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COMMENTARY

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The ongoing saga of poor blood pressure measurement: Past, present, and future perspectives

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My great concern is not whether you have failed, but whether you are content with your failure

Abraham Lincoln (1809–1865)

1 | INTRODUCTION

Blood pressure (BP) measurement is likely the most important diagnostic test performed in modern medicine because it generates data vital to the assessment of future cardiovascular risk.[1] When one considers that elevated BP is the leading cause of death or disability in the world,[2–4] affecting nearly 1.5 billion individuals globally,[5] it is not difficult to understand the importance of accurate BP measurement in the diagnosis and management of hypertensive individuals. Ever since BP measurement was first conceived in 1896, efforts have been made to improve its accuracy.[6] Seemingly a very simple procedure, clinic BP measurement is, in reality, quite complex, with multiple sources of potential inaccuracy, including patient-related factors (white-coat effect, insufficient rest prior to measurement, full bladder, caffeine ingestion, incorrect body position); device-related factors (lack of validation and proper calibration); and observer-related factors (hearing deficits, rapid deflation rate, improper Korotkoff sound recognition, terminal digit preference).[7]

Unfortunately, medical practitioners collectively have a long history of failing to perform BP measurement properly, and the direction of bias is generally towards falsely elevated readings.[1] This issue of inaccurate measurement is underrecognized and pervasive. In the current issue of the *Journal of Clinical Hypertension*, the excellent study by Rakotz and colleagues[8] refocuses attention on the poor state of BP measurement among medical students. The authors studied a convenience sample of medical students attending the American Medical Association's House of Delegates Annual Meeting. They had participants perform a case simulation to assess their skills in measuring BP. The authors elected to use an automated BP device to alleviate the layers of complexity that are inherent with the auscultatory method and to align with the guidelines recommending the automated BP method.[9–11] It should be noted that auscultatory BP measurement, when taken simultaneously by two blinded observers using a mercury sphygmomanometer, with agreement within 4 mm Hg, is still considered the gold standard method for BP measurement.[1,12] However, auscultation in this manner cannot be practically or feasibly implemented in clinical practice. Furthermore, for health, safety, and environmental reasons, use of mercury has been banned in many jurisdictions, replaced by aneroid devices that contain moving parts and require regular calibration, which is frequently not performed.[13] This further compromises the accuracy of auscultatory measurement in clinical practice. In addition, adherence to the auscultatory technique, and corresponding auscultatory BP measurement accuracy, declines over time without retraining and accuracy testing.[14] For these reasons, contemporary hypertension guideline committees have specifically recommended the use of automated office BP devices in lieu of auscultatory measurement.[9–11] Automation eliminates the potential for auscultatory procedure-related error (such as terminal digit preference and missing the auscultatory gap) and, if the provider leaves the room during the automated measurements, eliminates talking between patients and providers and minimizes the white-coat effect.

The 11 skills evaluated in the study by Rakotz and colleagues[8] were all procedure-related skills. Having the patient sit prior to starting the BP measurement was the skill the medical students missed most often. This likely reflects that in a busy clinical practice (role modeled to these medical students), it is difficult to ensure that patients rest quietly for 5 minutes before their BP is taken. Even the skills that were most often performed correctly were done by only 52% to 83% of the participants. The authors indicate that BP measurement is taught in first-year medical school in the United States and not reinforced during the rest of medical training. Although first-year students made up the majority of the study sample and would have been closest to the teaching of this skill, it was the 2nd- to 4th-year students who scored higher than the first-year students, which suggests that some reinforcement or further knowledge consolidation is occurring. Still, in highest-scoring group, a mean of only 4.9 of 11 skills were performed correctly.[8]

Rakotz and colleagues[8] identify the need to attain mastery during medical education but also appropriately emphasize the need for retraining to maintain mastery. Emerging literature supports the value of ongoing coaching, mentoring, and formative assessments throughout our medical careers to optimize continuing professional development.[15] Given the importance of BP measurement as a means to optimize the management of patients with or at risk for hypertension, it is essential that ongoing retraining in BP measurement be performed. Observer-related sources of error were not studied in the work by Rakotz and associates; however, in nurses, a 1-day retraining course with testing before and after the course has been shown to reduce BP measurement error.[16]

Despite the aforementioned advantages of automated devices, some potential concerns exist with the use of these devices, which are poorly understood and require further study. Using the cuff as a sensor, these devices measure and record oscillometric waveforms generated by arterial pulsations. Typically, BP is estimated by calculating systolic and diastolic thresholds from an envelope of these oscillometric waveforms.[17] BP derivation involves a calculation performed using an algorithm, which is proprietary to each device company and not publicly available. This lack of public disclosure limits understanding of how these algorithms perform across different patient populations. Conventional algorithms likely depend heavily on the presence of normally shaped waveform envelopes. Waveform envelope distortion, which, in theory, can occur in patients with vascular stiffness, chronic kidney disease, severe obesity, pregnancy, and atrial fibrillation, could potentially adversely impact BP estimation and device accuracy. Much has been written about this potential accuracy limitation in the engineering literature,[17] and awareness among clinicians is emerging. A recently published study reported that the Omron HEM-907, which is validated for use in the general population[18] and was used in the Systolic Blood Pressure Intervention Trial (SPRINT) study, was not accurate in patients with chronic kidney disease.[19] The authors speculated that this may have been due to the vascular stiffness and impaired vascular function associated with chronic kidney disease.[19]

Arguably the most important problem with clinic BP measurement is the practice of performing a single reading or set of readings closely spaced in time. BP is a continuous measure, fluctuating every second of the day in response to numerous physiological and environmental stimuli. Accordingly, the expectation that clinic BP can truly estimate an individual's true or "usual" BP is misguided. Of the three most common and accepted methods for assessing BP (ambulatory, clinic, and home), ambulatory BP measurement (ABPM) is preferred for diagnosis and prognosis.[20,21] The two major advantages of ABPM are the ability to take many readings and the availability of nocturnal readings, which are most prognostically useful.[20] Home BP measurement (HBPM) is a reasonable alternative to ABPM and is also a significant predictor of cardiovascular events.[22] Like ABPM, HBPM can detect white-coat and masked hypertension.[22] Both ABPM and HBPM are superior to clinic BP for prognostication.[22] HBPM also improves patient activation and encourages self-monitoring, and the act of home monitoring alone improves BP.[23,24] As an adjunct to HBPM, telemonitoring and pharmacist case management can further optimize BP control.[25] Therefore, out-of-office measurement modalities are preferred and have important advantages over in-office modalities, and their use should be encouraged.

2 | CONCLUSIONS

Because of the central importance that BP measurement plays in the care of medical patients, it is imperative that greater attention be paid to ensuring that clinic measurements are performed as accurately as possible. Inherent in this task is the need to ensure that automated device accuracy is optimized in the setting of diverse patient characteristics. This latter objective is critical because it also applies to automated devices used in the out-of-office setting. Contemporary practice patterns will shift gradually over time and we predict that use of out-of-office measurement for the diagnosis and follow-up of hypertension will increase, and appropriately so. Although this will diminish (but not eliminate) the importance of clinic BP measurement as a measurement modality, the importance of in-clinic measurement, even as a screening modality, should not be discounted. Therefore, we must redouble our efforts to train and retrain medical professionals to ensure that greater emphasis is placed on the proper execution of this universally performed and critically important diagnostic method.

CONFLICTS OF INTEREST

None.

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