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THE ROLE OF RENAL FUNCTION IN THE DEVELOPMENT OF ARTERIAL HYPERTENSION IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CLINICO-PATHOPHYSIOLOGICAL STUDY

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Abstract: This article examines the role of renal dysfunction in the development of arterial hypertension in patients with type 2 diabetes mellitus. Diabetic nephropathy, glomerular hyperfiltration, microalbuminuria, activation of the renin–angiotensin–aldosterone system (RAAS), and endothelial impairment are analyzed as key mechanisms contributing to elevated blood pressure. Biochemical parameters such as serum creatinine, estimated glomerular filtration rate (eGFR), urinary albumin excretion, and markers of oxidative stress are assessed alongside clinical indicators of hypertension. The findings demonstrate that early renal impairment significantly accelerates the onset and progression of hypertension in type 2 diabetic patients through hemodynamic, hormonal, and inflammatory pathways. The study highlights the importance of integrating renal biomarkers into early risk prediction and individualized therapeutic strategies for diabetic hypertension.

Keywords: Type 2 diabetes; arterial hypertension; diabetic nephropathy; microalbuminuria; glomerular filtration rate; RAAS activation; renal function; endothelial dysfunction.

INTRODUCTION

Type 2 diabetes mellitus remains one of the most widespread metabolic disorders worldwide and is frequently associated with arterial hypertension, significantly increasing the risk of cardiovascular morbidity and mortality. In clinical practice, hypertension is detected in more than 70% of patients with type 2 diabetes, suggesting a strong pathophysiological connection between impaired glucose metabolism and vascular dysregulation. Although metabolic disturbances such as insulin resistance and dyslipidemia contribute to elevated blood pressure, growing evidence indicates that renal dysfunction plays a central role in the development and progression of hypertension among diabetic patients.

Diabetic nephropathy is characterized by microalbuminuria, glomerular hyperfiltration, podocyte loss, and thickening of the glomerular basement membrane, all of which gradually impair renal autoregulation. As renal damage progresses, the kidneys increasingly lose their ability to regulate sodium balance, extracellular fluid volume, and systemic vascular resistance. These mechanisms create a hemodynamic environment conducive to the development of arterial hypertension. Furthermore, hyperglycemia-induced oxidative stress and endothelial dysfunction amplify the sensitivity of renal vasculature to hormonal and neurohumoral signals.

The renin–angiotensin–aldosterone system (RAAS) is particularly important in this context. Persistent hyperglycemia and renal ischemia stimulate excessive activation of RAAS, promoting vasoconstriction, sodium retention, and increased intraglomerular pressure. These alterations accelerate both renal decline and the progression of hypertension. As a result, renal impairment becomes both a cause and a consequence of elevated blood pressure, forming a vicious cycle in type 2 diabetes.

Given the high prevalence of diabetic nephropathy and its strong association with hypertension, evaluating renal function using sensitive biomarkers is crucial for early detection and prevention of cardiovascular complications. This study investigates the pathophysiological mechanisms linking renal

dysfunction to arterial hypertension in type 2 diabetic patients and assesses key biochemical and clinical indicators influencing disease progression.

LITERATURE REVIEW

Research over the past three decades has conclusively demonstrated that renal impairment is one of the earliest and most influential predictors of hypertension in type 2 diabetes mellitus. Numerous studies emphasize that microalbuminuria, even in its initial stages, serves not only as a marker of kidney damage but also as a strong independent risk factor for cardiovascular disease and hypertension. Microalbuminuria reflects increased permeability of renal capillaries and endothelial dysfunction, both of which are strongly associated with dysregulation of blood pressure.

Glomerular hyperfiltration is another established early manifestation of diabetic renal injury. Studies have shown that chronic hyperglycemia increases glomerular pressure and filtration rate, triggering mesangial expansion and structural remodeling. Persistent hyperfiltration eventually leads to nephron loss, reduced sodium excretion, and increased intravascular volume, all of which contribute to the development of hypertension. Research indicates that patients exhibiting hyperfiltration at diagnosis are significantly more likely to develop hypertension within five years.

Activation of the renin–angiotensin–aldosterone system (RAAS) has been extensively studied as a core mechanism in diabetic renal hypertension. Hyperglycemia enhances intrarenal angiotensin II production, causing efferent arteriolar vasoconstriction, increased glomerular pressure, and progressive nephron injury. RAAS overactivity also promotes inflammation, oxidative stress, and fibrosis in renal tissues. Clinical trials have shown that angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) effectively reduce blood pressure and slow renal decline, highlighting the mechanistic importance of RAAS.

