

Section G: Technical considerations

What time of the day should the venous insufficiency ultrasound examination be performed?

Recommendation G1: For increased sensitivity in the detection and measurements of venous reflux, it is preferable to perform duplex ultrasound in the afternoon to investigate chronic venous disease.

Level of Evidence: Moderate
Strength of Evidence: Moderate
Consensus: High

Summary Statement

Three studies ^[185-187] have provided evidence that veins when examined later in the day, as opposed to in the morning, are more likely to exhibit venous insufficiency. This is attributed to the prolonged stress on valves and progressive deterioration of valvular function throughout the day, which occurs in both asymptomatic and symptomatic lower limbs. Notably, as observed by Bishara et al. in 1986, the effect is more pronounced in individuals with symptomatic limbs, and more common in perforating veins (38%) than in the small saphenous veins (9%) and the great saphenous veins (2%), but not in alternate superficial pathways or at the saphenofemoral/saphenopopliteal junction. ^[186] Therefore, there is potential for incompetent veins, especially perforating and small veins, to be overlooked if duplex ultrasound (US) is performed in the morning. Future research could explore whether increased venous insufficiency is correlated with the time of day the duplex US is performed, whether the activities of the patient before undergoing duplex US are confounding factors and if the time of day the duplex US is performed impacts treatment decision-making and outcomes.

When scheduling a duplex US appointment to investigate chronic venous disease (CVD), an afternoon appointment is generally preferred from a technical viewpoint, except for individuals who have been active during the night, such as night shift workers whose scan are preferably performed in the morning. Patients should be informed about the potential benefits of undertaking the examination in the afternoon. However, in some cases, scheduling the scan in the afternoon may pose challenges relating to waiting list issues, the arrangement of follow-up appointments, sonographer's availability, or patient preferences. Sonographers should communicate to their reporting physicians if they believe there are limitations to the duplex US if performed in the morning.

What position should the patient be in during the venous insufficiency ultrasound examination?

Recommendation G2: We recommend that evaluation of reflux with duplex ultrasound should be performed with the patient standing, with the lower limb under examination non-weight bearing whenever possible. A sitting or reverse Trendelenburg position can be used if the patient cannot stand or if it is not safe for them to stand.

Level of Evidence: Moderate

Strength of Evidence: Strong

Consensus: High

Summary Statement

It is widely accepted that a standing position is optimal for demonstrating venous reflux because it replicates the physiological state, allowing for more definitive closure of competent valves and presenting a greater challenge to incompetent valves. This was confirmed in a prospective study of 80 limbs in 40 healthy subjects and 60 limbs of 45 patients with CVD. When leg veins were evaluated with duplex ultrasound for venous reflux, ^[116] more refluxing venous segments were demonstrated in the standing position compared to the supine position. Similarly, Houle et al. ^[188] reported lower percentages of false negative results when veins were tested in the standing position. Similar conclusions were made by DeMuth et al. ^[189] who found in their study, that the median difference in reflux time between the reverse Trendelenburg (RT) and supine positions was 0.15 seconds and the mean difference in the diameter of the great saphenous vein (GSV) between the RT and supine positions was 0.7 mm, with a standard deviation of 0.96 mm ($p < 0.0001$). Their study also revealed 15% of the GSVs that initially tested negative for reflux in the RT position were later found to show venous reflux in the supine position. This observation suggests that even though as standing or RT position is recommended, additional testing in the supine position may be prudent when a patient showing signs and symptoms of venous insufficiency does not demonstrate GSV reflux.

The standing position can be ergonomically difficult for both the sonographer and patient to maintain. A pilot study ^[89] suggested that several alternative positions (sitting, 10-25 degrees RT) could be used for assessing incompetent veins as long as the patient is not lying horizontal. These alternatives offer flexibility, when the standing position is difficult for patients to maintain, and if the position is ergonomically problematic for the sonographer. However, it should be noted that reflux time will vary with positions. Carty et al. ^[87] compared superficial reflux evaluated by duplex US in both RT (30 degrees) and standing position in 72 consecutive patients, and noted that reflux duration in the RT position was longer (by a factor of > 2.8) compared with the standing position, and that as a guide, RT reflux values of ≥ 1.5 sec anywhere along the extremity always correspond to > 0.5 sec standing reflux values ($p < 0.001$). Because of this overestimation of reflux time, they suggested that if the RT position was used, and the reflux time was less than 1.5 seconds, then the vein should be retested in the standing position, to compare it against the standing reflux time of 0.5s. Additionally, they found that isolated segmental reflux associated with an incompetent perforating vein is most accurately identified in the standing position. Further research comparing reflux time in alternate positions against standing as the reference standard for deep, superficial and perforating veins is needed and sonographers should test for venous reflux using alternate positions if reflux cannot be elicited in patients with signs and symptoms of CVD.

