

Uncontrolled blood pressure according to ambulatory blood pressure monitoring values in pregnant women is poorly predictable

Ewa Wojciechowska, Katarzyna Cienszkowska, Marta Ludwiczak, Piotr Sobieraj, Piotr Gryglas, Jacek Lewandowski

Department of Internal Disease, Hypertension and Vascular Diseases, Medical University of Warsaw, Warszawa, Poland

Correspondence to:

Jacek Lewandowski, MD, PhD,
Department of Internal Disease,
Hypertension and Vascular
Diseases,
Medical University of Warsaw,
Banacha 1A,
02-097 Warszawa, Poland,
phone: +48 22 599 28 28,
e-mail:
jacek.lewandowski@wum.edu.pl

Copyright by the Author(s), 2023

DOI: 10.33963/KPa2023.0104

Received:

February 10, 2023

Accepted:

April 20, 2023

Early publication date:

May 6, 2023

INTRODUCTION

The prevalence of hypertension-related disorders in pregnancy remains a significant clinical problem that contributes to an increase in maternal morbidity and mortality and influences the risk of future cardiovascular complications [1]. It is recommended to monitor blood pressure (BP) during pregnancy using office BP measurements (OBPM) with the support of outpatient measurements, which include home BP (HBPM) and ambulatory BP measurements (ABPM) [2]. ABPM is recognized as the best method for BP monitoring during pregnancy. Its role in management of hypertension in high-risk pregnant women is particularly emphasized [2, 3]. Experts do not indicate one specific algorithm for choosing the method for BP monitoring and the sequence and purposefulness of performing a specific type of BP measurement. Therefore, to define the role and importance of ABPM in relation to OBPM and HBPM, we decided to compare the results of these BP measurement methods in a group of women with high-risk pregnancies.

METHODS

Study group description

The study is a post-hoc analysis of data collected over 4 years (2015–2019) from 79 pregnant women referred to the clinic with a history of primary hypertension with eclampsia (89.9%) or pre-eclampsia (10.1%) in their previous pregnancy/pregnancies. All included women completed the study. The study was approved by the local ethics committee (no. AKBE/71/2018). The characteristics

of pregnant women are presented in the Supplementary material.

Description of analyzed variables

Every fifth week of the study, subjects underwent ABPM and OBPM with the last visit scheduled in the 37th week of pregnancy. Before each visit, HBPM measurements were performed. All measurements were performed in accordance with recommendations [2]. For each of the BP measurement methods, arterial hypertension was diagnosed at the commonly accepted BP thresholds (details in the Supplementary material).

Statistical analysis

Continuous variables were presented as mean and standard deviation. Categorical variables were presented as numbers followed by percentages. The reliability of OBPM or HBPM for assessment of ABPM measurement was assessed using Cohen's Kappa. In order to predict an abnormal ABPM result in BP measurement sets with well-controlled OBPM and HBPM values, mixed-effect logistic regression of all possible models including systolic and/or diastolic BP values from OBPM and/or HBPM as predictors was created. The model was evaluated in a randomly selected subset containing 80% of the measurement sets. The final model was selected on the basis of the lowest Akaike information criterion. Furthermore, accuracy of the model was evaluated in the remaining 20% of the data.

RESULTS AND DISCUSSION

During the trial, 706 office visits with BP measurements were performed, and finally,

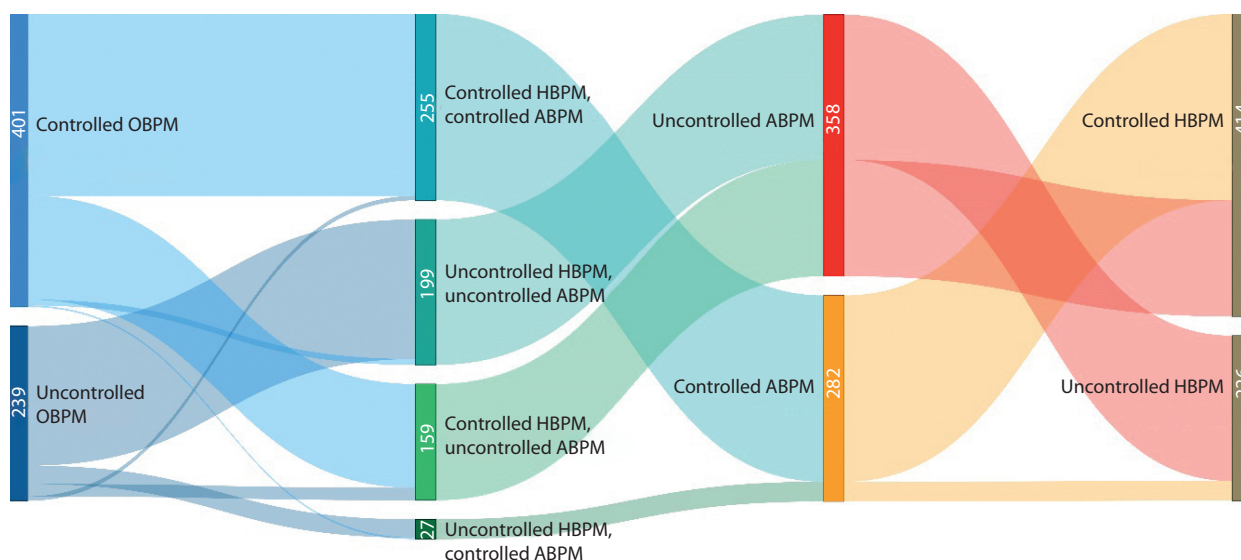


Figure 1. Dependency between controlled/uncontrolled values of OBPM, HBPM, and ABPM in the analyzed group of 640 sets of blood pressure measurements

