Year	Limbs (n)	Superficial reflux detected (%)	Deep reflux detected (%)	Superficial reflux only (%)
Van Bemmelen[11]	1990	25	92	92	8
Hanrahan[12]	1991	95	79	50	17
Mastroroberto[13]	1992	51	76	47	4
Shami[14]	1993	79	75	47	53
Lees[15]	1993	25	88	48*	52*
Van Rij[16]	1994	120			40
Myers[17]	1995	95	86	56	36
Labropoulos[18]	1996	120	90	58	37*
Scriven[19]	1997	95	88	43	57*
Stuart[20]	1997	69	87	69	31

*Including incompetent perforating veins

Various classifications have been used for venous disease. Most widely used are the Basle Classification, based largely on clinical appearances, and a classification adopted by the American Venous Forum. Derived from the Basle-based study, Widmer graded varicose veins according to degree, extent of tortuosity and prominence. Furthermore, patients with chronic venous insufficiency were classified into three grades from venous flare (grade1) to ulceration (grade 3).[21]

In 1994 following a consensus meeting of the American Venous Forum, a more comprehensive classification system was devised. Venous disease was described by clinical (C), aetiology (E), anatomical (A) and pathology (P) criteria (CEAP classification).[22] The CEAP classification provides detailed data, helpful for research purposes but it is laborious to use in practice. Commonly, only the clinical groupings are used. This grades the skin appearances and complications of venous disease from 0-6 (Table II).

Table II: CEAP Classification of Chronic Venous Disease[22]

Classification	Description/Definition
C, Clinical (subdivided into A for asymptomatic, S for symptomatic)	
0	No venous disease
1	Telangiectases
2	Varicose veins
3	Oedema
4	Lipodermatosclerosis or hyperpigmentation
5	Healed ulcer
6	Active ulcer
E, Etiologic	
Congenital	Present since birth
Primary	Undetermined etiology
Secondary	Associated with post-thrombotic, traumatic
A, Anatomic distribution (alone or in combination)	
Superficial	Great and short saphenous veins
Deep	Cava, iliac, gonadal, femoral, profunda, popliteal, tibial and muscular veins
Perforator	Thigh and leg perforating veins
P, Pathophysiological	
Reflux	Axial and perforating veins
Obstruction	Acute and chronic
Combination of both	Valvular dysfunction and thrombus

Investigation

Duplex scanning

Duplex scanning has become the method of choice for the investigation of lower limb venous disease and has revolutionised the anatomical and physiological examination of the deep and superficial venous system, almost completely replacing phlebography.[23] B-mode ultrasound provides real-time images of the vessels and the Doppler function gives information related to the direction and velocity of blood flow, expressed either as colour superimposed on the grey-scale

images or as a velocity spectral analysis. Duplex examination is non-invasive, well tolerated and reproducible making it ideal for both clinical and research purposes.[24] In most units, the number of patients with venous disease precludes a policy of scanning all patients. However three groups merit investigation.

1. Diagnosis of Chronic Venous Insufficiency

Chronic venous insufficiency is a failure of venous return from the lower limbs resulting in skin changes or severe symptoms. The resulting venous hypertension leads to clinical manifestations: oedema, skin changes (eczema, haemosiderin deposition and lipodermatosclerosis) and ultimately ulceration. Many clinicians believe that every patient with evidence of chronic venous insufficiency should undergo duplex scanning as it gives information on two important aspects.[19,25] Firstly, surgically correctable venous disease can be identified. A significant proportion of patients with the skin changes of chronic venous insufficiency have surgically correctable superficial venous reflux and normal deep veins (Table I). Secondly, duplex scanning in such patients identifies deep venous reflux and the less common, but prognostically poorer, chronic deep venous obstruction. The presence of popliteal vein reflux is also an adverse prognostic factor in relation to both ulcer healing and recurrence, following both conservative and operative treatment.[26]

2. Planning Surgery

Hand held Doppler (HHD) can be reliably used for confirming primary uncomplicated long saphenous varicose veins (accuracy of >95%).[27] This is probably sufficient for routine varicose veins although some would argue not ideal. However, if there is a suspicion clinically or on using the HHD of short saphenous reflux, a duplex scan should be arranged to confirm the need for popliteal fossa exploration and to confirm the anatomical arrangement in this area of notorious avariation in both healthy and diseased states.[28,29] Similarly, a duplex scan is highly desirable before surgery for recurrent varicose veins to identify the remaining sources of the varices, whether it be recurrent, or missed, sapheno-femoral disease, or short saphenous disease that was inadequately dealt with.

