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Closer to Noninvasive Out-of-Office Aortic Blood Pressure Assessment
A Time to Think and Act

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The noninvasive assessment of central (aortic or carotid) blood pressure (BP) is a challenge to the clinical investigation of arterial hypertension. The importance of central BP was recognized decades ago on the basis of invasive hemodynamic studies but has become widely acknowledged during the last 15 years. This is largely attributed to the work of highly respected pioneers, like Michael O’Rourke’s team, who created the first commercial device (SphygmoCor, AtCor, Sydney, Australia), enabling the wide application of the noninvasive assessment of aortic BP.

In this issue of Hypertension, Weber et al present the validation of a novel BP recording device that noninvasively assesses aortic BP based on the brachial cuff oscillometric method and the application of mathematical transformation. The present invasive and noninvasive validation is of importance because it is a straightforward demonstration of the strengths and disadvantages of a new generation of BP devices that opens the way to out-of-office aortic BP self-assessment. After briefly reviewing the reasons for estimating central BP, we discuss the novelty of this device, the findings, and limitations of this study, and some of the major issues that should arise in future clinical research and practice.

Why Assess Central Pressure?
The reasons have been extensively addressed in recent expert opinions and reviews and are only summarized here. Normally, central systolic BP (SBP) and pulse pressure (PP) are lower than peripheral SBP and PP (from 1 to 30 mm Hg). This PP disparity, defined as PP amplification, is an undisputable physiological phenomenon and depends on the individual’s hemodynamic and pathophysiological characteristics. Notably, PP amplification exhibits substantial within-subject time variability (eg, from 5 to 20 mm Hg; Figure) that is mainly attributed to variations in heart rate, pressure wave reflections, and arterial elasticity/diameter. The closer physiological relevance of central PP over brachial PP to cardiovascular disease/events is supported by published data. Both nonpharmacological and pharmacological interventions have clinically important effects on PP amplification, that is, on central PP rather than brachial PP, and potentially on cardiovascular outcomes. The above published data are derived from studies in laboratories and clinic settings; it is likely that out-of-office assessment of central BP or PP amplification will improve the models of cardiovascular risk assessment currently based solely on brachial BP.

Comment on the Novelty of the New Device
In the present study, a previously validated automatic oscillometric device for 24-hour ambulatory brachial BP recording (Mobilo-O-Graph NG, IEM, Stolberg, Germany) has been upgraded to record brachial waveforms and mathematically transform them by software analysis to aortic waveforms. These noninvasive data were validated to assess the aortic BP. The novelty of this application is the use of the brachial cuff instead of the most commonly applied radial applanation tonometry. The Mobil-O-Graph is suitable for out-of-office aortic BP assessment and facilitates the investigation of important clinical questions related to circadian variability of PP amplification (Figure). Moreover, this feature improves its potential for the application of aortic BP measurement to clinical practice by enhancing operator independence, time effectiveness, and general practitioner familiarity when compared with the previously applied method of applanation tonometry.

Central SBP assessment requires the calibration (either by noninvasive peripheral SBP and diastolic BP [DBP], or mean BP [MBP] and DBP) of the peripheral pressure wave. A second innovation of the present device is that the site of the BP calibrating measurement and the site of pressure waveform recording coincide at the brachial artery. Theoretically this should minimize miscalibration introduced by the brachial to radial PP amplification phenomenon.

Comments on the Present Study: Major Conclusions and Limitations
The aortic pressure derived from the Mobil-O-Graph was compared with the invasively recorded aortic pressure and the noninvasive-derived (by SphygmoCor device) aortic BP. The conclusions from these comparisons should take into consideration the accuracy of the new device to assess all 3 components of BP within the arterial tree: the steady (ie,
MBP, the pulsatile (ie, PP rather than SBP), and PP amplification.