Abbreviations: ABPM, ambulatory blood pressure measurements; HBPM, home blood pressure measurements; OBPM, office blood pressure measurements

640 (90.7%) complete sets of BP measurements were analyzed. Mean OBPM SBP/DBP was 134.0 (15.9)/83.7 (11.4) mm Hg, and HBPM SBP/DBP was 128.1 (16.6)/79.9 (11.3) mm Hg. Mean ABPM SBP/DBP values during 24-hour monitoring were 122.9 (13.1)/77 (9.9) mm Hg, during the activity period they were 126.9 (13.6)/80.9 (10.4) mm Hg, and at night 113.7 (13.8)/67.9 (9.9) mm Hg.

OBPM values ≥ 140 and/or 90 mm Hg were present in 239 (37.3%) sets of measurements. HBPM values ≥ 135 and/or 85 mm Hg occurred in 226 (35.3%) measurements. ABPM values ≥ 130 and/or 80 mm Hg during 24-hour or ≥ 135 and/or 85 mm Hg during the activity period or ≥ 120 and/or 70 mm Hg during night rest were present in 358 (55.9%) sets of measurements.

OBPM

In 401 cases, OBPM was rated as well-controlled; 10 (2.5%) HBPM and 150 (37.4%) ABPM results were recognized as uncontrolled. In sets with well-controlled OBPM, 8 (2%) indicated a lack of BP control in both HBPM and ABPM. In 239 sets of measurements fulfilling the criteria for uncontrolled OBPM, 216 (90.4%) HBPM and 208 (87.0%) ABPM were classified as uncontrolled BP (Figure 1). Reliability of OBPM for assessment of controlled/uncontrolled ABPM results was weak (kappa 0.45).

HBPM

In 414 sets with well-controlled HBPM, there were 23 (5.6%) uncontrolled OBPM and 159 (38.4%) uncontrolled ABPM. In 17 (4.1%) sets, both OBPM and ABPM were uncontrolled. In 226 measurement sets fulfilling the criteria for uncontrolled HBPM, 216 (95.6%) OBPM and 199 (88.1%) ABPM were as-

sessed as uncontrolled. Reliability of HBPM for assessment of controlled/uncontrolled ABPM was weak (kappa 0.44).

ABPM

In 282 well-controlled ABPM, 31 (11%) were uncontrolled in OBPM and 27 (9.6%) uncontrolled in HBPM. Both uncontrolled OBPM and HBPM were in 25 (8.9%) sets and uncontrolled OBPM or HBPM were in 8 sets (2.8%). In 358 sets of uncontrolled ABPM measurements, there were 208 (58.1%) uncontrolled OBPM and 199 (55.6%) uncontrolled HBPM. Both uncontrolled OBPM and HBPM were in 191 (53.3%) sets while 142 measurements were accompanied by well-controlled OBPM and HBPM.

ABPM in relation to OBPM and HBPM

Well-controlled hypertension according to both OBPM and HBPM was in 391 (61.1%) sets of measurements. Among them, there were 142 (22.2%) measurements indicating uncontrolled values according to ABPM. Both uncontrolled OBPM and HBPM were in 216 (33.8%) sets of measurements, and 33 (5.2%) fulfilled the criteria for uncontrolled hypertension in OBPM or HBPM. In subjects with uncontrolled hypertension both in OBPM and HBPM, 191 (88.4%) had uncontrolled hypertension in ABPM. In 33 sets of measurements with uncontrolled OBPM or HBPM, 25 (75.8%) fulfilled the criteria for uncontrolled ABPM.

Prediction of uncontrolled ABPM in subjects with well-controlled values of both OBPM and HBPM

In the training subset of the data with well-controlled values of both OBPM and HBPM, a model was selected for prediction of uncontrolled ABPM. The final logistic regres-

sion model included OBPM SBP, OBPM DBP, and HBPM DBP; the odds ratios for the prediction of uncontrolled ABPM were 1.09 (95% CI, 1.01–1.17), 1.52 (95% CI, 1.25–1.85), and 0.86 (95% CI, 0.72–1.02), respectively, for a 1 mm Hg increase. Using the remaining 20% of BP measurements we computed selected model accuracy equal to 0.592. These results suggest that high SBP and DBP in OBPM and low DPB in HBPM increase the likelihood of poor BP control in ABPM.

