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REVIEW

European Society of Hypertension Practice Guidelines for home blood pressure monitoring

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Self-monitoring of blood pressure by patients at home (home blood pressure monitoring (HBPM)) is being increasingly used in many countries and is well accepted by hypertensive patients. Current hypertension guidelines have endorsed the use of HBPM in clinical practice as a useful adjunct to conventional office measurements. Recently, a detailed consensus document on HBPM was published by the European Society of Hypertension Working Group on Blood Pressure Monitoring. However, in daily practice, briefer documents summarizing the essential recommendations are needed. It is also accepted that the successful implementation of clinical guidelines in routine patient care is dependent on their acceptance by involvement of practising physicians. The present document, which provides concise and updated guidelines on the use of HBPM for practising physicians, was therefore prepared by including the comments and feedback of general practitioners.
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Self-monitoring of blood pressure by patients at home (home blood pressure monitoring (HBPM)) is being increasingly used in many countries and is well accepted by hypertensive patients.[1–7] Current hypertension guidelines have endorsed the use of HBPM in clinical practice as a useful adjunct to

the conventional office measurements.[1–7] In 2008 a detailed consensus document on HBPM was published by the European Society of Hypertension Working Group on Blood Pressure Monitoring.[1] However, in daily practice, briefer documents summarizing the essential recommendations are needed. It is also accepted that the successful implementation of clinical guidelines in routine patient care is dependent on their acceptance by involvement of practising physicians. Therefore, this practice guidelines document on HBPM use was prepared by including the comments and feedbacks of two groups of general practitioners (see Acknowledgements).

HBPM: advantages—prerequisites

HBPM has several major advantages over conventional office blood pressure (BP) measurement: (1) it provides multiple measurements of BP in different days, weeks or months; (2) these measurements are made in the usual environment of each individual, away from the physician's office, a setting known to cause a BP increase in many subjects (white-coat effect); (3) home BP is more closely related to hypertension-induced target organ damage and predicts the risk of cardiovascular events better than conventional office measurements (Boxes 1 and 2). HBPM can detect the white-coat and masked hypertension phenomena, and it shares most of the above features with 24-h ambulatory BP monitoring (ABPM), another important technique for out-of-office BP monitoring (Box 1).[1–4] Compared with ABPM, HBPM provides measurements over a much longer period, is cheaper, more widely available, more convenient for patients particularly for repeated measurements, and has been shown to improve patients' compliance with treatment and hypertension control rates.[1–4,8] However, unlike ABPM it does not allow the assessment of BP during sleep or at work, or the quantification of short-term BP variability, although it may be possible to assess day by day BP variability,[9,10] thus offering a means to quantify long-term BP variations which, as recently suggested, may have prognostic significance.[11] Moreover, HBPM can be used as an educational tool in hypertensive patients for improving the understanding of their disease and its follow-up. Thus, it seems to be an appropriate method for the long-term follow-up of treated hypertension and is often used in conjunction with ABPM as a complementary method of BP assessment (Box 1).

There are important prerequisites for the optimal application of HBPM in clinical practice (Box 2). HBPM should be performed by patients who have been trained under medical supervision, and trained nurses and/or pharmacists can have an important part in the implementation of HBPM in daily practice and in the diffusion of correct recommendations.

Box 2 Key issues related to the methodology of HBPM

Medical supervision and patient training (see online Supplementary Material).
Appropriate choice of validated HBPM devices. Specific validation required in special populations (elderly, children, normal pregnancy, pre-eclampsia, end-stage renal disease and arrhythmias).
Adequate blood pressure measurements schedule and data reporting by patient.
Ability of physician to interpret the results correctly (averaging of values and normal thresholds).

Abbreviation: HBPM, home blood pressure monitoring.

Box 1 Summary of advantages and limitations of HBPM (modified with permission from Parati *et al.*[1])

Advantages	*Limitations*
A number of measurements of blood pressure and heart rate during the day and also over several days, weeks or months are possible.	Need of patient training (simple for automated devices).
Assessment of treatment effects at different times of the day and over extended periods.	Possible use of inaccurate devices.
No alarm (white-coat) reaction to blood pressure measurement.	Measurement errors.
Diagnosis of white-coat and masked hypertension.	Questionable reliability of blood pressure values reported by patients.
Good reproducibility.	Induction of anxiety, resulting in excessive monitoring.
Good prognostic value.	Risk of treatment changes made by patients on the basis of casual home measurements without doctor's guidance.
Relatively low cost.	Normality thresholds and therapeutic targets still debated, mainly in patients at high cardiovascular risk.
Patient-acceptance.	Lack of night-time recordings.
Education tool—involvement of patients in hypertension management.	Absence of reimbursement by insurance company or social security in most countries.
Possibility of digital storage, printout, PC download or teletransmission of blood pressure values (some devices).	
Improvement of patients' compliance to drug treatment.	
Improvement of hypertension control rates.	

