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Cuff-based blood pressure measurement challenges and solutions

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REVIEW ARTICLE

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Cuff-based blood pressure measurement: challenges and solutions

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ABSTRACT

Objective: Accurate measurement of arterial blood pressure (BP) is crucial for the diagnosis, monitoring, and treatment of hypertension. This narrative review highlights the challenges associated with conventional (cuff-based) BP measurement and potential solutions. This work covers each method of cuff-based BP measurement, as well as cuffless alternatives, but is primarily focused on ambulatory BP monitoring.

Results: Manual BP measurement requires stringent training and standardized protocols which are often difficult to ensure in stressful and time-restricted clinical office blood pressure monitoring (OBPM) scenarios. Home Blood pressure monitoring (HBPM) can identify white-coat and masked hypertension but strongly depends on patient adherence to measurement techniques and procedure. The widespread use of nonvalidated automated HBPM devices raises further concerns about measurement accuracy. Ambulatory blood pressure measurement (ABPM) may be used in addition to OBPM. It is recommended to diagnose white-coat and masked hypertension as well as nocturnal BP and dipping, which are the BP values most predictive for major adverse cardiac events. Nonetheless, ABPM is limited by its non-continuous nature and susceptibility to measurement artefacts. This leads to poor overall reproducibility of ABPM results, especially regarding clinical parameters such as BP variability or dipping patterns.

Conclusions: Cuff-based BP measurement, despite some limitations, is vital for cardiovascular health assessment in clinical practice. Given the wide range of methodological limitations, the paradigm's potential for improvement is not yet fully realized. There are impactful and easily incorporated opportunities for innovation regarding the enhancement of measurement accuracy and reliability as well as the clinical interpretation of the retrieved data. There is a clear need for continued research and technological advancement to improve BP measurement as the premier tool for cardiovascular disease detection and management.

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KEYWORDS
Blood pressure monitoring; hypertension; cuff-based blood pressure measurement; accuracy of blood pressure measurement; home blood pressure monitoring; ambulatory blood pressure monitoring; office blood pressure monitoring

PLAIN LANGUAGE SUMMARY

- Accurate blood pressure measurement is crucial for diagnosing, monitoring, and treating hypertension and preventing cardiovascular diseases.
- Manual blood pressure monitoring is common but may not always be reliable due to the stress and time constraints in clinical settings. It also fails to detect white-coat and masked hypertension.
- Home blood pressure monitoring helps to identify white-coat and masked hypertension but depends on how well patients follow the measurement instructions. Many devices are not validated, raising concerns about their accuracy.
- Ambulatory blood pressure measurement may be used in addition to office blood pressure measurement because of its better reproducibility and higher predictive value. It is recommended to diagnose white-coat and masked hypertension as well as nocturnal BP and dipping. However, it and can be prone to errors, affecting the reliability of results like BP variability or night-time dipping patterns.
- Patient's posture, physical activity, and conditions like atrial fibrillation can influence BP readings.
- Automated BP devices often have limitations in detecting measurement artefacts, underscoring the need for technological improvements.
- Despite its limitations, cuff-based blood pressure measurement is essential in everyday clinical practice but has unlocked potential for improvement.

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Introduction

The measurement of arterial blood pressure (BP) has been a central part of clinical medicine since the late nineteenth century [1]. Accurate and reliable BP measurement is the fundamental tool for the correct diagnosis, monitoring of hypertension therapy, as well as for preventive cardiovascular healthcare. Variations in BP, particularly hypertension or hypotension, are strong indicators of cardiovascular disease [2,3]. Consequently, BP serves as the most important modifiable predictor of cardiovascular health and risk [4–7]. Arterial hypertension poses a substantial public health challenge with a global prevalence of around one in four adults [8–12]. Lower levels of physical activity, poorer food environments and ageing populations further add to the global challenge of controlling hypertension [13].

Non-invasive cuff BP remains the most common method used in clinical practice. This technique involves the application of an inflatable cuff around the upper arm that is connected to a measuring device. The cuff inflates to constrict the brachial artery temporarily, then deflates, allowing the measurement of systolic and diastolic BP [4,14–16]. Automatic devices predominantly rely on the oscillometric approach, which detects fluctuations in pressure inside the cuff to determine BP [4,17–20]. However, automated auscultatory monitors also exist which rely on the automated detection of Korotkoff sounds [21]. Additionally, there are now efforts to determine BP without the need for a cuff and some approaches to 'cuffless' monitoring involve recording of various physiological signals and use of pulse wave analysis, transfer functions or AI-based models [22–24].

This narrative review will delve into the different approaches to measuring BP and their clinical applications and measurement challenges. Further, we aim to suggest possible solutions to the most important pitfalls that may improve BP measurement accuracy and clinical utility. The review will focus on recent novel discoveries such as the effect of correct time in bed determination and the correction of measurement artefacts as well as body position effects, all relevant to ABPM (Figure 1).

