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Bulletin de la Dialyse à Domicile

# Evaluation of the performance of conventional and sequential in-center blood pressure measurement in peritoneal dialysis patients in Dakar

(Évaluation de la performance de la mesure conventionnelle et séquentielle de la pression artérielle en centre chez les patients en dialyse péritonéale à Dakar )

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## Résumé

L'objectif de cette étude était d'évaluer les performances des mesures conventionnelles (MCPA) et séquentielles (MSPA) de la pression artérielle en prenant la MAPA comme référence.

Patients et méthodes : A travers une étude transversale incluant 17 patients suivis dans l'unité de DP de l'Hôpital Aristide Le Dantec, la PA a été mesurée par 3 méthodes i) une mesure automatisée (OMRON M3 COMFORT) effectué par un personnel de santé dite MCPA ; ii) la moyenne de 5 mesures automatisées chez un patient isolé dans un box dite MSPA ; iii) la MAPA des 24h avec l'appareil CONTECTM (Germany). L'HTA a été retenue devant une PA supérieure à 130/80 mmHg à la MAPA des 24h.
Résultats : L'aire sous la courbe (AUC) de la PAS était similaire (p=0,28) entre la MSPA [AUC, 0,933 ; IC à 95 %, 0,813 – 1,000] et la MCPA [AUC, 0,900 ; IC à 95 %, 0,752 – 1,000]. Concernant la PAD, la MSPA [AUC, 0,858 ; IC à 95 %, 0,638 – 1,000] était similaire (p=1) à la MCPA [AUC, 0,917 ; IC à 95 %, 0,753 – 1,000]. À l'analyse de Bland-Altman, la MCPA surestimait la PAS de 11,65 mmHg et la PAD de 3,94 mmHg. La MSPA quant à elle surestimait la PAS de 6,2 mmHg et la PAD de 4,35 mmHg.

Conclusion : La MSPA et la MCPA sont performantes dans le diagnostic de l'HTA ambulatoire chez les patients en dialyse péritonéale à Dakar.

**Mots clés** : mesure séquentielle, mesure conventionnelle, MAPA, dialyse péritonéale, Sénégal

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## Summary

The aim of this study was to evaluate the performance of conventional (CBPM) and sequential (SBPM) blood pressure measurements in peritoneal dialysis (PD) patients using ambulatory blood pressure measurements (ABPM) as a reference.

Patients and methods: Through a cross-sectional study including 17 patients followed in the PD unit of the Aristide Le Dantec Hospital, BP was measured by 3 methods: i) an automated measurement (OMRON M3 COMFORT) performed by a health care staff called CBPM; ii) the average of 5 automated measurements in an unattended patient isolated in a cubicle called SBPM; iii) 24-hour ABPM with the CONTECTM device (Germany). High blood pressure was considered when the BP was higher than 130/80 mmHg at the 24-hour ABPM.

Results: The area under the curve (AUC) for systolic blood pressure (SBP) was similar (p=0.28) between SBPM [AUC, 0.933; 95% CI, 0.813 – 1.000] and CBPM [AUC, 0.900; 95% CI, 0.752 – 1.000]. Regarding diastolic blood pressure (DBP), SBPM [AUC, 0.858; 95% CI, 0.638 – 1.000] was similar (p=1) to CBPM [AUC, 0.917; 95% CI, 0.753 – 1.000]. On Bland-Altman analysis, CBPM overestimated SBP by 11.65 mmHg and DBP by 3.94 mmHg. SBPM overestimated SBP by 6.2 mmHg and DBP by 4.35 mmHg.

Conclusion: SBPM and CBPM are efficient in the diagnosis of ambulatory hypertension in PD patients in Dakar.

