

THE CLINICAL FEATURES, PARACLINICAL CHARACTERISTICS, AND PULSE WAVE VELOCITY INDEX IN PATIENTS WITH RESISTANT HYPERTENSION IN CAN THO FROM 2023 TO 2024

Huynh Tuan An, Ta Quang Hieu*, Chau Ngoc Minh Anh, Le Hoang Thoai, Lang Quoc Cuong, Nguyen Thi Thu Hang, Hua Ngoc Anh Dang, Luu The Hung, Mac Thi Nha Linh, Nguyen Le Nhu Phuc

Can Tho University of Medicine and Pharmacy

*Corresponding author: tahieu14012002@gmail.com

Received: 11/4/2025

Reviewed: 13/4/2025

Accepted: 25/6/2025

ABSTRACT

Background: Resistant hypertension has become increasingly prevalent in recent years, raising concerns due to its impact on patient health and treatment outcomes. Despite appropriate treatment, blood pressure remains uncontrolled, leading to symptoms such as headaches, chest pain, and fatigue, which affect quality of life. The high rate of organ damage highlights the need for further research into clinical characteristics and pulse wave velocity (PWV) as an important indicator of vascular health. **Objectives:** To describe the clinical and paraclinical characteristics of resistant hypertension patients in Can Tho from 2023 to 2024 and evaluate the pulse wave velocity index in these patients. **Materials and methods:** This study was conducted on 60 patients with resistant hypertension at Cardiology Department at Can Tho Central General Hospital and Can Tho University of Medicine and Pharmacy Hospital. **Results:** 60 patients with an average age of 66.3 ± 14.9 years (65% female) showed a higher prevalence of hypertension in those over 65 years (58.4%). Fatigue was the most common reason for hospitalization (57%). The majority of patients had hypertensive crises (85%), with risk factors like diabetes (20.3%), dyslipidemia (13.3%), smoking (21.7%), and alcohol use (33.3%). Females had a higher incidence of overweight. Paraclinical findings showed that patients with resistant hypertension for ≥ 10 years had a higher risk of carotid artery stenosis (OR = 3.208). Those aged ≥ 65 were more likely to have stenosis (OR = 3.778). Abnormal ABI (≤ 0.9) was found in some, with 2 cases of severe peripheral artery disease. Females had a higher incidence of microalbuminuria (51.6%). Elevated CF-PWV was linked to higher cardiovascular risk and target organ damage. **Conclusion:** Females had elevated heart rates, blood pressure, and more complications. Age and gender influenced pulse wave velocity (PWV), with older patients having greater arterial stiffness. PWV and BMI were not significantly related. Early detection and management of resistant hypertension-related complications are keys.

Keywords: Resistant hypertension, CF-PWV.

I. INTRODUCTION

In recent years, resistant hypertension has become increasingly common among patients, impacting both their treatment and health, drawing attention from both local and international researchers [1]. According to the Vietnamese Cardiovascular Society, resistant hypertension is defined as a condition where blood pressure does not reach target levels despite adequate doses of a treatment regimen consisting of three appropriate medications, including a diuretic [2]. Estimate from NHANES suggests that the prevalence of resistant hypertension with a threshold of $\geq 140/90$ mmHg in the general population was 12.8% [3].

Clinically, resistant hypertension presents with a variety of symptoms, the most common being headaches, shortness of breath, and chest pain, which significantly affect patients' quality of life [4]. Blood pressure levels vary among patients, influencing their treatment approach. Therefore, studying clinical and paraclinical characteristics is essential. We decided to conduct the research entitled: "The clinical features, paraclinical characteristics, and pulse wave velocity index in patients with resistant hypertension in Can Tho from 2023 to 2024" with the following goals: (1) Describe the clinical and paraclinical characteristics of patients with resistant hypertension in Can Tho from 2023 to 2024. (2) Evaluate the pulse wave velocity index in patients with resistant hypertension in Can Tho from 2023 to 2024.

II. MATERIALS AND METHODS

2.1. Materials

Patients with resistant hypertension at Can Tho Central General Hospital, Can Tho University of Medicine and Pharmacy Hospital.

- **Sample selection criteria:** Resistant hypertension is defined when blood pressure remains above 140/90 mmHg despite optimal treatment with a regimen including a diuretic and combination of ACE inhibitors, calcium channel blockers and thiazide-like diuretics. Inadequate control is confirmed by home or ambulatory blood pressure measurement, and other causes of pseudo-resistant or secondary hypertension are excluded [2].