BP measurement in the everyday practice

When measuring BP, the cuff should be placed on the upper arm with the higher recorded BP which ensures more accurate monitoring and management. This approach is based on the fact that BP can vary between both arms due to anatomical or vascular differences. Consistently using the arm with the higher reading provides a more reliable assessment of cardiovascular risk [4].

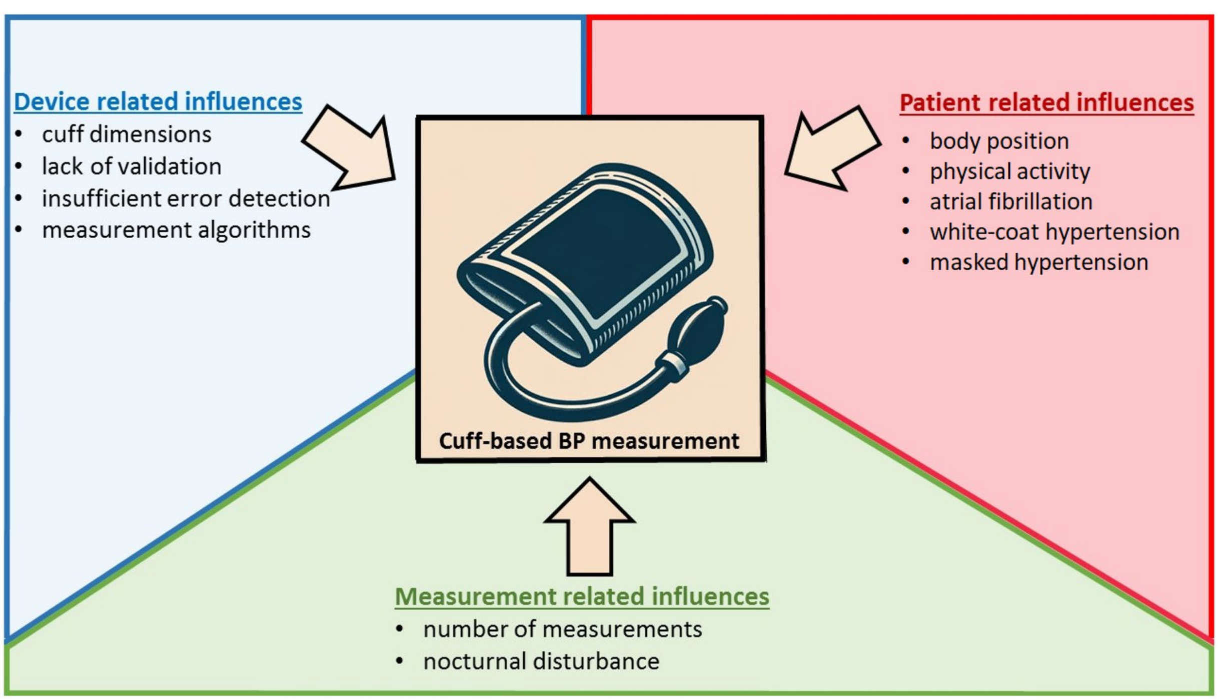

Figure 1. Influences on cuff-based BP measurement: the figure depicts the different factors that may influence the accuracy and reliability of cuff-based blood pressure measurement. BP, blood pressure.

Devices that measure BP at the wrist or finger are generally discouraged due to their susceptibility to inaccuracies caused by factors such as improper positioning and peripheral vasoconstriction [4]. However, wrist or finger measurement devices may be a promising approach under specific circumstances, such as for patients with medical conditions that prevent the use of upper arm cuffs, individuals with particularly large arm circumferences, or in situations where upper arm measurement is not practical. In these cases, it is essential to ensure that wrist and finger devices are properly calibrated and used according to manufacturer guidelines to minimise the risk of inaccurate readings [4].

Cuff-based BP measurement primarily involves three main approaches in everyday practice: Office BP Monitoring (OBPM), Home BP Monitoring (HBPM) and Ambulatory BP Monitoring (ABPM) [4].

Medical professionals usually conduct OBPM as part of routine health check-ups or during clinical visits. The setting of this approach provides the opportunity to determine BP under highly controlled conditions, which often represents the first instance of 'professional' measurement of a patient's BP. OBPM only allows a snap-shot of BP detection, and therefore is prone to inherent variability in BP, as well as potentially missing masked or white-coat hypertension [4,25,26]. Clinicians often lack the time and resources required to measure BP in accordance with guideline recommendations. Potential solutions to this issue could be the adoption of controlled, standardised measurement processes and/or the improved reimbursement for guideline-conforming BP measurement [27,28].

