Invasive Validation of the N-Point Moving Average Method

We read with great interest the recent paper by Williams et al. (1) introducing and validating a new method to derive central aortic systolic blood pressure (cSBP). We fully agree that simpler methods to derive cSBP will facilitate the distribution of this important measure into large clinical trials and, eventually, into clinical routine. However, some questions about the invasive validation need to be addressed.

Typically, in studies of this kind, mean differences between measured and calculated cSBPs are small (1 to 2 mm Hg), and SDs of differences are in the range of 7 to 11 mm Hg (2,3). Williams et al. (1) present the data as mean ± SE, which is unusual. SE is approximately a factor square root(n) smaller than SD, which must be kept in mind when interpreting the results. In the first paragraph of the section on invasive validation, the authors use the SE on the basis of n = 20 (invasive cSBP 139.6 ± 4.3 mm Hg) and then proceed to use the SE on the basis of n = 200 (invasive cSBP 139.6 ± 1.4 mm Hg) and stay unclear when presenting the differences between calculated cSBP and invasive cSBP (−0.41 ± 2.5 mm Hg). Supposing again n = 20 for SE, the usual presentation of these data on the basis of mean ± SD leads to a mean difference of −0.41 mm Hg and an SD of 11.2 mm Hg, which would be in line with the published literature.

The presentation of data stays unusual for Figure 5 of their paper (1). The assumption that data based on multiple sampling windows of 10 s, using the same calibration, are independent is questionable. Such data may not be suitable for regression analysis and provide misleading coefficients and p values. This is even visually unveiled by the vertical data clustering along the regression line (Fig. 5A of their paper [1]). It would be informative to see the corresponding Bland-Altman plot on a per-patient basis.

To summarize, we have significant questions about the presentation of the results of the invasive part of the validation study.

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Please note: Drs. Wassertheurer and Hametner are employees of the Austrian Institute of Technology, developing new methods for noninvasive hemodynamic monitoring. Drs. Weber and Eber have reported that they have no relationships relevant to the contents of this letter to disclose.

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Reply

We thank Dr. Wassertheurer and colleagues for their interest in our study (1) and note their agreement about the importance of developing simpler noninvasive methods for deriving central aortic systolic blood pressure (CASP) in man. They comment on the level of agreement between invasive and noninvasive measure-
ments and suggest that analyzing multiple 10-s sampling windows using the same noninvasive initial calibration values is inappropriate and may have influenced our results.

Calibration of radial pressure waves to a single brachial blood pressure (BP) measurement in the noninvasive measurement of CASP is standard practice for many devices. However, the A-pulse tonometer (HealthSTATS International, Singapore) used in our study operates in a different way. After calibration of the initial 10-s radial waveform block to brachial BP, pulse wave height is subsequently scaled automatically to generate updated brachial BPs. This method allows the device to update brachial BP on a block-by-block basis across the sampling period, accounting for natural fluctuations in brachial BP over time (2). This technique potentially reduces scatter in the agreement between invasive and noninvasive measurements, largely accounting for the improved accuracy reported. Indeed, it is remarkable that a single brachial BP calibration of initial radial pressure waves yielded such good results in previous studies over extended sampling periods.

Mindful of the above, we analyzed the influence of calibrating all 10-s data blocks acquired during sampling to the initial brachial BP, which constitutes standard practice for all other devices. In this, we also processed radial waveforms using the algorithm of an established method (SphygmoCor, AtCor Medical, West Ryde, Australia). Bland–Altman comparison of such processed data revealed a wider degree of scatter (p < 0.01) compared with that reported in our study (1) (Fig. 1). This finding suggests that waveform calibration drift across the sampling period is likely to contribute to greater inaccuracy in deriving CASP in other studies.

With regard to data presentation for t test comparison in our study (1), we presented mean ± SE values for invasive and noninvasive data from our 20 subjects, both as mean per subject and for each individual data block. By contrast, data for Bland–Altman comparisons are frequently presented as mean ± SD. Accordingly, this format was followed in presenting the difference between invasive and noninvasive data.

In summary, we thank Dr. Wassertheurer and colleagues for their comments, which prompted us to better define the importance of automated waveform calibration updating in radial tonometry measurements. This, together with use of an N-point moving average, seems to provide improved accuracy for the noninvasive measurement of CASP in man.

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