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Original research

EVALUATING MASKED HYPERTENSION AND ITS RELATIONSHIP TO CARDIOVASCULAR RISK FACTORS AND TARGET ORGAN DAMAGE USING 24-HOUR AMBULATORY BLOOD PRESSURE MONITORING

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ABSTRACT

Aims: *To determine the prevalence of MH and its correlation with cardiovascular risk factors and target organ damage in patients at C Hospital, Da Nang.*

Methods: *This study involved 120 participants aged 40 to 70 years who visited C Hospital, Da Nang, between April 2021 and September 2022. The participants were divided into two groups: 60 individuals with cardiovascular risk factors and 60 individuals diagnosed with hypertension. A cross-sectional descriptive methodology was used.*

Results: *The mean values of systolic blood pressure (SBP) and diastolic blood pressure (DBP) upon waking, the percentage of blood pressure (BP) overload, and morning BP surge were significantly higher in the MH group than in the non-MH group ($p < 0.05$). The percentage of non-dipping BP at night was also higher in the MH group, although the difference was not statistically significant ($p > 0.05$). The MH group exhibited higher BP levels and a greater 24-hour BP range than the non-MH group. Patients with obesity, central obesity, dyslipidemia, diabetes, coronary heart disease, and smoking had a higher prevalence of MH than those without these risk factors and comorbidities ($p < 0.05$). A correlation was found between 24-hour SBP and DBP and BMI, blood glucose, cholesterol, triglycerides, and LDL levels. The prevalence of left ventricular hypertrophy on ECG, fundus damage, and kidney damage was significantly higher in the MH group than in the non-MH group. The prognostic value of 24-hour SBP for left ventricular hypertrophy, assessed using the ROC curve, was higher than that of 24-hour DBP. Conversely, the prognostic value of 24-hour DBP for fundus and kidney damage was higher than that of 24-hour SBP.*

Conclusions: *MH is significantly associated with target organ damage. Additionally, 24-hour SBP and DBP levels correlate with BMI, blood glucose, cholesterol, triglycerides, and LDL levels.*

Keywords: *Masked hypertension, risk factors, target organ damage.*

I. INTRODUCTION

Masked hypertension is defined as normal blood pressure below 140/90 mmHg when measured at a healthcare facility, but ≥ 135/85 mmHg when measured at home or during 24-hour ambulatory blood pressure monitoring (ABPM), with a daytime average ≥ 135/85 mmHg and/or a 24-hour average ≥ 130/80 mmHg. Uncontrolled masked hypertension is defined as a treated hypertensive patient with controlled office blood pressure but still has elevated blood pressure outside the office (either continuous blood pressure monitoring or home blood pressure monitoring). Many studies have shown that individuals with cardiovascular risk factors have a higher prevalence of masked hypertension than that in the general population. Masked hypertension causes organ damage similar to that caused by sustained hypertension and is more dangerous

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because it remains undiagnosed and untreated. The 24-hour ABPM technique is especially valuable for detecting masked hypertension and helping physicians choose the optimal blood pressure control strategy [1-3].

Given the importance of these issues, we applied the 24-hour ABPM technique to conduct this study to explore the prevalence of masked hypertension and blood pressure variations in individuals with cardiovascular risk factors and hypertensive patients with normal blood pressure readings in the clinic at C Hospital, Da Nang; and evaluate the relationship between masked hypertension and the correlation of 24-hour blood pressure parameters with cardiovascular risk factors and target organ damage.

II. MATERIALS AND METHODS

2.1. Subjects

From April 2021 to September 2022, patients aged 40 to 70 who either attended the outpatient clinic or were hospitalized in the Cardiology Department of C Hospital Da Nang were considered for inclusion in the study. A total of 120 subjects were selected based on the inclusion and exclusion criteria of this study.

All patients diagnosed with essential hypertension or with ≥ 1 cardiovascular risk factor who agreed to participate in the study were divided into two groups:

Group with cardiovascular risk factors: 60 patients without hypertension (office blood pressure < 140/90 mmHg) but with ≥ 1 cardiovascular risk factor, such as old age, smoking, physical inactivity, obesity, and/or comorbidities such as diabetes, dyslipidemia, and coronary heart disease.

Hypertension group: 60 patients already diagnosed with essential hypertension, currently undergoing treatment with normal office blood pressure (< 140/90 mmHg).

Exclusion criteria: Patients with uncontrolled hypertension (office blood pressure ≥ 140/90 mmHg); those diagnosed with secondary hypertension; those with acute conditions affecting blood pressure; those whose 24-hour ABPM measurements were not valid for at least 85% of the total measurement time; and those who did not agree to participate in the study were excluded.