HBPM has gained popularity and is recommended in multiple guidelines for confirmation of high BP identified from conventional OBPM (which may be unreliable due to unstandardised measurement or white-coat/masked hypertension as mentioned above). HBPM is also useful for patients under continued hypertension treatment for intermittent monitoring to ensure efficacy of treatment. HBPM provides a more comprehensive overview of BP over a longer period of time, instead of the snapshot provided by OBPM and allows for potentially higher-quality repeated measurements for hypertension management (e.g. annually/after changes in medication) [4,29]. HBPM also encourages patient involvement in their own care, which may promote better understanding and management of their BP [30,31]. The ability to confirm diagnoses of hypertension through detection of masked and white-coat hypertension underscores the clinical importance of HBPM [4,30,31]. However, the more 'uncontrolled' scenario of the home environment can lead to unknown factors that could contribute to unreliable measurements, such as less accurate measurement execution, incomplete reporting of BP values by patients, and use of devices that may be nonvalidated [32,33]. However, patient education programs related to HBPM procedures, such as those conducted in line with the Canadian Hypertension Education Program, can improve understanding and measurement processes of patients [34]. Altogether these issues emphasise the need for standardised procedures and validation protocols for HBPM [35–37].

During ABPM measurements are performed at predetermined intervals, such as every 20 min, over a period of 24 h. This approach is instrumental in capturing the fluctuations of BP throughout the day and night, and in doing so offering a comprehensive view of a patient's BP profile [4]. Short-term spikes and drops of BP can be missed during ABPM [4]. The European Society of Hypertension (ESH) 2023 guidelines state that ABPM may be used in addition to clinic BP because of its better reproducibility and higher predictive value. Further, ABPM is recommended to assist with the diagnosis of white-coat and masked hypertension as well as nocturnal BP and dipping, which is the BP value most predictive for major adverse cardiac events [4,38]. Another frequently cited drawback of ABPM is the potential discomfort for patients, which can include sleep disturbance, pain, skin disturbances or irritation and bruising as well as disruption to daily activities [38,39]. Artefacts might occur during ABPM, as the measurement scenario is within the patient's daily life and may not be performed according to instructions (non-standardised) [40–42] (Figure 2). ABPM devices are expensive to purchase and in some clinical settings patients are required to pay or co-pay for the service. However, a recent modelling study commissioned by the Australian Government found that in the Australian context ABPM was more cost-effective than HBPM or clinic BP for diagnosis of hypertension [43]. A limitation of ABPM and other cuff methods is that short-term spikes and drops in BP can be missed. Novel technologies offering more frequent or continuous monitoring of BP have recently been developed that could address this limitation [44].

Novel methods not yet ready for clinical practice

Cuffless BP measurement has gained recognition in the scientific literature and a recent analysis by the European Society of Hypertension has shown, since

