Impact of Radial Artery Pressure Waveform Calibration on Estimated Central Pressure Using a Transfer Function Approach

To the Editor:

It is with great interest that we have read the excellent work of McEniery et al1 on the variability of the relation between central and brachial pulse pressure (pressure amplification, assessed in >10 000 subjects. We were, however, a little surprised about the magnitude of the central-to-brachial pressure amplification, which is in the order of 1.38 for the entire population (estimated from their Table 1). We hypothesize that these high values arise from the use of central aortic pressure curves synthesized from radial pressure tracings, with the most important factor not being the generalized pressure transfer function but the calibration of the radial pressure waveforms. To illustrate this, we applied 4 calibration strategies to radial artery pressure waveforms measured within the framework of the Asklepios Study.2

All of the strategies assume equal radial and brachial diastolic blood pressure (DBP). Method 1 further assumes similar radial and brachial systolic blood pressure (SBPBA and SBPRA, SBPBA=SBPRA, ignoring brachial-to-radial amplification). Methods 2 to 4 assume similar radial and brachial mean blood pressure (MAP), but MAP is calculated differently, as follows:

Method 2: one-third rule: MAP=DBP+(SBP−DBP)/3.
Method 3: 40% rule: MAP=DBP+0.4(SBP−DBP), following Bos et al.3
Method 4: pressure curve: MAP is the average of a calibrated brachial pressure curve.4

Central pressure waveforms were calculated using the transfer function as published by Karamanoglu et al,5 and the ratio of brachial:aortic pulse pressure was calculated (Table). All of the strategies assume equal radial and brachial diastolic blood pressure (DBP). Method 1 further assumes similar radial and brachial systolic blood pressure (SBPRA and SBPBA, SBPBA=SBPRA, ignoring brachial-to-radial amplification). Methods 2 to 4 assume similar radial and brachial mean blood pressure (MAP), but MAP is calculated differently, as follows:

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Central pressure waveforms were calculated using the transfer function as published by Karamanoglu et al,5 and the ratio of brachial:aortic pulse pressure was calculated (Table). Data clearly demonstrate the impact of the calibration procedure on the brachial-to-aortic amplification factor. Strategies 1 and 2 explicitly ignore or do not lead to brachial-to-aortic amplification; application of the transfer function to a nonamplified wave will yield a central pulse pressure, which is lower than the value obtained after transferring a radial pressure wave where some brachial-to-aortic amplification has been accounted for (methods 3 and 4).

Definite proof of the importance of brachial-to-radial amplification can only be provided by invasive data, but it seems unlikely that central-to-peripheral amplification would not continue in the radial artery. Invasive data have demonstrated that the one-third rule understimates MAP3 and, as illustrated in the Table, causes subsequent low estimates of radial SBP on radial artery waveform calibration.

Tonometer (radial and carotid) waveform calibration is a key factor in noninvasive central pressure estimation, often based on MAP estimated with the one-third rule. We might need to reconsider this widely adopted rule-of-thumb, especially in times where the debate is held on pressure differences in the order of a few millimeters of mercury. Moreover, given the fact that central-to-brachial amplification is susceptible to hemodynamic factors, such as heart rate, and to cardiovascular risk factors,1 it is per definition that a simple estimate of MAP based on only SBP and DBP must be susceptible to these very same factors.

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Disclosures

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Table. Pulse Pressure (SD) at Radial, Brachial, and Ascending Aorta Obtained With Radial-to-Aorta Transfer Function in Millimeters of Mercury

<table>
<thead>
<tr>
<th>Calibration Method</th>
<th>PPBA, mm Hg</th>
<th>PPRA, mm Hg</th>
<th>PPAT, mm Hg</th>
<th>PPBA/PPAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA=RA</td>
<td>54.9 (10.1)</td>
<td>54.9 (10.1)</td>
<td>46.9 (10.0)</td>
<td>1.18 (0.12)</td>
</tr>
<tr>
<td>One-third rule</td>
<td>48.6 (10.6)</td>
<td>54.9 (10.1)</td>
<td>41.3 (8.7)</td>
<td>1.34 (0.09)</td>
</tr>
<tr>
<td>40% rule</td>
<td>58.3 (12.7)</td>
<td>54.9 (10.1)</td>
<td>49.5 (10.5)</td>
<td>1.12 (0.07)</td>
</tr>
<tr>
<td>Pressure curve</td>
<td>61.4 (12.3)</td>
<td>54.9 (10.1)</td>
<td>52.3 (11.1)</td>
<td>1.06 (0.11)</td>
</tr>
</tbody>
</table>

BA indicates brachial artery; RA, radial artery; TF, ascending aorta obtained with radial-to-aorta transfer function; PP, pulse pressure.

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