- Exclusion criteria

+ Factors causing pseudo-resistant hypertension: non-adherence to treat, incorrect blood pressure measure, and white coat effect.

+ Certain conditions causing secondary hypertension: renal parenchymal disease (chronic kidney disease), renal vascular disease (renal artery stenosis), chronic obstructive pulmonary disease, endocrine disorders (primary aldosteronism, Cushing's syndrome, primary hyperparathyroidism, pheochromocytoma) with relevant medical history or symptoms.

+ Patients using medications that raise blood pressure: glucocorticoids, estrogen-containing contraceptives, sympathomimetic drugs (pseudoephedrine, ephedrine, cocaine, amphetamines), calcineurin inhibitors (cyclosporine, tacrolimus), and supplements like ginseng and licorice.

- **Study site:** Can Tho Central General Hospital and Can Tho University of Medicine and Pharmacy Hospital.

- **Study period:** 10/2023 - 10/2024.

2.2. Methods

- **Study design:** The study was conducted using a cross-sectional descriptive design.

- **Study size:**

$$N = \frac{Z_{1-\alpha/2}^2 \times p(1-p)}{d^2}$$

n is the sample size.

$Z_{1-\frac{\alpha}{2}}$ is the confidence limit coefficient, with a 95% confidence level ($Z_{1-\frac{\alpha}{2}} = 1,96$).

c is the allowable error (10%).

p is the proportion of patients with CF-PWV ≥ 14 m/s, which is 85.2% based on Claudia R. L. Cardoso's study [5], so p=0.17.

Using this, the calculated sample size is 54.2. In practice, the sample size was set to 60.

- Study content:

+ Blood pressure measurement, ABI, and arterial wave (CF-PWV). Equipment used: Boso ABI 100 - System Peripheral Artery Disease Diagnostic Machine. The device records the pulse wave velocity (CF-PWV). CF-PWV is considered abnormal when it exceeds 10 m/s.

+ ACR: A patient is diagnosed with microalbuminuria when the ACR is between 30-300 mg/g [2].

+ LVMI: Left ventricular hypertrophy is defined when the left ventricular mass index (LVMI) based on BSA (g/m²) is >95 in females and >115 in males (when BMI <30 kg/m²), according to the 2019 ESC echocardiography guidelines.

- Data processing: SPSS 26.0 software.

- Ethical approval: Approved by the Ethics Committee of Can Tho University of Medicine and Pharmacy (protocol code 23.103.SV/PCT - HĐĐĐ in 2023).

III. RESULTS

3.1. General characteristics of the study sample

The study of 60 patients with resistant hypertension found that females were more affected (65%) than males (35%), possibly due to biological factors like estrogen decline after menopause and longer life expectancy. The average age was 66.3 ± 14.9 years, consistent with research showing poor blood pressure control in older adults (> 60). The higher proportion of patients aged ≥ 65 highlights the impact of aging on heart risk.

3.2. Clinical characteristics in patients with resistant hypertension

Table 1. Characteristics of Pulse Index and Blood Pressure at Admission of patients

Characteristics		Results
Pulse (bpm) ($\bar{X} \pm SD$)	Males	93.05 ± 20.95
	Females	92 ± 16.75
Initial blood pressure (mmHg) (Mean \pm SD)	Males	189.05 ± 34.19
	Females	195.9 ± 23.59
Initial diastolic blood pressure (mmHg) (Mean \pm SD)	Males	95.71 ± 11.65
	Females	98.72 ± 10.56
Stage 1 Hypertension (n, %)		5 (8.3)
Stage 2 Hypertension (n, %)		4 (6.7)
Stage 3 Hypertension (n, %)		51 (85)

At admission, the average pulse rate was 93.05 ± 20.95 for males and 92 ± 16.75 for females. The average SBP was 189.05 ± 34.19 for males and 195.9 ± 23.59 for females, while the average DBP was 95.71 ± 11.65 mmHg for males and 98.72 ± 10.56 mmHg for females. Hypertensive crisis was the most common (85%), followed by stage 1 hypertension (8.3%) and stage 2 hypertension (6.7%).