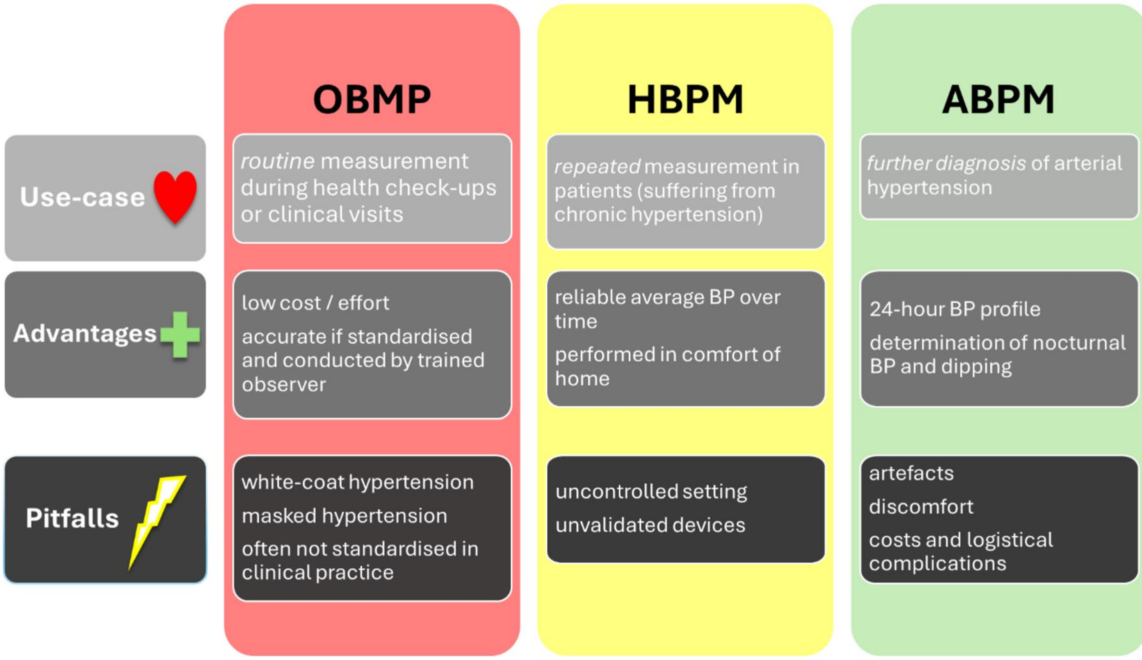

Figure 2. Different cuff-based BP measurement approaches: the three different cuff-based blood pressure measurement approaches and their use cases, advantages, and pitfalls. BP, blood pressure; OBPM, office blood pressure monitoring; HBPM, home blood pressure monitoring; ABPM, ambulatory blood pressure monitoring.

about 2015, an exponential increase in patents and publications related to this approach [45]. There are two different approaches: BP can be estimated using predictive markers such as pulse wave velocity or heart rate, with transfer functions based on physiological models [23,46–48]. Alternatively, estimation is achieved using artificial intelligence or machine learning-based systems without relying on human-made physiological models [24,49]. A combination of both approaches appears promising [22]. In this hybrid method, the most predictive parameters would first be selected and then used as input features for a machine or deep learning algorithm [22]. It is important to note that the recommendations for accuracy testing of cuff-less BP measurement devices published by the ESH have not yet, to our knowledge, been passed by any device. Thus, cuffless technologies for BP measurement are not yet recommended for use by any hypertension guidelines [4,45]. Altogether, the cuffless BP device space is a rapidly evolving and exciting field in which much further research and improvement are required before these methods are used in clinical practice.

The potential promise of cuffless BP devices for out of office BP measurement lies in the capacity to alleviate some of the patient burden related to HBPM and ABPM. Because cuffless methods do not require the inflation of a BP cuff and can be embedded in regular everyday items such as rings or watches, recordings can be made passively while people go about their daily life without discomfort. Preliminary qualitative research indicates that people who need to have BP measured are interested in the technology and in some studies it is preferred compared to HBPM and ABPM [50]. Nevertheless accuracy of cufless BP is a concern of both patient users and health professionals [51].

General influences on BP measurement

Temperature effect and seasonal changes

Studies have shown that BP varies depending on the season and temperature: BP tends to be higher in the winter months and lower in the summer months. Cold temperatures cause peripheral vasoconstriction (preserving energy) which leads to an increase in total peripheral resistance and a consequently higher BP. Conversely, warmth induces peripheral vasodilation (temperature regulation), resulting in a decrease in total peripheral resistance and therefore lower BP [52,53]. Indeed, a recent systematic review and meta-analysis of the influence of heat therapy on BP revealed reductions in systolic BP, diastolic BP and mean arterial pressure when compared with control [54]. Although the described changes in BP are independent of the cuff and measurement (measurement specific) technique, they may need to be considered

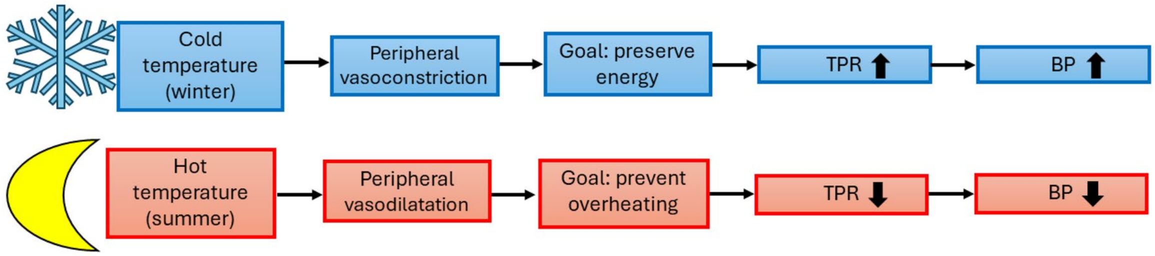

Figure 3. Influence of temperature and seasonal changes on blood pressure: This figure schematically illustrates the interaction between temperature, associated seasonal changes and blood pressure. TPR, total peripheral resistance; BP, blood pressure.

when comparing BP measurements within individual patients. Moreover, the use of out-of-office BP methods may be most useful to determine individual changes in BP across seasons (Figure 3).

Impact of device related influences on cuff-based BP measurement

Cuff dimensions

A cuff that is too small produces falsely high BP readings, as it compresses the arm excessively [55,56]. Conversely, a cuff that is too large can lead to falsely low readings, as it does not apply sufficient pressure on the arm. Additionally, the shape of the cuff is equally important; a poorly fitting cuff that does not conform adequately to the arm's contour can compromise the accuracy of the measurement [57–60]. This is especially important in patients with unusual arm geometries, such as very short or large arms [61–63]. Medical professionals and patients measuring their own BP at home should be encouraged to pay attention to cuff sizes and follow the manufacturer's recommendation in the routine of clinical work.

