Brazilian Journal of TRANSPLANTATION

ORIGINAL PAPER

Ambulatory Blood Pressure Monitoring in the Diagnosis and Management of Hypertension after Renal Transplantation

Fernando José Villar Nogueira Paes[1,2], Francisco Daniel Alves Albuquerque[3,*], Valdimir Ferreira Maciel[3], José Sebastião de Abreu[4], Silvana Daher da Costa[1], Ronaldo de Matos Esmeraldo[1], Tainá Veras de Sandes-Freitas[1,2,3]

1.Hospital Geral de Fortaleza – Setor de Transplantes – Fortaleza/CE, Brasil.

2.Universidade Estadual do Ceará – Mestrado Profissional em Transplantes – Fortaleza/CE, Brasil.

3.Universidade Federal do Ceará – Faculdade de Medicina – Departamento de Medicina Clínica – Fortaleza/CE, Brasil.

4.Universidade Estadual do Ceará – Programa de Pós-Graduação em Biotecnologia – Fortaleza/CE, Brasil.

https://doi.org/10.53855/bjt.v25i4.487_IN

Correspondence author:
danielldp2011@gmail.com

Section Editor:
Ilka de Fátima Santana Ferreira Boin

Received:
Oct. 19, 2022

Approved:
Nov. 24, 2022

Conflict of interest
Nothing to declare.

How to Cite:
Albuquerque FDA, Paes FJVN, Albuquerque FDA, Maciel VF, Abreu JS, Costa SD, Esmeraldo RM, Sandes-Freitas TV. Ambulatory Blood Pressure Monitoring in the Diagnosis and Management of Hypertension after Renal Transplantation. BJT. 2022.25(04):e0822. https://doi.org/10.53855/bjt.v25i4.487_IN

eISSN
2764-1589

ABSTRACT

Objective: To evaluate the behavior of blood pressure (BP) to ambulatory blood pressure monitoring (ABPM) in stable renal transplant recipients (LTx), comparing their findings with manual measurements. **Method:** Cross-sectional study including 44 recipients of LTx from quaternary public hospital, with stable renal function, between the 3th and 6th months after LTx. Agreement analyses between conventional measurement and ABPM were performed considering two limits of normality: limits I: ambulatory BP < 130/80 mmHg and mean total ABPM < 125/75 mmHg; limits II: ambulatory BP < 140/90 mmHg and mean total ABPM < 130/80 mmHg. **Results:** There was a predominance of men (54.5%) with a mean age of 44 years, taking antihypertensives (75%). The prevalence of *masked* systemic arterial hypertension (SAH) considering the limits I was 15.9% when compared to the closest measurement to the ABPM, and 31.8% when compared to the average of the three measurements prior to the ABPM. Considering the limits II, *masked SAH* occurred in 22.7% when compared with the closest measurement to the ABPM and in 38.6% when the average of the measurements was used. Nocturnal descent impairment occurred in 40 (90.9%) patients. Considering ABPM as the gold standard, the accuracy of manual gauging closest to monitoring was 72.7% for limits I. When considering the average of the measurements, the accuracy was 56.8% for the same limits. The accuracy according to the limits II was 68.2% and 54.6% for the closest measurement to the ABPM and for the average of the measurements, respectively. There was poor diagnostic agreement between ABPM and ambulatory measures (Kappa = 0.095 to 0.374). The linear coefficient (R) values for systolic pressures were 0.609 and 0.671 for the first measurement closest to the MAP and for the average of the measurements, respectively. These coefficients for diastolic pressures were 0.521 and 0.454, respectively. **Conclusion:** There was low agreement between manual measurements and ABPM, especially for diastolic BP. Most patients had an altered nocturnal descent. These data indicate the usefulness of ABPM in addressing hypertension in this population, as well as providing additional information regarding the circadian behavior of BP.

Descriptors: Blood Pressure; Kidney Transplantation; Chronic Renal Insufficiency.

INTRODUCTION

Systemic arterial hypertension (SAH) is a worldwide public health problem, with increasing impact on cardiovascular morbidity and mortality with advancing age groups in the population. Chronic kidney disease (CKD) and SAH are closely related, one being the cause of the other, and their concomitance a multiplier of cardiovascular risk.[1]

Traditionally, the diagnosis and follow-up of hypertensive disease is based on ambulatory blood pressure (BP) measurements. Ambulatory blood pressure monitoring (ABPM) has brought to the management of the hypertensive patient greater accuracy in diagnosis and better assessment of cardiovascular and renal prognosis.[2,3]

Evidence points to the relevance of ABPM in the management of hypertension in the general population and in renal transplant recipients (LTx).[3–5] In transplant recipients, a high prevalence of *masked hypertension* and changes in nocturnal descent and nocturnal hypertension has been demonstrated.[6] Despite this, ABPM has not been routinely used in most transplant centers around the world. Furthermore, there is no robust evidence to indicate in which group of patients ABPM should be prioritized.

This study will analyze the profile of hypertensive disease in stable LTx recipients in order to evaluate the benefit of implementing ABPM in the post-transplant care protocol.

MATERIAL AND METHODS

Design and sample

Cross-sectional study involving recipients of LTx from a single center belonging to a quaternary hospital located in Fortaleza, Ceará, Brazil. The study population consisted of adult renal transplant recipients with a transplant period of between three and six months, a period in which renal function is usually stable, with little or no manipulation of immunosuppression, but still under monthly outpatient follow-up. Data were collected from June 2017 to July 2018. According to the inclusion criteria, patients who met the following criteria were eligible:

- Recipients of LTx with a living or deceased donor who are older than 18 years and younger than 70 years of age;
- Be between the third and sixth month after LTx;
- Glomerular filtration rate (GFR) estimated by the CKD-EPI formula greater than 30 mL/min/1.73 m^2.

