Use of Doppler ultrasound in leg ulcer assessment

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About 1 per cent of the population will suffer a leg ulcer at some point in their lives (Callam et al 1985, Cornwall et al 1986). Population studies have shown that around 70 per cent of leg ulcers result from chronic venous insufficiency (CVI) and that 20 per cent are attributable to underlying arterial disease (Callam et al 1985 and 1987, Ruckley et al 1982).

Assessment remains the most important part of chronic wound management (Gibson 1998), and the use of good holistic techniques enables practitioners to make informed clinical judgements. Doppler ultrasound is integral to the holistic assessment of leg ulcers. This article reviews the procedure for measuring ankle/brachial pressure indices using Doppler ultrasound and outlines various diagnostic tests that employ the Doppler principle.

Summary

Adequate patient assessment is the most important element of chronic wound management, and the use of holistic techniques enables practitioners to make informed clinical judgements. Doppler ultrasound is integral to the holistic assessment of leg ulcers. This article reviews the procedure for measuring ankle/brachial pressure indices using Doppler ultrasound and outlines various diagnostic tests that employ the Doppler principle.

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Key words

- Leg ulcers
- Patient assessment
- Vascular disorders

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Doppler principle

Sound waves retain the same frequency when reflected off a stationary surface, but when reflected off moving objects, the frequency of these sound waves changes in relation to the velocity of the target (Donnelly et al 2000). This phenomenon was first explained by Christian Doppler, an Austrian physicist (Vowden and Vowden 1996), in the 19th century, but its first application in medicine was not until 1957 when it was used to study the structure and function of the heart (Yao 1970).

The principle behind its use in vascular studies lies in the ability of the ultrasonic probe to reflect sound waves off the moving red blood cells. The reflected waves are detected by the probe and amplified into an audible sound (Williams et al 1993). The resultant signal (or waveform) represents the blood flow through the vessel (Donnelly et al 2000). As Williams et al (1993) point out, significant arterial disease will result in blood flow disturbances causing a deviation from the normal Doppler ultrasound waveform. This provides an accurate measurement of any underlying arterial insufficiency, which might predispose the
patient to the development of leg ulceration (Fowkes and Callam 1994, Ghauri et al 1998). Vowden (1998) also suggests that the same principle can be used effectively to examine the venous system for reflux.

Doppler methods

Doppler ultrasound measurements of ankle or brachial pressure indices (ABPIs) are an essential part of holistic leg ulcer assessment (Jones 2000). However, it is important to acknowledge that measurements of ABPI can be unreliable if the operators have not undergone adequate training in this technique (Ray et al 1994).

In healthy patients, the arterial pressure in the lower limb is the same as, or higher than, the brachial pressure (Morison and Moffatt 1994). If there are ischaemic changes present and subsequent impairment of blood supply to the foot, the systolic pressure will be lower at the ankle (Herbert 1997, Morison and Moffatt 1994). This should be kept in mind when calculating the ABPI (Box 1).

The ABPI is calculated for each leg by dividing the highest ankle systolic pressure of each leg by the higher of the two brachial pressures (Jones 2000). The national clinical guidelines on leg ulcers recommend that patients with ABPIs of 0.8 or above are suitable for compression (RCN 1998). However, caution should be taken with diabetic patients and in patients with arteriosclerosis, as abnormally high readings might be because of calcified arteries (Pudner 1998). Without further investigations (such as arterial duplex imaging), these patients might have significant arterial disease and could be inappropriately given compression therapy. The implications of this could mean increased pain and ischaemia, and in extreme cases, amputation.

Keachie (1992) advises that an ABPI of less than 0.8 indicates the presence of significant arterial disease – the lower the ABPI reading the more severe the disease is. For example, an index of 1.0 indicates 100 per cent arterial flow, it follows that a reading of 0.8 indicates a 20 per cent reduction in perfusion to the lower limb. A good method for performing Doppler ultrasound assessment of ABPIs is summarised in Box 2.

Compression therapy is the recommended treatment for the management of venous leg ulcers (RCN 1998). The calculation of ABPIs greatly enhances the practitioner's ability to make the correct decision about treatment. A patient with an ABPI of 0.8 or greater is generally suitable for full external compression therapy, provided that he or she is able to tolerate this level of compression.

Pressures of 0.5-0.8 indicate evidence of significant arterial impairment (0.5=50 per cent reduction in arterial flow) and full compression therapy would be inappropriate for treating leg ulceration in these patients. Inappropriate application of compression to a limb where there is a significant degree of ischaemia can lead to ulcer mismanagement and, again, could precipitate the need for limb amputation (Morison and Moffatt 1994).

Patients with an ABPI of 0.5-0.8 might experience pain on walking (intermittent claudication) due to ischaemia. Many experts recommend using reduced compression in those patients who are able to tolerate it (Dealey 1999, Ghauri et al 1998, Pudner 1998), provided that the main factor leading to ulceration has been identified as venous in origin. In cases where the ABPI is calculated as less than 0.5, patients might experience pain at rest as well as during activity. This indicates a critically impaired arterial supply to the lower limb and necessitates urgent referral to the vascular surgeon. Under no circumstances should external compression be applied to these limbs.