**Key words** : sequential measurement, conventional measurement, ABPM, peritoneal dialysis, Senegal

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**Abreviations used in main text :**
ABPM : ambulatory blood pressure measurement, CBPM :conventional blood pressure measurement
SBPM : sequential blood pressure measurement
SBP : systolic blood pressure
DBP : diastolic blood pressure
AUC: area under the curve
CI : Confidence interfal

## INTRODUCTION

Arterial hypertension is defined as an arterial systolic blood pressure (BP) greater than or equal to 140 mmHg and/or a diastolic BP greater than or equal to 90 mmHg [1]. Hypertension can be both a cause and a consequence of chronic kidney disease (CKD). It is common and often poorly controlled in dialysis patients [1]. Hypertension is reported in more than 80% of patients at the time of initiation of dialysis, in more than 60% of patients treated with hemodialysis (HD), and in more than 30% of patients on peritoneal dialysis (PD) [2].

The continuous nature of PD and the absence of acute changes in BP and the hydration status are notable differences from in-center intermittent hemodialysis [3]. Even if BP measurement is performed routinely in consultation, the measurement in the office (sequential but, above all, conventional) does not reproduce the patient's usual living conditions. It may therefore be subject to variations. Ambulatory BP measurement (ABPM) is the gold standard for the diagnosis of hypertension [1,4]. The BP measured with 24-hour ABPM in the treated hypertensive subject is better correlated with the occurrence of target organ damage and with cardiovascular morbidity and mortality and is independent of the BP obtained in the doctor's office [5,6].

The management of the hypertensive subject, which is strongly dependent on the analysis of BP figures, makes reliable and precise BP measurement fundamental. False positives (white coat hypertension) characterized by elevated BP in the office and normal BP under usual living conditions concern approximately 10% of patients [4]. False negatives (masked hypertension) correspond to the reverse of the white coat effect, i.e., a patient with normotension in the center and hypertension at home. The prevalence of masked hypertension varies from 10% to 47% [4]. ABPM, despite its many advantages, is inaccessible to our patients because of its cost. Thus, office measurements are still used for the diagnosis and monitoring of hypertension in our practice setting. It is therefore important to assess the hypothesis that office measurements are alternatives to ABPM in our context.

No studies on the performance of sequential blood pressure measurements (SBPM) and conventional blood pressure measurement (CBPM) in PD patients have been performed in Senegal.

The objective of this study is to evaluate the performance of CBPM and SBPM in the outpatient diagnosis of hypertension in PD patients using ABPM as a reference measurement.

## PATIENTS ET METHOD

### Study population

This was a diagnostic study carried out over a period of 3 months from April 1 to July 1, 2021. It was approved by the research ethics committee of the Cheikh Anta Diop University (UCAD)

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of Dakar, Senegal, and registered under number CER/UCAD/AD/MsN/035/2021. The source population consisted of all PD patients in the PD unit at Aristide Le Dantec Hospital, Dakar. Patients with active infections during the study period, a loss of ultrafiltration, fewer than 70 ABPM measurements in two occasions, less than a month of PD, or an inability to perform ABPM, as well as patients who did not consent, were excluded.

### Data collection and patient assessment

Seventeen patients (10 men and 7 women) with a mean age of 44.59 ± 15.5 years were included *(Figure 1)*.