3.3. Paraclinical Characteristics

Table 2. Association between organ damage and hypertension duration

Target organ damage		Duration of resistant hypertension		OR	p
		< 10 years (n, %)	≥ 10 years (n, %)		
Left ventricular hypertrophy (LVH) on ECG	No	25 (53.2)	22 (46.8)	0.812	0.75
	Yes	7 (58.3)	5 (41.7)		
Myocardial ischemia on ECG	No	20 (57.1)	15 (42.9)	1.231	0.69
	Yes	13 (52)	12 (48)		
Carotid artery stenosis	No	22 (64.7)	12 (35.3)	3.208	0.038
	Yes	8 (36.4)	14 (63.6)		
Stroke	No	30 (55.6)	24 (44.4)	1.25	0.795
	Yes	3 (50)	3 (50)		

In patients with resistant hypertension duration <10 years, left ventricular hypertrophy (LVH) on ECG was present in 58.3%, myocardial ischemia in 52%, carotid artery stenosis in 36.4%, and stroke in 50%. In those with HTN duration ≥10 years, LVH on ECG was found in 41.7%, myocardial ischemia in 48%, carotid artery stenosis in 63.6% (OR=3.208, p=0.038), and stroke in 50%.

Table 3. Microalbuminuria through ACR index and gender

		Gender				p
		Males	Females	Total	OR(KTC95%)	
Microalbuminuria	Yes	15 (48.4%)	16 (51.6%)	31 (100%)	3.594 (1.147-11.256)	0.025
	No	6 (20.7%)	23 (79.3%)	29 (100%)		

The proportion of males with resistant hypertension and microalbuminuria was 48.4%, lower than females (51.6%). Conversely, the proportion of females without microalbuminuria (79.3%) was higher than males (20.7%). This difference was statistically significant (p=0.025; OR=3.594; 95%CI = 1.147-11.256).

3.4. Pulse Wave Velocity Index

Table 4. The number of patients with lower extremity arterial complications

		Gender				p
		Males	Females	Males	Females	
CF – PWV >10 m/s	Yes	11 (25.6%)	32 (74.4%)	43 (100%)	4.156 (1.272-13.581)	0.015
	No	10 (58.8%)	7 (41.2%)	17 (100%)		

The rate of males with resistant hypertension and lower extremity arterial complications was 25.6%, lower than the 74.4% in females. Conversely, the rate of females without such complications was 41.2%, while for males it was 58.8%. This difference was statistically significant (p=0.015; OR= 4.156; 95% CI = 1.272-13.581).

Table 5. Association between CF – PWV and age, gender, BMI

CF – PWV	Age		Gender		BMI	
	< 65	≥ 65	Males	Females	≥ 23	< 23
< 10 m/s	13 (52%)	2 (5.7%)	8 (38.1%)	7 (17.9%)	10 (47.6%)	5 (12.8%)
> 10 m/s	12 (47%)	33 (94.3%)	13 (61.9%)	32 (81.1%)	11 (52.4%)	34 (87.2%)
p	<0.05		0.12		0.005	
OR (KTC 95%)	17.875		0.355		0.162	

Most patients aged ≥ 65 have lower extremity artery complications (94.3%), while in the < 65 age group, the proportion of patients with and without complications was similar. The difference was statistically significant ($p < 0.05$, OR = 17.875). In the study on resistant hypertension, both genders showed a high rate of abnormal pulse wave velocity (≥ 10 m/s), with females having a higher rate (4.5 times greater than males), the difference was not statistically significant ($p = 0.12$, OR = 0.355). In the overweight group (BMI ≥ 23), the impact on pulse wave velocity was similar. However, in the group with BMI < 23, 87.2% had PWV > 10 m/s, with a statistically significant difference ($p < 0.05$, OR = 0.162).

Table 6. The Pearson correlation between pulse wave velocity and systolic blood pressure, diastolic blood pressure, and target organ damage

Relationship with CF - PWV	R	p
Systolic Blood Pressure (SBP)	0.307	0.014
Diastolic Blood Pressure (DBP)	0.299	0.017
eGFR	0.14	0.285
LVMI	- 0.202	0.122
ACR	- 0.123	0.35

The correlation between pulse wave velocity (PWV) and systolic blood pressure (SBP) is positive ($r = 0.307$), with statistical significance ($p = 0.014$). Similarly, PWV and diastolic blood pressure (DBP) had a positive correlation ($r = 0.299$), also statistically significant ($p = 0.017$). The Pearson correlation for the kidney damage prediction model was weak ($r = 0.14$) and not statistically significant ($p = 0.285$). The correlation between microalbuminuria and PWV was negative ($r = -0.123$, $p = 0.350$), and between the prediction model and heart damage was also negative ($r = -0.202$, $p = 0.122$), with no statistical significance.

