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# Ultrasound of peripheral veins

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## Introduction

The widespread use of ultrasound that occurred in the last few decades has led to major changes in the diagnostic approach to diseases of the venous system leading to an almost complete replacement of venography that was previously considered the standard reference technique. Ultrasound enables visualization of deep and superficial veins of the lower and upper extremities, pelvis and abdomen. Ultrasonography is presently the standard test to confirm or exclude deep venous thrombosis (DVT) and to diagnose a number of clinically similar conditions. It is also used to diagnose chronic venous insufficiency and reflux and is vital for pre-operative assessment of varicose veins [(1-3)].

The most important indication is the assessment of deep vein thrombosis. Venous thromboembolism (VTE) is the third most common vascular disease and is the first cause of in-hospital death. The estimated incidence of DVT in the United States of America ranges from 300,000 to 600,000 [35]. The sensitivity and specificity of DVT sonographic assessment is greater than 90% in proximal peripheral veins.

In this chapter we will give an overview of peripheral venous anatomy, describe the technique of ultrasound examination, and present the clinical importance of ultrasound in diagnosing DVT. We will also review the use of ultrasound for pathological conditions of the superficial venous system, veins in the upper extremities and neck. Lastly, we will describe ultrasound findings of some conditions that can be mistaken for DVT

## Clinical DVT and a diagnostic overview

VTE is a serious clinical condition with substantial morbidity and mortality. DVT is caused by stasis, injury to endothelium, or hypercoagulable states. Risk factors can be categorised as genetic and acquired:

- Genetic: family history, factor V Leiden, prothrombin G20210A, protein C deficiency, protein S deficiency, antithrombin deficiency.
- Acquired: Age, antiphospholipid antibodies, cancer, chronic disease, obesity,
- Transient acquired: Pregnancy, oral contraceptives, hormone therapy, hospitalization, immobilization, surgery and trauma [35].

Prior DVT is a risk factor for new (recurrent) DVT. A quarter to a half of patients have no known risk factors and more than 65% of cases of DVT remain clinically silent [(4-6)]. A clinical assessment of pre-test probability is useful to triage patients. The most commonly used clinical decision rule for risk stratification is the Wells score which allows to define the pre-test-probability based on a checklist of predisposing factors and commonly associated conditions **(Table 1)** [36,37**]**; among ambulatory patients with suspected DVT a score of ≥2 indicates that the probability of deep venous thrombosis is likely; a score of 1 or less indicates that the probability of deep venous thrombosis is unlikely.

**Table 1 Pre-test probability (Wells Score) for DVT.**

| **Factor** | **Points** |
|---|---|
| Active cancer in last 6 months | 1 |
| Recently bedridden ≥3 days, or major surgery requiring regional or general anesthetic in the previous 12 weeks | 1 |
| Paralysis, paresis, or recent cast immobilization of lower extremities | 1 |
| Localized tenderness along distribution of deep venous system | 1 |
| Swelling of entire leg | 1 |
| Calf swelling ≥3 cm compared to asymptomatic calf (measured 10 cm below tibial tuberosity | 1 |
| Collateral superficial veins (non-varicose) | 1 |
| Pitting oedema (confined to symptomatic leg) | 1 |
| Previously documented deep-vein thrombosis | 1 |
| Alternative diagnosis at least as likely as DVT | -2 |

Clinical probability simplified score

- DVT “likely” - 2 points or more
- DVT is “unlikely” - 1 point or less

Many patient pathways include a D-dimer blood in the low risk patient with leg swelling. The D-dimer pathology test has a high negative predictive value and it can be used for screening; if negative, DVT can be safely excluded. If positive an ultrasound is indicated [(3, 9-21). The most serious complication of DVT is pulmonary embolism (PE), which is a life-threatening condition with high mortality. Symptomatic proximal DVT is associated with pulmonary embolism in approximately half of all patients, and even for those who survive the initial embolic event the risk of subsequent emboli and death remains high, especially in the older

patients and those with malignancies or cardiovascular disease. Because anticoagulant therapy has been demonstrated to lower mortality related to PE, early and accurate diagnosis is crucial [(7)].

Since sensitivity and specificity of DVT clinical symptoms is poor; several imaging and measurement modalities have been developed to diagnose DVT including contrast venography, ultrasound and, more recently magnetic resonance venography. Older techniques such as plethysmography and radionuclide studies have been replaced by ultrasound. Contrast venography was long considered the reference DVT screening procedure since it provides good quality images of deep and superficial veins; but is no longer extensively used due to limited accessibility, and to concerns including the need to inject large volumes of contrast medium into a small veins and to avoid falsely negative results due to weak opacification, streaming artefacts and high interobserver variability. Contrast venography is still used in difficult cases when other diagnostic modalities are inconclusive, or when thrombosis of innominate veins or the superior vena cava is suspected [(1, 2, 8)].