What provocation manoeuvres should be used to elicit venous reflux?

Recommendation G3: We recommend that to confirm valvular incompetence, venous reflux should be elicited using the following manoeuvres for the following veins:

- Common femoral vein: Valsalva manoeuvre to increase intra-abdominal pressure and/or distal augmentation.
- Saphenofemoral junction: Valsalva manoeuvre to increase intra-abdominal pressure and/or distal augmentation.
- Vein segments distal to saphenofemoral junction: Distal augmentation.

Distal augmentation is performed using manual or cuff compression distal to the point of examination.

Sonographers should be aware of alternate methods to elicit venous reflux that may be more applicable in different circumstances such as,

- where patient or sonographer comfort is compromised,
- when the patient cannot perform Valsalva,
- the patient has a large body habitus,
- or if venous reflux is suspected but cannot be demonstrated using Valsalva or distal augmentation.

Level of Evidence: Moderate

Strength of Evidence: Strong

Consensus: High

Summary statement

Provocation manoeuvres are used to elicit reflux to test the valvular competence by stressing them. Normal valves in the lower limb act as gatekeepers to block blood in the veins from flowing away from the heart, that would otherwise occur due to physiologic pressures.^[35] A provocation manoeuvre needs to create a high-pressure gradient across the venous segment under examination in order for reflux to occur, therefore identifying failing or incompetent valves.^[35]

Two existing clinical practice guidelines made specific evidence-based recommendations regarding the manoeuvres that should be used.^[8,10] Both recommend that the appropriate manoeuvre for the CFV and the SFJ is Valsalva, and that more distal veins should be assessed with manual or cuff compression. In addition, these manoeuvres should be performed in an upright position.^[8]

Findings by Berther et al.^[191] support the use of Valsalva to test for reflux in the CFV. The sensitivity of detecting reflux in the CFV was slightly higher using Valsalva (50%) compared to cuff compression (42.9%) in patients with deep vein thrombosis (DVT), and the same for patients with varicose veins (87.5%). This study also partially supports using manual compression for the femoral vein (FV) as sensitivity for detecting reflux in the FV was higher for cuff compression (50%) compared to Valsalva (42.9%) in DVT patients. However, in varicose vein patients, the sensitivity was higher for Valsalva (87.5%) compared to cuff compression (71.4%).

Masuda et al.^[191] also compared the cuff compression method against Valsalva across more venous segments including the CFV, FV, deep femoral, the GSV in the upper thigh, popliteal, and posterior tibial veins (PTVs) at the ankle. The results indicated that the Valsalva method is best performed in the RT 15 degrees position as opposed to standing, whereas the cuff technique is more effective in the standing position. A case-by-case analysis identified a large amount of variability between techniques, and inconsistencies could not be used to identify one technique as better than the other. Examination of the PTVs by all methods produced inconsistencies and a low yield of reflux in symptomatic limbs.

Demirpolat et al.^[192] compared the efficacy of the Valsalva manoeuvre and cuff compression techniques, both performed in the standing position, in detecting lower extremity deep venous insufficiency (i.e., the FV, popliteal vein) and saphenofemoral insufficiency including the GSV segment near the junction and its caudal segment at the medial aspect of the knee. The study showed that cuff deflation technique was superior for detecting insufficiency at the popliteal vein and caudal segment of the GSV. The Valsalva manoeuvre was superior at the FV.

Yamaki et al.^[193] demonstrated that manual and cuff compression can be used interchangeably as they found no significant differences in the duration of reflux initiated by both methods at tested sites. This was observed in patients with minor signs and symptoms; at the SFJ, saphenopopliteal junction (SPJ), GSV, as well as in patients with more severe symptoms at the SFJ and SPJ.

Due to the variability of methods and results in research studies, and the variability in individuals, further investigation is needed to determine the best provocation manoeuvres to elicit reflux, including patient positions. Different provocation methods (physiological and non-physiological), including alternate methods are described below. Alternate provocation manoeuvres may be useful when confirming the presence of reflux proves difficult in symptomatic patients due to technical factors.