The exclusion criteria were:

- Cognitive deficit that could compromise the quality of the ABPM;
- Presence of diseases or conditions in the upper limbs that could make BP measurements impossible, such as: severe peripheral vascular disease compromising the auscultatory method of BP measurement, amputation of the upper limbs, presence of active arteriovenous fistula in both limbs or in a single limb, severe skin lesions in both limbs or in a single upper limb;
- Multiple organ transplant recipients;
- Brachial diameter in which no suitable cuff is available;
- Patients who, after two attempts at ABPM, have recorded less than 16 BP measurements in 24 hours or less than four measurements during the night. The most recent guideline was used at the time of project preparation.[7]

The convenience sample was estimated at 50 patients, based on the number of kidney transplantations performed in the service within a year, the proposed selection criteria, the high percentage of patients living in other municipalities or states, and the ability of the service's ABPM sector to perform the tests. There was no sample size calculation.

Immunosuppression protocol of the Center

The center's standard immunosuppressive regimen at the time of the study consisted of induction with antithymocyte globulin (4.5–6.0 mg/kg) and maintenance with tacrolimus (target: 3–5 ng/mL) and everolimus (target: 4–8 ng/mL). Except for patients at high immunological risk and those with other clinical indications (such as glomerulopathies and autoimmune diseases), the maintenance regimen was steroid-free from the start. Patients with contraindications for mTOR inhibitors (severe dyslipidemia and primary segmental and focal glomerulosclerosis) received mycophenolate sodium 1,440 mg/day.

Ethical aspects

The study was developed based on the legal and ethical principles involving research with human beings, established in Resolution No. 466/2012 of the National Health Council, of the Brazilian Ministry of Health, and was submitted to the Ethics Committee for Research in Human Beings of the Hospital Geral de Fortaleza (CAAE 68449817.9.0000.5040). The study procedures began only after the Informed Consent Form was obtained.

ABPM's execution and report

The tests were performed at the service's Hypertension Outpatient Clinic. The monitor used was from the manufacturer Cardios models Dyna-MAPA or Dyna-MAPA-Plus (ANVISA/MS Registration: 10361050010). The guidance on proper clothing during monitoring, as well as care to avoid damage to the equipment, was provided by the nursing staff at the Hypertension Outpatient Clinic. The monitor was fed with patient data and programmed with standard protocol used by the ABPM service. Measurements

were scheduled every 15 minutes during wakefulness and every 30 minutes during sleep. The day after the end of the monitoring period, the monitor's records were transferred and analyzed for the preparation of the MAPA report.

The reports were issued by the hospital's Hypertension Service team and made available to the patient's attending physician at the post-transplant clinic.

The file with the measurement records was used by the researcher to collect data about the patient's BP behavior. The following data were collected from these recordings: number of total measurements; number of measurements in the night period; 24-hour, wakefulness, and sleep period blood pressure averages, and the values for the nightly decline.

Ambulatory measurements

The measurements were performed by the nursing staff in a similar way to the measurements performed on the other transplant patients being followed up in the outpatient clinic. Aneroid device was used with auscultatory technique with patient always sitting in the same chair with the sphygmomanometer at fixed height. Some measurements were taken with semiautomatic oscillometric sphygmomanometers.

The last manual ambulatory measurement closest to the performance of ABPM and the average of the last three manual measurements recorded in the ambulatory follow-up form before the performance of ABPM were considered. If three previous ambulatory measurements were not possible, one measurement on a date close to the date of the ABPM was considered, as long as there was no change in conduct in view of the findings. The last three measurements were used for the hypothetical purpose that their average would have more correlation with the gold standard.

Statistical analysis

Quantitative variables were expressed as means and standard deviation. The medians were presented when the standard deviation exceeded the mean. Categorical variables were expressed as frequencies and percentages. Distribution analysis of the variables was done using the Shapiro–Wilk and Kolmogorov–Smirnov tests. The numerical variables were correlated with Spearman's rho and Pearson's R correlation coefficients, depending on normality. Cohen's Kappa test was used to measure agreement between categorical variables. The manual measurements and the mean total BP on ABPM were analyzed in two-by-two tables. The mean total BP at MAP was determined as the gold standard at two normal limits. Limit I was the mean total BP less than 125/75 mmHg, and limit II was the mean total BP less than 130/80 mmHg. The normality limits of the manual measurements were 130/80 and 140/90 mmHg for limits I and II, respectively.

Manual BP was assessed by the average of the last three ambulatory measurements and the measurement closest to the performance of the ABPM. The tests were considered significant when the p-value was less than 5%. The software used was SPSS 24 and 25 (SPSS Inc. Chicago, IL, USA).

RESULTS

Sample description

During the study period, 117 LTx were performed at the service. Of these, 98 were eligible. Of the eligible, 33 refused to participate in the study. Among the 65 eligible patients who signed the informed consent form, 17 were unable to undergo the test, and 4 had an ABPM, but the technical quality was inadequate. Thus, 44 patients were analyzed in this study.

The included patients were predominantly male (54.5%), brown (79.5%), with a mean age of 44 (SD = 12.1) years (21 to 67 years), with a body mass index of 23.4 (SD = 3.6) kg/m^2, ranging from 15.74 to 29.8 kg/m^2. Twenty-five (56.8%) patients had undetermined etiology of CKD, in none the hypertensive nephrosclerosis was unequivocal, and in 15.9% the etiology was diabetic nephropathy. Patients spent an average of 62.1 (SD = 68.3) months on dialysis before transplantation (median 37 months), 2 (4.5%) were retransplants, and 42 (96.6%) received a deceased donor transplant. At the time of ABPM, patients were 135.5 (SD = 29.5) days post-transplant (93 to 191), receiving as their main immunosuppressive regimen the combination of tacrolimus and a mTOR inhibitor (79.5%), no steroids (61.4%), and baseline estimated GFR was 65.4 (SD = 19.7) mL/min/1.73 m^2 (Table 1).

