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Relationship between Catecholamines Levels and Branched Chain Amino Acids in Patients with Chronic Kidney Disease in Thi-Qar Province, Iraq

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ABSTRACT

Background & Objective: Chronic kidney disease (CKD) is a major global health issue with increasing morbidity and mortality. Early stages are often asymptomatic, delaying diagnosis and treatment. This study aimed to evaluate the relationship between branched-chain amino acids (BCAAs) and catecholamine hormones-dopamine, epinephrine, and norepinephrine in CKD patients in Thi-Qar province, Iraq.

Materials & Methods: This case-control study was conducted on 88 patients with CKD and 40 healthy controls. Blood samples were collected, and serum levels of BCAAs (valine, leucine, and isoleucine) and catecholamines were measured by ELISA method and relevant kits. Data were analyzed using SPSS version 11.5. The Mann-Whitney U test compared group means, and Spearman's rank correlation assessed associations between variables. Statistical significance was defined as $P<0.05$.

Results: BCAA concentrations were significantly lower in CKD patients compared with controls (35.53 ± 3.37 µg/ml vs 61.06 ± 5.39 µg/ml; $P<0.001$). Catecholamine levels were also significantly reduced in CKD patients: dopamine (20.22 ± 8.18 pg/ml vs 48.80 ± 13.74 pg/ml), epinephrine (0.22 ± 0.072 pg/ml vs 0.48 ± 0.13 pg/ml), and norepinephrine (1.21 ± 0.23 pg/ml vs 2.31 ± 0.40 pg/ml) (all $P<0.001$). Positive correlations were observed between BCAA and dopamine (r = 0.11), epinephrine (r = 0.22), and norepinephrine (r = 0.22).

Conclusion: The findings indicate that decreased BCAA levels in chronic kidney disease (CKD) may contribute to impaired catecholamine synthesis. Monitoring these metabolic and neurochemical biomarkers could enhance disease assessment and management. Early nutritional interventions such as targeted amino acid supplementation may offer therapeutic benefits and merit further clinical investigation.

Keywords: Catecholamines, Branched Chain Amino Acids, Chronic Kidney Disease

1. Introduction

The kidneys are an important part of the body's biological balance of several substances that play an active role in reabsorbing, converting, and regulating their levels in the blood (1). The kidneys serve a crucial function in the metabolic processing of branched-chain amino acids (BCAAs), specifically comprising leucine, isoleucine, and valine (2). These organs function not merely as excretory systems, but also contribute to the regulation of amino acid concentrations within the circulatory system (3).

According to the International Kidney Foundation, problems in kidney structure or function that last longer than three months and have an impact on human health are considered chronic renal disease (4). The prevalent ailment known as chronic kidney disease (CKD) is a serious risk to human health. The incidence of CKD is rising as a result of severe morbidity and death, as well as significant public healthcare expenses (5, 6). The glomerular filtration rate (GFR) is linked to the process of diagnosing CKD, identifying its phases, and estimating the risk of complications and related death (7, 8).

The first three phases of chronic kidney disease are characterized by no symptoms. GFR, or glomerular filtration rate, reflects each stage of kidney damage: GFR

> 90 ml/min per 1.73 m² is stage one; GFR 60–89 ml/min per 1.73 m² is stage two; GFR 30–59 ml/min per 1.73 m² is stage three, with little renal damage; and GFR 15–29 ml/min per 1.73 m² is stage four. GFR ≥ 1.73 m² in Stage 5 (9, 10). CKD is frequently regarded as one of the most significant global health issues. In underdeveloped nations, CKD-related morbidity and death are a serious problem (11). Kidney illness affects an estimated 850 million people globally, the majority of whom reside in low- and lower-middle-income nations (LMICs). Many of these people do not have access to kidney disease diagnosis, prevention, or treatment (12). In areas with limited resources and a weak primary care infrastructure, up to 90% of people with CKD are ignorant of their illness and do not seek treatment (13, 14). In the upcoming decades, the prevalence of CKD in LMICs and LICs would rise significantly due to population aging and expansion (15). It is a world health problem that causes high mortality rates and economic burden (16). Other risk factors for CKD include hypertension, diabetes, obesity, protein in the urine, race, family history, genetic disorders, low birth weight, and advanced age (17, 18). Reversible risk factors for CKD can be identified and treated early to slow the illness's progression and consequences and lower the risk of cardiovascular disease (19). CKD significantly affects the balance of hormones in the body, including catechol amines such as epinephrine, norepinephrine, and dopamine. These hormones are secreted by the adrenal glands and sympathetic nervous system and play an important role in regulating hypertension and cardiovascular function (20).

