E-ISSN: 3078-4514 | P-ISSN: 3105-1316
Vol. 3, No. 1, 2026
DOI: 10.71295/JHDT.2026.03.1.12

RESEARCH ARTICLE

Prediction of the Individual Efficacy of Fixed Triple-Component Therapy in the Management of Severe Hypertension

Nurana Azayeva*

Scientific Research Institute of Cardiology named after acad. J.M. Abdullayev, Baku city, Azerbaijan

Corresponding Author: *Nurana Azayeva, Email: nurdoc06@yahoo.com*

Received: 16/07/2026 **Revised:** 24/07/2026 **Accepted:** 31/07/2026

Abstract

Summary. This study evaluated the effects of fixed triple-component antihypertensive therapy on clinical and hemodynamic parameters in patients with Grade 3 arterial hypertension and identified predictors of individual treatment efficacy.

Materials and methods. A total of 50 patients underwent comprehensive clinical, laboratory, and instrumental examinations, including ambulatory blood pressure monitoring, echocardiography, Doppler echocardiography, and carotid Doppler ultrasound at baseline and after six months of therapy. Treatment efficacy was defined as a reduction of at least 10% in left ventricular myocardial mass, and multivariable logistic regression and ROC analyses were used to determine prognostic factors.

Results. Higher baseline left ventricular myocardial mass and left ventricular diastolic dimension significantly decreased the likelihood of treatment efficacy, whereas a higher baseline ejection fraction increased the probability of achieving the therapeutic target. Carotid intima-media thickness was identified as the strongest independent vascular predictor of an unfavorable individual response to therapy. The combined cardiac and vascular prognostic model demonstrated high predictive performance, with an AUC of 0.892, sensitivity of 86.7%, and specificity of 82.4%.

Conclusion. Fixed triple-component therapy efficacy in severe arterial hypertension can be predicted using baseline echocardiographic and carotid vascular parameters. The developed mathematical model may support personalized treatment planning and the early identification of patients at risk of poor therapeutic response.

Keywords: Arterial hypertension, Triple-component therapy, Prognostic model, Echocardiography, Intima-media thickness.

Introduction

Arterial hypertension (AH) remains one of the most critical challenges in modern cardiology and global healthcare. According to international epidemiological studies, more than 1.28 billion people worldwide suffer from AH, with a continuing upward trend [1]. Grade 3 (severe) arterial hypertension is characterized by the highest level of cardiometabolic risk. In this patient cohort, the risk of target organ damage (heart, brain, kidneys, and major vessels) as well as severe complications such as stroke, myocardial infarction, and chronic kidney disease is sharply elevated compared to other grades [2].

According to current clinical protocols and guidelines of the European Society of Cardiology (ESC) and the International Society of Hypertension (ISH), the immediate initiation of fixed triple-component combination therapy (typically a RAAS blocker + calcium channel blocker + diuretic) is recommended to achieve and maintain target blood pressure (BP) levels in patients with severe AH [3, 4]. The use of fixed combinations significantly improves patient adherence (compliance) by reducing the pill burden and enables target BP to be reached in a shorter timeframe [5].

Nevertheless, in clinical practice, individual responses to standard fixed triple pharmacotherapy regimens vary widely among patients. Treatment efficacy and organoprotective properties depend directly on the patient's age, gender, duration of AH, baseline lipid and electrolyte (sodium, potassium) profiles, as well as the structural and functional status of the vascular wall [6, 7]. Currently, the advancement of personalized medicine in cardiology necessitates the prediction of the individual efficacy of triple combinations prior to treatment, based on ambulatory blood pressure monitoring (ABPM), echocardiographic, and functional vascular parameters [8].

In this regard, developing prognostic criteria for the individual impact of fixed triple-component therapy on clinic-functional, hemodynamic, and metabolic parameters in patients with Grade 3 AH is highly relevant and determines the rationale of this study.

Aim of the study

Therefore, the aim of the study is to investigate the effect of fixed triple-component antihypertensive therapy on clinico-functional and hemodynamic parameters over a 6-month dynamic period in patients with Grade 3 arterial hypertension, as well as to determine the baseline criteria that allow for the prediction of the individual efficacy of this therapy.

Materials and Methods

The study included 50 patients with severe AH, comprising 28 females (56%) and 22 males (44%). The mean age of the patients was 58.4 ± 0.60 years. The duration of AH ranged from 5 to 15 years.

All patients enrolled in the study underwent comprehensive clinical, laboratory, and instrumental examinations. Before treatment and 6 months later, all patients underwent ambulatory blood pressure monitoring (ABPM), echocardiography and Doppler-echocardiography, as well as Doppler ultrasound of the carotid arteries.

Against the background of 6 months of fixed triple therapy, changes in the geometric model of the left ventricle based on echocardiography and the structural-functional status of major vessels (e.g., intima-media thickness) analyzed via carotid Doppler ultrasound allowed for the identification of baseline instrumental criteria predicting the individual efficacy of this therapy.