Nonvalidated devices

The prevalence of nonvalidated devices in the market, which is especially relevant to HBPM, poses a serious risk in accurate diagnosis and management of hypertension. These devices have no evidence of undergoing validation and may produce unreliable BP readings [64–70]. Unfortunately, nonvalidated devices are cheaper than validated devices, which may make the former more attractive to purchase for some consumers [64–66,71]. There are tools available, such as the STRIDE BP website, which allow people to identify validated devices [72].

Signal interpretation algorithms

Automated BP measurement devices primarily function using the oscillometric method. This method relies on the interpretation of oscillometric signals, which equal arterial pressure signals from within the cuff. However, each oscillometric device depends on its specific algorithms for signal interpretation. These algorithms are proprietary and operate like a 'black box', providing only final BP values, without revealing signal interpretation steps involved in the process [17,19,73,74].

Indeed, meta-analyses of individual level data have highlighted the extent of this problem by showing major differences in the BP readings from automated BP devices compared with intra-arterial BP at the brachial artery and central aorta [67]. The need for transparency in these algorithms is therefore paramount, as it directly impacts the accuracy and reliability of BP measurements obtained from automated BP devices (Figure 4).

Errors in signal detection

Errors in signal detection constitute a major source of inaccuracy in BP measurement devices. Such errors can stem from a variety of factors, including patient movement, irregular heart rhythms, or external environmental or device induced noise [40,42]. Issues like inaccurate detection of oscillometric waveforms, disturbances in pressure curves are critical factors that can lead to incorrect BP readings and are present in more than 25% of individual measurements within ABPM [40,42]. Artefact-affected measurements showed higher BP values compared to artefact-free measurements of around 5 mmHg for systolic BP. Exclusion of artefacts led to a changed hypertension classification for 10% of patients regarding the 24-hour mean values. Additionally, changes in dipping patterns were observed in approximately 23% of patients [40,42].

To enhance the accuracy of automated BP devices, it is essential to ensure that they are equipped with sophisticated algorithms capable of identifying and compensating for these errors, or, alternatively, implementing protocols to exclude or repeat measurements

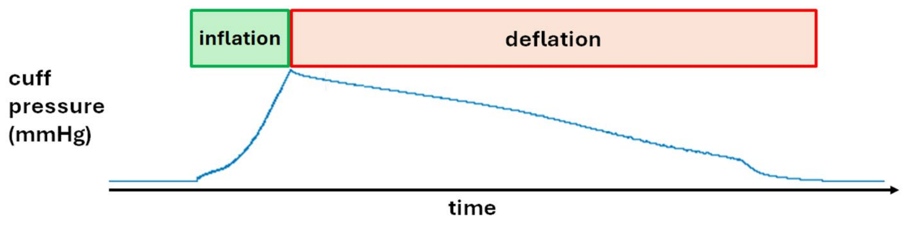

Figure 4. Cuff pressure of oscillometric BP measurement: the figure shows the pressure curve in the cuff of an oscillometric BP measurement device. Initially, there is a rapid inflation of the cuff, followed by a slower deflation process. The specific algorithm used to derive actual BP values from this signal is not transparent and operates like a 'black box'.

Table 1. Device related influence factors: overview over the main device related influences on BP measurement highlighting their specific effect and possible solutions.

Influence factor	Effect	Possible solution
Cuff dimensions	• Too small leads to false high BP • Too big results in false low BP	• Follow the manufacturer's recommendations for cuff selection • Manufacturer should build easily adjustable/conical cuffs
Nonvalidated devices	• Inaccurate BP measurement (more likely)	• Usage of validated devices only • Use of available tools to find validated devices
Error in signal detection	• Inaccurate BP measurement	• Identify errors • Compensate for errors/repeat or exclude measurement

BP, blood pressure.

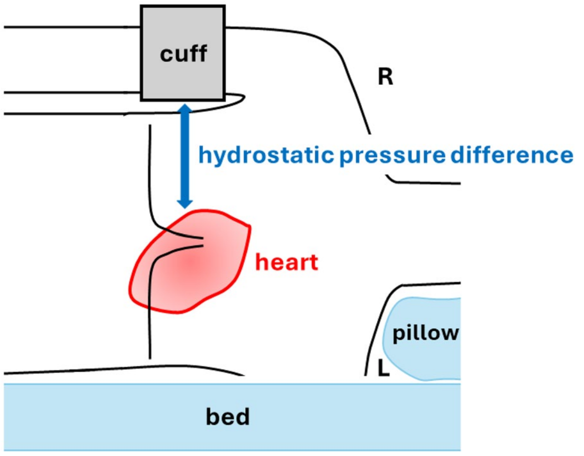

Figure 5. Hydrostatic pressure difference between cuff and heart level: the figure shows a schematic illustration of the hydrostatic pressure difference between heart level and the cuff for a patient wearing the cuff on the right arm while lying on the left side. Particularly during nocturnal measurements of 24-h ABPM, the hydrostatic pressure difference resulting from a changed body position is a relevant source of error. R, right; L, left.

that are affected by errors. Open source and effective approaches to improve overall measurement accuracy by detecting unambiguous measurement artefacts have been published [40,42] (Table 1).