IV. DISCUSSION

The study of 60 patients with resistant hypertension found that 65% were female and 35% male, with an average age of 66.3 ± 14.9 years. The higher prevalence in females may be due to menopause-related estrogen decline and longer life expectancy. The high proportion of patients aged 65+ highlights the impact of aging on resistant hypertension. This contrasts with Mai Tien Dung's 2014 study, where it was more common in men (74.6% men and 25.4% women) [1].

Our study found the average heart rate at admission was 93.05 ± 20.95 in males and 92 ± 16.75 in females. Systolic and diastolic blood pressure were higher in females, with average SBP of 189.05 ± 34.19 in males and 195.9 ± 23.59 in females, and average DBP of 95.71 ± 11.65 in males and 98.72 ± 10.56 in females. Most patients (85%) had hypertensive emergencies, with stage 1 and stage 2 hypertension at 8.3% and 6.7%.

Target organ damage is crucial for predicting cardiovascular risk in hypertensive patients. Our study found similar results to Pham Ly Giao Linh's, with carotid artery stenosis at 36.4% in the <10 years group and 63.6% in the ≥10 years group (OR=3.208, p=0.038) [6]. Resistant hypertension increases the risk of complications like heart failure and stroke, with long-term hypertension causing structural changes in the heart and arteries, making control more challenging [7].

In hypertensive emergency patients with microalbuminuria, the male-to-female ratio was nearly equal (48.4% vs. 51.6%), while females predominated in the group without it (79.3% vs. 20.7%). Males had a higher prevalence of microalbuminuria, likely due to hormonal differences, poorer blood pressure control, lower treatment adherence, and more comorbidities like smoking, diabetes, and metabolic disorders [6], [8].

In our study, 72% of hypertensive emergency patients had cf -PWV >10m/s, with a higher rate in females (74.4%) compared to males (25.6%). This contrasts with Cardoso's study [5], where only 34.2% had CF-PWV >10m/s, likely due to differences in sample size, characteristics, and gender-related vascular physiology.

The study found that 74.4% of females with resistant hypertension had lower extremity artery complications, compared to 25.6% in males. This supports Max J. van Hout's research showing higher PWV values in women with hypertension (p = 0.005) [9]. Additionally, 94.3% of patients aged ≥ 65 experienced lower extremity artery complications, aligning with Nguyen Van Hai's study on increased carotid intima-media thickness in older patients [10]. PWV was an independent cardiovascular risk predictor, with a 1 m/s increase correlating to a 12% higher risk [11]. No significant relationship was found between PWV and BMI, consistent with studies by Świerblewska Ewa and Abushamat Layla A. [12], [13].

The relationship between pulse wave velocity (cf-PWV) and both systolic and diastolic blood pressure shows a positive correlation, meaning that when one of these values increases, the other tends to increase as well. This is a logical finding, as higher blood pressure, especially systolic, is often associated with increased arterial stiffness, which in turn raises cf-PWV.

Previous studies have linked kidney damage and arteriosclerosis to chronic inflammation, oxidative stress, and endothelial dysfunction. Chaoyi Ye and colleagues found that albuminuria is associated with increased cf-PWV, even before reaching the threshold for microalbuminuria diagnosis [14].

Yaya Bai and colleagues found a positive correlation between cf-PWV and LVMI ($r=0.325$, $p < 0.01$), indicating that increased arterial stiffness is linked to left ventricular hypertrophy [15]. However, our data showed the opposite: the group with normal LVMI had higher arterial stiffness. This could be due to a small sample size, data variability, or uncontrolled confounding factors (e.g., blood pressure, age, underlying conditions). The study shown no statistically significant correlation between the kidney damage prediction model, microalbuminuria, and cf-PWV, possibly due to uncontrolled factors like underlying diseases, age, and blood pressure. Therefore, cf-PWV may not be a strong predictor of kidney damage.

V. CONCLUSION

Our study shows higher prevalence of resistant hypertension in females, with aging increasing cardiovascular risk. Females had elevated heart rates, blood pressure, and more complications. Age and gender influenced pulse wave velocity (PWV), with older patients having greater arterial stiffness. PWV and BMI were not significantly related. Early detection and management of resistant hypertension-related complications are keys.