Abbreviation: HBPM, home blood pressure monitoring.

Training should include information regarding hypertension, BP variability, conditions and procedure for self-monitoring, advice on equipment choice (based on validation, technical features, price and individual experience) and its proper use, and interpretation of results (see Supplementary material). The HBPM technique, when applied using electronic devices, is not particularly complex and can be explained to the patient during a single training session (possibly with subsequent periodic verification of correct monitoring performance during office visits). However, in some patients (in particular the elderly with motor or cognitive impairment and in young children), the support of a trained nurse or family member may be needed. Telephonic assistance for patients having doubts or problems with correct HBPM performance may prove to be useful. A standardized BP logbook structured according to the required monitoring schedule is useful for ensuring the accuracy of data reporting and for improving adherence to measurements schedule (see Supplementary material). Manufacturers can facilitate HBPM by providing devices with a range of cuffs for varying arm sizes and capable of automatically calculating average BP. The provision of telemonitoring facilities may be of further advantage.[12]

Devices and cuffs

The conventional mercury sphygmomanometer, regarded as the gold standard for BP measurement, is being progressively banned in several countries for environmental reasons (Box 3). Aneroid devices are more prone to inaccuracy than mercury devices.[1,2,4] Moreover, patients only rarely master the auscultatory technique required for using these devices. Therefore, except for special cases (for example, patients with arrhythmias trained in auscultatory BP measurement) the use of auscultatory devices (mercury, aneroid or other) is not recommended for HBPM.

Semi-automated (manual cuff inflation) or automated electronic devices that measure BP at the level of the upper arm are preferred for HBPM.[1–5] These devices require less training, avoid observer bias, and, if equipped with an automated memory, have the potential to prevent patients from misreporting their BP measurements.[13,14]

Finger devices are less accurate and more susceptible to flaws in measurement technique and are not recommended. Wrist devices are not recommended, because they are more subject to inaccuracies (incorrect position in relation to the heart, measurement of BP in two arteries—radial and ulnar, peripheral pulse wave distortion, and so on), and are best avoided, unless brachial measurements are difficult or impossible to obtain (for example, in subjects with very large arm circumference or extreme obesity).[1,2,4]

Box 3 Devices for HBPM

Only validated semi-automated or automated oscillometric (electronic) arm cuff devices are recommended.
Devices with memory are preferred.
Auscultatory (aneroid or mercury) devices are not recommended except under specific circumstances (for example, arrhythmia, requiring repeated auscultatory measurements).
Finger cuff devices not recommended.
Wrist cuff devices are not recommended at present, yet possible applications are still under investigation, as in the case of patients in whom brachial BP measurements are impossible or very difficult (for example, extreme obesity).
Appropriately sized (small, standard or large) cuffs should be used according to arm circumference.

Abbreviation: HBPM, home blood pressure monitoring.

Among the large number of HBPM devices available on the market only those that have been validated for accuracy in independent studies performed according to internationally recognized protocols should be used.[15,16] Up to date lists of validated devices are available at the dedicated websites (for example, www.dableducational.org, www.bhsoc.org and www.pressionearteriosa.net). It should not be assumed that a device that has been validated in the general population will be accurate in special circumstances, such as obesity, patients with arrhythmias, older age, children or pregnancy in which devices should be specifically validated.

The selection of the appropriate size of the cuff to fit the arm of each individual is essential for an accurate BP measurement (the inflatable bladder of the cuff should cover 80–100% of the individual's arm circumference).[1,2,4] The use of a small cuff for the size of the arm can result in overestimation of BP, whereas a too large one in its underestimation. Although standard cuffs are appropriate for most patients, in those with small (<24 cm) or large (>32 cm) arm circumference only the devices equipped with appropriate sized cuffs should be used.

Conditions of measurement

Conditions under which HBPM is performed can greatly affect the measured BP levels (Box 4). The cuff should be wrapped around the arm with its inflatable bladder centred on the arm anterior surface (most cuffs have an indication of proper placement) with the lower edge of the cuff approximately 2–3 cm above the bend of the elbow. The bladder should be positioned at the heart level (particular attention must be paid to this recommendation if, for any reason, a wrist device is used). The measurement should be performed in a quiet room and the patient should remain seated comfortably, immobile with the arm resting on a table or other support and should not talk. The results should be reported in a logbook immediately after each measurement. Alternatively, memory equipped

Box 4 Conditions of measurement

At least 5-min rest, 30 min without smoking, meal, caffeine intake or physical exercise.
Seated position in a quiet room, back supported, arm supported (for example, resting on the table).
Subject immobile, legs uncrossed, not talking and relaxed.
Correct cuff bladder placement at heart level.
Results immediately reported in a specific logbook or stored in device memory.

devices, which are recommended, can store the readings with time and date for each measurement. Sometimes devices are used to measure BP in other family members and it is important to ensure that these are not included with a patient measurement. In rare cases of significant (>10 mm Hg) and consistent BP difference between arms, the physician should advise the patient to use the arm with higher BP values also for HBPM.