Impact of patient related influences on the accuracy of cuff-based BP measurement

Body position

Measurements of BP vary according to body position. Whether a patient is sitting, standing, or lying down leads to markedly different BP values [55]. The influence of changing body positions is particularly important for ABPM. If the cuff is not at heart level during measurement, hydrostatic differences can occur. This is especially true when laying on the side. For example, when lying on the right side with the cuff on the right arm, blood pressure readings can be approximately 20 mmHg falsely low because the cuff is higher than the heart. This could result in inaccurate classification nocturnal hypertension and dipping status. Further research is necessary to quantify the influence of body position on nocturnal BP [75,76] (Figure 5).

Therefore, adhering to standardised body position protocols are crucial for ensuring consistent and reliable cuff-based BP measurements.

Artefacts due to movement and physical activity

Movement of the entire body or even just the arm can result in artefacts that may lead to incorrect BP readings. Thus, it is recommended for patients remain still during HBPM (and in-clinic BP) [42,77], and to remain still during inflation and deflation of the cuff when undertaking ABPM. Neglecting this can lead to falsely elevated readings, potentially leading to an erroneous diagnosis of hypertension. For example, 23% of participants in a recent ABPM study crossed the hypertension threshold of 24-hour, daytime or night-time BP because of artefact identified in the oscillometric cuff pressure curves [40]. In this study approximately 16% of all daytime measures and 5% of night-time showing evidence of motion artefact. Even though patients are instructed to remain still at the time of BP

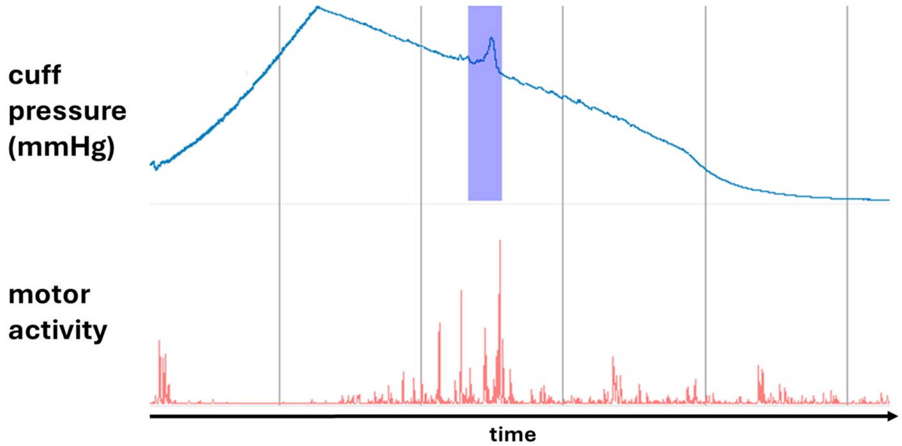

Figure 6. Influence of motoric activity on cuff pressure: the figure shows how cuff pressure changes in response to physical activity. The upper row represents cuff pressure, while the lower row shows activity as determined by an accelerometer. A spike in cuff pressure is marked in blue. Despite the influence of physical activity on the cuff pressure curve during measurement, the device did not flag this measurement. The vertical grey lines indicate intervals of 10 s.

Table 2. Patient-related influence factors: the specific effect and possible solutions of the specific patient-related factors are presented.

Influence factor	Effect	Possible solution
Body position changes	• Increased variability in BP values due to body position changes that can lead to misclassification of BP	• Detecting the patient's body position and correcting for hydrostatic pressure difference between cuff and heart level • Adhering to standardised positioning (e.g. seated position) • No change of body position during measurement in ABPM
Physical activity	• Increase of BP	• Substantial rest period before measurement • No activity during measurement in ABPM
Atrial fibrillation	• Inaccurate BP measurement	• Perform multiple readings • Usage of sphygmomanometer or automated devices specifically validated for atrial fibrillation

BP, blood pressure; ABPM, ambulatory blood pressure monitoring; OBPM, office blood pressure monitoring.

measurement during ABPM, not all movements affecting measurement accuracy can be prevented. Therefore, current research recommends considering excluding measurements affected by physical activity or body movement from further analysis [42] (Figure 6).

