Letters to the Editor

Clinical Assessment of Wave Reflection

To the Editor:

In their paper on wave reflection, Millasseau et al.1 questioned whether quantification of wave reflection phenomena required synthesis of the ascending aortic waveform from the radial pulse through use of a generalized transfer function, or whether similar information could be extracted directly from the radial pulse. We had introduced the SphygmoCor™ system, not only to study central hemodynamics, but also because we could not reliably or consistently identify evidence of wave reflection on the falling systolic limb of the radial waveform. Problems were most commonly encountered when augmentation was low, or wave reflection came late (young persons), or was reduced by vasodilator therapy, or when heart rate was fast and augmentation obscured by the cardiac incisura. By generating aortic pressure, we sought to eliminate the effects of wave reflection within the upper limb so that we could determine effects of reflection from all parts of the body on aortic pressure throughout systole and on left ventricular load. The validity of this system has been confirmed,2 as has its reproducibility.3 Absolute synthesized values are within the Association for the Advancement of Medical Instrumentation (AAMI) SP10 criteria when compared with direct aortic pressure recordings.4

In the limited comparisons undertaken by Millasseau, greater variability of aortic augmentation than absolute pressure is predictable, because the former is measured from 2, and the latter from just 1 point on the wave. We were pleasantly surprised by the close fit between radial augmentation index (AIx) and calculated aortic AIx (authors’ Figure 4); this was the only real concern raised by Chen et al.2 (authors’ Reference 9) in accurate calculation of aortic AIx. We have introduced the carotid waveform. We have not seen such a dissociation in paired recordings from 548 subjects, except (as seen by Millasseau) when values of augmentation were low and, so, of little clinical importance (Figures 22.18, 22.19 in Nichols and O’Rourke5). Millasseau et al. tested their hypothesis by comparing aortic waveforms when generated by transfer functions at the 95% extremes of confidence limits as published by Chen et al2 and found greater difference in AIx than aortic systolic pressure. This is a tough test in itself, but was generated with just one (atyypical) youthful waveform with 2 late systolic shoulders, rather than one.

We have repeated this test with more realistic radial waveforms taken in an older person with a single late systolic shoulder. Both under control conditions and after sublingual nitroglycerin, calculated systolic and augmentation differences were within 3 mm Hg when generated from the 95% confidence extremes of the transfer functions.

While radial waveforms may contain effects of wave reflection as seen in the synthesized aortic pulse, the automated process that generates the aortic pressure waveform is more practical and more consistent for automated feature extraction and more clinically useful than analysis of the radial pulse alone to determine ventricular load.

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Response: Augmentation Index and the Radial-to-Aortic Transfer Function

We thank Professor O’Rourke and colleagues for their comments. We agree that the use of a radial-to-aortic transfer function (TF) for estimation of systolic blood pressure (SBP) and pulse pressure has been validated,1–3 although the accuracy of central blood pressure obtained in this way depends critically on the calibration of the radial pressure pulse.4–6 Agreement between aortic augmentation index (AIx) estimated using a TF and measured values is less convincing.1 Indeed, in a recent study, Hope et al7 report no correlation between measured and TF-estimated AIx. We suggested that a greater error in TF-estimated AIx than in TF-estimated central SBP could result from the greater variability of the TF at high frequencies that contribute more to AIx than to central SBP. We illustrated this with an example from a 46-year-old man. We have now run a similar analysis on all the subjects in our study and find greater variability in AIx than in central SBP, but we agree that other explanations, including additive errors, may account for the greater error in AIx than in central SBP. Because AIx typically ranges from −20% to +20%, a small absolute error may represent a large proportion of the pathophysiologic range.

Carotid tonometry does require a degree of expertise to obtain optimal traces.8 However, the operator in our study (S.M.) was experienced in performing carotid measurements, and only measurements satisfying the default quality controls of the SphygmoCor™ were used. It is unlikely, therefore, that our findings were due to the poor quality of the carotid pulse recordings. The discrepancy between values of AIx obtained from the carotid and radial arteries was most marked in young subjects, and this is important for the many studies using AIx in young healthy volunteers.9–11 We do not dispute the use of a TF to estimate central blood pressure, provided the radial pulse wave is correctly calibrated. Although we remain to be convinced of an added benefit (beyond measurements taken directly from the radial pulse) of using a TF to assess wave reflection, we are enthusiastic in using pulse contour–derived measurements to study arterial structure and function. This is one of the many important contributions made by Professor O’Rourke and colleagues to the understanding of arterial hemodynamics.

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