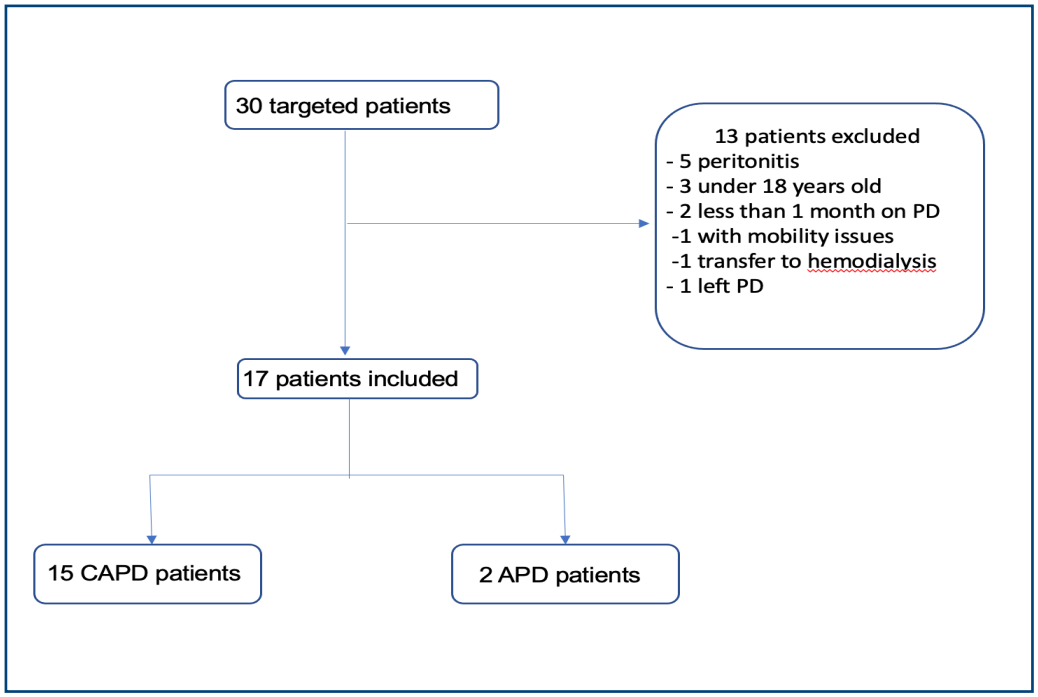


*Fig. 1: Flow diagram of the 30 patients followed by peritoneal dialysis (PD). HD: hemodialysis; CADP: continuous ambulatory PD; APD: automated PD. The other characteristics are given in Table I.*

Data collection was carried out retrospectively using a clinical and paraclinical data collection sheet, an CBPM record sheet, a patient record sheet, an SBPM sheet, and an ABPM survey sheet.

CONTEC$^{TM}$ (Germany) brand ABPM devices were used for the ambulatory blood pressure measurements (ABPM). The ABPM machine's BP recording was done every 30 minutes at night and every 15 minutes during the day. The recording was said to be valid if at least 72 (90% validity) measurements were valid within 24 hours. Hypertension was defined in ABPM as a BP greater than or equal to 130/80 mmHg.

The measurements in the office were performed with the same OMRONM3 Comfort$^{TM}$ brand automatic BP monitor in SBPM as in CBPM for the same patient.

The BP taking with CBPM was done by a doctor or nurse in the PD unit. Regarding SBPM , the patient was isolated in a box where he or she took 6 BP measurements spaced 2 minutes apart. The first measure was excluded from the interpretation. The average of the last 5 values was

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calculated and regarded as the BP obtained by SBPM . CBPM and SBPM were performed on the day the ABPM machine was installed.

The other characteristics of selected patients are given in Table I.

⬇ *Table1. Basic characteristics of the 17 patients followed by peritoneal dialysis (PD) included in the study.*

| Qualitative data | n (%) |
|---|---|
| Geographic origin | |
| Dakar | 11 (64.71) |
| Thiès | 5 (29.41) |
| Diourbel | 1 (5.88) |
| Gender | |
| Man | 10 (58.82) |
| Woman | 7 (41.18) |
| PD modalities | |
| CAPD | 15 (88.23) |
| APD | 2 (11.77) |
| Initial nephropathy | |
| Nephroangiosclerosis | 8 (47.06) |
| Non-determined nephropathy | 7 (41.18) |
| CTIN | 1 (5.88) |
| Mixed (diabetes + SAH) | 1 (5.88) |
| Clinic | |
| Residual diuresis | 17 (100) |
| LLO | 7 (41.18) |
| Electrocardiogram (n=13) | |
| LAH | 3 (23.08) |
| LVH | 6 (46.15) |
| Long cQT | 4 (30.77) |
| Anti-hypertensive treatment (n=15) | |
| BSRA | 14 (93.33) |
| ICC | 14 (93.33) |
| Dual therapy | 7 (46.67) |
| Triple therapy | 8 (53.33) |
| Diuretics | 6 (40.00) |
| Quantitative data | Mean ± standard deviation |
| Age (years) | 44.59 ± 15.5 |
| Hemoglobin (g/dl) | 8.0 ± 1.6 |
| Calcemia (mg/l) | 81.9 ± 14.9 |
| Phosphatemia (mg/l) | 52.6 ± 27.2 |