3. Detection of Anatomical Abnormalities

An atypical distribution of varices should alert the clinician to doubt the diagnosis of simple saphenous disease. Congenital venous anomalies such as Klippel-Trenaunay syndrome can present with laterally placed varices and is associated with deep venous hypoplasia. The recognition of deep venous impairment is essential to avoid the removal of superficial veins acting as collaterals.

Assessment of Venous Function

Duplex scanning gives qualitative information, but unlike echocardiography, gives almost no information on the haemodynamic function of the limb's venous system. Ambulatory venous pressure (AVP) measurement remains the evidence-base standard for assessment of venous hypertension and overall venous function.[30] AVP is measured by cannulating a superficial vein on the dorsum of the foot of a standing subject. This is connected to a pressure transducer, amplifier and recorder and a baseline pressure recorded. The subject performs a standard repeated exercise (usually ten "tiptoe" movements) to activate the calf pump mechanism.[31] The recorded pressure at this point is described as the AVP and in health is usually 15-30mmHg. The patient then rests again as the pressure returns to the basal level, the time taken for this to occur is the venous refilling time, more rapid in the presence of reflux. Both the refilling time and the AVP itself are dependent on the function of the venous valves and the patency of all the veins in the leg. AVP measurement is rarely used due to its invasive nature. However, it offers useful assessment of established or new methods in the treatment of venous disease and is primarily used as a research tool.

Varicose Veins

Lower limb varicose veins are common. The Edinburgh Vein Study reported the age-adjusted prevalence of trunk varices as 40% in men and 32% in women, although women are more likely to consult their doctor.[32]

Pathology

Varicose veins are enlarged, elongated, tortuous and incompetent superficial veins of the lower limb. Varicose veins are usually distributed in the course of the long saphenous or short saphenous veins (20%) and/or their tributaries. Varicose veins are thought to be due to a primary valve failure, or agenesis, or secondary valve failure due to an underlying weakness in the vein wall leading to valve-cusp separation and incompetence.

Clinical

The clinical presentation of varicose veins varies widely, but the patients can be divided into those with and those without complications.[33] The uncomplicated group presents with issues of cosmesis or discomfort. Those with complications are more likely to be associated with a high ambulatory venous pressure and these patients present with superficial thrombophlebitis, bleeding, skin changes and chronic venous ulceration. One of the more difficult tasks can be identifying the cause of leg pain and deciding whether or not it is due to varicose veins. The pain of venous insufficiency is described as an ache, worse at the end of the day and after prolonged periods of standing and relieved by lying down. Itch is another common symptom of CVI.

Treatment

Conservative measures

Many, but by no means most, patients referred to hospital with varicose veins do not actually wish surgery. If minor symptoms of ache can be alleviated by simple compression hosiery then these patients will be satisfied. This is also a useful diagnostic manoeuvre. If stockings do not help the aches and pains, it is less likely that surgery will either.

Graduated stockings come in various forms, but can be most easily categorised by the degree of compression and the part of the leg covered. Compression is divided into Classes I to III (or IV with some manufacturers), defined by the pressure exerted by the stocking on the skin. The effect is graduated, with pressure diminishing up the leg, squeezing the blood upwards and reducing the risk of a proximal tourniquet effect. Ideally, the patient should use the greatest compression possible but donning and removing stockings is a major undertaking (especially when new), so consideration must be given to hand function, general mobility and flexibility and help

to hand at home. Most patients can cope with Class II stockings but patients with arthritis will struggle. Full-length stockings, with or without waistbands, are available and are used for patients with severe venous disease (and most commonly lymphoedema) but most patients prefer, and are therefore more likely to wear, the below-knee versions. Patients should be referred to a trained orthotist for measurement and fitting. The stockings should be replaced every six months and two pairs supplied each time.

