The importance of accurate methodology in ABPI calculation when assessing lower limb wounds

Abstract

Recent health economic publications have highlighted the cost of wound care and demonstrated the important role played by community and practice nurses in delivering care. Leg ulcers form a significant proportion of the wounds managed in the community. Data indicates that many patients are managed with no specific diagnosis or without calculation of the ankle brachial pressure index (ABPI), despite care guidelines emphasising the importance of a full assessment including Doppler ABPI calculation in patient management.

This article highlights the important role Doppler ABPI plays in patient assessment and describes the methodology, focusing on the importance of correct application of the technique if reliable reproducible results are to be obtained. The rationale for obtaining blood pressure readings from both arms is discussed, and the possible error resulting from reliance on single upper limb blood pressure measurement for both manual and automated ABPI calculation is highlighted and its impact on ABPI calculation illustrated.

■ Doppler ■ ABPI ■ Methodology ■ Automated systems ■ Leg ulcer

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The role of ankle brachial pressure index (ABPI) in leg ulcer management is highlighted in national guidance (Scottish Intercollegiate Guidelines Network, 2010). Additionally, ABPI has a potential role in monitoring cardiovascular risk; a reduced ABPI indicates an increased risk of a cardiovascular event (Al-Qaisi et al, 2009). The ABPI, which is defined as the ratio between the arm and ankle systolic blood pressure, is calculated by dividing the ankle systolic blood pressure by the arm systolic blood pressure and is an objective measurement of arterial insufficiency. The ratio is usually above 1, and a value of below 0.92 is considered abnormal, indicating peripheral arterial disease (Vowden and Vowden, 2001a). Calculating the ABPI is a recognised part of the assessment process of lower limb ulceration, informing both the diagnosis and treatment of lower limb wounds.

In a study looking at the economic burden wounds impose on the NHS, Guest et al (2015) identified over 41% of wounds are on the lower limb. This study also highlighted failures in lower limb assessment, including the ABPI calculation, which was absent from many records (Guest et al, 2017). This is observed by a number of studies that have demonstrated either a failure to, or delays in, undertaking Doppler ABPI calculation as part of the overall assessment process for patients with lower limb ulceration (Srinivasaiah et al, 2007; Vowden and Vowden, 2009; Guest et al, 2017). Reasons for delay are varied, ranging from skill, equipment availability or time constraints. The importance of accurate and timely assessment in wound care cannot be underestimated and now is the subject of a Commissioning for Quality and Innovation (CQUIN) indicator aimed at reducing unwarranted variation in wound care (Adderley et al, 2017). This CQUIN indicator aims to ensure there are no delays or deficiencies in the assessment process that prevent appropriate and early intervention and care.

The fundamental principle underpinning ABPI calculation is accurate measurement of blood pressure. This is a basic

Box 1. Methodology for the calculation of ABPI using a hand-held Doppler

Explain the procedure and obtain consent. The subject should be rested, comfortable, lying flat and relaxed with no external pressure on the proximal vessels.

Measure the brachial systolic blood pressure (ideally this should be done synchronously with the measurement of the ankle systolic pressure):

- Place an appropriately sized cuff* around the upper arm
- Locate the brachial pulse and apply ultrasound contact gel
- Angle the Doppler probe at 45 degrees 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 highest of the two values to calculate the ABPI.

Measure the ankle systolic pressure:

- Place an appropriately sized cuff* around the ankle immediately above the malleoli, having first protected any ulcer that may be present
- Examine the foot, locating the dorsalis pedis or anterior tibial pulse, and apply contact gel
- Continue as for the brachial pressure, recording this pressure in the same way
- Repeat this for the posterior tibial and, if required, the peroneal 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.

$$\text{ABPI(Right)} = \frac{P(R)}{P(B)} \qquad \text{ABPI(Left)} = \frac{P(L)}{P(B)}$$

P(R) = Highest systolic pressure obtained from the vessels at the right ankle

P(L) = Highest systolic pressure obtained from the vessels at the left ankle

P(B) = Highest of the two brachial pressures

** The bladder of the cuff should fit around at least 80% of the limb but not more than 100%. A cuff that does not fit properly will not give an accurate reading; considerable overestimation can occur if the cuff is too small (Wofford et al, 2002).*

Adapted from Vowden and Vowden,0 2001b

skill for all healthcare professionals and underpins the identification and management of a number of medical conditions. The methodology, whether using stethoscope and sphygmomanometer, Doppler or an automated system for non-invasive measurement of blood pressure is well established. One component of this process is, however, often ignored: the need to establish which arm should be used as the reference limb for future blood pressure monitoring.