Results

A Multi-factorial analysis was applied based on the echocardiographic data obtained for all 50 patients at baseline (pre-treatment) and 6-month follow-up: left ventricular diastolic dimension (LVDD), systolic dimension (LVSD), ejection fraction (EF%), interventricular septum thickness (IVST), posterior wall thickness (PWT), and left ventricular myocardial mass (LVMM).

In accordance with clinical protocols, the regression of left ventricular hypertrophy (a reduction in LVMM of ≥10%) was adopted as the criterion for the individual efficacy of fixed triple therapy in severe arterial hypertension. Patients were divided into two groups ("Effective" = 1, "Ineffective" = 0), and a Binary Logistic Regression analysis was performed. A multivariable logistic regression analysis was applied to evaluate the impact of baseline (pre-treatment) echocardiographic parameters on the 6-month individual efficacy of the fixed triple-component antihypertensive therapy and its predictive capacity. Stepwise regression analysis revealed the strongest independent prognostic factors (predictors) influencing treatment efficacy (Table 1).

Multivariate analysis shows that higher baseline LVMM and LVDD values statistically decrease the likelihood of individual treatment efficacy (OR < 1). Every 10 g increase in baseline LVMM reduces the likelihood of treatment efficacy by 32% (p = 0.004), while every 1 mm increase in LVDD reduces it by 21.4% (p = 0.014). Conversely, a higher baseline EF value increases the likelihood of achieving the therapeutic target by 1.2-fold (20.3%) (OR = 1.203, p = 0.012).

Based on the results of the mathematical-statistical analysis, a multivariate mathematical prognostic model (formula) has been developed, enabling the calculation of the 6-month individual treatment efficacy probability (P) in a specific patient with Grade 3 AH receiving fixed triple-component therapy:

$$P = 1/1 + e^{-z}$$

Here, the linear equation z is expressed by the following formula:

$$z = 14.82 - 0.032 \times (LVMM) + 0.185 \times (EF) - 0.241 \times (LVDD)$$

Note

The patient's baseline echocardiographic parameters (LVMM, EF, and LVDD) are substituted into the equation to calculate the probability (P). If the resulting P ≥ 0.5 (50%), the fixed triple combination is predicted to show high individual efficacy in that patient. If P < 0.5, the patient is predetermined to exhibit resistance or a poor response to the treatment. To verify the prognostic significance of the established multivariable mathematical model, a ROC analysis yielded an area under the curve of AUC = 0.864 ± 0.042 (95% CI: 0.782 - 0.946; p < 0.001). This proves that

Table 1: Results of multivariate logistic regression analysis of baseline echocardiographic parameters predicting individual efficacy of triple-component therapy

Parameters (baseline)	*Regression coefficient (β)*	*Standard error (SE)*	*Wald statistic*	*p-value*	*Odds ratio (OR)*	*95% Confidence interval (CI)*
Constant	14,82	6,12	5,86	0,015	—	—
LVMM (g)	-0,032	0,011	8,47	0,004	0,968	0,948 – 0,990
EF (%)	0,185	0,074	6,25	0,012	1,203	1,041 – 1,391
LVDD (mm)	-0,241	0,098	6,05	0,014	0,786	0,649 – 0,952

Table 2: Results of multivariate logistic regression analysis of baseline clinic-functional parameters predicting individual efficacy of triple-component therapy

Parameters (baseline)	*Regression coefficient (β)*	*Standard error (SE)*	*Wald statistic*	*p-value*	*Odds ratio (OR)*	*95% Confidence interval (CI)*
Constant	16,14	5,84	7,63	0,006	—	—
LVMM (g)	-0,028	0,009	9,67	0,002	0,972	0,955 – 0,989
IMT (mm)	-3,142	1,215	6,69	0,010	0,043	0,004 – 0,466
EF (%)	0,162	0,068	5,68	0,017	1,176	1,029 – 1,344
LVDD (mm)	-0,198	0,089	4,95	0,026	0,820	0,689 – 0,977

the prognostic capability of the developed mathematical-statistical model is at a "very good / high" level. The individual sensitivity and specificity of the model were confirmed to be 84.3% and 79.2%, respectively.

In addition to left ventricular geometric parameters, the analysis also included the carotid Intima-media thickness (IMT), which is an important marker of target organ damage. This parameter is one of the most critical criteria for assessing the structural and functional status of blood vessels and the presence of subclinical atherosclerosis.

To evaluate the independent impact of baseline (pre-treatment) echocardiographic and vascular parameters on the 6-month individual efficacy of the fixed triple-component antihypertensive therapy, a multivariable logistic regression analysis was performed once again.

The final results of the stepwise regression model are presented in Table 2.

