

The influence of dipper vs. non-dipper pattern on left ventricular function and ascending aorta dimensions in hypertensive patients in Angola

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Abstract

Background. The objective of the present study is to evaluate the effect of the dipper vs. non-dipper patterns on left ventricular function and the dimensions of the ascending aorta in hypertensive patients in Angola.

Material and methods. This is a descriptive, observational study performed at the Department of Cardiology of Luanda Medical Center. For this purpose, information on demographic data, echocardiographic parameters and 24-hour-ambulatory blood pressure measurement parameters was collected. All patients underwent both echocardiographic study and 24-hour-ambulatory blood pressure measurement. Dipper pattern is considered when there is a decrease in the nocturnal BP in relation to the daytime BP greater than 10%; if this decrease is not observed either in the systolic blood pressure or in the diastolic blood pressure, the patients are considered non-dippers.

Results. We enrolled 159 patients, of which 85 (53.46%) were dippers and 74 (46.54%) were non-dippers, and 87 (54.71%) were male. The mean age (SD) was 43.62 (\pm 10.73) years. The patients with the non-dipper pattern had larger ascending aortic diameters (29.68 \pm 4.88 vs. 27.8 \pm 5.18, p = 0.001), higher left ventricular diastolic diameters (52.85 \pm 9.24 vs. 50.24 \pm 4.16, p = 0.027) and greater posterior wall thickness (10.73 \pm 1.94 vs. 10.07 \pm 1.70, p = 0.024). In addition, the left ventricular diastolic dysfunction (LVDD) (B = 0.103, p = 0.001) and the posterior wall (PW) thickness (B = 0.350, p = 0.001) are significant estimates of non-dipper pattern.

Conclusions. The results show that hypertensive patients with non-dipper pattern have more alterations in left ventricular geometry, but not in left ventricular systolic and diastolic function.

Key words: essential hypertension; echocardiography; ambulatory blood pressure measurement; dipper, non-dipper

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Introduction

Systemic arterial hypertension (HBP) is a public health problem in Angola, where its prevalence is 23% [1]. The progression of the disease is strongly associated with functional and structural cardiac alterations, which can be diagnosed by transthoracic echocardiography and, if present, they are indicators of morbidity, mortality and target organ damage. Echocardiography is an extremely useful technique for the evaluation of hypertension and its complications, especially ventricular remodeling and progression to hypertensive heart disease and heart failure, and plays a fundamental role in the diagnosis and therapeutic orientation of these complications [2].

Ambulatory blood pressure measurement (ABPM) is a diagnostic tool that is increasingly used in clinical practice in the evaluation of hypertensive patients [3]. The non-dipper pattern, defined as the insufficient reduction of arterial pressures at night (< 10%), has been related to a higher cardiovascular and cerebrovascular risk and higher morbidity and mortality with a high prognostic value [4]. However, data about the influence of the non-dipper pattern on cardiac function, when compared to the dipper, in hypertensive patients are conflicting [5, 6].

The aim of the present study is to evaluate the effect of the dipper *vs.* non-dipper pattern on left ventricular function and ascending aorta dimensions in hypertensive patients in Angola.

Material and methods

Patients studied

A descriptive observational study was conducted in the Department of Cardiology of Luanda Medical Center in the period from February 2016 to August 2017. We enrolled all hypertensive patients with more than one year of evolution who underwent both transthoracic echocardiography (TTE) and ambulatory blood pressure measurement (ABPM) at the request of the attending physicians.

Echocardiography

Transthoracic echocardiography (TTE) and the Doppler study were performed with subjects in partial left decubitus position using ultrasound machine (Samsung Medison EKO 7), equipped with a P4-12 transducer. All studies were performed according to the guidelines of the American Society of Echocardiography [7, 8]. The

left atrial area was measured in 2 and 4-apical chamber view. The aortic root diameter, the inter-ventricular septum and the posterior wall thickness, the LV end-diastolic and end-systolic diameter were measured from two-dimensional guided M-mode tracing. The left ventricular ejection fraction (LVEF) was calculated by the Simpson method. Left ventricular filling was assessed by recording mitral flow by standard pulse Doppler technique, and the following parameters were considered: early diastolic peak flow velocity (E), late diastolic peak flow velocity (A) and the ratio of the early to late flow velocity peaks (E/A ratio). Pulsed-wave tissue Doppler imaging was used to measure early diastolic peak wave velocity (e'), and late diastolic peak velocity wave (a'). In addition, the ratio of the early to late wave velocity peaks (e'/a'), and ratio of the early diastolic peak flow velocity to early diastolic peak wave velocity (E/e') ratio were calculated.