2.2. Methods

The study was conducted using a cross-sectional descriptive method. A convenient sample size was chosen, with a total of 120 participants (60 in the hypertension group and 60 in the cardiovascular risk factor group).

Sampling in the hypertension group: Patients aged 40 - 70 years who were diagnosed with essential hypertension and were undergoing treatment were included. Blood pressure was measured using a mercury sphygmomanometer (Omron). Patients were asked to rest in the clinic for at least 5 min before the measurement. Clinical blood pressure was calculated as the average of two readings taken at least 1 min apart during one visit. If the blood pressure difference between the two readings exceeded 10 mmHg, a third measurement was taken after resting for at least 5 min. The recorded blood pressure was the average of the last two readings. Blood pressure measurements were recorded in mmHg as systolic/diastolic blood pressure (BP). Patients with normal office blood pressure underwent a general clinical examination. If they met the inclusion and exclusion criteria, the following laboratory tests were performed for research purposes: fasting blood glucose, triglycerides, cholesterol, HDL-C, LDL-C, and urine microalbumin; ECG; fundus examination; and 24-hour ambulatory blood pressure monitoring [4]. Hypertension was diagnosed according to the ISH 2020 and VSH 2021 [5, 6]. Masked hypertension was diagnosed when office blood pressure was < 140/90 mmHg, but 24-hour ABPM showed a daytime average blood pressure ≥ 135/85 mmHg and/or a 24-hour average ≥ 130/80 mmHg.

Sampling in the cardiovascular risk factor group: Patients aged 40 - 70 years without a history of hypertension but with ≥ 1 cardiovascular risk factor, such as age, obesity, smoking, physical inactivity, and/or a history of dyslipidemia, diabetes, coronary heart disease, or stroke were included. These patients underwent blood pressure measurements and general clinical examinations at the clinic. If the office blood pressure was normal and the patients met the inclusion and exclusion criteria,

the subsequent steps were the same as those for the hypertension group.

Variables for cardiovascular risk factors and comorbidities: Age (men ≥ 45 years, women ≥ 55 years); obesity; smoking; physical inactivity; dyslipidemia; diabetes; and coronary heart disease [7].

Variables for target organ damage: The criteria for target organ damage in the heart, kidneys, eyes, and brain in hypertensive patients can be assessed using the following criteria for each organ:

Heart: Left ventricular hypertrophy (LVH) detected by electrocardiogram or echocardiogram; Diastolic dysfunction; Coronary artery disease; Heart failure

Kidney: Elevated serum creatinine (> 1.3 mg/dL in men, > 1.2 mg/dL in women); Decreased estimated glomerular filtration rate (eGFR) < 60 mL/min/1.73 m²; Microalbuminuria (urinary albumin excretion 30 - 300 mg/24h or albumin-to-creatinine ratio 30 - 300 mg/g); Proteinuria (urinary protein excretion > 300 mg/24h)

Eyes: Hypertensive retinopathy (Grade I: Arteriolar narrowing; Grade II: Arteriovenous nicking; Grade III: Retinal hemorrhages and exudates; Grade IV: Papilledema)

Brain: Stroke (ischemic or hemorrhagic); Transient ischemic attack (TIA); Cognitive impairment or vascular dementia; White matter lesions on brain MRI [4, 5, 8, 9]

2.3. Data processing methods

Data were collected and processed using SPSS version 20. Statistical tests were used to examine the correlations, and the Youden index was employed to determine the optimal cut-off points for the 24-hour systolic and diastolic blood pressure.

III. RESULTS

3.1. Prevalence of Masked Hypertension and Characteristics of 24-Hour Blood Pressure Variability

The overall prevalence of masked hypertension was 30% in both groups, with 33.3% in the hypertension group and 26.7% in the cardiovascular risk factor group; the difference was not statistically significant (p = 0.426). The prevalence of masked hypertension was highest in patients with diabetes (58.3%), followed by those with coronary heart disease (51.2%), high cholesterol (50.9%), high triglycerides (45.3%), and overweight/obesity (44.6%) (Table 1).