The blood pressure in the arms may vary in the normal population; differences of more than 15 mmHg, however, indicate likely aortic arch or upper limb arterial disease (Carter, 1993) and may prompt further action. A systematic review by Clark et al (2012) highlights the blood pressure variation that can occur in both arms and supports the recommendations from the National Institute for Health and Care Excellence (NICE). It states, in its information for the public, that 'The first time your blood pressure is checked, the doctor or nurse should measure it in both arms' (NICE, 2011). Measuring the pressure in both arms and using the higher of the two pressures increases the non-invasive accuracy of measurement of central systolic pressure, and only in this way will the best true non-invasive estimate of central blood pressure be obtained. Accurate measurement of upper limb blood pressure is particularly important when it is the basis of treatment decisions such as the management of hypertension, or when calculations such as the ABPI, the basis for treatment decisions regarding the safe application of compression therapy, or involvement of the vascular team in patient management, are required.

ABPI method

The process for undertaking Doppler assessment and the calculation of ABPI is described in *Box 1* and *Box 2*. The methodology for accurate ABPI determination is well established and has been described in a number of publications (Vowden et al, 1996; Ruff, 2003; Aboyans et al, 2012). It has been detailed again in recently published guidelines on the management of peripheral arterial disease (Aboyans et al, 2017a; 2017b; Gerhard-Herman et al, 2017).

The whole process is dependent on an accurate measurement of both upper and lower limb blood pressure. This requires that the prescribed methodology is followed and that blood pressure is measured in both arms and both lower limbs, and that the arm with the highest systolic pressure is used as the denominator for the ABPI calculation. *Figure 1* demonstrates the potential effect that reliance on a single upper limb blood pressure measurement—in this case the right arm—or an incorrect upper limb blood pressure measurement may have on ABPI calculation, and the impact this may then have on treatment decisions. The example illustrates how this could result in the inappropriate use of high compression bandaging or complications resulting from a failure to recognise peripheral arterial disease.

ABPI accuracy

In a review of nurses' understanding of Doppler assessment and ABPI, Vowden and Vowden (2001a) highlighted where errors in methodology can result in incorrect ABPI calculation.

Accuracy can be improved by the following measures:

- Ensuring that the sphygmomanometer cuff is the correct size
  - Too small a cuff at the ankle will overestimate the systolic pressure and elevate the ABPI
- Measuring the blood pressure in both arms

  - Measuring the pressure in one arm may provide inaccurate results (see *Figure 1*)
- Ensuring the lower limb cuff is placed at the ankle
  - Placing the cuff above the ankle will elevate the pressure and the ABPI
  - Placing and inflating the cuff around the calf is painful
- Deflating the cuff slowly, particularly if the pulse is irregular
  - A rapid deflation of the cuff may miss the highest pressure and underestimate the ABPI
  - When the pulse is irregular slow deflation is important for accuracy
- Ensure the subject is rested appropriately when using a hand-held Doppler
  - Examination without resting may result in lower ankle systolic pressure and a reduced ABPI
- Ensuring the subject's legs are elevated to heart level
  - Dependent lower limbs will elevate the systolic pressure and raise the ABPI giving a falsely high reading.
- There is a note made of medical conditions that can alter the accuracy of ABPI
  - Limb size
  - Vascular calcification or non-compressibility can also falsely elevate the systolic pressure reading and the ABPI (Vowden and Vowden, 2001b)
- Another potential source of error is using different techniques to measure the arm and ankle systolic pressures (Jeelani et al, 2000).

An automated system of limb blood pressure measurement and ABPI calculation can assist practitioners; however, it is important to recognise that all cuff-based systems, whether hand-held Doppler is used or an automated system, are subject to the same limitations imposed by the use of a sphygmomanometer cuff. Automated systems synchronously measure arm and leg blood pressure and can potentially provide comparable results to that obtained with the hand-held Doppler, and may reduce the skill and training required to perform this test (Clairotte et al, 2009; Lewis et al, 2016; Span et al, 2016; Sultan et al, 2016).

