ORIGINAL ARTICLE

Home Blood Pressure Monitoring: A Few minutes of Rest Before Measurement May Not Be Appropriate

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BACKGROUND

Home blood pressure measurement (HBPM) is recommended for the diagnosis and follow-up of hypertensive patients. While measurement protocols emphasize a rest period before taking the measurement, this directive has not been supported by any specific study to date. This analysis aimed to determine whether the respect or non-respect of rest before HBPM could introduce a difference between daytime ambulatory blood pressure measurement (ABPM) and HBPM; whether this rest is observed “in real life” among educated hypertensive patients.

METHODS

In this open, prospective study we compared HBPM, with and without rest, and ABPM among 52 office/clinically controlled hypertensive patients. HBPM was performed during 3 days (French HAS instructions); 24-hour ABPM was performed within 3 days of HBPM. All patients who regularly performed HBPM before the study were asked how they practiced HBPM in real life.

RESULTS

There was a differential impact of rest on differences observed in daytime ABPM and HBPM. Systolic HBPM decreased with rest, while diastolic HBPM did not significantly increase. HBPM systolic BP (SBP) without rest was not significantly different from daytime ABPM SBP (P = 0.27). HBPM SBP without rest was lower than daytime and 24-hour systolic ABPM. Diastolic HBPM after rest was not significantly different from daytime diastolic ABPM (P = 0.09). None of the 38 patients who regularly performed HBPM were compliant with a period of rest before beginning the measurements.

CONCLUSIONS

Rest before HBPM induces a bias that underestimates SBP vs. daytime ABPM and perhaps complicates patient adherence to HBPM protocols.

Keywords: blood pressure; home blood pressure measurement; hypertension; hypertension measurement.

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INTRODUCTION

Twenty-four-hour ambulatory blood pressure measurement (ABPM) is useful at the time of hypertension diagnosis and at varying intervals during treatment.1 However, long-term ABPM would be constraining and not of real value. Hence, such measurements are not usually performed, whereas home blood pressure measurement (HBPM) can be helpful. HBPM is thus recommended by the European Society of Hypertension (ESH),2 the Comité Français de Lutte contre l’Hypertension Artérielle (CFLHTA), and the Société Française d’Hypertension Artérielle3 for the diagnosis and follow-up of hypertensive patients. While their respective measurement protocols are slightly different (2 morning and evening measurements for 3 to 7 days for the ESH and 3 morning and evening measurements for 3 days for the Haute Autorité de Santé (HAS)), both emphasize the need for preliminary patient education prior to initiating HBPM and a period of rest before starting the measurement. The second international consensus on home blood pressure monitoring (ESH) requires “at least 5 min of rest”,4,5 while the CFLHTA and HAS stipulate “a few minutes of rest”6 preceding measurement. However, the directive whereby 5 minutes or a few minutes rest should precede the measurement has not been supported by any specific study to date. Indeed, the 2007 ESH consensus conference referenced Sala et al.6 whose study was based on clinical measurement but not HBPM.

Certain studies have compared home and ABP monitoring.7–10 ABPM appears to be more sensitive than HBPM in diagnosing hypertension, white coat hypertension, and masked hypertension. However, Stergiou et al.11 estimated that HBPM is sufficient and effective when ABPM is unavailable and HBPM and ABPM are measured with the same device.12 The reference values for HBPM, established from the metaanalysis of Forette et al. in 1998,13 were based on clinical protocolized studies, although it is not known if patients complied with a 5-minute rest period during HBPM. The same BP levels are used to define hypertension (in untreated patients) or uncontrolled hypertension (in treated patients), as diagnosed by HBPM or daytime ABPM, and to manage hypertensive patient treatment. However, Ishikawa et al. observed that daytime and nighttime systolic
BPs (SBPs) measured by ABPM were 15% and 30%, respectively, less than the mean SBP assessed by HBPM.14

In light of the above, we endeavored to determine whether this rest is observed “in real life” among educated hypertensive patients who regularly performed HBPM over many years, whether resting or not resting before HBPM could explain the above differences, and whether the number of BP readings (i.e., 1, 2, 3) influences the differences between both methods in addition to rest.