CAPD: continuous ambulatory peritoneal dialysis; APD: automated peritoneal dialysis; CTIN: chronic tubulointerstitial nephropathy; LLO: lower limb oedema; LAH: left auricular hypertrophy; LVH: left ventricular hypertrophy; cQT: corrected QT interval ; BSRA: blockers of the renin-angiotensin system; ICC: calcium channel inhibitors.

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## Statistical analysis and data processing

Data were entered into Excel 2019 software and analyzed using SPSS software version 23.0.0 and R software version 4.1.1.

Quantitative data were presented as means and standard deviations or medians and extremes depending on the distribution of the variables. Qualitative data were presented as a proportion.

The sensitivity and specificity of SBPM and CBPM were assessed by receiver operating characteristic (ROC) curves with the calculation of the area under the curve (AUC) and its 95% confidence interval (CI).

The measurement was said to be effective if the lower value of the CI of the AUC was greater than 0.5. The measurement performed poorly if the AUC was between 0.50 and 0.70, medium if the AUC was between 0.70 and 0.80, good if the AUC was between 0.80 and 0.90, and very good if the AUC was between 0.90 and 1.00. The comparison of the AUC between SBPM and CBPM was made by the roc.test package of the R software.

The best cutoff value for the diagnosis of ambulatory hypertension at 24-hour ABPM was determined for CBPM and SBPM by calculating the Youden index (IY):

IY = Sensitivity + Specificity - 1.

Diastolic blood pressure (DBP) and systolic blood pressure (SBP) with a high Youden index were considered to be the best cutoff values of the measurement method.

The concordances between SBPM and ABPM and between CBPM and ABPM were analyzed by the diagram of Bland and Altman. The mean of the differences (bias) between the measurements, with the standard deviation and 95% CI, as well as the 95% agreement limits, were evaluated.

The correlations between the measurements were determined by the Pearson correlation coefficient.

A probability <0.05 was considered significant for all comparisons.

## RESULTS

Thirteen patients were hypertensive on CBPM, 11 on SBPM, and 13 on 24-hour ABPM (*Table II*).

Table III shows the average BP values.

The AUC of SBP for detecting a 24-hour ambulatory SBP ≥130 mmHg was 0.933 (95% CI [0.813-1.000]) and 0.900 (95% CI [0.752-1.000]) for SBPM and CBPM, respectively, without a statistically significant difference (95% CI [-0.094-0.027], p = 0.28). The AUC of DBP for detecting a 24-hour DBP ≥ 80 mmHg in an outpatient setting was 0.917 (95% CI [0.753-1.000]) for

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SBPM and 0.858 (95% CI [0.638-1.000]) for CBPM (*Figure 2*), without a statistically significant difference (95% CI [-0.057-0.057], p = 1).

*Table II. Distribution of the 13 hypertensive patients with 24-hour ABPM according to the severity of the hypertension.*

| HBP severity | Number | Proportion (%) |
|---|---|---|
| Severe HBP | 2 | 15.38 |
| Moderate HBP | 5 | 38.46 |
| Light HBP | 6 | 46.15 |
| Total | 13 | 100 |

*Table III. Means of SBP and DBP according to the type of blood pressure (BP) measurement in the 17 patients included in the study. SD = standard deviation; ABPM = ambulatory BP measurement; SBPM = sequential measurement of BP; CBPM = conventional BP measurement.*

| Type of measurement | Mean SBP ± SD (mmHg) | Mean DBP ± SD (mmHg) |
|---|---|---|
| ABPM (24h) | 137.41 ± 19.62 | 87.53 ± 15.04 |
| ABPM (nocturnal) | 135.24 ± 23.50 | 84.47 ± 18.54 |
| ABPM (diurnal) | 138.00 ± 18.61 | 88.06 ± 14.42 |
| SBPM | 143.65 ± 21.25 | 91.88 ± 15.03 |
| CBPM | 149.06 ± 24.74 | 91.47 ± 17.94 |

