

# Doppler and ABPI or LOI in screening for arterial disease

Doppler ultrasound is frequently used as a screening tool when assessing patients for arterial disease. The use of Doppler ultrasound to calculate the ankle brachial pressure index (ABPI) has been tested for reliability and reproducibility and has been found to be an accurate technique when used regularly by appropriately trained practitioners. An alternative to Doppler has been suggested using pulse oximetry to calculate the Lanarkshire Oximetry Index (LOI), which has been described as a feasible alternative to ABPI. This article compares the techniques and discusses the implications for practice.

Kathryn Vowden, Peter Vowden

## KEY WORDS

Doppler  
ABPI  
LOI  
Arterial assessment  
Leg ulceration

The assessment and monitoring of peripheral arterial disease is not only a fundamental skill required for all health care professionals concerned with the management of patients with lower limb ulceration, but it is also a necessary component in the management of any patient with suspected lower limb ischaemic symptoms. As such, primary care staff require the skills necessary to conduct such a procedure as they will often be required to carry out the initial patient assessment.

To date, the gold standard for such screening has centred on the use of the hand-held continuous wave Doppler ultrasound and the measurement of

Kathryn Vowden is Nurse Consultant, Bradford Teaching Hospitals NHS Foundation Trust and University of Bradford; Professor Peter Vowden is Consultant Vascular Surgeon, Bradford Teaching Hospitals NHS Foundation Trust and Visiting Professor of Wound Healing Research, University of Bradford, Bradford

ankle systolic blood pressure from which the ankle brachial pressure index (ABPI) can be derived.

An alternative technique, using pulse oximetry to calculate the Lanarkshire Oximetry Index (LOI), has been described as a method of assessing if patients with lower limb venous ulceration are suitable for compression therapy (Bianchi, 2005). It has been suggested that the rationale for introducing a change in practice is that community staff have difficulty in performing assessments using Doppler (Bianchi et al, 2000; Bianchi, 2005). Is Doppler ultrasound in fact too difficult to use or does this indicate that there is a deficiency in training, competence and service delivery?

Certainly the authors' experience in a secondary care specialist unit would indicate that the use of Doppler is not a difficult skill to acquire with training and regular practice. The technique has routinely been applied for a number of years as part of the assessment of patients with possible peripheral arterial disease.

With the increasing emphasis on primary care screening, early diagnosis and detection of disease, the role of vascular assessment will move progressively to a primary care setting. Nurses are ideally placed to take on

this role and should have no difficulty applying Doppler ultrasound techniques as the basic examination is easily undertaken and Doppler equipment is now widely available.

## Doppler ultrasound and ABPI

The Doppler principle, first described in 1842, relates the frequency of a source to its velocity related to an observer. The principle was first applied in medicine by Satomura in 1957 (Satomura, 1957; Yao, 1970) to study heart structure and function and was developed to allow examination of blood flow in peripheral arteries. In 1950, Winsor noted the difference between arm and ankle blood pressures (Winsor, 1950), and Hocken, using a stethoscope and Korotcow sounds, found that comparison of arm and ankle pressures was a useful indicator of arterial disease (Hocken, 1967). However, it was not until Yao et al (1968) reported using Doppler ultrasound to record arterial blood flow that the method became widely applicable.

The method for carrying out an arterial assessment and deriving an ABPI has not changed significantly since its initial description other than the introduction of modern Doppler equipment. The basic method is set out in *Table 1*. Using this technique, Yao and others (Sumner, 1989) were

**Table 1.**

Method for Doppler peripheral arterial pressure measurement and Ankle Brachial Pressure Index (ABPI) calculation (Vowden et al, 1996)

Explain the procedure, reassure the patient and ensure that he/she is lying flat and is comfortable, relaxed and adequately rested with no pressure on the proximal vessels

**1. Measure the brachial systolic blood pressure:**

- ▶▶ Place an appropriately sized cuff around the upper arm
- ▶▶ Ensure that the equipment and the arm are at heart level
- ▶▶ Locate the brachial pulse and apply ultrasound contact gel
- ▶▶ Angle the Doppler probe at 45degrees and move the probe to obtain the best signal
- ▶▶ Inflate the cuff until the signal is abolished then deflate the cuff slowly and record the pressure at which the signal returns, being careful not to move the probe from the line of the artery
- ▶▶ Repeat the procedure for the other arm
- ▶▶ Use the higher of the two values as the best non-invasive estimate of central systolic pressure and use this figure to calculate the ankle brachial pressure index (ABPI)