MATERIALS AND METHODS

An open prospective study was performed between July 2009 and December 2009 among 52 hypertensive-controlled patients who were followed in primary care. All patients received oral and written information and gave oral consent to participate. Our local ethics committee approved this standard care study, defined by French legislation.

Patients

Inclusion criteria included treated and noncomplicated (without target organ damage) hypertensive outpatients, aged 40–85 years, followed for more than 1 year, previously educated for HBPM, with stable antihypertensive treatment for more than 3 months, and with clinically controlled hypertension, according to current 2009 recommendations (i.e., casual BP < 140/90 mm Hg or BP < 130/80 mm Hg for diabetics).15,16 Exclusion criteria included HBPM contraindications (i.e., obese with >33 cm arm circumference, as well as arrhythmia, severe cognitive impairment, pregnancy), nonstabilized illness, and ongoing treatment titration.

Measurement protocols

Office/clinic measurements. The 6 previous casual clinical measurements during the 6–9 months prior to inclusion were collected for each patient. Patients were seated quietly with their backs supported, without crossing their legs, and with both arms positioned and supported at the heart level for 5 minutes before the measurements were taken. Office/clinic BP was measured with auscultation by a physician (2 readings) using a mercury sphygmomanometer. The mean of 2 successive measurements on each arm (total of 4 measurements) was used.

HBPMs. The HBPMs were performed with a humeral automatic device (Hartmann 89504, Heidenheim, Germany; Hartmann Duocontrol Tensoval Comfort) validated by the ESH and the Agence Française de Sécurité Sanitaire des Produits de Santé.17,18 All patients were asked to comply with the following instructions: perform measurements on the nondominant arm, be in a sitting position, do not cross your legs, take measurement in the morning before breakfast and in the evening after dinner, perform over a 3-day period (CFLHTA and HAS instructions).15 Three measurements, 1 minute apart, had to be performed immediately after positioning the arm cuff and then 5 minutes after the first series, without moving.

ABPMs. The 24-hour ABPM was performed on the nondominant arm, within 3 days before the HBPM, with a Spacelab device (Spacelabs Healthcare, Snoqualmie, WA). All patients were to continue taking their antihypertensive treatments at the designated time (during breakfast and/or dinner) during the HBPM and ABPM sequences, both of which were not performed on the weekend.

Statistics

There are very little data regarding the correlation between HBPM with 5 minutes of rest and daytime ABPM. Jula et al.19 observed a correlation coefficient of 0.78 for SBP and 0.70 for diastolic BP (DBP) among 249 nontreated hypertensive patients.19 A global correlation can thus be established at 0.75. We hypothesized that by not allowing 5 minutes of rest prior to starting the measurement, the experimental error could be increased by half.

Forty-six patients were recruited to demonstrate an improvement in the correlation coefficient between HBPM and ABPM from $r = 0.50$ to $r = 0.75$ when a 5-minute rest period was applied before HBPM. The protocol anticipated enrolling 52 patients in order to circumvent the possible loss of observations. HBPM and ABPM measurements were compared using the paired Student or Wilcoxon test when required and their correlation illustrated by Bland–Altman plots. Correlation analyses were carried out using the Spearman method. Intraclass correlation coefficients were computed using mixed repeated measures analysis of variance, with “method used” as fixed effect and subject as random factor. Agreement between ABPM and HBPM after/without rest was assessed using the kappa test. All analyses were performed using the SAS R9.1.3 software (SAS Institute, Cary, NC). The 2-tailed significance level was set at $P < 0.05$.

RESULTS

Thirty-eight of the 52 patients regularly performed HBPM prior to their enrollment in the study (1 HBPM before each office visit for at least 1 year). Their clinical features are presented in Table 1.

Measurements with rest resulted in lower SBP and tendency toward lower (not significantly) DBP (Figure 1A, 1B). Confirmation that the 5-minute rest period was observed is demonstrated by a decrease in heart rate (Figure 1C).

There was an excellent intraclass correlation between daytime ABPM and HBPM with or without rest, as shown in Figure 2. The Bland–Altman plots do not suggest any difference between ABPM and HBPM regardless of the mean BP level.