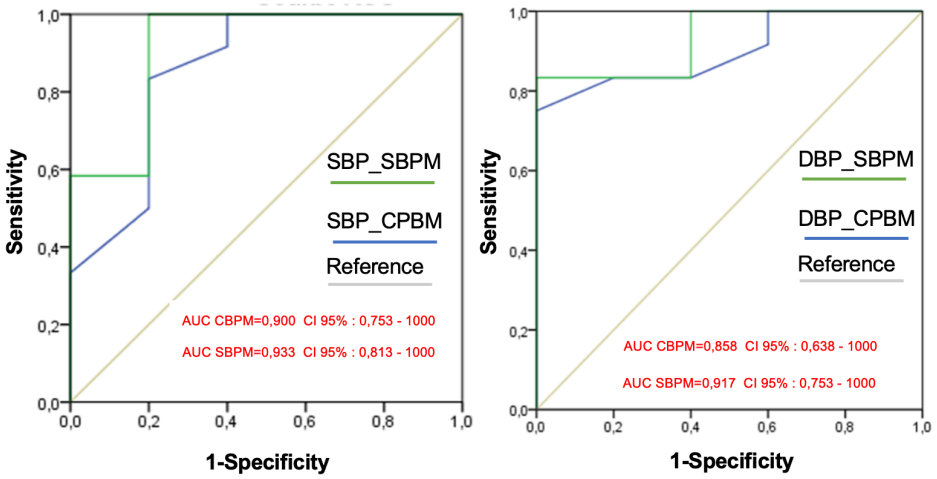


*Figure 2: ROC curve of arterial pressure at CBPM (blue curve) and SBPM (green curve). (A) ROC curve of SBP in SBPM and CBPM. (B) ROC curve of DBPs in SBPM and CBPM.*

The optimal diagnostic thresholds for SBP at CBPM and SBPM were 139.5 mmHg and 136.5 mmHg, respectively. For DBP, the optimal cutoffs for CBPM and SBPM were 82.5 mmHg and 82.5 mmHg, respectively (Table IV).

*Table IV. Blood pressure threshold for the diagnosis of ambulatory hypertension in conventional (CBPM) and sequential measurement of blood pressure (SBPM). SBP: systolic blood pressure; DBP: diastolic blood pressure; RV: likelihood ratio; NA: not applicable.*

| Parameters | CBPM | | CBPM | |
|---|---|---|---|---|
| | SBP | DBP | SBP | DBP |
| Optimal BP threshold (mmHg) | 139.5 | 82.5 | 136.5 | 82.5 |
| Sensibility (%) | 83.0 | 83.0 | 83.0 | 100 |
| Specificity (%) | 80.0 | 80.0 | 100.0 | 80.0 |
| Youden index | 0.63 | 0.63 | 0.83 | 0.80 |
| RV positive | 4.15 | 4.15 | NA | 5 |
| RV negative | 0.21 | 0.21 | 0.17 | 0 |