**2. Measure the ankle systolic pressure:**

- ▶▶ Place an appropriately sized cuff around the ankle immediately above the malleoli having first protected any ulcer or fragile skin that may be present
- ▶▶ Examine the foot, locating the dorsalis pedis pulse and apply contact gel
- ▶▶ Continue as for the brachial pressure, recording this pressure in the same way again with limb and sphygmomanometer at heart level
- ▶▶ Repeat this for the posterior tibial and if required the peroneal and anterior tibial arteries
- ▶▶ Use the highest reading obtained to calculate the ABPI for that leg
- ▶▶ Repeat for the other leg
- ▶▶ Calculate the ABPI for each leg using the formula below or look up the ABPI using a reference chart

$ABPI = \frac{\text{Highest pressure recorded at the ankle for that leg}}{\text{Highest brachial pressure obtained for both arms}}$

ABPI normally > 1.0

ABPI < 0.92 indicates arterial disease

ABPI > 0.5 and < 0.9 can be associated with claudication and if symptoms warrant, a patient should be referred for further assessment

ABPI < 0.5 indicates severe arterial disease and may be associated with gangrene, ischaemic ulceration or rest pain, and warrants urgent referral for a vascular opinion

able to define what constituted a normal and abnormal pressure index. They, following research, concluded that normal individuals generally had an ABPI of > 1.00, with an ABPI of 0.92 generally being regarded as the cut-off for normal.

Carter (1969) emphasised that meticulous attention to detail is necessary to obtain valid and reproducible measurements. A lack of awareness of the limitations of the ABPI and a failure to utilise all the information obtained can lead to

conflicting results and misinterpretation of the data. These issues have been reviewed by Vowden and Vowden (2001). For example, even though the calculation method may give an ABPI of 1.00 it does not mean that arterial disease is not present. A pressure difference of 15mmHg or more between vessels at the ankle indicates proximal disease in the vessel with the lower pressure. This could be relevant when assessing the potential risk of bandage pressure damage or assessing cardiovascular risk.

Bianchi (2005) has highlighted a number of concerns over performing Doppler evaluations. These are:

- ▶▶ Perceived problems in locating foot pulses which should be overcome by training and basic knowledge of anatomy
- ▶▶ Cited difficulties associated with the probe angle and maintaining the position of the probe over the artery. These issues have been largely overcome by recent design modifications to the Doppler which now incorporates a wider probe head and a moulded surface which helps users to maintain the correct probe angle. For simple pressure measurement, probe angle is not as important as the signal itself, and is not subject to analysis. However, the probe angle is relevant when more detailed analysis of the signal, such as waveform analysis, is required. Probe angle will also affect the sound characteristics and therefore a good technique will aid the overall assessment process although it may have little effect on simple pressure measurement
- ▶▶ All techniques measuring systolic pressure require the patient to be appropriately positioned with the limb to be assessed at heart level. This is no different if Doppler or pulse oximetry is used to measure systolic pressure; in both cases the patient needs to be supine. Experience, and with it increasing skill, overcomes problems related to limb laterality cited by Fowkes et al (1988)
- ▶▶ Extremities of both hyper- and hypotension impact directly on

the accuracy of non-invasive measurements of peripheral systolic pressure and will effect the accuracy of both ABPI and LOI calculations (Carser, 2001). The impact of this is likely to be small, however, particularly in the range ABPI 0.8 to 1.0.

- ▶▶ Assessment of patients with severe arterial disease may be difficult as detection of blood flow, and therefore pressure, is difficult no matter which measurement technique is used. Patients with an ABPI of 0.8 or higher should, however, have a good strong signal which should be easily obtained. Patients with leg ulcers and pressures below these levels should be referred to a specialist centre in line with guidelines (Royal College of Nursing [RCN], 1998; Scottish Intercollegiate Guidelines Network [SIGN], 1998). Variations of up to 10% in ABPI are of some relevance in research studies or borderline cases but in clinical practice and in epidemiological studies, a single assessment is acceptable (Fowkes et al, 1988)
- ▶▶ The presence of oedema and lymphoedema can compromise pressure measurements, irrespective of the technique used. To minimise this, the correct cuff size selection is required. Use of alternative Doppler probes, such as a 5 rather than an 8 MHz probe will improve the depth of ultrasound penetration and aid vessel detection.