Thirty-three (75%) patients were taking antihypertensives at the time of the ABPM, and 22 (50%) were using two or more classes of therapy. The most used classes of antihypertensives were calcium channel blockers (52.3%), beta blockers (45.5%), centrally acting sympatholytics (20.5%), and direct acting vasodilators (13.6%).

Table 1. Demographic characteristics of the sample.

Variable	N (%); total = 44
Age (years)	44 (12.1)
Sex – male	24 (54.5)
BMI (kg/m^2)	23.4 (3.6)
BMI by category:	
Low weight (< 18.5 kg/m^2)	3 (6.8)
Normal weight (18.5–24.9 kg/m^2)	24 (54.5)
Overweight (25.0–29.9 kg/m^2)	38.6 (32)
Race	
Brown	35 (79.5)
Caucasian	4 (9.1)
Black	5 (11.4)
CKD etiology	
Undetermined	25 (56.8)
Diabetic nephropathy	7 (15.9)
Focal segmental glomerulosclerosis	2 (4.5)
Polycystic disease	3 (6.8)
Urinary lithiasis	1 (2.3)
Urinary tract malformation	1 (2.3)
Other familial nephropathies	1 (2.3)
Other glomerulopathies	4 (9.1)
Time on dialysis (months)	62.1 (68.3) (median = 37)
Donor type – deceased	42 (96.6)
Retransplantation	2 (4.5)
Transplantation time (days)	135.5 (29.5)
Immunosuppression	
TAC + mTORi	35 (79.5)
TAC + MPS	8 (18.2)
TAC + MPS + mTORi	1 (2.3)
Immunosuppression with corticoids	17 (38.6)
Estimated GFR (mL/min/1.73 m^2)	65.4 (19.7)

BMI: body mass index; CKD: chronic kidney disease; TAC: tacrolimus; mTORi: mammalian target of rapamycin inhibitor; MPS: mycophenolate sodium; GFR: glomerular filtration rate. Numerical variables expressed as means (standard deviation). Median presented when standard deviation is greater than the mean. Categorical variables presented as frequencies and percentages.

Descriptive evaluation of ABPMs

ABPMs were of satisfactory quality. The total number of measurements per examination was 80.1 (SD = 4.6) with 91.1% (SD = 12.8%) valid measurements. Thirty-four (77.3%) patients had above 90% valid measurements.

The mean total systolic BP on ABPM was 121.9 (SD = 12.8) mmHg and the mean total diastolic BP was 79.7 (SD = 9.2) mmHg. Based on the limits established by the *V Brazilian Guideline of ABPM*, only 11 (25%) individuals in the sample had normal BP behavior, 7 (15.9%) had borderline behavior, and 26 (59.1%) had abnormal BP behavior. Thirty-five (79.5%) subjects showed nocturnal hypertension, 40 (90.9%) some impairment of nocturnal descent, with 20 (45.5%) of these showing reversal of the sleep-wake cycle (Table 2).

Table 2. ABPMs results.

Variable	N (%); total = 44
Total systolic BP (mmHg)	121.9 (12.8)
Total diastolic BP (mmHg)	79.7 (9.2)
BP behavior*	
Normal (mean BP 24 h < 125/75 mmHg)	11 (25)
Borderline (average BP 24 h 125/75 to 129/79 mmHg)	7 (15.9)
Abnormal (mean BP 24 h ≥ 130/80 mmHg)	26 (59.1)
Systolic BP in sleep (mmHg)	121 (14.9)
Diastolic BP in sleep (mmHg)	79.5 (9.0)
Nocturnal hypertension (mean BP ≥ 120/70 mmHg)	35 (79.5)
Nocturnal systolic dip (mmHg)	0.5 (7.2) (median = 1.0) (–13 –19)
Nocturnal diastolic dip (mmHg)	3.1 (9.8) (median = 3.0) (–18 –24)
Nocturnal drop ranking	
Normal	4 (9.1)
Abnormal	40 (90.9)
SW cycle inversion	20 (45.5)

BP: blood pressure; ABPM: ambulatory blood pressure monitoring; SW: sleep/wakefulness. *BP behaviors to ABPM according to the *V Brazilian ABPM Guideline*.

The sample categorized by limits I and II showed normal BP behavior in 25% and 40.9%, respectively. For limit I, 3 (6.8%) patients were considered normotensive; and for limit II, 6 (13.6%) patients. Controlled SAH was found in 8 (18.2%) patients for limit I and in 12 (27.3%) patients for limit II. Most individuals had abnormal BP behavior on ABPM, 32 (75%) for limit I and 26 (59.1%) for limit II. Table 3 details the diagnosis on ABPM considering the presence of drug therapy for hypertension at the time of the examination.

Table 3. Diagnosis to ABPM.

	Limit I (total average BP < 125/75 mmHg (n = 44) (%)	Limit II (Total average BP < 130/80 mmHg (n = 44) (%)
Normotensive	3 (6.8)	6 (13.6)
Controlled SAH	8 (18.2)	12 (27.3)
Normal behavior (total)	12 (25.0)	18 (40.9)
Untreated SAH	8 (18.2)	5 (11.4)
Uncontrolled SAH	25 (56.8)	21 (47.7)
Abnormal behavior (total)	32 (75.0)	26 (59.1)

SAH: systemic arterial hypertension; BP: blood pressure. Variables presented as frequencies and percentages.

Descriptive evaluation of manual BP measurements at the outpatient clinic

The mean systolic and diastolic BP of the three manual measurements prior to the ABPM were 125.4 (SD = 14.0) mmHg and 76.4 (SD = 8.2) mmHg, respectively. Considering the most stringent control target (limit I), 20 (45.5%) individuals showed normal BP behavior. Considering the least stringent target (limit II), 32 (72.7%) individuals showed normal BP behavior (Table 4).