Monitoring schedule

For the initial evaluation of hypertension and the assessment of the effects of antihypertensive treatment (including changes in drug or dose) HBPM should be performed daily during at least 3 and preferably 7 days before the doctor's visit (Box 5). Duplicate measurements should be obtained in the morning (before drug intake if treated) and in the evening.[17] Measurements of the first monitoring day are usually higher and unstable and are excluded. Treated hypertensive patients may also perform less frequent, regular home BP measurements as a long-term follow-up (for example, once or twice per week), with the additional aim to reinforce their compliance with treatment. However, this issue is still matter of debate and isolated readings should never be used for diagnostic purposes.[1–4] Overuse of the method and self-modification of treatment on the basis of HBPM should be avoided.

Interpretation of HBPM

The average of a series of measurements taken as described above should be used for the clinical decisions based on HBPM readings (Box 6). Casual, isolated home measurements can be very misleading and should not by themselves constitute the basis for clinical decisions. The users should be informed that BP may vary between measurements and be instructed not to be alarmed by high or low BP measured on a single occasion, unless an important elevation or reduction persists or is associated with symptoms of clinical relevance (for example, dyspnoea, chest pain). Average systolic home BP $\geqslant 135$ mm Hg and/or diastolic $\geqslant 85$ mm Hg indicates elevated BP. The levels of 'normal' and 'optimal' home BP are still under investigation, provisionally suggested values being $<130/80$ mm Hg for normal home BP.[1–4,18] Therapeutic decisions based on home

Box 5 Monitoring schedule

Seven-day home measurements (minimum 3 days).
At initial assessment, when assessing treatment effects, and in the long-term follow-up before each clinic/office visit.
Morning (before drug intake if treated) and evening (before eating) readings per day.
Two measurements per occasion (1–2 min apart).
Long-term follow-up: less frequent measurements (for example, once or twice per week) could be regularly performed aimed at reinforcing compliance, although isolated readings should never be used for diagnostic purposes.
Overuse of the method and self-modification of treatment should be avoided.

Box 6 Interpretation of home BP readings

Average BP from several monitoring days should be considered (for schedule see Box 5).
BP values measured on the first monitoring day should be discarded.
Mean home systolic BP $\geqslant 135$ mm Hg and/or diastolic BP $\geqslant 85$ mm Hg should be considered as elevated.
Systolic and diastolic home BP <130 and <80 mm Hg, respectively, should be considered normal in most subjects.
In high-risk subjects home BP targets should probably be lower.

Abbreviation: blood pressure.

monitored BP should always take into consideration overall cardiovascular risk profile and comorbidities. In high-risk subjects (for example, those with diabetes or chronic kidney disease) lower home BP values should probably be achieved but the targets have not yet been defined.

Discrepancies between home and office BP

In the majority of patients, HBPM will lead to the same clinical conclusion regarding the diagnosis of hypertension as the conventional office measurements (normotension or controlled hypertension if both are normal; uncontrolled hypertension if both are elevated). However, cases of disagreement in diagnosis between office and home (or ambulatory) BP measurements are not uncommon in both untreated and treated subjects. Elevated BP in the office with low home (or ambulatory) BP is known as 'white-coat' (or 'isolated office') hypertension. Conversely, normal BP in the office with elevated home (or ambulatory) BP has been termed masked hypertension.[1–4,19–21] These diagnostic conclusions should be reinforced by performing further investigations including repeated office BP measurements and either a repeated session of HBPM or a 24-h ABPM.[4,19,22]

Subjects with white-coat hypertension are at a marginally increased cardiovascular risk and also at an increased risk to develop sustained hypertension.[4,22] Therefore, they should be regularly followed using office and home BP measurements. On the other hand masked hypertension is associated with increased risk of cardiovascular events, similar

to that of uncontrolled hypertension.[23] Given this between-method discrepancy, treatment decisions in white-coat and masked hypertension should probably be made on the basis of both office and out-of-office BP measurements (the latter through ABPM or HBPM, provided that they are reliable and have been repeatedly performed), always taking into account the patient's total cardiovascular risk profile.[1,2,4]