Diagnostic tests involving Doppler ultrasound

The use of Doppler ultrasound to calculate ABPIs forms only one part of leg ulcer assessment. A

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**Box 1. Formula for calculating ABPI**

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\text{ABPI} = \frac{\text{Highest ankle pressure (each leg)}}{\text{Highest brachial pressure}}
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(Morison and Moffatt 1994)

**Box 2. Procedure for measuring ABPI using Doppler ultrasound**

1. Ensure that the patient is lying flat and resting for 10-20 minutes before the procedure – this ensures that there is no pressure on the proximal vessels

2. Explain the procedure to the patient to reassure him or her and help to alleviate anxiety

   - Place the cuff around the arm. Locate the brachial pulse and apply ultrasound gel
   - Angle the probe at 45° and move around until the best signal is located
   - Inflate the cuff until the signal disappears, then deflate slowly and record the pressure at which the signal returns
   - Repeat the procedure for the other arm

3. Use the highest of the two brachial pressures to calculate the ABPI

4. To calculate the ABPI, divide the highest ankle systolic pressure for each ankle by the higher of the two brachial pressures


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**REFERENCES**


range of other investigations involving the use of Doppler ultrasound is available to trained personnel, such as vascular technologists and specialist nurses to aid diagnosis of the underlying aetiology. These investigations include venous reflux analysis to allow greater understanding of the severity of venous disease, and waveform analysis, segmental pressures and the pole test, all of which might contribute to the identification of arterial occlusion.

Waveform analysis
The frequency changes caused by the flow of blood are converted into a frequency waveform which returns via the Doppler’s oscilloscope as an audible signal (Williams et al 1993). A normal waveform is triphasic (Vowden and Vowden 1996), whereas a biphasic signal indicates the blood is flowing at increased velocity, which is usually due to the presence of stenosis (Donnelly et al 2000). Monophasic signals suggest a greatly increased velocity through tighter stenoses. The presence of a monophasic pulse in the arteries of the lower limb provides evidence of proximal stenoses and the presence of distal arterial disease.

Segmental pressures
Using Doppler ultrasound, pressure readings can be measured segmentally along the leg to aid location of arterial stenoses. Segmental pressures are recorded when arterial disease has been diagnosed through reduced ABPI (Williams et al 1993). A pressure difference of 30mmHg between each segment represents significant arterial stenosis in that area (Herbert 1997).

Pole test
This test is useful for identifying severe arterial disease (Williams et al 1993), particularly when the patient is diabetic or when abnormally high ABPIs indicate calcified vessels (Donnelly et al 2000, Vowden and Vowden 1996). As Herbert (1997) explains, pedal pulses are not usually lost when the leg is elevated, but this can occur in patients with impaired arterial blood supply. On using Doppler ultrasound to locate the pedal pulses, the leg is raised against a pole which is calibrated in mmHg (Donnelly et al 2000, Smith et al 1994). The point at which the pulse disappears represents the ankle pressure. In the absence of a graduated pole, the height of the foot above the bed can be measured in centimetres and multiplied by 0.735 to convert this measurement to a pressure in mmHg (Sumner 1989).

Venous reflux analysis
Doppler assessments can also be made on patients with varicose veins or with established clinical manifestations of CVI to identify the severity of venous reflux (Herbert 1997). This test is conducted with the patient standing in an upright position (Vowden 1998). Once the vein has been located with the Doppler probe, the leg is squeezed to apply pressure (Herbert 1997). A ‘whooshing’ noise is heard as pressure is applied to the leg. If venous valve incompetence is present, reflux will be heard as soon as the pressure is released.

Although this procedure is simple and relatively quick to perform, Doppler assessment of venous reflux can miss up to 12 per cent of saphenofemoral and up to 20 per cent of saphenopopliteal junction reflux when compared with venous duplex imaging (Donnelly et al 2000).

Discussion
Doppler ultrasound plays a crucial role in holistic assessment of patients with leg ulcers. The inclusion of Doppler ultrasound in assessment protocols has greatly improved the ability of nurses to diagnose underlying aetiology (Hislop 1997). However, it is essential that all practitioners receive appropriate training and supervision before using Doppler ultrasound and that they are aware of their professional accountability (Hislop 1997, Morison and Moffatt 1994, Ray et al 1994).

Patient education should not be overlooked and it is important for practitioners to involve patients at every stage of the assessment process and to discuss the relevance of performing Doppler studies. This enables patients to feel more at ease and will allow more accurate assessment of resting systolic pressures. Incorrect measurement of ABPIs can lead to unnecessary mismanagement and patient suffering. It is vital, therefore, that nurses performing this procedure are proven competent in Doppler use and have access to a specialist nurse or vascular technologist for supervised practice.

The assessment and diagnosis of patients with leg ulcers is increasingly becoming the responsibility of the nurse (Vowden and Vowden 1998). When combined with a full holistic assessment, taking into consideration not only the ulcer and surrounding skin but also the patient and any predisposing history, Doppler ultrasound will provide sufficient information to enable the correct treatment pathway to be instigated and prompt referrals to be made for further vascular investigations.