

Use of Color Flow Doppler for Determination of Ankle Brachial Index

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Introduction

Continuous wave (CW) Doppler has been the traditional method for obtaining ankle pressures and for determination of the ankle brachial index (ABI). With increased use of duplex ultrasound equipment, color imaging has been adopted for use as a Doppler detection device. Although the use of a large, expensive duplex scanner as a simple flow detection device is admittedly overkill, situations may arise in which this technique can be useful, convenient, and occasionally beneficial. To better determine the viability, advantages, and the disadvantages of CW Doppler versus color flow imaging, the following elements will be discussed: cost, ease of use, accuracy, and reproducibility.

Cost

Any argument involving cost is easily on the side of the CW Doppler device. Cost-effectiveness alone is perhaps the best argument against using the duplex scanner for the purposes of flow detection and ABI. The CW Doppler ranges in price from a few hundred dollars for models with a simple analog audio output to tens of thousands for models with spectral analyzers and computerized printing capabilities. For the purpose of ankle pressure flow detection, the simplest pencil Doppler has withstood the test of time. In contrast, color duplex equipment ranges from \$100,000 to \$250,000 and would be ludicrous to use primarily for ABI determination, because this examination is non-reimbursable in many cases. The simple and inexpensive CW Doppler, therefore, has a clear advantage when considering the element of cost.

Ease of Use

To determine ABI, both devices require a blood pressure cuff to be positioned at the ankle level of the extremity to be measured. Either technique requires the examiner to insonate the posterior tibial (PT) and/or the dorsal pedal (DP) artery. The ankle cuff is in-

flated until the vessel occludes and then slowly deflated until systolic blood flow is detected.

Insonation and adjustments with CW Doppler are generally simple: the unit is turned on, volume is adjusted, and a small amount of gel is placed on the tip of the transducer. Portable CW Dopplers are usually battery powered, small, light, portable, and the transducer can easily be manipulated into tight places. In comparison, a color duplex scanner is cumbersome and requires considerable maneuvering to obtain an acceptable position.

The typical linear array transducer ranges from 4–10 cm in length, and its comparatively bulky nature can complicate access to a vessel on the less than an optimally positioned patient. Although the determination of ankle pressure using the duplex scanner is simply a matter of flow detection with color Doppler, the instrument has a myriad of controls that require proper adjustment to obtain an adequate signal. Power, gain, sampling interval, and pulse repetition frequency (PRF) must be optimized for a paramalleolar artery. Depth (critical for maintaining frame rate) and ensemble length (the number of pulse-listen cycles) require adjustment for a superficial structure. A proper angle, in conjunction with beam steering and heel-toe transducer manipulation, is often needed to help maximize color fill. Inflating and deflating the cuff, while simultaneously watching the imager monitor for the return of color and the sphygmomanometer for the exact pressure, can seem highly intimidating for a simple ABI. In practice, however, most of the aforementioned controls can be preset, and many are not that critical to the technique. Nonetheless, CW Doppler once more has the distinct advantage in ease of use.

Accuracy and Reproducibility

Cost and ease of use aside, the accuracy and reproducibility of each method are the primary issues that must pass the test, or all other arguments become moot. A large number of studies have addressed the reproducibility of ABI measurements, which consistently range between 10%–20%.¹⁻⁵ In addition, because an ABI is in fact a ratio, as long as any error is consistent, the ratio will be unaffected. For obtaining absolute pressure measurements, however, any error could be a significant factor, and it is imperative that a consistent technique be used.

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The ability to reliably detect a Doppler shifted frequency is generally $\pm 10\%$ – 15% .⁶ From a practical aspect, therefore, this is the accuracy that one needs to attain for measuring blood pressure. The ability to detect low flow velocities is substantially better with color flow imaging. Most CW Dopplers have a high pass or other type of wall filter that is typically not adjustable. In some devices, this can be as high as 800 Hz. Although duplex scanners often use wall filters, these are commonly adjustable, and most can be turned off completely. Low-velocity detection, however, is not a common problem with either device. It is our experience that initial opening velocity of an artery after cuff deflation is commonly within the capability of either instrument. Low flow detection becomes an issue when velocities are less than 10 cm/sec; however, at that point, the pressure is already known to be severely low.

Technical Considerations

When color duplex imaging is used for flow detection, there are a few important controls that need specific attention. The sampling interval (the size and/or distance between sample volumes) needs to be small enough to “fit within” the vessel of interest. If too much of the sample volume lies outside the flow channel, the Doppler signal will be lost.⁷ The pulse repetition frequency (PRF) needs to be set properly for the range of velocities one expects to encounter. The transmit power and receiver gain need attention for optimal display. A satisfactory Doppler angle of incidence must be maintained, preferably at less than 60 degrees. Finally, frame rate needs to be adequate to maintain an acceptable temporal resolution. Slow frame rates steal from our ability to “see” events in real time. As a consequence, the first or even second systole could be missed, resulting in a falsely low measurement.

Color Flow Advantages

With the duplex scanner, visualizing the vessel of interest is of great advantage, and the operator can better determine whether the data are optimal. Specific vessels can be identified, and pressure measurements can be obtained for each. In part, because of its

large field of view, the duplex scanner is superior for small vessel identification, and collaterals can be differentiated from main arteries. The presence of medial calcinosis can often be readily appreciated and alert the examiner to the possibility of incompressible or partially compressible vessels. Because direction of flow is more readily appreciated, it is easier to differentiate antegrade from retrograde flow. This is important information when assessing the adequacy of collateral flow and can aid in determining patency of the pedal arch. For example, while visualizing the dorsalis pedis during cuff deflation, an initial period of retrograde fill from the foot followed by forward flow suggests that another artery is dominant, with a higher pressure, and that the pedal arch is also likely to be patent.⁸

Conclusion

There is little difference in ankle pressure and ABI measurements using CW or color flow Doppler. Although cost and ease of use are clearly on the side of CW Doppler equipment, color flow imaging can yield some additional and useful information.

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