Correlations between HBPM with rest and HBPM without rest were excellent ($r = 0.99$).

Measurements without rest were no less stable than measurements after rest, as shown in Table 2. The coefficient of variation for SBP and DBP did not significantly differ whether a period of rest was respected or not.

There was a differential impact of rest on differences observed between daytime ABPM and HBPM. For SBP, a significant decrease was observed in HBPM SBP with rest
vs. daytime ABPM as opposed to a nonsignificant increase in HBPM DBP with rest vs. daytime ABPM, as shown in Table 2.

HBPM SBP with rest was significantly lower than 24-hour ABPM: HBPM, 121.5 ± 10.9 vs. 24-hour ABPM, 124.0 ± 9.9 (Student: \( P = 0.02 \), Wilcoxon \( P = 0.03 \)).

HBPM SBP without rest was not significantly different from daytime ABPM SBP (\( P = 0.27 \)) as opposed to a significant increase in HBPM DBP without rest vs. daytime ABPM DBP (\( P < 0.001 \)). HBPM DBP after rest was not significantly different from daytime ABPM DBP (\( P = 0.09 \)).

As shown in Table 2, sensitivity analysis, which eliminated the first of the 3 successive measurements, did not change the trends reported above. According to our study inclusion criteria, all patients displayed controlled BP levels (i.e., casual BP <140/90 mm Hg or BP <130/80 mm Hg for diabetics).

When considering HBPM with rest, 4/52 patients were classified as having masked (uncontrolled) hypertension vs. 6/52 when HBPM without rest is considered. Therefore, the misclassification concerned 2 patients using rest (6/9 vs. 4/9) among the 9 patients classified as having masked hypertension with daytime ABPM (no significant (ns)). The kappa test allowed acceptance of a concordance between daytime ABPM and HBPM without rest but not with HBPM after rest.

Thirty-eight of the 52 patients regularly performed HBPM before entering the study, while 14 were specifically educated for the present study. We asked the 38 patients to assess the duration of rest before measurements in “real life” prior to the study. None of these patients were compliant with the recommended 5 minutes of rest before beginning measurements: 4/38 estimated allowing 2 minutes of rest, 5/38 estimated 1 minute of rest, and 29/38 began measurements without rest, regardless of the recommendations that all had received during HBPM education. All respondents mentioned rest as a genuine constraint.

### Discussion

The following five noteworthy findings can be drawn for this study: systolic HBPM but not diastolic HBPM decreased with rest; diastolic HBPM without rest was significantly higher than daytime diastolic ABPM; HBPM values without rest were closer to daytime ABPM compared with HBPM after rest; as a consequence, HBPM appears to underestimate the prevalence of masked hypertension; and none of the participants respected the recommended rest period in real life outside of the present study.

A short rest before HBPM (5-minute rest or a few minutes of rest) is systematically recommended in the various guidelines, although such recommendation is not supported by any dedicated clinical study. Moreover, the rest duration varies between guidelines, ranging from 1 minute (Japanese guidelines) to 5 minutes (ESH guidelines). In contrast, a rest period before office/clinic measurements is necessary and particularly relevant, as highlighted by Sala. We therefore wondered whether a rest before HBPM is also necessary since the patient is probably more relaxed at home and likely unstressed in the absence of medical staff.

All previous studies that have established standards of HBPM and its prognostic value were based on allowance of a few minutes of rest before readings with a 1-minute interval between readings. However, it is not known whether patients strictly obeyed this condition. In fact, we do not know what happens at home since HBPM is performed, by definition, by the patients without any medical staff. In the present study, all patients were asked to perform 2 sequences of HBPMs (3 readings immediately after positioning the cuff and then 5 minutes after the first series, at rest), and thus we could ascertain that they actually did rest to some degree, as evidenced by the significant decrease in heart rate observed after rest.

By contrast, Stergiou et al. compared HBPM and daytime ABPM in 45 treated hypertensive patients who were asked to take a 5-minute rest before each HBPM sequence. The authors did not observe any statistically significant difference between BP parameters. However, the corresponding heart rates did not differ either, thereby strongly suggesting that the 5-minute rest may have not been strictly followed at home in the study that, at the outset, did not aim to specifically compare HBPM with and without rest, as done in the present study.