Clinical indications for HBPM

Given the fallibility of conventional office BP measurements, HBPM provides clinically useful information on BP level and profile to practising doctors, because it enables a more precise initial diagnosis of hypertension and more accurate titration of antihypertensive drug treatment (Box 7). It also offers useful information on home heart rate[24] and on day-by-day BP variability.[9,10] Therefore, if feasible, it should be used in all treated hypertensive patients. Its use is also recommended for the identification of patients with suspected white-coat or masked hypertension, (particularly among subjects with borderline or highly variable office BP, high cardiovascular risk and normal office BP, hypotension symptoms in spite of inadequate office BP control by treatment, no signs of organ damage in spite of the high office BP).[23,25,26] HBPM is further recommended in patients with poor compliance with treatment (HBPM may increase their involvement in hypertension management), and possibly also in some high-risk populations in whom close BP control is mandatory (pregnant women, renal and diabetic patients). In pregnancy, HBPM should be performed with devices validated in this condition and available evidence suggests that the diagnostic thresholds should be the same as in the general population, although more studies are needed on this issue.

A contraindication for HBPM performed with oscillometric devices is the presence of relevant arrhythmias (atrial fibrillation, numerous extrasystoles and important bradycardia) in which these devices can be unreliable. However, recent evidence suggests that in subjects with atrial fibrillation some oscillometric devices may not be always inaccurate—an issue that deserves further investigation.[27] In these circumstances, HBPM may be performed using auscultatory devices provided that the patient has been properly trained, an approach, however, which would require further investigation.

Box 7 Indications for HBPM

All patients receiving antihypertensive medication.
To evaluate white-coat hypertension and false uncontrolled hypertension.
To evaluate masked hypertension.
To evaluate resistant hypertension.
To improve compliance with long term treatment.
To improve hypertension control rates.
Conditions where strict blood pressure control is mandatory (high-risk patients and pregnancy).

Abbreviation: HBPM, home blood pressure monitoring.

Conclusion

HBPM is a valuable tool in the daily management of hypertension. However, it should be always used under medical supervision and taking into account the patients' overall clinical conditions and cardiovascular risk profile.[5,6]

Conflict of interest

Gianfranco Parati is on the speaker's bureau of Omron Health Care, Microlife and Bayer Healthcare. George S Stergiou has received research support from Microlife and UEBE Medical; and is a consultant for Microlife. Roland Asmar has received research support from Novartis, Boehringer Ingelheim and Omron and is a consultant for Novartis, Takeda and Bayer. He is on the speaker's bureau of Astra Zeneca, Bayer, Boehringer Ingelheim, Novartis, Sanofi and Recordati. Grzegorz Bilo is on the speaker's bureau of Recordati, Docleader; and is a Consultant for Boehringer-Ingelheim and Daiichi Sankyo. Yutaka Imai has received research support from Takeda, Pfizer, AstraZeneca, Kyowa, Sankyo, Asteras and Novartis; and is on the speaker's bureau of Takeda, Bayer, Pfizer, AstraZeneca, Kyowa, Sankyo, Asteras and Novartis. Kazuomi Kario is on the speaker's bureau of Sankyo, Takeda, Pfizer and Boehringer Ingelheim. Athanasios Manolis has received research support from Glaxo and Sanofi; and is on the speaker's bureau of Menarini and Recordati. Thomas Mengden is on the speaker's bureau of Bayer, Boehringer Ingelheim, Customed, Fukuda Denshi, Merckle Recordati, Microlife, Servier, Takeda and UCB/Schwarz Pharma Germ. Eoin O'Brien has received research support from Omron Healthcare. Takayoshi Ohkubo has received research support from Omron Healthcare and Microlife. Paul Padfield has received research support from Microlife and is on the speaker's bureau of Microlife. Miriam Revera is on the speaker's bureau of Docleader. Luis M Ruilope has received research support from Bayer, Novartis, Pfizer; and is a consultant for Daiichi Sankyo, Merck and Co, D, Novartis, Menarini, Bayer, Pfizer, Sanofi Aventis, GSK, Recordati and Servier. He is on the speaker's bureau of Daiichi Sankyo, Merck and Co, D, Novartis, Menarini, Bayer, Pfizer, Sanofi Aventis, GSK, Recordati and Servier. Andrew Shennan has received research support from Omron, Microlife, GE Medical, Johnson and Johnson, Health and Life, Rossmax, SpaceLabs, Welch Allyn, Hartmanns and Nessei; and is on the speaker's bureau of Microlife, Omron, Hartmanns. Alberto Zanchetti has been reimbursed by Menarini International, Recordati, Servier for attending symposia, and has received speaking fees by Menarini

International, Recordati and Abbott. The remaining authors declare no conflict of interest.

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