Table 1: Prevalence of masked hypertension by risk factor

Risk Factor	Prevalence of Masked Hypertension (%)
High Cholesterol	50.9%
High Triglycerides	45.3%
Overweight/Obesity	44.6%
Coronary Heart Disease	51.2%
Diabetes	58.3%

The trends of systolic and diastolic blood pressure variability were similar in both the hypertension and cardiovascular risk factor groups. There were two peaks in blood pressure, from 6 - 10 am and 4 - 8 pm, and two troughs, from 12 - 2 pm and 10 pm-2 am. Both the masked and non-masked hypertension groups had two similar peaks and troughs in blood pressure over 24 h. However, the masked hypertension group had higher blood pressure levels and greater blood pressure variability than the non-masked hypertension group (Table 2). Blood pressure upon waking: Systolic and diastolic blood pressure upon waking were higher in the masked hypertension group than in the non-masked hypertension group, and the difference was statistically significant. Morning blood pressure surge: The prevalence of morning blood pressure surge was higher in the masked hypertension group than in the non-masked hypertension group, and the difference was statistically significant (p < 0.005). Nocturnal blood pressure dipping: The prevalence of non-dipping nocturnal blood pressure was high in both the masked and non-masked hypertension groups. However, the masked hypertension group had a higher prevalence of non-dipping nocturnal blood pressure (83.3% vs. 78.6%), but the difference was not statistically significant (p > 0.05).

Table 2: Characteristics of 24-Hour Blood Pressure Variability

Parameter	Hypertension Group	Cardiovascular Risk Factor Group
Prevalence of Masked Hypertension (%)	33.3%	26.7%
SBP upon Waking (mmHg)	147 ± 11	122.6 ± 8.9
DBP upon Waking (mmHg)	90.9 ± 9.1	73.9 ± 7.4
Morning BP Surge (%)	66%	53.85%
Non-dipping Nocturnal BP (%)	83.3%	76.8%

3.2. Association Between Masked Hypertension and 24-Hour Blood Pressure Parameters with Cardiovascular Risk Factors and Target Organ Damage

The prevalence of masked hypertension was higher in individuals with a history of dyslipidemia, coronary heart disease, diabetes, overweight/obesity, central obesity, and smoking than in those without these conditions. There was a positive correlation between 24-hour systolic and diastolic blood pressure and BMI, blood glucose, and cholesterol levels. The prevalence of left ventricular hypertrophy on ECG was higher in the masked hypertension group than in the non-masked hypertension group, and the difference was statistically significant.

Prediction of left ventricular hypertrophy: The area under the ROC curve and the sensitivity of 24-hour systolic blood pressure (SBP) were greater than those of 24-hour diastolic blood pressure (DBP) in predicting left ventricular hypertrophy. Kidney damage: There was a statistically significant association ($p < 0.05$) between masked hypertension and kidney damage (increased microalbuminuria). The area under the ROC curve and the sensitivity of 24-hour DBP were greater than those of 24-hour SBP in predicting renal damage. Fundus damage: The masked hypertension group had a higher prevalence of fundus damage than the non-masked hypertension group ($p < 0.05$). In both study groups, most cases of fundus damage were mild (Grade III). The area under the ROC curve and the sensitivity of the 24-hour DBP were greater than those of the 24-hour SBP in predicting fundus damage. Cerebral stroke: No cases of cerebral stroke were observed in either study group; therefore, the relationship between masked hypertension and cerebral stroke could not be evaluated (Figure 1).

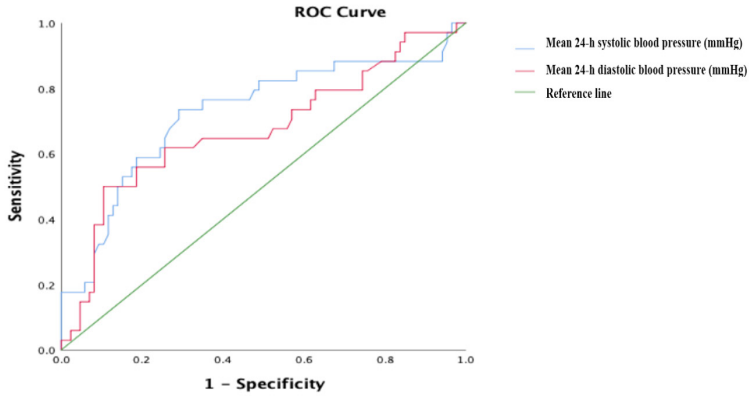

Figure 1: Predictive Value of 24-Hour Mean Systolic and Diastolic Blood Pressure for Target Organ Damage. AUC of Mean 24 SBP: 0.82, Sens: 81%, Spec: 73%, $p < 0.05$. AUC of Mean 24 DBP: 0.75, Sens: 78%, Spec: 69%, $p < 0.05$

IV. DISCUSSION

4.1. Prevalence of Masked Hypertension and Characteristics of 24-Hour Blood Pressure Variability

In our study, the prevalence of masked hypertension in both groups was 30% (33.3% in the hypertension group and 26.7% in the cardiovascular risk factor group), which is similar to the study by Desart et al.(2010), where the prevalence of masked hypertension was 28.9% [10].