A number of such systems are now commercially available and several provide a direct readout of limb ABPI and a printout of the waveform. Patients with abnormal results can be highlighted and decisions made regarding further action such as investigation or referral. The principles of ABPI, whether using hand held devices or automated systems, are the same, and it is necessary to ensure that systolic blood pressure is accurately measured in both arms and both lower limbs using the correct sized cuff and that the correct arm pressure is used in subsequent ABPI calculations.

Box 2. Methodology for the calculation of ABPI using an automated system

Explain the procedure and obtain consent. The subject should be rested, comfortable, lying flat and relaxed with no external pressure on the proximal vessels.

Measure the brachial and ankle systolic blood pressure (this is done synchronously)

- Place an appropriately sized cuff* around both the upper arms and the lower limbs around the ankle immediately above the malleoli, having first protected any ulcer that may be present
- The machine inflates the cuff until the signal is abolished then automatically deflates the cuff slowly and records the pressure at which the signal returns. The highest of the two arm values is used to calculate the ABPI
- Results are displayed with a waveform, which is useful additional information when patients have abnormal readings or have diabetes.

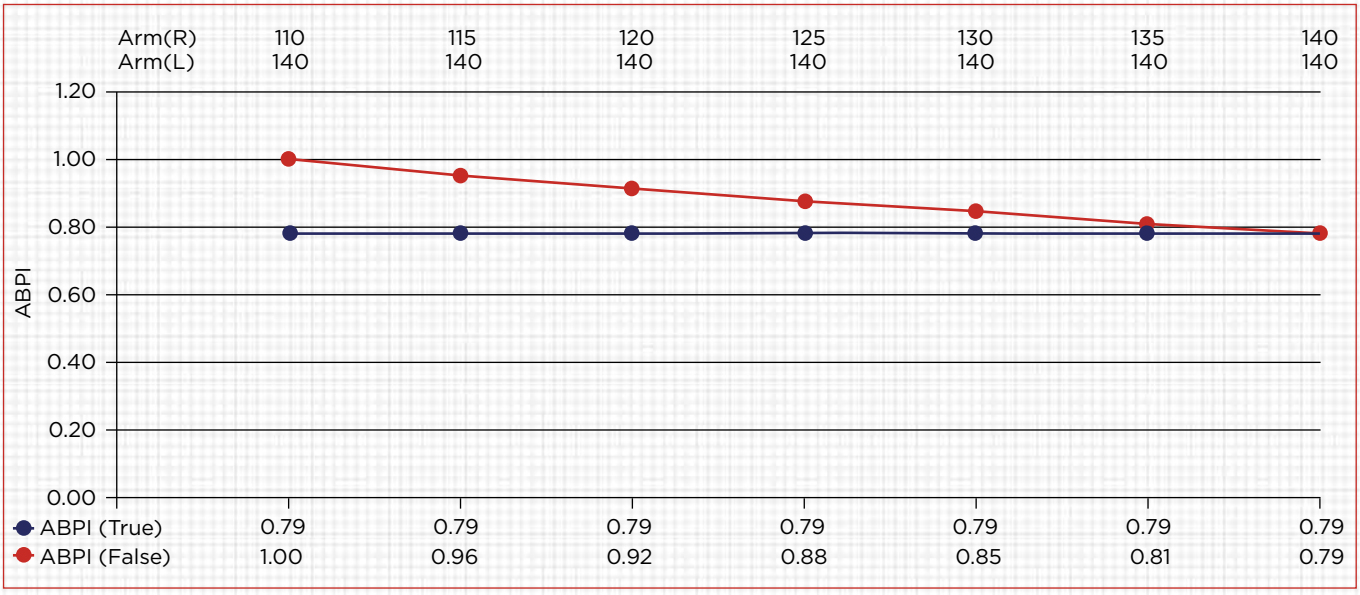

Figure 1. Potential impact of not checking blood pressure in both arms on ABPI BP (mmHg)—highest ankle pressure 110

Conclusion

The ABPI has a pivotal role in the assessment process of patients with lower limb ulceration, supporting both diagnosis and treatment planning. The key to accurate calculation of the ABPI is adherence to correct methodology and an understanding of the causes or potential errors in systolic pressure measurement.

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