Atrial fibrillation

The hallmark of atrial fibrillation is an irregular and often rapid heart rhythm, which can lead to

Table 3. Measurement related influence factors: Influence factors directly related to the measurement procedure.

Influence factor	Effect	Possible solution
Low number of measurements	• Miss short-term fluctuation • Over- or underestimation of BP if they are measured coincidentally	• Change to ABPM • Usage of alternative, continuous BP measurement approaches

BP, blood pressure; OSAS, obstructive sleep apnoea syndrome.

considerable fluctuations in BP readings. The fluctuations in BP stem from inconsistent ventricular filling and varying stroke volumes associated with each heartbeat. Consequently, obtaining a stable and reliable BP measurement in patients with atrial fibrillation can be challenging. Automated oscillometric BP measurement devices may struggle to accurately interpret the varied pulse rates and pulse amplitudes, leading to inconsistent readings [42,78–80]. Oscillometric BP measurements tend to be more reliable for SBP than for DBP [80]. Therefore, it may be necessary to perform multiple measurements to obtain a more reliable average reading. Additionally, manual auscultation, despite its challenges, might offer more reliable results in the presence of atrial fibrillation, as it allows the practitioner to account for the irregular rhythm [81,82]. However, because most out-of-office BP devices use oscillometric principles, there is a clear need for ongoing research focused on developing and validating BP measurement techniques and standardised protocols that are specifically designed for patients with atrial fibrillation.

Nocturnal BP and dipping

Physiological dipping is characterised by a reduction of 10 to 20% in night-time BP mean values compared to daytime BP mean values. Large outcome studies have shown that nocturnal dipping is a predictive marker for cardiovascular risk [83–86]. However, a challenge with current cuff-based ABPM is that individual measurements may fluctuate due to a variety of factors, including measurement errors, daily variations in activity and stress, and inconsistencies in measurement conditions. As a result, the same patient may be classified in one measurement as dipper and as non-dipper across a different assessments, posing challenges in establishing a 'definitive' nocturnal BP profile [40]. Further, nocturnal BP profiles cannot be predicted based on OBPM and there are only few HBPM devices that can be programmed to measure BP throughout the night, meaning the primary method to detect nocturnal BP is ABPM [87–89].

Another important consideration is how night-time is defined when calculating the nocturnal BP. A common clinical practice has been to use a fixed narrow interval for night-time (e.g. between 10 pm and 6 am), but this clearly may not accurately reflect individual sleep times and could lead to incorrect interpretations of nocturnal BP and dipping patterns [90,91]. A recent study shows that the dipping pattern of 27% of patients was different when comparing individual time in bed to fixed intervals between 10 pm and 6 am Mean nocturnal BP levels were lower during time in bed (2 mmHg for systolic and 1 mmHg for diastolic BP). Since this was only a pilot study, the effect sizes need to be further investigated [92].

Different sleeping postures can also lead to variation in the measured cuff ABPM, influenced by the hydrostatic effect resulting from changes in the heart's position relative to the cuff. Additionally, postural changes alter venous return to the heart, affecting both cardiac output and BP [40,93,94]. However, ensuring such consistency is challenging, as control and detection of sleeping postures is limited [95–97]. Most importantly, sleep pathologies can greatly increase nocturnal BP and are themselves highly relevant cardiovascular risk factors [98,99]. Subsequently, detection of elevated nocturnal BP is not only important for isolated risk prediction but can further serve as tool to identify patients with important underlying health conditions. Primarily, obstructive sleep apnoea syndrome gravely increases nocturnal BP with common increases of around 30–50 mmHg in mean arterial pressure during apnoeic episodes [100,101]. Beyond that, obstructive sleep apnoea syndrome represents a crucial target for treatment, both regarding risk reduction and quality of life improvement for often greatly suffering patients [95–97] (Table 2).

Measurement procedure induced influences on BP measurement accuracy

Number of measurements

Cuff-based BP measurement approaches are characterised by their periodic assessments. OBPM, for instance, may not accurately represent a patient's usual BP due to the potential for white-coat or masked hypertension, psychological effects that alter readings in a clinical setting [91,102]. Further, BP changes month-to-month, week-to-week, day-to-day, hour-to-hour and even heartbeat-to-heartbeat, such that OBPM is essentially a 'snapshot' in time [2,103].

ABPM, although providing a more in-depth view of BP fluctuations over a 24-hour period, is not without its limitations: ABPM does not measure BP continuously on a beat-to-beat basis. Instead, it records readings at predetermined intervals. This methodology may overlook transient spikes or drops in BP that occur between measurements, potentially leading to an over- or underestimation of BP levels [103,104]. Intermittent measurements that provide an average BP across 7-days (HBPM) or 24-hours (ABPM) may be sufficient for appropriate hypertension management [103,104] (Table 3).