Ambulatory blood pressure measurement

The 24-hour ambulatory blood pressure measurement was carried out using a Welch Allyn ABPM 7100 device; the dataset was transferred and analyzed on the CardioPerfect 1.6.6 workstation. The cuff was placed on the non-dominant arm, the patients were asked to perform their usual day-to-day activities without any restrictions. The patients were instructed to record in the diary the time they went to sleep and they woke up. The device was set to obtain BP readings at 20 min intervals during the daytime period (7:00–23:00 hours) and at 30 min intervals during the night (23:00–7:00 hours). Each ABPM dataset was first automatically scanned to remove artefactual readings, according to preselected editing criteria. Systolic readings > 260 mm Hg or < 70 mm Hg and diastolic readings > 150 mm Hg or < 40 mm Hg were automatically discharged. The recording was analyzed to obtain 24 h, daytime and night-time average SBP, DBP and pulse pressure.

The nocturnal pressure drop was calculated according to the following formula:

$$(\%) 100 \times [1 - (\text{nocturnal blood pressure} / \text{diurnal arterial pressure})]$$

The dipper pattern is considered when there is a decrease in the nocturnal AP in relation to the daytime BP greater than 10%, if this decrease is not observed either in the systolic blood pressure or in the diastolic blood pressure the patients are considered non-dippers.

Statistical analysis

Values have been expressed as means \pm standard deviation (SD) or as percentages. Comparisons between the two groups relative to quantitative variables were conducted using the t-test for independent samples or the corresponding non-parametric (Mann-Whitney), when the assumption of normality was not verified. The association of independent categorical variables was tested using the χ^2 test or Fisher's exact test. In order to determine an independent association of non-dipper pattern with posterior wall thickness (PWT) and left ventricular diastolic dysfunction (LVDD) multiple logistic regression analysis adjusting for age, gender was performed. All statistical analysis was performed using the statistical software SPSS®, 25 for Windows. All tests were two-sided for consistency and $p < 0.05$ was considered to be statistically significant.

Results

The demographic variables and the ambulatory blood pressure measurement parameters are illustrated in Table I and the echocardiographic and Doppler study parameters in Table II. We enrolled 159 patients, of whom 87 (54.72%) are males and 72 (45.28%) are females, with a mean age of 43.62 (± 10.73) years.

As can be seen in Table I, according to data from the 24-hour ABPM registry of 159 hypertensive patients, 85 patients were classified as dippers and 74 patients as non-dippers. The distribution by age and gender was similar between the two groups ($p = 0.503$ and $p = 0.338$ respectively). As expected, night-time systolic and diastolic pressures were significantly higher in non-dippers than those in dip-

Table I. Demographic and ambulatory blood pressure measurement (ABPM) parameters of studied population

Studied population (n = 159)			
Variables	Non-dipper (n = 74)	Dipper (n = 85)	p value
Age (Y)	44.23 \pm 11.15	43.08 \pm 10.38	0.503
Gender			0.338
Female N, (%)	37 \pm 50.0	35 \pm 41.2	
Male N, (%)	37 \pm 50.0	50 \pm 58.8	
ABPM			
24-hour SBP [mm Hg]	135.03 \pm 15.21	132.79 \pm 15.30	0.357
24-hour DBP [mm Hg]	81.65 \pm 11.66	79.38 \pm 9.38	0.176
Daytime SBP [mm Hg]	136.72 \pm 15.61	137.69 \pm 16.42	0.702
Daytime DBP [mm Hg]	83.39 \pm 12.29	83.22 \pm 10.04	0.924
Night-time SBP [mm Hg]	129.91 \pm 14.63	117.33 \pm 13.38	0.001*
Nighttime DBP [mm Hg]	75.30 \pm 11.06	66.86 \pm 9.10	0.001*

ABPM — ambulatory blood pressure measurement; SBP — systolic blood pressure; DBP — diastolic blood pressure