Our study also compared the effect of resting or not resting before HBPM readings to daytime ABPM, which is considered to be the “gold standard” measure, in line with the study by Hodgkinson et al. regarding the diagnosis of hypertension. Head and colleagues support the appropriateness of the ambulatory equivalents to clinical measurements, particularly for stage 1 and 2 thresholds. Even if HBPMs and ABPMs do not have the same significance on diagnosis and/or prognosis and cannot be placed on the same level, they nonetheless lead the clinician to the same management
even if HBPM could be a reliable alternative to ABPM for the assessment of nocturnal BP with the detection of nondippers.\textsuperscript{29}

All of our patients were educated prior to HBPM (education before study participation or upon study participation). Excellent correlations were observed between rest and no-rest HBPM and ABPM. Similarly, correlations between HBPM with rest and ABPM without rest were excellent (data not shown).

However, mean HBPMs were found to be closer to mean daytime ABPM when patients did not observe any rest before measurements. Moreover, HBPM SBP after rest was always lower than ABPM SBP (daytime ABPM and even 24-hour ABPM, which strengthens our results), suggesting that the prognostic value of HBPM after rest is less accurate than without rest (because the prognostic value of ABPM is based on 24-hour ABPM and not only diurnal ABPM). Furthermore, although not statistically significant, probably owing to the small number of study participants, an underestimation of masked hypertension prevalence seemed to be observed when rest HBPM was considered, as opposed to measurements taken as soon as the cuff was positioned. This suggests that rest may lead to a suboptimal treatment of patients.

Furthermore, the fact that SBP levels were underestimated is of paramount importance, since several studies have emphasized the critical relationship between SBP (rather than DBP) and cardiovascular outcomes.\textsuperscript{30--33} The differences observed between systolic and diastolic readings with or without rest may be explained by the hypothesis that SBP may be more prone to react immediately to adrenergic tone variations associated with rest compared with DBP.

The first of 3 consecutive measurements probably overestimates BP compared with the 2 last measurements, as shown by our study. Indeed, because of the movements performed during the transition from standing to sitting and positioning of the cuff, the first reading can be artificially higher. The second reading has to be performed 1 minute after the first reading according to Eguchi \textit{et al.},\textsuperscript{22} as performed in our study. However, according to our sensitivity analysis, withholding the first measurement did not alter the trends observed.

Physicians are asked to diagnose hypertension and to monitor hypertensive patients (treatment titration) and to perform HBPM beyond their casual measurements (casual measurement with a mercury sphygmomanometer in standardized conditions remains the gold standard method for diagnosing hypertension). In real life, it is unclear whether HBPMs are usually performed according to the measurement protocol followed in clinical studies. Indeed, in our study, a 5-minute rest period before measurement was felt to be a genuine constraint by patients and, in fact, was actually never respected outside of the protocol, despite appropriate education. Today HBPM is very popular. In the US National Health and Nutrition Examination Survey 2009–2010, approximately 14.5% of adults and almost 50% of adults with hypertension engaged in monthly or more frequent HBPM.\textsuperscript{34} However, we have no idea if these hypertensive adults adhere to HBPM protocols.

Finally, one might wonder if only 1 (the first) measurement without rest would be sufficient for diagnosis and decision-making for treatment, as opposed to being
Figure 2. Correlation between HBPM (18 measurements: SBP and DBP without rest and after 5 minutes of rest) and ABPM (daytime: 6:00 a.m.– 10:00 p.m.). Bland–Altman plots are shown. Abbreviations: ABPM, ambulatory blood pressure measurement; ANOVA, analysis of variance; DBP, diastolic blood pressure; HBPM, home blood pressure measurement; SBP, systolic blood pressure.

Table 2. Mean systolic blood pressure (SBP) and diastolic blood pressure (DBP), mm Hg, home blood pressure measurement without rest and after 5 minutes of rest.