Our results were higher than those of Vo Thi Ha Hoa (2013) in Da Nang, who reported a prevalence of 21.4% (22.9% in the hypertension group and 20% in the cardiovascular risk factor group) [11]. A study by Pham Thi Xuan Thao (2019) found a prevalence of 21.7% [12]. A study by Nguyen Van Luc (2020) at Gia Dinh People's Hospital reported a prevalence of 24.5% [13]. A study by Obara and Ohkubo (2008) in Japan, which included 3,303 outpatients with hypertension, found that among 1,386 patients with normal office blood pressure, masked hypertension was diagnosed based on home blood pressure measurements, with different rates for systolic blood pressure (28.8%) and diastolic blood pressure (20.9%) (kappa coefficient = 0.43) [14].

Currently, according to ISH 2020, the blood pressure threshold for diagnosing hypertension has been lowered by 5 mmHg (24-hour BP ≥ 130/80 mmHg compared to the previous ≥ 135/85 mmHg) [6], which may explain why the prevalence of masked hypertension in our study is higher than that in some previous studies.

Both the masked hypertension and non-masked hypertension groups exhibited two peaks in blood pressure (6 - 10 am and 4 - 8 pm) and two troughs (12-2 pm and 10 pm-2 am). This finding is consistent with the studies by Vo Thi Ha Hoa [11], Pham Thi Xuan Thao [12], Tran Thi Ai Xuan [15], and several international studies. Generally, in studies on 24-hour blood pressure variability, both masked and non-masked hypertension groups showed similar patterns of blood pressure peaks and troughs. However, the masked hypertension group had higher blood pressure levels and greater variability than the non-masked hypertension group [11, 12]. This indicates the dangerous characteristics of blood pressure values and variability in the masked hypertension group, which poses a greater risk of cardiovascular complications.

In our study, the blood pressure upon waking in the masked hypertension group was 147 ± 11 / 90.9 ± 9.1, which was higher than that in the non-masked hypertension group, which was 122.6 ± 8.9 / 73.9 ± 7.4, with a statistically significant difference ($p < 0.05$). This result is consistent with the studies by Vo Thi Ha Hoa [11], Pham Thi Xuan Thao [12], Thomas G. Pickering [16], and Kawano Y [17]. The prevalence of morning blood pressure surge in our masked hypertension group was 66%, compared to 53.85% in the study by Pham Thi Xuan Thao et al. Our study also found that the prevalence of non-dipping nocturnal blood pressure in the masked and non-masked hypertension groups did not differ significantly, but the non-dipping nocturnal blood pressure was higher in the masked hypertension group (83.3% compared to 76.8%).

4.2. Association Between Masked Hypertension and 24-Hour Blood Pressure Parameters with Cardiovascular Risk Factors and Target Organ Damage

The prevalence of masked hypertension was higher in individuals with a history of dyslipidemia, coronary heart disease, diabetes, overweight/obesity, central obesity, and smoking than in those without these conditions. In our study, the prevalence of masked hypertension was 50.9% in the high cholesterol group, 45.3% in the high triglyceride group, 44.6% in the overweight/obesity group, 51.2% in the coronary heart disease group, and 58.3% in the diabetes group. These results are consistent with those of studies by both domestic and international authors [10, 11, 18, 19]. There was a positive correlation between 24-hour systolic and diastolic blood pressure and BMI, blood glucose, and cholesterol levels.

The prevalence of left ventricular hypertrophy on ECG was higher in the masked hypertension group than in the non-masked hypertension group (55.6% vs. 16.7%, $p < 0.05$). The prevalence of

microalbuminuria was also higher in the masked hypertension group than in the non-masked hypertension group (41.7% vs. 13.1%, $p < 0.05$). Additionally, 55.6% of patients with masked hypertension had fundus damage, with severity ranging from mild to severe, but predominantly mild (52.8%). The non-masked hypertension group had fundus damage in only 19% of the patients, and this difference was statistically significant ($p < 0.05$). These results are consistent with those of studies by both domestic and international authors [11, 12, 20].

V. CONCLUSION

The masked hypertension group had higher blood pressure levels and greater variability than the non-masked hypertension group. Patients with obesity, central obesity, dyslipidemia, diabetes, coronary heart disease, and smoking had a higher prevalence of masked hypertension. There was a positive correlation between 24-hour blood pressure parameters and BMI, blood glucose, cholesterol, triglyceride, and LDL levels. The prevalence of left ventricular hypertrophy, fundus damage, and kidney damage was significantly higher in the masked hypertension group. This study highlights the importance of screening for masked hypertension in patients with cardiovascular risk factors or treated hypertension using 24-hour ABPM.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of C Hospital Da Nang.

Disclosure

The authors report no other conflicts of interest in this work.

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