Table 4. BP behavior assessed by the average of the last three manual ambulatory measurements.

Variable	N (%); total = 44
Systolic BP (mmHg)	125.4 (14.0)
Diastolic BP (mmHg)	76.4 (8.2)
BP behavior – Limit I	
Normal BP	20 (45.5)
Abnormal BP	24 (54.5)
BP behavior – Limit II	
Normal BP	32 (72.7)
Abnormal BP	12 (27.3)
Changing antihypertensive therapy between measurements	9 (20.5)

BP: blood pressure.

Accuracy of ambulatory BP measurements according to ABPM findings

The findings of the ABPM showed low accuracy of the manual measurements, regardless of whether more or less stringent BP limits were used. Tables 5 and 6 detail the diagnoses on ABPM, correlating them with manual ambulatory BP measurements.

Table 5. Correlation between ABPM and the average of the last three manual ambulatory BP measurements.

	Limits I ABPM < 125/75 mmHg Outpatient < 130/80 mmHg	Limits II ABPM < 130/80 mmHg Outpatient < 140/90 mmHg
Diagnosis		
True normal	6 (13.6)	15 (34.1)
True abnormal	19 (43.2)	9 (20.5)
White coat	5 (11.4)	3 (6.8)
Masked hypertension	14 (31.8)	17 (38.6)
Abnormal BP behavior (%)	75	59.1
Efficiency of manual ambulatory BP measurements in detecting SAH		
Sensitivity (%)	57.6	34.6
Specificity (%)	54.5	83.3
PPV (%)	79.2	75
NPV (%)	30.0	46.9
Positive likelihood ratio	1.27	2.08
Negative odds ratio	0.78	0.78
Accuracy (%)	56.8	54.6
Kappa agreement measure	0.095 (p = 0.484)	0.160 (p = 0.189)

BP: blood pressure; PPV: positive predictive value; NPV: negative predictive value. Positive likelihood ratio: > 10 (optimal accuracy); 5–10 (moderate accuracy); 2–5 (small accuracy); 1–2 (zero accuracy). Negative odds ratio: < 0.1 (optimal accuracy); 0.1–0.2 (moderate accuracy); 0.2–0.5 (small accuracy); 0.5–1.0 (zero accuracy).

Table 6. Correlation between ABPM and the 1st BP measurement closest to the date of the ABPM.

	Limits I ABPM < 125/75 mmHg Outpatient < 130/80 mmHg	Limits II ABPM < 130/80 mmHg Outpatient < 140/90 mmHg
Diagnosis		
True normal	6 (13.6)	14 (31.8)
True abnormal	26 (59.1)	16 (36.4)
White coat	5 (11.4)	4 (9.1)
Masked hypertension	7 (15.9)	10 (22.7)
Abnormal BP behavior (%)	75	59.1
Efficiency of manual ambulatory BP measurements in detecting SAH		
Sensitivity (%)	78.8	61.5
Specificity (%)	54.5	77.8
PPV (%)	83.9	80.0
NPV (%)	46.2	58.3
Positive likelihood ratio	1.73	2.77
Negative odds ratio	0.39	0.49
Accuracy (%)	72.7	68.2
Kappa agreement measure	0.314 (p = 0.36)	0.374 (p = 0.01)

BP: blood pressure; PPV: positive predictive value; NPV: negative predictive value. Positive likelihood ratio: > 10 (optimal accuracy); 5–10 (moderate accuracy); 2–5 (small accuracy); 1–2 (zero accuracy). Negative odds ratio: < 0.1 (optimal accuracy); 0.1–0.2 (moderate accuracy); 0.2–0.5 (small accuracy); 0.5–1.0 (zero accuracy).

Figures. 1 and 2 illustrate the diagnosis of the ambulatory BP measurement (last and the average of the three) according to the result of the ABPM and the limit used.

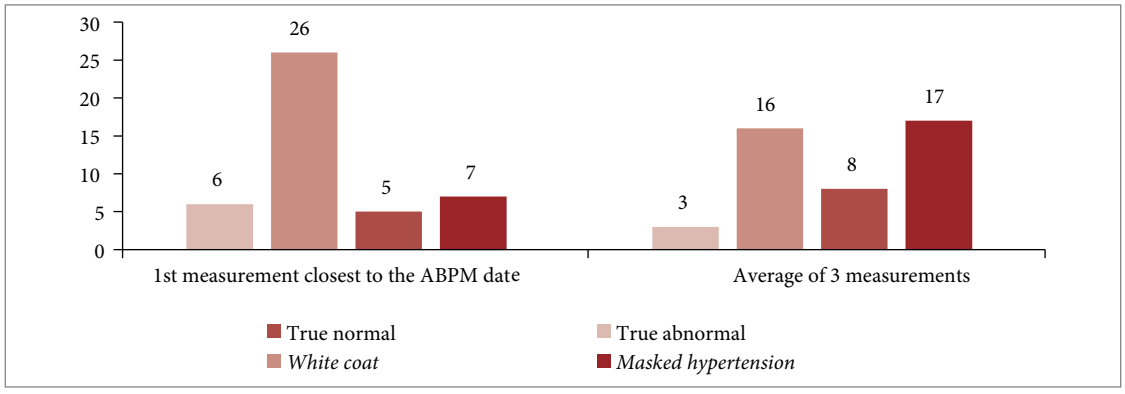

Figure 1. Diagnosis of ambulatory BP measurement (the closest measurement to the ABPM and the average of the three measurements) according to the result of the ABPM using limits I as reference.