Table II. Echocardiographic and Doppler study parameters of studied population

Studied population (n = 159)			
Variables	Non-dipper (n = 74)	Dipper (n = 85)	p value
Aortic root [mm]	32.20 \pm 4.18	31.62 \pm 4.66	0.414
A Ao	29.68 \pm 4.88	27.8 \pm 5.18	0.001*
LVDD [mm]	52.85 \pm 9.24	50.24 \pm 4.16	0.027*
IVST [mm]	11.12 \pm 2.03	10.67 \pm 1.90	0.151
PWT [mm]	10.73 \pm 1.94	10.07 \pm 1.70	0.024*
LVEF (%)	69.30 \pm 9.29	67.93 \pm 8.46	0.333
LA [cm ²]	19.44 \pm 5.05	19.15 \pm 5.51	0.729
E/A	1.19 \pm 0.45	1.22 \pm 0.39	0.678
e' [cm/s]	15.60 \pm 5.98	16.01 \pm 5.11	0.647
E/e'	5.33 \pm 1.88	5.25 \pm 1.79	0.788

Ao — ascending aorta; LVDD — left ventricular diastolic diameter; IVST — interventricular septal thickness; PWT — posterior wall thickness; LVEF — left ventricular ejection fraction; LA — left atrium

pers (129.91 ± 14.63 mm Hg *vs.* 117.3 ± 13.38 mm Hg, $p < 0.001$) and (75.30 ± 11.06 mm Hg *vs.* 66.86 ± 9.10 mm Hg, $p < 0.001$), respectively. The remaining ABPM parameters were similar in both groups.

The echocardiographic and Doppler study parameters are presented in Table II. Non-dippers had larger ascending aortic diameters (29.68 ± 4.88 *vs.* 27.8 ± 5.18 , $p = 0.001$), higher left ventricular diastolic diameters (52.85 ± 9.24 *vs.* 50.24 ± 4.16 , $p = 0.027$) and greater posterior wall thickness (10.73 ± 1.94 *vs.* 10.07 ± 1.70 , $p = 0.024$) than those in dippers. The dimensions of the aortic root, the thickness of the ventricular septum, as well as left ventricular ejection fraction, likewise, the left atrium area, E/A ratio and E/e ratio were similar in both groups. These data suggest that there are no differences in the LV systolic and diastolic function between dipper and non-dipper hypertensive patients.

On the other hand, the multiple logistic regression analysis adjusted for gender and age revealed that the LVDD ($B = 0.103$, $p = 0.001$) and the posterior wall thickness ($B = 0.350$, $p = 0.001$) are significant estimators of non-dipper hypertensive patients.

Discussion

In Angola, hypertension has become an increasingly important public health problem [1]. In the study by Pires et al. [1] the prevalence of hypertension in Angola is 23% (95% CI: 21% to 25.2%). The authors also noted that among hypertensive individuals, 21.6% (95% CI: 17.0% to 26.9%) were aware of their status. Only 13.9% (95% CI: 5.9% to 29.1%) of the subjects aware of their condition were under pharmacological treatment, of which approximately one-third were controlled. To our knowledge in Angola there are no studies on the effect of the dipper *vs.* non-dipper pattern on cardiac morphology and function in hypertensive patients.

The main results of the present study revealed that patients with non-dipper pattern have greater left ventricular diastolic diameter and greater posterior wall thickness. In addition, these two parameters proved to be independent predictors of belonging to the non-dipper group. These findings have also been reported by other authors. Yokota et al. [9] report that among hypertensive patients with left ventricular hypertrophy the non-dipper pattern was associated with LV remodeling. Ferrara et al. [10] concluded that the increase in the LV telediastolic dimension was associated with a non-dipper pattern. Verdecchia et al. [11] studied 137 untreated and 98 healthy

hypertensive patients concluded that interventricular thickness and posterior wall thickness were associated with the non-dipper pattern. Mozdžan et al. compared echocardiographic parameters among hypertensive treated patients with conserved global systolic function concluded that concentric LVH is the prevalent pattern in non-dippers [12]. Ivanovic et al. studied hypertensive patients, most of the sample being untreated for hypertension (69%), and concluded that structural alterations were associated with the non-dipper and inverted dipper patterns compared with the other patterns [13]. Cuspidi et al. (in 2003) who studied treated — controlled and uncontrolled — hypertensive patients concluded that the non-dipper pattern had no association with increased LV mass and LVH prevalence [5]. But in 2004, when they studied a sample of hypertensive patients diagnosed with dipper *vs.* non-dipper patterns based on two ABPM studies, they concluded that the persistent non-dipper pattern is associated with more cardiac abnormalities [14].

In our study, patients with non-dipper pattern were shown to have larger ascending aorta dimensions. These findings were also reported by Cuspidi et al. [14], who studied recently diagnosed hypertensive patients, and Karaagac et al. [15], who studied 70 hypertensive patients with metabolic syndrome, concluded that the diameter of the thoracic aorta was higher in patients with non-dipper pattern. In turn, Ozdemir et al. [16] verified an association between carotid artery diameter and non-dipper pattern.