The major difficulty and limitation of the present study derive from the lack of invasive brachial BP recordings that would allow the accurate invasive assessment of PP amplification. Such data are very limited in the literature, and the actual level of PP amplification is an issue of debate, because no gold standard or agreement on the noninvasive methodology to assess aortic BP exists.\(^1\)

The results from the comparison of the noninvasively calibrated Mobil-O-Graph data with the invasively recorded aortic pressure are enlightening. Brachial MBP was only slightly overestimated by 2 to 4 mm Hg, given the fact that it is expected to be 1 to 2 mm Hg lower than the aortic pressure.\(^1\) Conversely, the invasive aortic PP was underestimated by \(\approx 11\) to 22 mm Hg, depending on the mode of noninvasive calibration of the brachial waveform (MBP/DBP or SBP/DBP, respectively). However, the assessment of aortic SBP alone was quite acceptable, especially with the MBP/DBP calibration mode, which led, however, to the erroneous result of negative PP amplification, that is, lower brachial PP than aortic PP. Finally, the most impressive (but not unexpected) result was the large underestimation of brachial SBP (by \(\geq 14\) mm Hg, if a modest upper limb SBP amplification of 5 mm Hg is taken into consideration) and the overestimation of brachial DBP (of \(\approx 8\) mm Hg) by the brachial cuff oscillometric method. Actually, this magnitude of error is almost identical to the mean deviation of aortic SBP and DBP as assessed by Mobil-O-Graph (calibrated by the brachial SBP and DBP) from the invasive aortic BP. Taken all together, these data highlight once more what has been shown previously,\(^10\) that is, the fact that the major limiting step in the attempt to assess aortic BP noninvasively and accurately is the inaccurate recording of systolic and diastolic brachial pressures.

Regarding the comparison of the 2 devices (Mobil-O-Graph and SphygmoCor), both the invasive and noninvasive substudies showed acceptable agreement. The small observed differences might be attributed to the presence of brachial to radial PP amplification that leads to greater underestimation of aortic SBP by the SphygmoCor device. This is an important result suggesting that the available data on aortic BP based on SphygmoCor might be applicable to the aortic BP assessment with the Mobil-O-Graph.

**BP Assessment: Perspectives in Clinical Research and Practice**

The present and future innovations in biomedical engineering will bring “out of the office” aortic BP assessment into clinical trials and potentially into daily clinical practice. For that reason, the scientific community must be prepared to lead the changes. This requires combined action from experts in both peripheral and central BP assessment to set gold standards for device validation protocols, for normal values in central BP and PP amplification, and for diagnostic/treatment algorithms. Some of these projects are already underway.

Systematic inaccuracy as introduced by the auscultatory method in brachial BP readings, compared with the actual invasive BP, has been accepted and incorporated in clinical trials, daily practice, and validation protocols for automatic oscillometric devices. In this respect, it seems “unfair” to demand accurate noninvasive aortic BP assessment. Moreover, the present study shows that, although acceptable assessment of the actual invasive aortic SBP is feasible from the brachial cuff (MBP/DBP calibration), this introduces erroneous values in terms of the expected physiological PP amplification. If the brachial BP device and its values are to be accepted, it seems reasonable to compromise with the incorporation of this systematic error into aortic BP assessment.

The value of brachial pressure to guide BP management is beyond any doubt. Whether central hemodynamics will replace brachial pressure or be used as complementary data will be a debate for the years to come. A reasonable approach is to detect subpopulations (especially young adults) that will benefit significantly from the assessment of central pressure. However, we should also consider cost-effectiveness, as well as the risk of complicating daily clinical practice by introducing complex diagnostic algorithms to assess office and out-of-office brachial and aortic BP. Do we have other alternatives? Brachial MBP is readily available by oscillometric devices and is the most accurate and simple marker of aortic pressure (because of the lack of MBP amplification throughout the entire arterial tree). A new approach to BP management might be based on the MBP and uncalibrated central and peripheral pressure waveforms that incorporate all 3 components of arterial BP and an estimation of vascular age.

In conclusion, given the described results, limitations, and perspectives, the new validated brachial cuff-based method represents the next step forward in noninvasive aortic BP assessment. Feasibility and reproducibility studies should validate the option of 24-hour ambulatory aortic assessment.
before incorporating it in clinical trials to test its prognostic value.

**Disclosures**

None.

**References**


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