Magnetic resonance imaging has recently shown itself to be a sensitive and specific test for DVT in the calf, thigh and pelvis. It is particularly useful because it can differentiate acute DVT from scarring in suspected recurrent DVT and can show extra-vascular causes of leg pain even when the clinical presentation is consistent with thrombotic venous obstruction or venous insufficiency. MRI scanners, however, are still not available in many centers; in addition the examination is expensive and requires a long acquisition time. Multidetector-row (multislice) CT allows accurate depiction of thrombus in peripheral veins and can be done during a chest CT for PE. However, it requires administration of contrast media, exposure to ionizing radiation, and is more expensive than ultrasound [(1, 2)].

Over the past 20 years venous Duplex ultrasound has been the worldwide method of choice for DVT diagnosis. Venous Duplex exhibits many advantages over contrast venography: it is accurate, non-invasive, well tolerated by the patient. Both examination risk and costs are low; and the test can be repeated, whenever needed, with no harm for the patient. Venous testing is one of the most challenging applications of vascular ultrasound techniques, especially in cases of large legs, obese patients, and for the investigation of the veins below the knee for suspected recurrent DVTs or venous scars. Only high quality equipment should be employed; the accuracy of the examination is highly operator dependent; therefore, to achieve a reliable

investigation an appropriate training and sufficient learning curve are mandatory to develop specific manual expertise and interpretation ability.

## Venous anatomy and examination technique

The veins of the lower and upper extremities are divided into the deep and superficial venous system. The deep veins lie below the muscular fascia and travel alongside arteries.

The anatomy of the deep veins of the lower extremity is subject to some variability. Most of this is accounted for by the instances of duplications of the femoral and popliteal veins. The distal superficial femoral vein is duplicated over at least a short length in 15 to 20% of patients while the popliteal is duplicated in up to 35% of patients. The duplicated segments of the superficial femoral vein vary in length and rejoin the main venous trunk

The popliteal vein receives some muscular venous tributaries arising from the calf: the soleal and gastrocnemius veins, and some unnamed tributaries. If calf veins are to be examined the gastrocnemius, and soleal veins may be investigated since these have a DVT occurrence similar to the posterior tibial and peroneal veins [(22)]. The deep venous system of the calf includes 6-paired veins: posterior tibial veins, anterior tibial veins and peroneal (fibular) veins. The posterior tibial, peroneal (or together as the tibioperoneal trunk) and gastrocnemius and soleal veins converge to form the popliteal vein: the two anterior tibial veins cross anteriorly the interosseous membrane to join the popliteal vein 6 cm below the knee. Posteriorly, the tibial-peroneal trunk is divided into two true posterior tibial veins and into two peroneal veins (soon after their origin each tibial vein breaks into two paired tibial veins). The tibioperoneal trunk is difficult to visualize in the upper third of the calf. The posterior tibial-paired veins can be imaged as they migrate more superficially at the mid calf and then continue to the back of the medial malleolus. The paired peroneal veins lie deeper and closer to the fibula.

The anterior tibial is rarely the location of an isolated calf vein DVT and most protocols exclude this from a full lower limb examination. In the distal lower leg the deep system consists of plantar veins of the foot. The femoral vein belongs to the deep venous system, and the name “superficial femoral vein” is no longer accepted nomenclature and may be confusing [(23)]. Above the inguinal ligament the vein is the external iliac vein that when joined with internal iliac vein, becomes the common iliac vein. The right and left common iliac veins converge to form the inferior vena cava [(1, 2)]. The superficial system includes two major veins and their

tributaries: the great saphenous vein and the small saphenous vein. The deep and superficial systems are connected through the saphenofemoral and saphenopopliteal junctions and through several perforator veins. The great saphenous vein runs from the tibial malleolus and courses medially upwards to join the common femoral vein the saphenofemoral junction in the groin. The small saphenous vein runs superficially through the posterior calf from the lateral malleolus up to the popliteal fossa. The position of the saphenopopliteal junction is extremely variable; in approximately 30% of people it is situated at the level of the knee joint, in 50% it lays above the knee and in the other 20% it is located below the knee. Basic anatomy of lower extremity veins is shown in the [Figure 1].

**Figure1 Lower extremity veins.**