The authors agree that Doppler skills need to be enhanced. This technique is necessary, not just for the management of patients with venous leg ulceration but also as part of the assessment of any patient with potential peripheral vascular disease. Indeed it has been shown that there is a direct relationship between ABPI and cardiovascular risk (Ogren et al, 1993) indicating that this test should be actively applied as part of cardiac assessment in primary care.

The concerns raised by Bianchi (2005) are, therefore, mainly related to operative skill and experience

that should be overcome by training and practice. Rather than looking for an alternative to this method of assessment, healthcare professionals should increase their use of the hand-held Doppler to allow more widespread application of this screening test for peripheral vascular disease.

**The authors agree that Doppler skills need to be enhanced. This technique is necessary, not just for the management of patients with venous leg ulceration but also as part of the assessment of any patient with potential peripheral vascular disease.**

#### Pulse oximetry and LOI

Bianchi (2005) has reviewed the development of pulse oximetry from the early reports of the measurement of oxygen consumption using spectroscopy in 1874. Much of the initial work using pulse oximetry centred on its use in anaesthetics and emergency medicine. More recently it has been recognised that the pulse oximeter can detect tissue perfusion (Joyce et al, 1990), peripheral arterial disease by reactive hyperaemic testing, (Couse et al, 1994) and arterial occlusion pressure.

Jawahar et al (1997) found that pulse oximetry was not a good method of detecting early peripheral arterial disease, which raises questions over the use of the technique in the venous leg ulcer population. Johansson et al (2002) found that toe systolic pressures could be recorded accurately, however, this is a different technique for LOI to that described by Bianchi (2005). Johansson's paper confirmed the advantage of toe systolic pressure measurement, whether by photoplethysmography, strain gauge, oximetry or Doppler, in the assessment of some patients with diabetes. True toe systolic pressure has been related to foot ulcer healing in the patient with diabetes (Carter, 1993).

Bianchi has suggested that this method of assessing peripheral arterial disease by measuring systolic pressure using a pulse oximetry probe may be of value in assessing patient suitability for compression therapy for lower limb venous ulceration (Bianchi et al, 2000; Bianchi and Douglas, 2002; Bianchi, 2005).

In the technique described in the LOI, the blood pressure cuff is placed around the ankle in the same position as used for Doppler ankle systolic pressure measurement (Bianchi, 2005). As the pressure recorded is at the site of the cuff and not the site of the probe, this technique measures the ankle systolic pressure and not the toe pressure as implied by the calculation methods. As such it suffers from the same limitations as ABPI calculations and has the same potential for inaccuracy in the presence of vascular calcification and medial sclerosis. These inaccuracies may actually be increased

#### Key Points

- ▶▶ Vascular assessment is not just a number but an integration of clinical signs, symptoms and investigation results.
- ▶▶ Doppler arterial assessment and ABPI provide more information on vascular status than LOI.
- ▶▶ LOI is subject to many of the difficulties and potential inaccuracies caused by vascular disease that apply to ABPI assessment and is not a replacement for a comprehensive Doppler assessment of the peripheral circulation.
- ▶▶ Demand within primary care for general cardiovascular and peripheral vascular risk assessment will increase use of Doppler and, therefore, skill in ABPI measurement.

as there is the potential for disease in the foot vessels to further bias the results. The recommendation for all pressure measurement techniques is to place the detector as close to the site of vessel compression as is possible. Other potential problems that have been highlighted (Bianchi, 2005) with the LOI technique include:

- ▶▶ Thickened or trophic toe nails
- ▶▶ Peripheral cyanosis
- ▶▶ Digital vasospasm (Raynaud's phenomenon)
- ▶▶ Localised and well collateralised peripheral vascular disease.

A further disadvantage of using this technique from the patient's perspective is that the ankle cuff remains inflated for a longer period of time potentially causing increased discomfort and pain. Another fundamental disadvantage is that although the technique may give an indication of limb perfusion, it gives no information on the status of the individual crural vessels.

As with all techniques for measuring blood pressures, patient positioning is important if reliable and reproducible readings are to be obtained. The correct cuff size and position must be selected but problems will still arise due to abnormal limb size and non-compressible vessels since these are factors related to the cuff and compression and not to the method of blood flow detection.

Equipment availability and maintenance are also potential problems for both techniques, however, given the significant increase in the availability of Doppler equipment since the RCN and SIGN guidelines were published, accessibility should no longer be a problem (Royal College of Nursing, 1998; Scottish Intercollegiate Guidelines Network, 1998).