Multivariate analysis indicates that a high baseline IMT is the strongest independent vascular predictor that sharply decreases the likelihood of individual efficacy for fixed triple therapy (OR = 0.043, p = 0.010). This implies that the greater the baseline vascular wall thickening and atherosclerotic tendency, the more difficult it is to achieve regression of target organ damage and stable blood pressure in the patient.

At the same time, baseline LVMM (p = 0.002) and LVDD (p = 0.026) retain their negative prognostic impact, while baseline EF (p = 0.017) acts as a positive factor increasing the likelihood of treatment success.

Taking into account both cardiac (echocardiographic) and vascular (Doppler) factors simultaneously, a new and more accurate multivariate mathematical prognostic model has been formulated as follows:

$$P=1+e^{-z1}$$

Here, the linear equation z is expressed with new coefficients as follows:

$$z = 16.14 - 0.028 \times (LVMM) - 3.142 \times (IMT) + 0.162 \times (EF) - 0.198 \times (LVDD)$$

Thus, the practical significance of the study lies in the fact that prior to initiating treatment, by substituting these four parameters of the patient into the formula, one can predetermine the probability of individual efficacy (P) for the fixed triple-drug preparation (P ≥ 0.5 indicates efficacy, while P < 0.5 indicates a poor response). The incorporation of the IMT parameter into the model further enhanced prediction accuracy. Based on the ROC analysis, the area under the curve was AUC = 0.892 ± 0.031 (95% CI: 0.821 - 0.963; p < 0.001). This result demonstrates that the prognostic capability of the model is close to excellent ("outstanding"). The individual sensitivity and specificity of the model are 86.7% and 82.4%, respectively.

Conclusion

The study demonstrates that while fixed triple-component antihypertensive therapy is a standard recommendation for Grade 3 arterial hypertension, its individual efficacy is significantly influenced by baseline cardiac and vascular structural parameters. The regression of left ventricular hypertrophy—the primary indicator of therapeutic success in this cohort—is closely linked to the initial degree of target organ damage.

Specific findings lead to the following conclusions:

Cardiac predictors

Higher baseline values of Left Ventricular Myocardial Mass (LVMM) and Left Ventricular Diastolic Dimension (LVDD) are independent negative predictors of treatment success. Specifically, every 10 g increase in LVMM and every 1 mm increase in LVDD reduce the likelihood of achieving the therapeutic target by 32% and 21.4%, respectively. Conversely, a higher baseline Ejection Fraction (EF) serves as a positive prognostic factor.

Vascular Impact

Carotid Intima-Media Thickness (IMT) was identified as the strongest independent vascular predictor. A high baseline IMT sharply decreases the probability of individual efficacy (OR = 0.043), suggesting that advanced vascular remodeling and subclinical atherosclerosis significantly hinder the regression of target organ damage.

Prognostic modeling

The integration of both echocardiographic and vascular parameters into a unified mathematical model

(z=16.14−0.028×LVMM−3.142×IMT+0.162×EF−0.198×LVDDz = 16.14 - 0.028 x LVMM - 3.142 x IMT + 0.162 x EF - 0.198 x LVDD; z=16.14−0.028×LVMM−3.142×IMT+0.162×EF−0.198×LVDD) provides an "outstanding" level of prognostic accuracy (AUC = 0.892) with high sensitivity (86.7%) and specificity (82.4%). *In summary,* the practical application of this multivariate model allows clinicians to calculate the probability of success (PPP) for fixed triple therapy before treatment initiation. This personalized approach facilitates the early identification of patients likely to be resistant to standard regimens, enabling more precise and timely adjustments in the management of severe hypertension.

References

1. NCD Risk Factor Collaboration (NCD-RisC). (2021). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *The Lancet*, 398(10304), 957-980.
2. Williams, B., et al. (2022). High blood pressure and target organ damage: From mechanisms to clinical outcomes. *Journal of Human Hypertension*, 36(4), 341-352.
3. Stergiou, G. S., et al. (2023). 2023 European Society of Hypertension (ESH) Guidelines for the management of arterial hypertension. *Journal of Hypertension*, 41(12), 1874-2071.
4. Unger, T., et al. (2020). 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension*, 75(6), 1334-1357.
5. Parati, G., et al. (2024). Single-pill combinations in hypertension management: Focus on triple therapies for high-risk patients. *European Heart Journal*, 45(8), 612-625.
6. Volpe, M., et al. (2023). Predictors of response to antihypertensive combination therapies: The role of metabolic and target organ damage profiling. *High Blood Pressure & Cardiovascular Prevention*, 30(2), 115-124.
7. Kario, K. (2022). Management of severe hypertension and prediction of cardiovascular events using home and ambulatory blood pressure monitoring. *Hypertension Research*, 45(4), 565-575.
8. Mancia, G., et al. (2024). Personalized medicine in hypertension: Utilizing baseline clinical and laboratory biomarkers to predict treatment efficacy. *Journal of the American College of Cardiology*, 83(5), 499-512.