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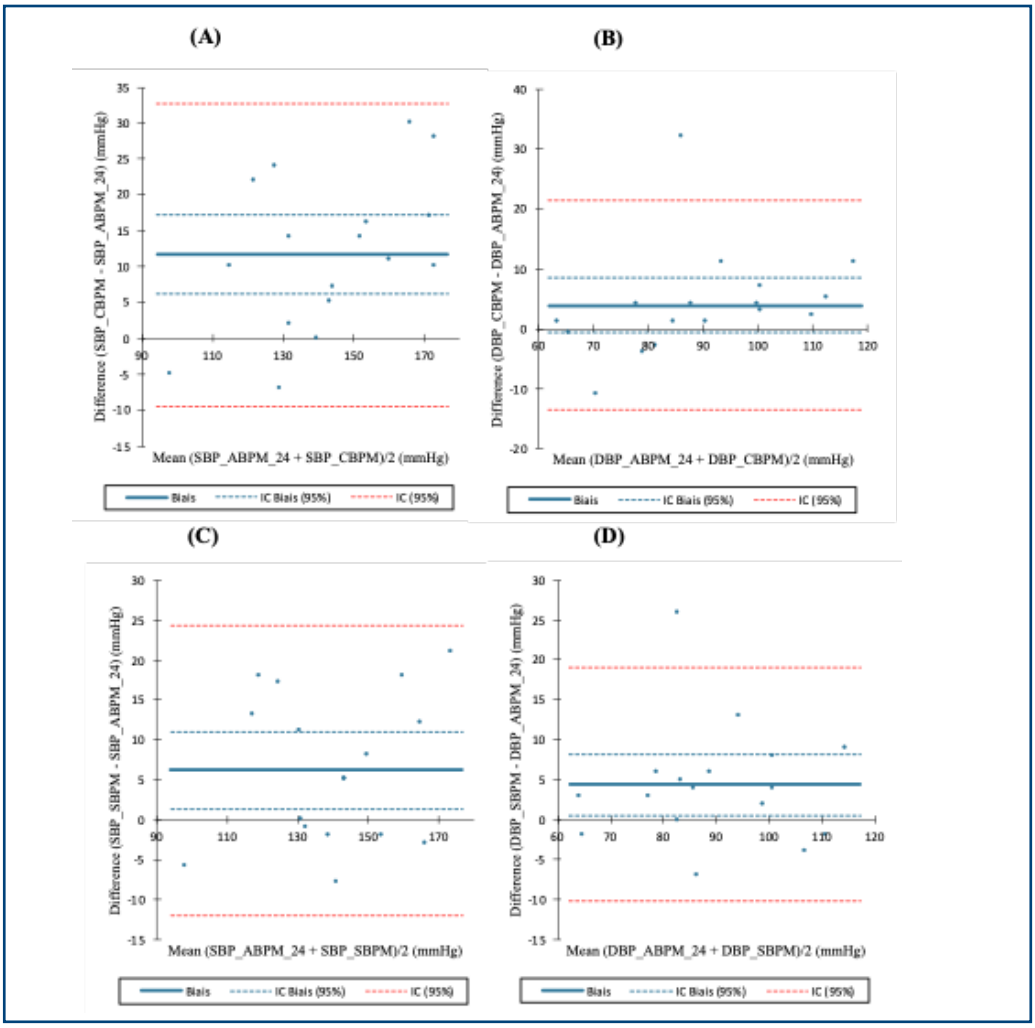
The agreement of CBPM and SBPM with respect to ABPM is shown in Figure 3.
The difference between the DBPs in CBPM and ABPM was not significant (3.9 ± 8.97; 95% IC [-0.67-8.55]) (Figure 3B).




⬆ *Fig. 3 : Agreement of sequential and conventional BP measurements compared with ABPM (Bland and Altman graph). (A) Agreement of SAP measurements in CBPM. (B) Agreement of DBP measurements in CBPM. (C) Agreement of SAP measurements in SBPM. (D) Agreement of DBP measurements in SBPM. IC interval confidence.*

Pearson's linear correlation between CBPM and ABPM was positive for SBP (r = 0.3) and DBP (r = 0.5). The correlation between SBPM and ABPM was positive for SBP (r = 0.2) and negative for DBP (r = -0.0007) (Figure 4).

Only the correlation of DBP with CBPM and ABPM (*Figure 4B*) was statistically significant (95% CI [-0.008-0.794]).