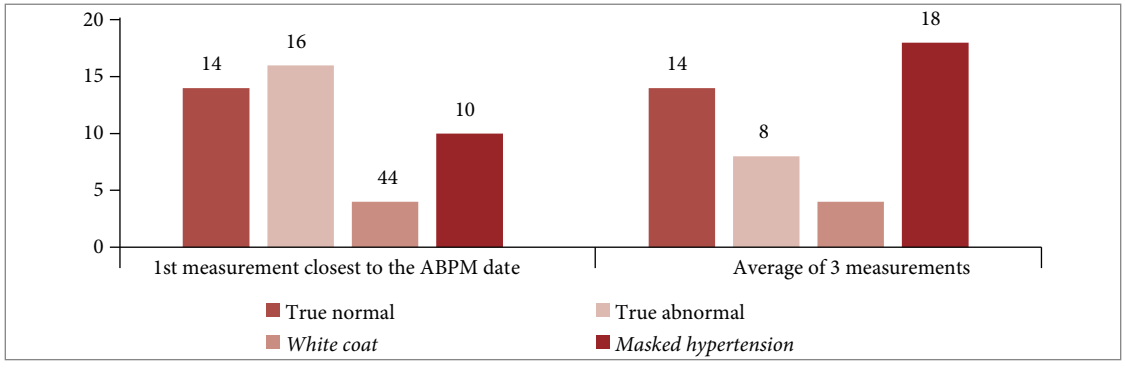

Figure 2. Diagnosis of ambulatory BP measurement (the closest measurement to the ABPM and the average of the three measurements according to the result of the ABPM using limits II as reference.

Correlation between the systolic and diastolic pressures obtained in the manual measurements with the mean total systolic and diastolic BPs obtained with ABPM

When comparing the correlation coefficients between the manual measurements and the ABPM, a trend towards better correlation was observed in the measurement closest to the achievement of the ABPM relative to the average of the three measurements. The correlation of systolic pressures was better than the correlation of diastolic pressures. The scatter plots in the Figs. 3-6 illustrate these analyses.

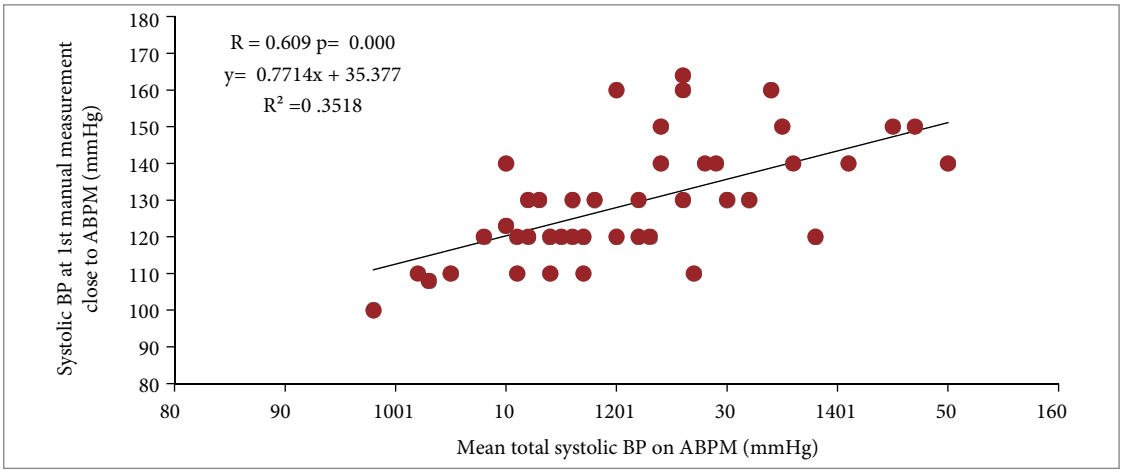

Figure 3. Scatter plot: systolic pressures on ABPM vs. manual systolic pressures (manual measurement closest to performing ABPM).

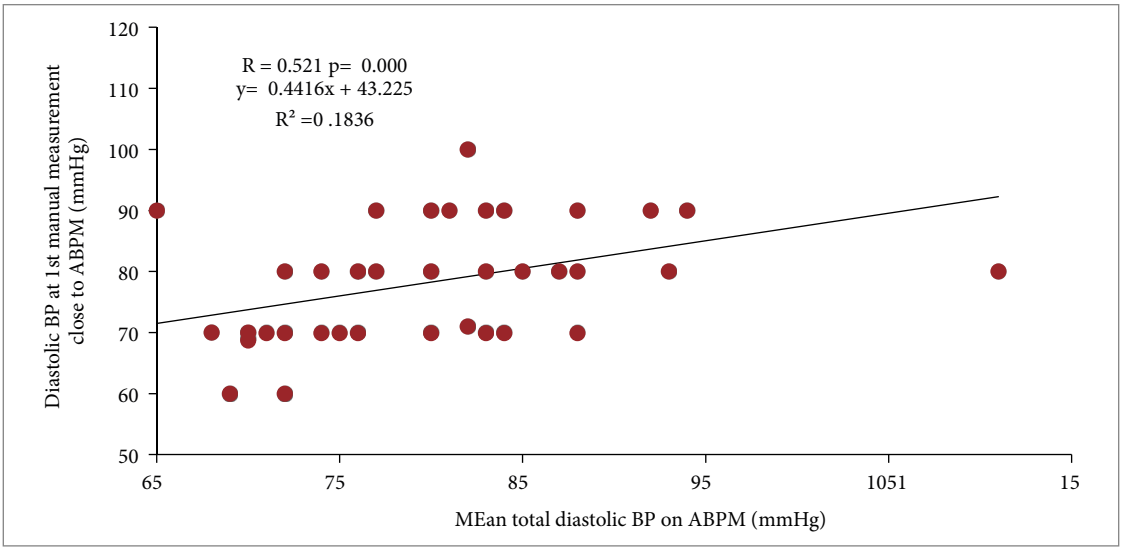

Figure 4. Scatter plot: diastolic pressures on ABPM vs. manual diastolic pressures (manual measurement closest to performing ABPM).