Invasive Procedures for Varicose Veins

For those patients who require a surgical procedure, it is important to explain the potential complications, particularly to those patients with minor symptoms or concern primarily about cosmesis. Varicose vein surgery-related nerve injury remains the largest cause of medicolegal claims against general surgeons.[34] The high recurrence rate should also be mentioned. The interventions for varicose veins include conventional surgery, endovenous laser ablation, radiofrequency ablation and foam sclerotherapy.

Conventional surgery

A recent British Medical Journal review argued that despite advances in other techniques, surgery still remained the standard by which other procedures should be judged.[35] The aims of surgery for varicose veins are disconnection of the deep from the superficial systems at the point(s) of incompetence and removal of unsightly superficial vessels.[36] Randomised controlled data comparing a high tie and long saphenous vein thigh strip with high tie alone, initially demonstrated significantly reduced recurrence rates in the stripping group. However, at 11 years follow-up, recurrence rates reached at least 62%, with no statistical difference between groups, even in the hands of an experienced surgeon.[37] The LSV should be stripped in the thigh alone, as stripping below the knee is associated with a high risk of saphenous nerve damage.[38] Care is also required when performing stab avulsions due to the potential proximity of other structures (eg common peroneal nerve, sural nerve).

Surgery for short saphenous varices involves saphenopopliteal ligation. Preoperative mapping of the highly variable sapheno-popliteal junction by duplex ultrasound is desirable to allow accurate placement of incision. On dissection of the short saphenous vein, care is required not to damage the nearby and often adherent sural nerve.

Endovenous Radiofrequency and Laser Ablation

These methods are minimally invasive alternatives to conventional treatment for long saphenous varices. Both methods involve the application of thermal energy to the endoluminal surface of the vein, resulting in permanent vessel occlusion due to thermal injury and scarring. Ultrasound guidance ensures the all segments are treated together with any duplicated LSV systems, and also prevents injury to the deep vessels.

The safety and efficacy of these methods have been well documented.[39,40] However, controlled trials are required to establish the long-term outcomes of these methods versus current treatments.

Foam Sclerotherapy

A chemical phlebitis results in a venous occlusion following injection of foam generated by rapidly passing a sclerosant from one syringe to another through a three-way tap. The air-sclerosant mixture is injected directly into an emptied vein and a bandage applied tightly in the conventional sclerotherapy technique. This appears efficacious for both main trunk and minor vein disease but several sessions may be required.[41] The technique can be performed as an outpatient without the need for anaesthesia.

Chronic Venous Ulceration

Epidemiology and Aetiology

Chronic venous ulceration (CVU) is now the preferred term for the end-stage of the skin complications of chronic venous insufficiency. Older terms like "the post-phlebitic limb" and "varicose ulcers" give clues to the aetiology of this condition, but can be misleading.

CVU is common, affecting approximately one per cent of the general population at some point in their lives, and is associated with obesity, immobility and poor socio-economic status.[42] The prognosis of venous ulceration is poor: 20% remain open at two years and eight per cent remain open at five years.[43] Once healed, the annual recurrence rate varies from 6-15%.[44,45,46] CVU is associated with thrombophilic states, inflammatory conditions such as rheumatoid arthritis, and is often accompanied by arterial disease (Table III).[47] Diagnosis is, therefore, difficult on occasion due to confusion with arterial tissue loss and vasculitic lesions.

The Lothian and Forth Valley Leg ulcer study found that 21% of the 660 patients assessed with an ulcerated limb had an ankle brachial pressure index (ABPI) ≤ 0.9 and 10% had an ABPI <0.7.[48] More than half of the limbs with arterial impairment also had clinical evidence of venous disease.