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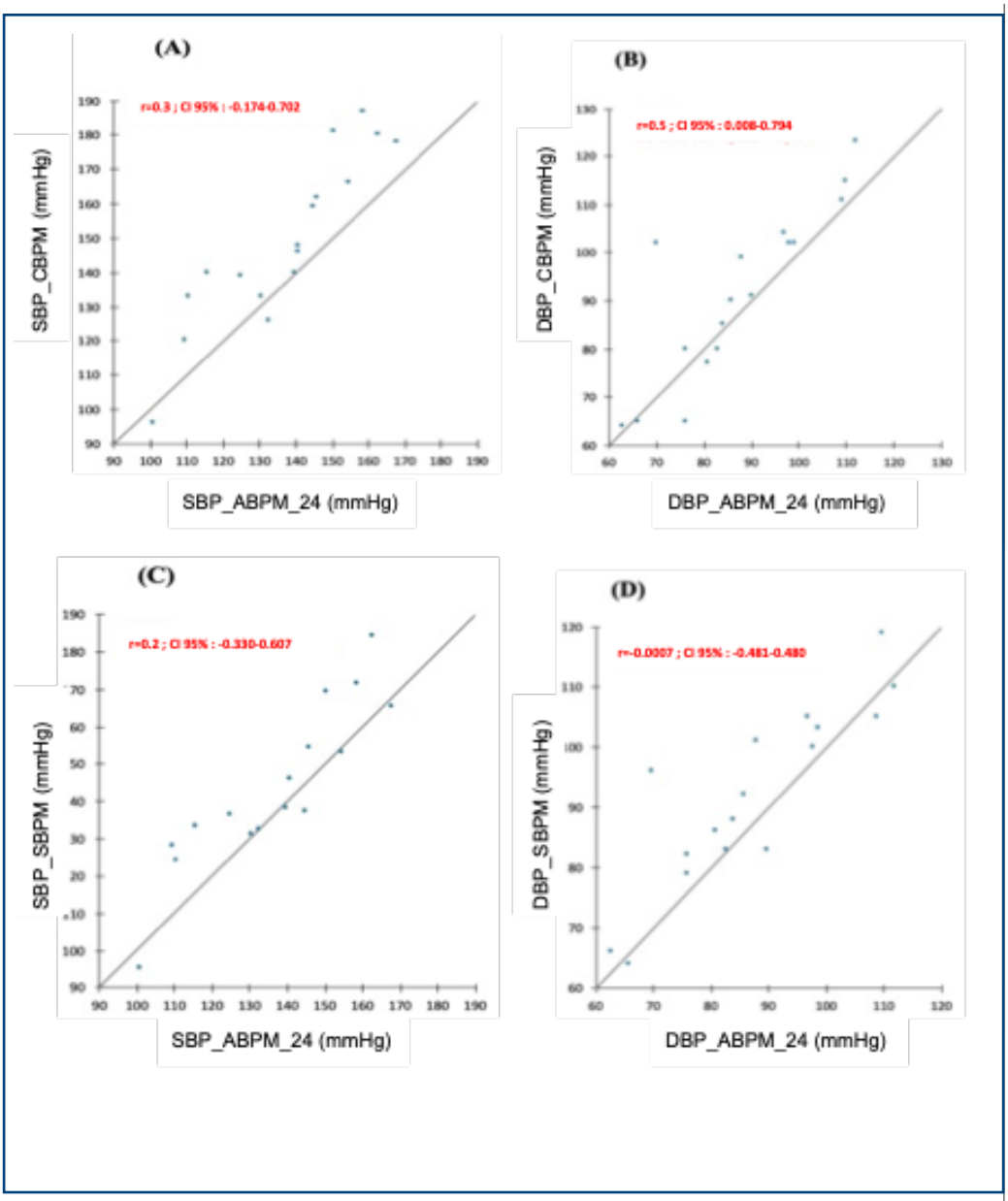


*Fig. 4 :Linear correlation between peritoneal dialysis measurements (SBPM and CBPM) and outpatient measurements. (A) Correlation between CBPM and ABPM in the measurement of SAP. (B) Correlation between CBPM and ABPM in the measurement of DBP. (C) Correlation between SBPM and ABPM in the measurement of SBP. (D) Correlation between SBPM and ABPM in the measurement of DBP.*