These substances circulate throughout the body and impact growth, development, energy, weight, and bone strength in a variety of ways (21). Catecholamine hormones are important neurohormones in the body. They play a pivotal and essential role in balancing blood circulation via the heart. They also have a significant impact on kidney function, as they affect the proximal and distal renal tubules (22-24) and control the balance of renal blood flow (25). A significant relationship has emerged between dietary intake and the bioavailability of branched-chain amino acids, which is defined as the amount of BCAA digested and absorbed. Factors such as malnutrition, dialysis, metabolic acidosis, and the systemic inflammatory response in patients with CKD may play an important role in the observed decrease in branched-chain amino acid concentrations in patients with CKD (26, 27).

2. Materials and Methods

This clinical study included 88 patients referred to Nasiriya Teaching Hospital in Thi Qar, Iraq. Participants were diagnosed with chronic kidney disease (CKD) after being assessed by specialist physicians. All patients with prostate cancer and other malignancy, patients with heart, hepatitis and joints were eluded from the study. The study included all patients with chronic kidney disease who suffer from obesity, high blood pressure and diabetes. The profile was relied upon to identify the differences. Blood samples were taken from the patients. These blood samples were collected from male and female patients aged between [35–70] years, and from forty blood samples from male and female control subjects aged between [35-50] years. Serum hormone concentrations (epinephrine, norepinephrine, and dopamine) were measured using an enzyme-linked immunosorbent assay (ELISA) method (23), following the steps supplied with the assay kit developed by Sun long Biotech in Hangzhou, China. The principle of this method is based on competitive binding. This technique uses a sandwich ELISA method. A hormone-specific antibody was deposited on the ELISA microchip supplied with the kit. Appropriate wells of the ELISA microchip were filled with standard or sample samples and then mixed with the specific antibody. Each ELISA microchip was then completely coated with an HRP-conjugated anti-hormone antibody and incubated. Free fragments were removed by washing. TMB substrate solution was added to each well. Upon addition of the stop solution, the color of the wells containing only the hormone and HRP-conjugated anti-hormone antibody changed from blue to yellow. A spectrophotometer was used to measure the optical density (OD) at a wavelength of 450 nm. Hormone concentration is directly related to the OD value. By comparing the OD of samples to a standard curve, hormone levels can be determined. Branched-chain amino acids (BCAAs) were determined in serum by following the instructions included with the test kit, developed by Sun long Biotech in Hangzhou, China. The quantities of the branched-chain amino acids (BCAAs), namely valine, leucine, and isoleucine, were determined using an enzyme-linked immunosorbent assay (ELISA) technique (28). This system is based on competitive binding. This system uses the sandwich-ELISA method. The system comes with a microELISA slide coated with a BCAA-specific antibody. The appropriate microelisa slide cavities are filled with standard or sample samples, which are then mixed with the specific antibody. An HRP-conjugated antibody specific for BCAAs is then applied to each microELISA slide cavity and incubated. Free fragments are removed by washing. TMB substrate solution is added to each cavity. Upon addition of the stop solution, only the wells containing BCAA and HRP-conjugated antibodies will turn blue and yellow. A spectrophotometer set to 450 nm is used to determine the optical density (OD). The BCAA concentration is related to the OD value. By comparing the OD of samples to a standard curve, the BCAA content can be determined. Every value that was obtained was presented as mean ± standard deviation (SD). The difference in means between the study group and the control group was compared using the Mann-Whitney U test. Statistical significance was defined as a P-value of less than 0.05. The association between hormones and branched-chain amino acids was investigated using Spearman's rank correlation analysis. For statistical analysis, SPSS for Windows, version 11.5, was used.

3. Result

Our current study included measuring the concentration levels of branched-chain amino acids and catecholamine hormones (epinephrine, norepinephrine, and dopamine) in the blood serum of patients with CKD to monitor the decline in kidney function in these patients. According to the study findings, individuals with CKD had significantly lower levels of BCAAs in their serum (P<0.005). The mean concentration level was (35.53 ± 3.37 μg/ml) compared to the serum concentration level of control group (61.06 ± 5.39 μg/ml), as shown in Table 1 and Figure 1.