The Valsalva manoeuvre (physiological):

This technique requires clear instruction to the patient and their cooperation.^[48] The patient should be encouraged to Valsalva forcefully and rapidly (within 0.5 seconds) and for a sustained period of time (at least three seconds) to increase the intra-abdominal pressure.^[45] If performed in veins distal to competent veins it may elicit a false-negative result.^[48]

Simulated Valsalva (physiological):

This may be used if the patient finds it difficult to perform an adequate Valsalva. ^[48] The patient should be instructed to take a deep breath and hold, during which the sonographer pushes on the patient's abdomen with their free hand by firmly leaning into the patient. The patient is instructed to resist or guard against the pressure, creating a simulated Valsalva manoeuvre. ^[48]

Distal augmentation, manual or with pressure cuff (non-physiological):

Perform by applying compression over and distal to the examined vein with gradual, firm and prolonged pressure to create orthograde (normal direction, feet to heart) flow. The compression is then rapidly released to detect any insufficiency in the examined vein. ^[45] This technique ensures that a large volume of venous blood is emptied out of the calf in order to create a high-pressure gradient on release. The pressure can be applied either by manual compression or by using an automated cuff applied on the lower leg or foot which the operator can inflate with the push of a button. The cuff inflates to a desired peak pressure and then rapidly deflates. ^[35] Sonographers will have a personal preference in using manual compression or a cuff. The cuff method allows for standardisation and sonographers may find it easier to remain in an ergonomic position using a pneumatic cuff device, ^[86, 113] however some sonographers may find the cuff cumbersome, particularly in the presence of venous ulcers.

The strength and duration of augmentation as well as the speed of release can have an influence whether reflux is or is not observed and for what duration. Augmentation at the foot or ankle can be less effective due the low venous volume at these sites. To maximise the sensitivity of detecting reflux, augmentation should be applied at a site over the examined vein, and just distal to the vein segment being tested. Increased pressure may be also useful to push a greater volume of blood in an orthograde direction through the vein.

Alternate reflux provocation methods:

Alternate reflux provocation methods can be used when reflux in varicose veins cannot be elicited by the above methods. More research is needed to determine the efficacy of these alternate provocative manoeuvres. If reflux still cannot be provoked, this may be due to other variables such as the diameter of the re-entry vein. ^[45]

•**Cremona manoeuvre (physiological)**: A modified Valsalva manoeuvre, the patient is instructed to blow through a straw with the other end closed. This action leads to increased thoraco-abdominal pressure and push the flow to go backwards. A technique akin to the Cremona manoeuvre was demonstrated by Deb Coghlan (vascular sonographer, Precision Vascular Imaging) during the 18th International Union of Phlebology (UIP) conference in 2018. In this method, a patient was directed to place his/her thumb in the mouth and exhale forcefully into it.

•**Double hands distal augmentation (non-physiological)**: Squeeze the leg using two hands (with the help of an assistant). ^[45] Distal compression at the calf is appropriate for proximal veins, and distal compression of the foot is appropriate for distal calf veins. ^[81]

•**Elevation-dependency manoeuvre (physiological)**: The patient is placed supine with raised legs for 20 seconds to empty the vein. The patient then is asked to stand and the vein is re-examined during venous re-filling without provocation manoeuvre. ^[45]

•**Paraná manoeuvre (physiological)**: The sonographer asks the patient to shift their weight slightly forwards, which applies pressure to the sacrum. In response, the patient involuntarily tenses the triceps surae muscle (i.e., gastrocnemius and soleus) to maintain balance. The activated muscle pump causes a strong, physiological, orthograde flow in the calf veins. This manoeuvre is challenging, as the sonographer has to move their left hand from the keyboard to the patient. The movement of the patient increases the chances of image blurring, and some patients may find it difficult to keep their balance. Additionally, the manoeuvre can cause them to move back and forth incessantly, which continuously activates the muscle pump in an uncontrolled manner. ^[108]

•**Wunstorf manoeuvre (physiological)**: also known as the toe elevation manoeuvre, is a physiological method that patients can perform independently without the need for an examiner's assistance. During the procedure, the examined leg should remain as still as possible. Venous flow can be elicited by either raising the toes (dorsiflexion of the forefoot) or clawing the toes (plantarflexion of the forefoot). The elevation of the toes or forefoot leads to highly effective orthograde blood flow, which can be measured all the way up to the CFV and is often detectable in the trunks of the saphenous veins. ^[45, 81, 108]

•**Proximal augmentation (non-physiological)**: involves applying manual compression above the transducer level. This technique induces valvular closure by generating a pressure wave directed towards the valves, similar to Valsalva. While this method has demonstrated comparable outcomes in detecting venous reflux when compared to both Valsalva and distal augmentation, its accuracy and reliability, particularly for the assessment of the superficial venous system, have yet to be determined. ^[194, 195]