Table III: Aetiology of leg ulcers

Aetiological factors [47]	Incidence (%)
Venous	58
Mixed arterial/venous	18
Arterial	9
Trauma	8
Vasculitis	5
Malignant	1
Self-harm	1

Pathophysiology

Macrocirculation

Colour-flow Doppler imaging has changed the understanding of the underlying venous pathology. It is now clear that venous reflux is the most common abnormality, rather than obstructed segments, occurring in both the deep and superficial systems. The contribution of incompetent perforating veins (IPV) in CVU is less clear. The association of number, size of IPV and worsening clinical status of CVU has been well documented.[18,49] However, to date it has not been possible to demonstrate

haemodynamic benefits of perforator surgery, partly because the vast majority of IPV exist in association with superficial and deep venous reflux. Although less common, obstruction of the deep veins causes a functional outflow obstruction which can lead to CVU.[50] Obstruction may occur due to previous DVT with inadequate recanalization or extrinsic compression (ex. gravid uterus, malignancy or common iliac artery).

Microcirculation

The link between raised venous pressure and ulceration is incompletely understood. Currently the accepted mechanism of tissue damage is the white cell trapping.[51] White cells activated within the venous microcirculation marginate and then adhere to the vessel walls. The white blood cell then passes from the intravascular space to the subcutaneous tissues, following which proteolytic enzymes and oxygen free radicals are released which in turn causes the endothelial and tissue damage. The initiation of this process is unexplained.

Management

It is important to consider the other causes of leg ulceration before starting management for CVU (Table III).[47]

Compression therapy

The use of graded compression therapy using multi-layer bandaging is the mainstay of conservative treatment. Compression therapy reduces venous pressure at the ankle, reduces oedema, increases ulcer healing and improves quality of life in patients with CVU.[52] These benefits are only realised if patients remain compliant, and augment compression with prolonged limb elevation. "Elevation" requires the ankle to be at least as high as the hip and ideally as high as the heart. Elevating the foot of the bed continues this through the night.

The presence of arterial disease in patients with CVU requires at least modification of, and may be a complete contra-indication to, compression bandaging.

Despite best efforts, up to 20% of ulcers remain unhealed after more than 50 weeks of appropriate compression therapy.[53]

Operative treatment

Superficial venous surgery

Duplex ultrasound has shown superficial vein incompetence is present in most patients with CVU. Several studies have suggested that corrective surgery for superficial venous reflux may have clinical benefits for ulcer healing and recurrence. The effect of surgery and compression on healing and recurrence (ESCHAR) study aimed to address this issue.[54] No significant healing benefit was conferred by the addition of surgery to compression at three years. However, surgery and compression together did reduce ulcer recurrence rates and increased ulcer-free time compared to compression alone. This clinical benefit was greatest for those patients with isolated superficial venous reflux and those with associated deep venous reflux in limited segments of deep veins.

Perforator Vein Surgery

Surgical correction of superficial venous reflux may lead to the correction of IPV if the deep system is normal.[55,56] The role of perforator surgery remains unclear. In the presence of correctable main stem venous disease the role of perforator surgery appears unjustified. In the presence of non-correctable, non-occlusive venous disease there may be a role for perforator surgery.[57] When perforator surgery is considered, subfascial endoscopic perforator surgery (SEPS) showed a number of advantages over the traditional open method (Cockett's and Linton's procedures) in terms of complications and duration of post-operative stay.[58]

Skin Grafting

Skin grafts have also been used to promote healing for persistent venous ulceration. A number of grafts have been used: autografts (pinch graft, split skin graft, full thickness graft), allografts (taken from other human sources), xenograft (ex pig) and artificial skin. A recent Cochrane review assessed the effect of skin grafts for treating venous leg ulcers.[59] The authors concluded bilayer tissue-engineered skin replacement plus compression heals venous leg ulcers more effectively than dressings and compression. At present, there is not enough reliable evidence to assess the effectiveness of any other skin graft material for the treatment of venous ulceration.[52] If skin grafting is to be considered a clean ulcer base is essential.

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