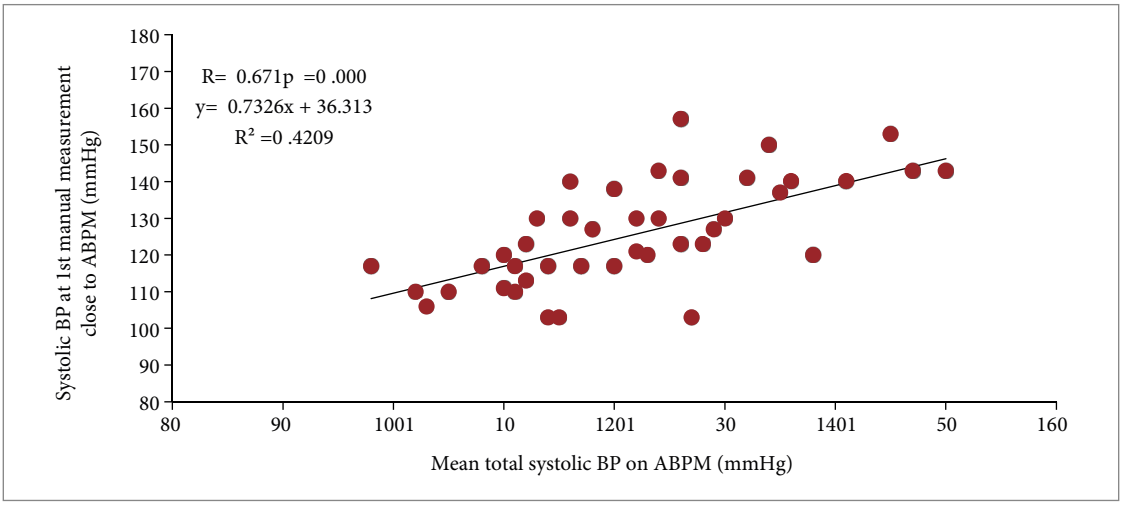

Figure 5. Scatter plot: systolic pressures on ABPM vs. manual systolic pressures (average of the last three manual BP measurements).

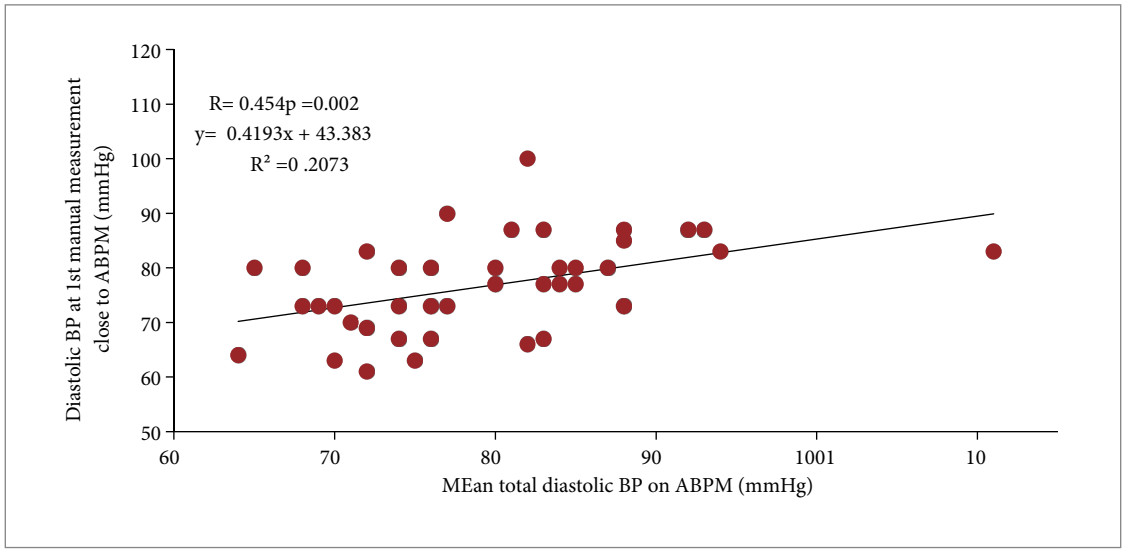

Figure 6. Scatter plot: diastolic pressures on ABPM vs. manual diastolic pressures (average of the last three manual BP measurements).

DISCUSSION

This study demonstrated that there was a high prevalence of abnormal BP behavior in this sample of recent renal transplant patients and that ambulatory BP measurements failed to diagnose such changes, especially due to inaccuracies of diastolic BP measurements, raising the prevalence of *masked SAH*.

The patients included in the study had the usual demographic characteristics of the center: adults around 40 years of age, brown, with CKD of undetermined etiology and a long time on dialysis. It is worth noting that patients with CKD and no clear evidence of hypertensive nephrosclerosis were categorized as indeterminate. This explains the absence of CKD due to SAH and the predominance of CKD of undetermined etiology, with percentages above those usually described in local and national cohorts. Since this bias is difficult to resolve due to the lack of standardization of this variable by chronic renal care services, any analysis of the influence of CKD etiology on blood pressure behavior is impossible.[8]

As expected, 2/3 of the sample was taking some antihypertensive. This number agglomerates previously hypertensive patients and those who became hypertensive after transplantation. Contrary to current guideline recommendations regarding the choice of antihypertensive drugs for CKD patients, a low percentage of patients were on drugs that block the renin-angiotensin-aldosterone system. However, this is in line with routine practices in the management of kidney transplant CKD patients. This is because the use of angiotensin-converting enzyme inhibitors or angiotensin receptor blockers is usually avoided in the early stages of transplantation, until renal function is adequate and stable, the patency of the renal artery is assessed by Doppler ultrasound, and until potassium reaches normal values (hyperkalemia is frequent due to type IV renal tubular acidosis induced by calcineurin inhibitors). In addition, calcium channel blockers are attributed a *renal protective effect*, counterbalancing the afferent arteriole vasoconstriction induced by cyclosporine or tacrolimus.[9–12] In line with major international reports, the technical quality of ABPMs was quite satisfactory, with more than 90% of the tests having a valid measurement rate above 70%.[13]