Using data from BP measurements in patients with high-risk pregnancy, we showed that the discrepancy between OBPM and HBPM may be considered as a relevant clinical problem. According to our results, physicians assessing BP control only using OBPM may overlook 37.4% of subjects with uncontrolled hypertension according to the ABPM control criterion. Surprisingly, using only HBPM values may result in under-recognition of 38.4% of subjects with ABPM values higher than expected. In our study, achieving ABPM target values of elevated BP treatment was associated with a low rate of uncontrolled OBPM (11%) and HBPM (9.6%) values. The evaluated model showed that physicians can predict uncontrolled ABPM values using data from OBPM and HBPM in fewer than two-thirds of sets of measurements.

Our results remain of special significance when compared to the current guidelines, indicating ABPM superiority in predicting pregnancy outcomes over routine BP measurement [4]. Many clinicians, using the results of studies evaluating the agreement between OBPM, HBPM, and ABPM using the Bland-Altman methodology, may be convinced that HBPM is closest to daily ABPM results. Actually, using the same data as in our study, we also confirmed that finding [5]. However, the assumption that HBPM can be used interchangeably with ABPM is incorrect as shown by Hodgkinson et al. [6] in the systematic review of 20 studies. In their analysis, pooled sensitivity and specificity of OBPM for ABPM were 74.6% (95% CI, 60.7%–84.8%) and 74.6% (95% CI, 47.9%–90.4%), respectively. Pooled sensitivity of HBPM for OBPM and ABPM was 85.7% (95% CI, 78%–91%) and 62.4% (95% CI, 48%–75%).

We did not find similar analyses concerning differences in OBPM, HBPM, and ABPM values, thus our results should be considered new.

However, our study has several limitations. Due to the relatively small sample size and study design, we were not able to evaluate how the discrepancy between OBPM,

HBPM, and ABPM impacts the outcome of pregnancy. Also, the day and night period schedule set in ABPM reports may not reflect the day-and-night cycle of our study participants.

In conclusion, our results indicate that good BP control in OBPM or HBPM does not mean achieving controlled BP in ABPM. In addition, based on the results of both OBPM and HBPM, we are unable to predict the result of ABPM. Therefore, especially considering the advantages in terms of predicting pregnancy outcomes, ABPM should be the standard for BP monitoring in pregnant women.

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/kardiologia_polska.

Article information

Conflict of interest: None declared.

Funding: None.

Open access: This article is available in open access under Creative Commons Attribution-Non-Commercial-No Derivatives 4.0 International (CC BY-NC-ND 4.0) license, which allows downloading and sharing articles with others as long as they credit the authors and the publisher, but without permission to change them in any way or use them commercially. For commercial use, please contact the journal office at kardiologiapolska@ptkardio.pl.

REFERENCES

1. Lipczyńska M, Janisz K, Szymański P, et al. Pregnancy-related cardiac non-elective hospitalizations and pregnancy outcomes. A tertiary referral cardiac center experience. *Kardiol Pol.* 2021; 79(7-8): 789–795, doi: [10.33963/KP.15985](https://doi.org/10.33963/KP.15985), indexed in Pubmed: [33926168](https://pubmed.ncbi.nlm.nih.gov/33926168/).
2. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J.* 2018; 39(33): 3021–3104, doi: [10.1093/eurheartj/ehy339](https://doi.org/10.1093/eurheartj/ehy339), indexed in Pubmed: [30165516](https://pubmed.ncbi.nlm.nih.gov/30165516/).
3. Prejbisz A, Dobrowolski P, Kosiński P, et al. Management of hypertension in pregnancy: prevention, diagnosis, treatment and longterm prognosis. *Kardiol Pol.* 2019; 77(7-8): 757–806, doi: [10.33963/KP.14904](https://doi.org/10.33963/KP.14904), indexed in Pubmed: [31322138](https://pubmed.ncbi.nlm.nih.gov/31322138/).
4. Cifková R, Johnson MR, Kahan T, et al. Peripartum management of hypertension: a position paper of the ESC Council on Hypertension and the European Society of Hypertension. *Eur Heart J Cardiovasc Pharmacother.* 2020; 6(6): 384–393, doi: [10.1093/ehjcvp/pvz082](https://doi.org/10.1093/ehjcvp/pvz082), indexed in Pubmed: [31841131](https://pubmed.ncbi.nlm.nih.gov/31841131/).
5. Wojciechowska E, Sobieraj P, Siński M, et al. Consistency among Office, Home, and Ambulatory Blood Pressure Values in Women with Chronic Hypertension and History of Eclampsia or Preeclampsia. *J Clin Med.* 2022; 11(17), doi: [10.3390/jcm11175065](https://doi.org/10.3390/jcm11175065), indexed in Pubmed: [36078995](https://pubmed.ncbi.nlm.nih.gov/36078995/).
6. Hodgkinson J, Mant J, Martin U, et al. Relative effectiveness of clinic and home blood pressure monitoring compared with ambulatory blood pressure monitoring in diagnosis of hypertension: systematic review. *BMJ.* 2011; 342: d3621, doi: [10.1136/bmj.d3621](https://doi.org/10.1136/bmj.d3621), indexed in Pubmed: [21705406](https://pubmed.ncbi.nlm.nih.gov/21705406/).