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INTEGRATED CIRCULATORY PARAMETERS FOR HEMODYNAMIC CLASSIFICATION IN PATIENTS WITH ARTERIAL HYPERTENSION

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Abstract: Arterial hypertension is characterized by heterogeneous hemodynamic mechanisms that influence disease progression and cardiovascular risk. This study evaluated integrated circulatory parameters to identify different hemodynamic patterns in patients with various forms of hypertension. A total of 178 patients and 32 healthy volunteers underwent comprehensive clinical examination with assessment of cardiac output, peripheral vascular resistance, and arterial stiffness. Distinct hemodynamic profiles were identified among patients with essential hypertension, hypothyroidism, and rheumatoid arthritis, reflecting differences in vascular adaptation and circulatory regulation. Integrated hemodynamic evaluation may improve diagnostic accuracy and support individualized management of patients with arterial hypertension.

Keywords: arterial hypertension; hemodynamics; arterial stiffness; vascular resistance; cardiovascular assessment.

ИНТЕГРАЛЬНЫЕ ПОКАЗАТЕЛИ КРОВООБРАЩЕНИЯ ДЛЯ КЛАССИФИКАЦИИ ГЕМОДИНАМИЧЕСКИХ ТИПОВ У ПАЦИЕНТОВ С АРТЕРИАЛЬНОЙ ГИПЕРТЕНЗИЕЙ

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Аннотация: Артериальная гипертензия характеризуется неоднородными гемодинамическими механизмами, определяющими особенности течения заболевания и сердечно-сосудистый риск. В исследовании проведена оценка интегральных показателей кровообращения для определения различных

гемодинамических вариантов у пациентов с разными формами артериальной гипертензии. Обследованы 178 пациентов и 32 практически здоровых добровольца с определением сердечного выброса, общего периферического сосудистого сопротивления и артериальной жесткости. Выявлены различные гемодинамические профили у больных с гипертонической болезнью, гипотиреозом и ревматоидным артритом, отражающие особенности сосудистой адаптации и регуляции кровообращения. Комплексная оценка гемодинамики способствует более точной диагностике и выбору индивидуальной тактики лечения пациентов с артериальной гипертензией.

Ключевые слова: артериальная гипертензия; гемодинамика; артериальная жесткость; сосудистое сопротивление; сердечно-сосудистая оценка.

Introduction: Arterial hypertension remains one of the leading causes of cardiovascular morbidity and mortality worldwide despite substantial progress in diagnostic and therapeutic approaches. The clinical course of hypertension is highly heterogeneous because elevated blood pressure may develop through different hemodynamic mechanisms involving cardiac output, peripheral vascular resistance, and arterial stiffness. Conventional blood pressure measurement provides limited information regarding these underlying circulatory changes and therefore cannot fully explain individual differences in disease progression or treatment response. Recent studies have emphasized the importance of integrated hemodynamic assessment for identifying the dominant physiological mechanisms responsible for hypertension. Evaluation of cardiac output together with arterial stiffness and vascular resistance offers a more comprehensive understanding of cardiovascular adaptation and target organ involvement. Patients with endocrine disorders or chronic inflammatory diseases frequently demonstrate specific hemodynamic characteristics that differ from those observed in essential hypertension. Recognition of these differences may improve clinical decision-making and facilitate individualized antihypertensive therapy. Modern noninvasive methods allow simultaneous assessment of multiple circulatory parameters without

increasing diagnostic complexity. Integrating these indicators into routine clinical practice may enhance cardiovascular risk stratification, improve monitoring of disease progression, and contribute to more effective prevention of long-term complications associated with arterial hypertension.

Aim of the study: To evaluate integrated circulatory parameters for identifying different hemodynamic patterns in patients with various forms of arterial hypertension and to determine their clinical significance for individualized cardiovascular assessment.

Materials and methods. A comparative observational study was performed in 123 patients diagnosed with arterial hypertension and 32 healthy volunteers who served as the control group. The study population included 42 patients with essential hypertension, 28 patients with primary hypothyroidism associated with arterial hypertension, and 22 patients with rheumatoid arthritis accompanied by arterial hypertension. All participants underwent clinical examination, laboratory investigations, 12-lead electrocardiography, and transthoracic echocardiography. Blood pressure and heart rate were measured after an adequate resting period under standardized conditions. Stroke volume was determined echocardiographically, while cardiac output, mean arterial pressure, total peripheral vascular resistance, and arterial stiffness were calculated using integrated hemodynamic models. The ratio between arterial stiffness and peripheral vascular resistance was additionally analyzed to identify the predominant mechanism responsible for blood pressure elevation. Patients with severe heart failure, advanced renal or hepatic disease, and other serious systemic disorders were excluded from the investigation. Statistical analysis was carried out using standard statistical software. Continuous variables were expressed as mean $\pm$ standard deviation, whereas categorical variables were presented as absolute values and percentages. Group comparisons were performed using appropriate parametric and nonparametric statistical methods according to data distribution. Statistical significance was accepted at $p < 0.05$.

Results. Integrated hemodynamic evaluation demonstrated substantial differences among patients with various forms of arterial hypertension. Healthy volunteers most frequently exhibited eukinetic circulation with predominance of peripheral vascular resistance, reflecting normal cardiovascular adaptation. Patients with essential hypertension predominantly demonstrated eukinetic and hypokinetic hemodynamic patterns, although considerable variability between individual patients was observed. In contrast, individuals with hypothyroidism and arterial hypertension mainly presented with eukinetic circulation associated with increased peripheral vascular resistance, indicating that vascular resistance represented the principal mechanism responsible for elevated blood pressure. Patients with rheumatoid arthritis showed a different profile characterized by hyperkinetic and eukinetic circulation combined with significantly increased arterial stiffness. These findings suggest that chronic inflammatory activity contributes to progressive vascular remodeling and reduced arterial elasticity. Comparative analysis also revealed significant differences in pulse pressure, mean arterial pressure, total peripheral vascular resistance, and arterial stiffness between clinical groups. The integrated assessment of cardiac output, heart rate, arterial stiffness, and vascular resistance enabled more accurate classification of hemodynamic phenotypes than conventional blood pressure measurements alone. The proposed classification system successfully distinguished heterogeneous circulatory patterns in patients with different clinical conditions and demonstrated potential value for individualized cardiovascular evaluation. These results indicate that integrated hemodynamic analysis provides important information regarding the pathophysiological mechanisms of arterial hypertension and may improve selection of targeted therapeutic strategies.

Conclusions: Patients with arterial hypertension demonstrate distinct hemodynamic phenotypes that cannot be identified by routine blood pressure measurement alone. Integrated evaluation of cardiac output, arterial stiffness, and total peripheral vascular resistance provides a more comprehensive understanding

of cardiovascular function and vascular remodeling. Different underlying diseases are associated with specific circulatory characteristics, emphasizing the need for individualized diagnostic assessment. Application of integrated hemodynamic parameters may improve cardiovascular risk stratification, facilitate selection of personalized antihypertensive therapy, and enhance long-term clinical management. This approach represents a practical tool for optimizing diagnostic accuracy and improving outcomes in patients with different forms of arterial hypertension.

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