Considering more aggressive limits for BP control, the prevalence of abnormal behavior on ABPM in this study was significant and higher than that observed in previous studies. In a study of the Italian population, 46% of the patients had abnormal blood pressure behavior.[14] In a Canadian sample, 35% of patients were labeled as hypertensive on ABPM.[15] It should be noted that the comparison between such prevalence is sometimes hampered using different BP normality limits. As an example, the Spanish RETENAL study used 130/85 mmHg as normal limits for the total average of the measurements.[16] In addition, demographic, social, and clinical differences between these populations must be considered.

As for the manual measurements, we chose to use the average of the last three manual ambulatory measurements in order to get as close as possible to the baseline BP value, since BP fluctuations can occur, especially in hospital/ambulatory settings. However, we observed that about 20% of the patients underwent changes in antihypertensive therapy between these measurements. Thus, we chose to analyze also the last measure prior to ABPM (the most contemporary one), which, in fact, had better accuracy. We did not exclude these patients to avoid the bias of removing hypertensive patients from the sample. It is worth noting that,

although we selected stable patients, it is not uncommon to change doses and associations of antihypertensive drug classes in the first year after transplantation.[17]

One of the most relevant findings of our study was the high prevalence of masked SAH, supplanting the finding of *white coat effect*. These results are, however, similar to those reported by a Brazilian study conducted in the general population. That study considered the same normality limits for ambulatory BP and ABPM as were used in our study, and the ambulatory measurements were performed with greater technical rigor than we were able to operationalize. The accuracy of the ambulatory measurements was lower when compared to this study, 45% and 54.8%, for the lowest and highest limits, respectively.[18] Similarly, a New Zealand study in the kidney transplant population, using less stringent limits (limits I) and without standardization of ambulatory measurement techniques, obtained an accuracy of only 39%.[19]

We observed worse correlation between ABPM and manual measurements when assessing diastolic BP. We did not find this precedent in the literature, and one of the reasons is that most of them evaluated only the mean pressure, which, in fact, seems to have a better correlation with cardiovascular outcomes and target organ damage.[20] The lower correlation between diastolic arterial pressures may be related to the technical difficulty at the time of ambulatory BP measurement by the auscultatory method.

This study has limitations, some of which prevent extrapolation of its results to other populations:

- This is a single-center study, which may affect outpatient BP measurements, since each center has a different way of doing it (manual, automatic or semiautomatic; nursing technician, nurse or physician; appropriate place or not, etc.);
- The sample obtained by convenience was small, which may compromise the robustness of the analysis and generalizability of the findings;
- We did not standardize the way to measure BP in the outpatient clinic.);
- The sample, obtained by convenience, was small, which may compromise the robustness of the analysis and the generalization of findings;
- We did not standardize the way to measure BP in the outpatient clinic. Despite being a limitation, our goal was to portray the day-to-day care in the post-transplantation outpatient clinic;
- The time elapsed between the ABPM and the three outpatient measurements was not standardized, being determined by the date of the patient's visit recorded in the outpatient follow-up form; e) patients who had their antihypertensive therapy changed during their follow-up were not excluded. Despite the limitations cited, this is the first study of this nature conducted in our population and using a *real-life* setting.

Considering the findings of this study and the low accuracy of ambulatory measurement in diagnosing BP control disorders, we believe that ABPM has an important role in the diagnosis and management of transplant patients, notably those at high cardiovascular risk (for diagnosis of masked hypertension and true hypertension), patients with suspected hypertension or *white coat effect*, as well as those with suspected episodes of hypotension, autonomic dysfunction, or reports of paroxysmal pressure spikes.

CONCLUSION

The results of this study showed that there is a high prevalence of abnormal BP among LTx stable between the 3rd and 6th month after transplantation. There was a high prevalence of *masked SAH*, and nocturnal dip changes and low prevalence of hypertension or *white coat effect*. Furthermore, the diagnostic agreement between ABPM findings and manual measurements was poor. The correlation between values was lower for diastolic measurements than for systolic measurements. These data alert us to the need to review and standardize manual ambulatory measurements and to the need to use other BP assessment techniques, such as residential BP measurements and ABPM.

AUTHORS' CONTRIBUTION

Substantive scientific and intellectual contributions to the study: Freitas TVS, Albuquerque FDA, Paes FJVN, Abreu JS, Esmeraldo RM, Costa SD and Maciel VF; **Conception and design:** Freitas TVS and Paes FJVN; **Data analysis and interpretation:** Freitas TVS, Paes FJVN and Abreu JS; **Article writing:** Freitas TVS, Albuquerque FDA and Paes FJVN; **Critical review:** Freitas TVS, Albuquerque FDA, Paes FJVN, Abreu JS, Esmeraldo RM, Costa SD and Maciel VF; **Final approval:** Freitas TVS, Albuquerque FDA, Paes FJVN, Abreu JS, Esmeraldo RM, Costa SD and Maciel VF.

AVAILABILITY OF RESEARCH DATA

The data will be available upon request.

FUNDING

Not applicable.

ACKNOWLEDGEMENTS

The authors would like to thank the entire staff of the Hospital Geral de Fortaleza, especially Francisca Dantas Alencar de Lima and Beatriz Melina Alencar de Lima, for their dedicated work in assisting the patients and for their fundamental help in this study.