Accuracy and reproducibility of cuff-based BP

Validation of automated devices

The process of determining accuracy of an automated cuff-based BP measurement device requires investigators to follow an internationally accepted validation study protocol [105]. The current global standard is the ISO 81060-2 protocol, also known as the 'universal standard'. The validation process involves comparing readings from the device being tested with those obtained from a manual BP reference, measured by two blinded observers and overseen by a third observer. Participants of diverse demographics are recruited with the aim to ensure the device's accuracy across all ranges of age, arm sizes, and different BP levels. Conducted in a laboratory environment, these validation scenarios are characterised by quiet, temperature-controlled rooms and the seated positioning of patients, with the aim to replicate ideal conditions as closely as possible [4,105–107]. However, for ABPM there is an additional criterion in which the same accuracy criteria (mean difference $\leq 5 \pm 8$ mmHg) must be met during dynamic exercise (e.g. bike ergometer) with a required mean heart rate increase of 15%. The dynamic exercise test is conducted in laboratory settings and is limited in evaluating measurement accuracy in real world circumstances [42]. Most validation studies are conducted among general populations, however, there are special populations designated in the ISO 81060-2 protocol (e.g. children, pregnant women) among whom automated devices should be specially tested and validated before use.

Reproducibility of measurement in individual patients

The reproducibility of cuff-based BP is superior in population-level studies compared to individual patient assessments. This discrepancy is particularly evident in the assessment of nocturnal BP patterns, such as dipping pattern [108–110]. Beyond that, reproducibility is also limited regarding spot and mean BP level, mostly used for treatment decision making and control [111–113]. More specifically, short-term (within one month) reproducibility of ABMP results (both mean BP and dipping) is very limited for individual patients [114]. The reproducibility of HBPM is generally better compared to HBPM (likely due to more homogenous measurement conditions, e.g. always awake and seated vs. 24-hour measurement) but still limited on the individual patient levels [115]. While good reproducibility on population levels are important for medical studies, doctors need to make treatment decisions based on individual patients' data. Low reproducibility (= low measurement certainty) for individual patients therefore equals limited diagnostic certainty and consequently high chances of suboptimal BP treatment.

Clinical importance of cuff-based BP measurement and its unlocked potential

Cuff-based BP measurement according to guideline recommended protocols remains the current cornerstone in the assessment and management of cardiovascular risk and treatment. Despite advances in medical technology and the emergence of various diagnostic tools, the evaluation of BP is unparalleled in its clinical importance. Detecting and interpreting high BP is crucial for identifying individuals at risk of cardiovascular diseases, guiding therapeutic decisions, and monitoring the effectiveness of interventions [4,116,117].

This fundamental clinical tool, through its various approaches, offers a comprehensive assessment of a patient's cardiovascular health and in devising personalised treatment strategies. Each measurement approach contributes to the overall clinical assessment, providing invaluable insights into the patient's BP and its implications for cardiovascular risk and management.

Summary and conclusion

Both manual and automated cuff BP measurement devices present unique challenges and benefits in clinical practice.

The variability inherent to manual BP measurements highlights the necessity for standardised protocols and highly skilled observers. The increasing availability of nonvalidated automated devices raises concerns about the accuracy of HBPM. There is an imperative for comprehensive training of both healthcare professionals and patients in the correct handling and critical evaluation of these measurement devices. The reliability of BP measurement is also challenged by the limitations of error detection software in automated devices, leading to potential misdiagnoses. Patient-related influences add layers of complexity to obtaining accurate BP assessments. Moreover, while ABPM offers a more comprehensive view of a patient's BP profile, it still represents a snapshot approach. It captures BP readings at predetermined intervals rather than providing continuous, beat-to-beat monitoring. Despite these challenges, cuff-based BP measurement remains the most important tool for assessing cardiovascular risk making it a cornerstone in the diagnosis and management of hypertension.

Continued innovation and research in this field are essential to fully harness this potential fully, with the aim of improving the detection and management of cardiovascular diseases and ultimately enhance patient outcomes.

Disclosure statement

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MEMBER INFO

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I hereby declare that the completion of this document is my own effort without any assistance.

SIGNED: DATE:

Assignment for the theme: Research
E7(26) Cuff-based blood pressure measurement challenges and solutions

INSTRUCTIONS

- Read the article.
- Discuss the challenges of cuff-based blood pressure measurement in different patients and explain possible nursing solutions to improve accuracy.
- Compare the challenges encountered when performing cuff-based blood pressure measurements on two patients with different clinical characteristics and describe appropriate nursing interventions to ensure accurate readings.

Patient survey questions

1.____

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2.____

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3.____

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Feedback Patient 1

1.____

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2.____

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3.____

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Feedback Patient 2

1.____

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2.____

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3.____

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Summary of my findings and how they relate to this article:

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RETURN ANSWER SHEET TO

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