<table>
<thead>
<tr>
<th></th>
<th>Daytime ABPM</th>
<th>HBPM without rest</th>
<th>P*</th>
<th>HBPM after rest</th>
<th>P*</th>
<th>P**</th>
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<tbody>
<tr>
<td><strong>SBP (mean of first, second, and third readings)</strong></td>
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<td>HBPM (mean of first, second, and third readings) mean ± standard deviation</td>
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<td>SBP</td>
<td>126.3 ± 10.1</td>
<td>127.9 ± 12.0</td>
<td>0.20</td>
<td>121.5 ± 10.9</td>
<td>&lt;0.0001</td>
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<tr>
<td>DBP</td>
<td>74.2 ± 7.8</td>
<td>78.0 ± 8.7</td>
<td>&lt;0.001</td>
<td>76.0 ± 9.0</td>
<td>0.08</td>
<td>&lt;0.0001</td>
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<td><strong>SBP (first reading)</strong></td>
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<td>HBPM (mean of first and third readings)</td>
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<tr>
<td>SBP</td>
<td>126.3 ± 10.1</td>
<td>131.2 ± 12.7</td>
<td>&lt;0.001</td>
<td>122.0 ± 11.0</td>
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<tr>
<td>DBP</td>
<td>74.2 ± 7.8</td>
<td>78.8 ± 9.5</td>
<td>&lt;0.001</td>
<td>76.5 ± 9.8</td>
<td>0.03</td>
<td>&lt;0.0001</td>
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<td><strong>SBP (mean of second and third readings)</strong></td>
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<td>HBPM (mean of second and third readings)</td>
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<tr>
<td>SBP</td>
<td>126.3 ± 10.1</td>
<td>126.1 ± 12.1</td>
<td>0.86</td>
<td>121.2 ± 11.0</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
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<tr>
<td>DBP</td>
<td>74.2 ± 7.8</td>
<td>77.6 ± 8.7</td>
<td>&lt;0.001</td>
<td>75.8 ± 8.8</td>
<td>0.11</td>
<td>&lt;0.0001</td>
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<td><strong>Coefficient of variation (days 1, 2, 3)</strong></td>
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<tr>
<td>SBP</td>
<td>8.3 (7.4–9.9)%</td>
<td>8.1 (6.7–9.9)%</td>
<td>0.24</td>
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<tr>
<td>DBP</td>
<td>10.2 (7.9–13.1)%</td>
<td>9.4 (7.9–11.3)%</td>
<td>0.11</td>
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Abbreviations: ABPM, ambulatory blood pressure measurement; DBP, diastolic blood pressure; HBPM, home blood pressure measurement; SBP, systolic blood pressure.

Daytime SBP and DBP ABPM (6–22 h). n = 52. Figures are means ± standard deviation or medians (interquartile range), with P values from the paired Student or Wilcoxon test (P*: daytime ABPM vs. HBPM without or after rest; P**: HBPM without rest vs. HBPM after rest) when requested.

936 American Journal of Hypertension 27(7) July 2014
averaged over a certain period, as suggested by Imai et al. and Kawabe et al., as well as the Japanese Society of Guidelines for HBPM. However, it would be of interest to know which method would be perceived as less burdensome by patients.

Our study did have limitations. For practical reasons, ABPM was not performed concurrently with HBPM. Indeed, we chose to perform ABPM and HBPM on the same arm, which would not have been possible simultaneously, given the type of device used. However, treatments remained unchanged during these 2 periods. Moreover, we ensured that ABPM and HBPM were performed respectively during a business day or during 3 business days.

We cannot completely exclude that the knowledge that BP results before rest may have influenced BP results after rest. However, unpredictable “noise” may have decreased the study power to detect a significant difference between both states.

Finally, this study was conducted in clinically controlled hypertensive patients. Whether the present findings may be extrapolated to a general population or to untreated hypertensive patients (i.e., for hypertension diagnosis and white coat effect) warrants further dedicated studies.

Our results, as well of the limited availability of data to support a rest period, put into question current recommendations to systematically have a rest period before performing HBPM, which is ultimately never respected by the patients. However, a replication of our observation in larger samples is warranted. As these measures must be repeated every 3 or 6 months, lifelong, one wonders whether removing the instruction for a rest period would improve patient adherence to HBPM protocols. This also needs further study.

ACKNOWLEDGMENTS

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DISCLOSURE

The authors declared no conflict of interest.

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