REFERENCES

1. Sarnak MJ, Levey AS, Schoolwerth AC, Coresh J, Culleton B, Hamm LL et al. Kidney disease as a risk factor for development of cardiovascular disease: A statement from the American Heart Association Councils on kidney in cardiovascular disease, high blood pressure research, clinical cardiology, and epidemiology and prevention. Circulation. 2003;108(17):2154-69. https://doi.org/10.1161/01.CIR.0000095676.90936.80
2. Sega R, Facchetti R, Bombelli M, Cesana G, Corrao G, Grassi G, Mancia G. Prognostic value of ambulatory and home blood pressures compared with office blood pressure in the general population: Follow-up results from the Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study. Circulation. 2005;111(14):1777-83. https://doi.org/10.1161/01.CIR.0000160923.04524.5B
3. Lovibond K, Jowett S, Barton P, Caulfield M, Heneghan C, Hobbs FD et al. Cost-effectiveness of options for the diagnosis of high blood pressure in primary care: A modelling study. Lancet. 2011;378(9798):1219-30. https://doi.org/10.1016/S0140-6736(11)61184-7
4. Gaziano TA. Accurate hypertension diagnosis is key in efficient control. Lancet. 2011;378(9798):1199-200. https://doi.org/10.1016/S0140-6736(11)61299-3
5. Bonafini S, Fava C. Home blood pressure measurements: Advantages and disadvantages compared to office and ambulatory monitoring. Blood Press. 2015;24(6):325-32. https://doi.org/10.3109/08037051.2015.1070599
6. Lee MH, Ko KM, Ahn SW, et al. The impact of kidney transplantation on 24-hour ambulatory blood pressure in end-stage renal disease patients. J Am Soc Hypertens. 2015;9(6):427-34. https://doi.org/10.1016/j.jash.2015.04.001
7. [V Brazilian guidelines for ambulatory monitoring of arterial pressure and III Brazilian guidelines for home monitoring of blood pressure]. J Bras Nefrol. 2011;33(3):365-88. https://doi.org/10.1590/S0101-28002011000300013
8. Marinho AWGB, Penha AP, Silva MT, Galvão TF. Prevalence of chronic renal disease among Brazilian adults: A systematic review. Cad Saúde Colet. 2017;25(3):379-88. https://doi.org/10.1590/1414-462X201700030134
9. Henny FC, Kleinbloesem CH, Moolenaar AJ, Paul LC, Breimer DD, van Es LA. Pharmacokinetics and nephrotoxicity of cyclosporine in renal transplant recipients. Transplantation. 1985;40(3):261-5. https://doi.org/10.1097/00007890-198509000-00008
10. Juurlink DN, Mamdani MM, Lee DS, Kopp A, Austin PC, Laupacis A, Redelmeier DA. Rates of hyperkalemia after publication of the Randomized Aldactone Evaluation Study. N Engl J Med. 2004;351(6):543-51. https://doi.org/10.1056/NEJMoa040135
11. Cross NB, Webster AC, Masson P, O'Connell PJ, Craig JC. Antihypertensive treatment for kidney transplant recipients. Cochrane Database Syst Rev. 2009;2009(3):CD003598. https://doi.org/10.1002/14651858.CD003598.pub2
12. Khosla N, Kalaitzidis R, Bakris GL. The kidney, hypertension, and remaining challenges. Med Clin North Am. 2009;93(3):697-715. https://doi.org/10.1016/j.mcna.2009.02.001
13. Banegas JR, Ruilope LM, de la Sierra A, Vinyoles E, Gorostidi M, de la Cruz JJ et al. Relationship between clinic and ambulatory blood-pressure measurements and mortality. N Engl J Med. 2015;378(16):1509-20. https://doi.org/10.1056/NEJMoa1712231
14. Mallamaci F, D'Arrigo G, Tripepi R, Leonardis D, Porto G, Testa A et al. Office, standardized and 24-h ambulatory blood pressure and renal function loss in renal transplant patients. J Hypertens. 2018;36(1):119-25. https://doi.org/10.1097/HJH.0000000000001530
15. Wen KC, Gourishankar S. Evaluating the utility of ambulatory blood pressure monitoring in kidney transplant recipients. Clin Transplant. 2012;26(5):E465-70. https://doi.org/10.1111/ctr.12009
16. Fernandez Fresnedo G, Franco Esteve A, Gómez Huertas E, Cabello Chaves V, Díz Gómez JM, Osorio Moratalla JM et al. Ambulatory blood pressure monitoring in kidney transplant patients: RETENAL study. Transplant Proc. 2012;44(9):2601-2. https://doi.org/10.1016/j.transproceed.2012.09.037
17. Zucchelli P, Santoro A, Zuccala A. Genesis and control of hypertension in hemodialysis patients. Semin Nephrol. 1988;8(2):163-8.

18. Grezzana GB, Moraes DW, Stein AT, Pellanda LC. Impact of different normality thresholds for 24-hour ABPM at the primary health care level. Arq Bras Cardiol. 2017;108(2):143-8. https://doi.org/10.5935/abc.20160204

19. Ahmed A, Ozorio V, Farrant M, Van Der Merwe W. Ambulatory vs office blood pressure monitoring in renal transplant recipients. J Clin Hypertens (Greenwich). 2015;17(1):46-50. https://doi.org/10.1111/jch.12448

20. Powers BJ, Olsen MK, Smith VA, Woolson RF, Bosworth HB, Oddone EZ. Measuring blood pressure for decision making and quality reporting: Where and how many measures? Ann Intern Med. 2011;154(12):781-8. https://doi.org/10.7326/0003-4819-154-12-201106210-00005

21. Drawz PE, Alper AB, Anderson AH, Brecklin CS, Charleston J, Chen J et al. Masked hypertension and elevated nighttime blood pressure in CKD: Prevalence and association with target organ damage. Clin J Am Soc Nephrol. 2016;11(4):642-52. https://cjasn.asnjournals.org/content/11/4/642