## DISCUSSION

BP measurement with CBPM and SBPM had a very good performance for the detection of systolic hypertension with an AUC of 0.900 and 0.933, respectively. CBPM performed well for the detection of diastolic hypertension with an AUC of 0.858, and SBPM performed very well with an AUC of 0.917. There was no statistical difference between the performance of SBPM and CBPM. These results are similar to those of Vaios et al. [7], who reported good reliability of the BP measurement in the office with an AUC of 0.859 and 0.958 for the detection of systolic and diastolic hypertension, respectively, and that this performance was similar to BP measurement at

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home. This result is important to consider in our context where ABPM and home self-measurement are not accessible to patients. By respecting the validity criteria of the measurement in the office, the SBPM maintains a very good performance in diagnosing and monitoring hypertension.

The optimal threshold is currently 140/90 mmHg [1]. At this threshold, the 2 measurements in the cabinet performed poorly. In this study, the optimal threshold for detecting 24-hour ABPM hypertension was 139.5/82.5 for CBPM with a Youden index of 0.63 for SBP and DBP. This threshold was 136.5/82.5 for SBPM with a Youden index of 0.83 for SBP and 0.80 for DBP. These results are similar to those of Vaios et al. [7], who reported an optimal threshold of 139 mmHg for the detection of systolic hypertension corresponding to a Youden index of 0.61.

On Bland and Altman's analysis, SBPM and CBPM overestimated the 24-hour ambulatory SBP by 6.2 ± 9.3 and 11.6 ± 10.7 mmHg, respectively, and DBP by 4.35 ± 7.5 and 3.9 ± 8.97 mmHg. However, both methods had broad agreement limits compared with the reference method. In a 2013 study of 17 PD patients, O'Shaughnessy et al. [8] explored the agreement between office BP, automated unattended office BP (BpTRU), and home BP with daytime ABPM. Measurements at the office and at the BpTRU underestimated the diurnal SBP in ABPM by 3.4 and 6.1 mmHg, respectively, but these differences were not statistically significant.

Patient isolation could explain why SBPM overestimated SBP less than CBPM, thus reducing the risk of white coat hypertension. This hypothesis is supported by a 2019 meta-analysis of 31 diagnostic test studies integrating data from 9,279 patients. The meta-analysis showed that the mean difference between SBP in an unattended automated office and daytime ambulatory SBP was only 0.3 mmHg (95% CI [-1.1-1.7]) [9].

There was a positive correlation between CBPM and ABPM with a Pearson's r of 0.5 and 0.3 for SBP and DBP. SBPM correlated positively with ABPM for SBP with a Pearson's r of 0.2 and correlated with ABPM with an almost zero correlation for DBP with a Pearson's r of -0.0007.

These results are similar to those of O'Shaughnessy et al. [8], who reported a positive correlation between SBP at office measurement and diurnal SBP at ABPM with a Pearson's r of 0.45 and a positive correlation between SBP at BpTRU and diurnal SBP at ABPM with a Pearson's r of 0.49.

For PD patients, the international society of peritoneal dialysis (ISPD) recommends home BP recording at least once a week and at each visit to the PD unit [10,11]. According to the results of the present study, SBPM may be a good alternative to ABPM and self-monitoring, which are not always accessible in our practice setting. However, ABPM should always be performed in patients with suspected masked or white coat hypertension.
Overall, SBPM has shown better results than CBPM. In our practice context, it is the most suitable BP measurement method. This diagnostic performance could certainly be improved with a better understanding of the procedure by the patients but also by repeating the study on a larger cohort of patients. Indeed, this study has limitations. The sample is small compared with the number of subjects needed, which was 173 patients.

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## CONCLUSION

CBPM and SBPM performed very well in the diagnosis of ambulatory systolic hypertension without a significant difference between both methods. The diagnostic performance of ambulatory diastolic hypertension measurement by SBPM and CBPM was very good and good, respectively. The optimal threshold for the diagnosis of hypertension was 139.5/82.5 for CBPM and 136.5/82.5 for SBPM.

## FINANCIAL SUPPORT

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## CONFLICTS OF INTEREST

*The authors declare no conflicts of interest in connection with this work.*

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