In the present study the left atrial size, systolic and diastolic function parameters were similar between the two groups, which is in accordance with results reported by Sokmen et al. [6] and Cuspidi et al. [5] in treated hypertensive patients/patients with controlled hypertension and with the results reported by Grandi et al. [17] in untreated patients. These authors did not find significant differences in left ventricular size, systolic and diastolic function or prevalence of cardiac hypertrophy between the dipper *vs.* non-dipper patterns. Likewise, Verdecchia et al. [11], found no association between LV systolic function and the dipper pattern. In turn, Della Mea et al. [18], who studied a sample of untreated hypertensive patients, did not find significant differences in diastolic function between dipper and non-dipper patterns.

More recently, in hypertensive patients, 3D echocardiography and strain echocardiography revealed subclinical changes in left ventricular systolic and diastolic function and left atrial function, which have not been demonstrated by conventional echocardiography. These new echocardiographic

methods become important tools in evaluating the effect of the dipper versus non-dipper patterns on cardiac morphology and function in hypertensive patients [19–23].

A study published in 2016 [19], conducted in newly diagnosed hypertensive patients where cardiac function, in addition to conventional echocardiography, was evaluated by 3D echo, the authors showed that the non-Dipper pattern was associated with LVH and diastolic dysfunction both by 2D parameters (E/e' increased in the non-Dipper pattern) and by 3D (increase in the LA minimum volume, the LA pre-contraction volume of the E and total LA systolic volume).

A study published in 2018 [20], conducted in treated hypertensive patients, where cardiac function beyond conventional echocardiography was also assessed by tissue Doppler and Speckle Tracking with Strain evaluation. In this study, the authors concluded important data on differences in morphology and cardiac function between the dipper *vs.* non-dipper patterns, demonstrating an association between non-dipper pattern and LV remodeling, diastolic dysfunction and reduction of myocardial strain also compatible with LV systolic dysfunction and they alert that patients with uncomplicated hypertension should always consider performing ABPM or another innovative method that provides information on the nocturnal blood pressure pattern to better stratify cardiovascular risk and delineate therapeutic strategies.

The conflicting findings in the existing literature may partially reflect methodological problems [5]. Several factors have been described [5, 17]: first, the inclusion in most of the previous studies of patients who were receiving or had been receiving treatment until shortly before the study may have disturbed in a complex way the relationship between BP and organ damage. In addition, it is possible that the greater prevalence of LVH reported by some studies in non-dippers is a function of a higher cumulative 24-h pressure loads rather than the non-dipping phenomenon per se; second, the definition of the night-time and daytime periods. Some authors have defined night-time BP somewhat arbitrarily as the BP during the hours most likely to correspond to sleep, without referring to diaries reporting when patients actually retire and awake. In contrast, others have used narrower time spans that exclude the morning and evening transitional periods during which a variable proportion of patients are actually awake or asleep. Finally, the classification into dippers and non-dippers has a low reproducibility over time; this limited reproducibility is presumably related to the fact that the quality and depth of sleep as well as

the mental and physical activity during daytime can markedly vary from one recording session to another.

In the present study, we compared left ventricular function and aortic dimensions between dipper and non-dipper patterns in hypertensive patients with more than one year of evolution. The definition of dippers and non-dippers was based in only one 24-hour ABPM study, with fixed definition of the daytime and night-time periods. Using this methodology we found more alterations in left ventricular morphology and ascending aortic diameter in non-dipper patients. No differences regarding left ventricular systolic and diastolic function between groups were found.

Limitations of the study

The present study has a number of limitations that we would like to emphasize. Although the population studied had been diagnosed with hypertension for over a year, we do not know if everyone was taking medication. The evaluation of cardiac function was performed using conventional echocardiography, Doppler study and tissue Doppler, but more recent techniques such as 3D echocardiography or strain were not used. Finally, we did not evaluate the presence of other cardiovascular risk factors that could have better characterized the study population.

Conclusion

The results show that hypertensive patients with more than one year of evolution presented with non-dipper pattern have more alterations in left ventricular geometry, but not in left ventricular systolic and diastolic function. We believe that further studies on the effect of dipper and non-dipper patterns on hypertensive patients in Africa are needed to confirm the data presented here.

Conflict of interests

None to declare.

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