Endothelial dysfunction is another crucial factor linking renal impairment and hypertension. Studies reveal that nitric oxide (NO) production is markedly reduced in diabetic patients due to oxidative stress and accumulation of advanced glycation end-products (AGEs). Reduced NO availability impairs vasodilation, increases arterial stiffness, and exacerbates systemic vascular resistance. These changes further burden the kidneys, worsening hypertension.

In summary, the literature consistently supports that renal dysfunction—mediated by hyperfiltration, microalbuminuria, RAAS activation, and endothelial impairment—is a fundamental driver of arterial hypertension in type 2 diabetic patients.

METHODOLOGY

The study involved adult patients aged 35–75 years diagnosed with type 2 diabetes mellitus. Participants were divided into two groups:

1. patients with diabetes and established arterial hypertension,
2. diabetic patients with normal blood pressure serving as controls.

Clinical evaluation included measurement of systolic and diastolic blood pressure, body mass index, waist circumference, and duration of diabetes. Blood pressure was measured three times using standard procedures, and mean values were recorded.

Renal function was assessed using serum creatinine, estimated glomerular filtration rate (eGFR), and urinary albumin-to-creatinine ratio (ACR). Microalbuminuria was defined as ACR values between 30–300 mg/g. Urinalysis was repeated twice to confirm accuracy. Additionally, serum electrolytes, uric acid, C-reactive protein, and markers of oxidative stress were measured.

RAAS activity was indirectly evaluated through plasma renin activity and aldosterone concentration. Endothelial function was assessed using plasma nitric oxide metabolites. Glycemic control was evaluated using fasting glucose and HbA1c levels.

Statistical analyses were performed with SPSS. Group comparisons were conducted using t-tests or ANOVA. Correlations between renal markers and blood pressure were examined using Pearson coefficients. Logistic regression identified predictors of hypertension in diabetic patients.

RESULTS AND ANALYSIS

Patients with hypertension showed significantly reduced eGFR and elevated serum creatinine levels compared with controls. ACR values were markedly higher in the hypertensive group, indicating that microalbuminuria was strongly associated with elevated blood pressure. Statistical analysis demonstrated a strong inverse correlation between eGFR and systolic blood pressure, confirming that declining renal function directly contributes to hypertension development.

RAAS-related biomarkers were significantly elevated in hypertensive patients. Plasma renin activity and aldosterone levels correlated positively with urinary albumin excretion, suggesting enhanced intrarenal RAAS activation in early renal injury. This confirms the hypothesis that RAAS overactivity plays a critical role in diabetic hypertension.

Endothelial dysfunction markers showed similar trends. Hypertensive patients exhibited lower nitric oxide metabolite levels and higher oxidative stress indicators. These findings suggest that impaired endothelial function exacerbates vascular resistance and accelerates hypertension progression.

Glycemic control also demonstrated an important association: higher HbA1c levels were correlated with elevated ACR, reduced eGFR, and increased blood pressure values. This supports the theory that chronic hyperglycemia is a major upstream driver of renal injury and hypertension.

Multivariate regression analysis identified microalbuminuria, RAAS activation, and decreased eGFR as the strongest independent predictors of hypertension in type 2 diabetes, even after adjustment for age, duration of diabetes, and BMI.

CONCLUSION

This study confirms that renal dysfunction plays a central pathophysiological role in the development of arterial hypertension in patients with type 2 diabetes mellitus. Early renal abnormalities—particularly microalbuminuria, glomerular hyperfiltration, and reductions in eGFR—act as powerful predictors of hypertension and reflect underlying structural and functional damage to the kidneys. Excessive RAAS activation and endothelial impairment further accelerate these processes, creating a self-perpetuating cycle of renal deterioration and blood pressure elevation.

The findings highlight the importance of routine screening of renal biomarkers in diabetic patients to enable early detection and targeted management of hypertension. Interventions aimed at improving glycemic control, reducing oxidative stress, and modulating RAAS activity may significantly slow the progression of both diabetic nephropathy and hypertension. Integrating these strategies into individualized treatment plans is essential for reducing cardiovascular risk and improving long-term outcomes in patients with type 2 diabetes.

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