### Conclusion

LOI provides a method of monitoring patients during treatment with compression therapy but should not be seen as a replacement for the hand-held continuous wave Doppler and ABPI during the initial assessment

of a patient with lower limb ulceration or potential peripheral vascular disease. Whichever method of arterial assessment is applied, and the authors would continue to favour the use of Doppler ABPI, it should, however, be remembered that the use of Doppler supports the overall diagnostic and management strategy. Results should not be used in isolation but as part of the overall holistic patient assessment process. **WUK**

### **LOI provides a method of monitoring patients during treatment with compression therapy but should not be seen as a replacement for...Doppler and ABPI during the initial assessment of a patient with lower limb ulceration or potential peripheral vascular disease.**

#### References

Bianchi J (2005) LOI: an alternative to Doppler in leg ulcer patients. *Wounds UK* **1**(1): 80–5

Bianchi J, Douglas S (2002) Pulse oximetry vascular assessment in patients with leg ulcers. *Br J Community Nurs* **7** (9 Suppl): 22–8

Bianchi J, Douglas WS, Dawe RS et al (2000) Pulse oximetry: a new tool to assess patients with leg ulcers. *J Wound Care* **9**(3): 109–12

Carser DG (2001) Do we need to reappraise our method of interpreting the ankle brachial pressure index? *J Wound Care* **10**: 59–62

Carter SA (1969) Clinical measurement of systolic pressures in limbs with arterial occlusive disease. *JAMA* **207**(10): 1869–74

Carter SA (1993) Role of pressure measurement. In: Bernstein EF, ed. *Vascular Diagnosis*. Mosby, St Louis, Missouri: 486–512

Couse NF, Delaney, CP, Horgan PG et al (1994) Pulse oximetry in the diagnosis of non-critical peripheral vascular insufficiency. *J R Soc Med* **87**(9): 511–2

Fowkes FG, Housley E, Macintyre CC, Prescott RJ, Ruckley CV (1988) Variability of ankle and brachial systolic pressures in the measurement of atherosclerotic peripheral arterial disease. *J Epidemiol Comm Health* **42**(2): 128–33

Hocken AG (1967) Measurement of blood-pressure in the leg. *Lancet* **1**(7488): 466–8

Jawahar D, Rachamalla HR, Rafalowski A, Ilkhani R, Bharathan T, Anandarao N (1997) Pulse oximetry in the evaluation of peripheral vascular disease. *Angiology* **48**(8): 721–4

Johansson KE, Marklund BR, Fowelin JH (2002) Evaluation of a new screening method for detecting peripheral arterial disease in a primary health care population of patients with diabetes mellitus. *Diabet Med* **19**(4): 307–10

Joyce WP, Walsh K, Gough DB, Gorey TF, Fitzpatrick JM (1990) Pulse oximetry: a new non-invasive assessment of peripheral arterial occlusive disease. *Br J Surg* **77**(10): 1115–7

Ogren M, Hedblad B, Jungquist G, Isacson SO, Lindell SE, Janzon L (1993) Low ankle-brachial pressure index in 68-year-old men: prevalence, risk factors and prognosis. Results from prospective population study 'Men born in 1914', Malmo, Sweden. *Eur J Vasc Surg* **7**(5): 500–6

Royal College of Nursing (1998) *The Management of Patients with Venous Leg Ulcers*. RCN Institute, York

Satomura S (1957) Ultrasonic Doppler method for the inspection of cardiac function. *J Acoust Soc Am* **29**: 1181–5

Scottish Intercollegiate Guidelines Network (SIGN) (1998) *The Care of Patients with Chronic Leg Ulcer*. SIGN, Edinburgh

Sumner DS (1989) Non-invasive assessment of peripheral arterial occlusive disease. In: Rutherford KS, Saunders WB, eds. *Vascular Surgery*. Vol 1. Mosby, Philadelphia: 61–111

Vowden KR, Vowden P (2001) Doppler and the ABPI: how good is our understanding? *J Wound Care* **10**(6): 197–202

Vowden KR, Goulding V, Vowden P (1996) Hand-held Doppler assessment for peripheral arterial disease. *J Wound Care* **5**: 125–8

Winsor T (1950) Influence of arterial disease on the systolic pressure gradients of the extremities. *Am J Med Sci* **220**: 117

Yao ST (1970) Experience with the Doppler ultrasound flow velocity meter in peripheral vascular disease. In: Gillespie JA, ed. *Modern Trends in Vascular Surgery I*. Butterworth, London: 281–309

Yao ST, Hobbs JT, Irvine WT (1968) Pulse examination by an ultrasonic method. *Br Med J* **4**(630): 555–7