REFERENCES

1. Mai Tien Dung. Study on certain complications in patients with resistant hypertension. *Journal of Practical Medicine*. 2014. 4(914), 25-29, http://dspace.hmtu.edu.vn/handle/DHKTYTHD_123/1643.
2. Vietnam Heart Association. Guidelines for the diagnosis and treatment of hypertension. 2022. URL: <http://www.vnha.org.vn/congress12.asp?hoinghi=25>.
3. Kaczmarek, KR, Sozio, SM, Chen, J, Sang, Y, Shafi, T. Resistant Hypertension and Cardiovascular Disease Mortality in the US: Results from the National Health and Nutrition Examination Survey (NHANES). *BMC Nephrol*. 2019. 20(1), 138. doi: 10.1186/s12882-019-1315-0.
4. Huynh Ngoc Diep. Study on clinical and paraclinical characteristics of hospitalized hypertensive patients at Thap Muoi Regional General Hospital. *Vietnam Heart Association*. 2016, pp. 23-30, URL: <https://timmachhoc.vn/nghien-cuu-dac-diem-lam-sang-can-lam-sang-benh-nhan-tang-huyet-ap-nam-vien-tai-benh-vien-da-khoa-khu-vuc-thap-muoi/>.
5. Cardoso, CRL, Salles, GF. Prognostic Value of Changes in Aortic Stiffness for Cardiovascular Outcomes and Mortality in Resistant Hypertension: A Cohort Study. *Hypertension*. 2021. 79(2), 447-456. doi: 10.1161/hypertensionaha.121.18498.
6. Pham Ly Giao Linh, Tran Viet An, Huynh Tuan An, Huynh Thi Ngoc Giau, Le Van Cuong. Study on the characteristics of certain target organ damages in patients with uncontrolled hypertension at Can Tho University of Medicine and Pharmacy Hospital and Can Tho Central General Hospital. *Vietnam Medical Journal*. 2024. 538(2), 134-139. doi: <https://doi.org/10.51298/vmj.v538i2.9503>.
7. Muiyesan, Maria Lorenza, Salvetti, Massimo, *et al*. Resistant Hypertension and Target Organ Damage. *Hypertens Res*. 2013. 36(6), 485-91. doi: 10.1038/hr.2013.30.
8. Tran Thi Thu Thao, Tran Thi Nga. The prevalence of urinary microalbumin and the relationship between urinary microalbumin, the microalbumin/creatinine ratio in random urine samples, and glomerular filtration rate in patients with type 2 diabetes mellitus. *Vietnam Medical Journal*. 2023. 529(1), 284-389. doi: 10.51298/vmj.v529i1.6320.
9. Van Hout, M. J., Dekkers, I. A., Westenberg, J. J., Schalij, M. J. Normal and Reference Values for Cardiovascular Magnetic Resonance-Based Pulse Wave Velocity in the Middle-Aged General Population. *Journal of Cardiovascular Magnetic Resonance: Official Journal of the Society for Cardiovascular Magnetic Resonance*. 2021. 23(1), 1-9. doi: 10.1186/s12968-021-00739-y.
10. Nguyen Van Hai. Evaluation of carotid intima-media thickness in patients with type 2 diabetes mellitus and hypertension. *Journal of 108 - Clinical Medicine and Pharmacy*. 2021. 16(DB4), 45-50. doi: 10.52389/ydls.v16iDB4.1027.
11. Vlachopoulos, C., *et al*. Prediction of Cardiovascular Events and All-Cause Mortality with Brachial-Ankle Elasticity Index: A Systematic Review and Meta-Analysis. *Hypertension*. 2012. 60(2), 556-562. doi: 10.1161/hypertensionaha.112.194779.
12. Abushamat, Layla A. Resistant Hypertension and Cardiovascular Disease Mortality in the US: Results from the National Health and Nutrition Examination Survey (NHANES). *BMC Nephrol*. 2019. 20(1), 138. doi: 10.1186/s12882-019-1315-0.
13. Swierblewska, E., Hering, D., Kara, T., Kunicka, K., Kruszewski, P., Bieniaszewski, L., Boutouyrie, P., Somers, V. K., & Narkiewicz, K. An Independent Relationship Between Muscle Sympathetic Nerve Activity and Pulse Wave Velocity in Normal Humans. *Journal of Hypertension*. 2010. 28(5), 979-984. doi: 10.1097/hjh.0b013e328336ed9a.
14. Ye Chaoyi, *et al*. Relationship between high-normal albuminuria and arterial stiffness in Chinese population. *Journal of clinical hypertension*. 2020. pp. 35. doi: 10.1111/jch.13979.
15. Zhao D, Wang J, Li Z, Zhang S, Yang J, Zhang C. The relationship between arterial stiffness and kidney function in patients with hypertension: A review. *Front Cardiovasc Med*. 2022. 9, 839875. doi: 10.3389/fcvm.2022.839875.