The findings demonstrated that dopamine serum level in control group was 48.80 ± 13.74 pg/ml compared to CKD patients' group (20.22 ± 8.18 pg/ml). The concentration of epinephrine was 0.22 ± 0.072 pg/ml in the serum of CKD patients compared to control group (0.48 ± 0.13 pg/ml), and the concentration of norepinephrine hormone was 2.31 ± 0.40 pg/ml in the control group compared to CKD patients (1.21 ± 0.23 pg/ml). As shown in Table 2 and Figures 2-4, the hormones dopamine, epinephrine, and norepinephrine showed significant differences between control group and CKD patients in the serum at a probability level of (P<0.001).

The linear correlation coefficient (r) for the BCAA in the blood serum and hormones (epinephrine, norepinephrine, and dopamine) in CKD individuals was positive, as shown in Figures 5-7.

Table 1. The clinical and pathological features of breast cancer patients.

Parameters	Groups	Number	Mean	Std. Deviation	T-value	P-value
BCAA	Control	40	61.06 µg/ml	5.39	24.96	0.001
	Patients	88	35.53 µg/ml	3.37		

Table 2. The associations between the characteristics of patients and the features of tumors (r: the correlation coefficient; the significant associations were bolded).

Parameters	Groups	Number	Mean	Std. Deviation	T-value	P-value
Epinephrine	Patient	88	0.22	0.07	11.89	0.001
	Control	40	0.48	0.13		
Norepinephrine	Patient	88	1.21	0.23	15.81	0.001
	Control	40	2.31	0.40		
Dopamine	Patient	88	20.22	8.18	12.22	0.001
	Control	40	48.80	13.74		

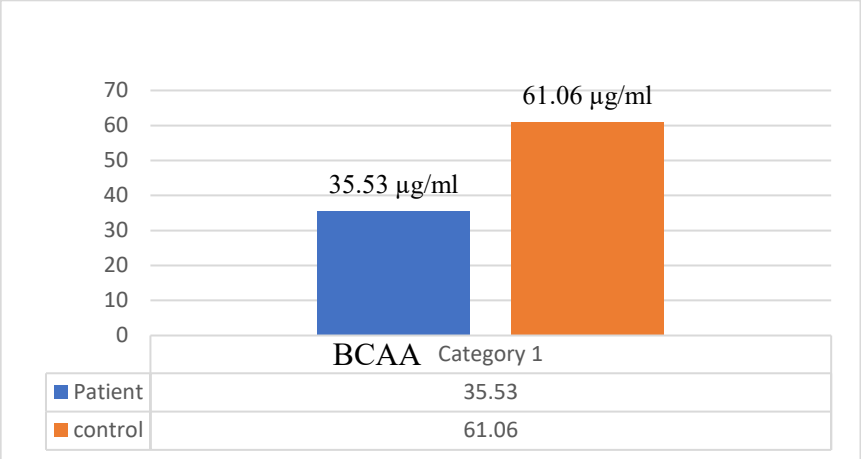

Figure 1. The mean concentrations of BCAAs. The serum level of BCAA was significantly lower in CKD group compared to control (P<0.005) (**Prepared by Authors, 2025**).

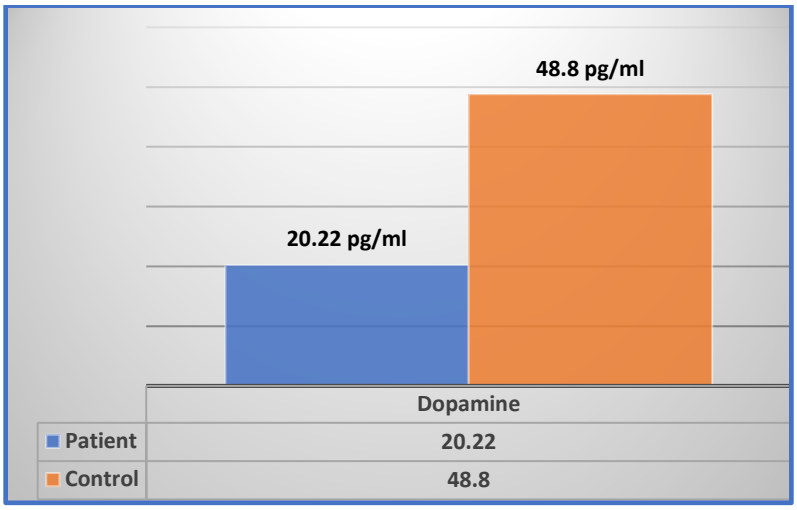

Figure 2. Dopamine concentration. The serum level of Dopamine was significantly lower in CKD group compared to control (P<0.001) (**Prepared by Authors, 2025**).

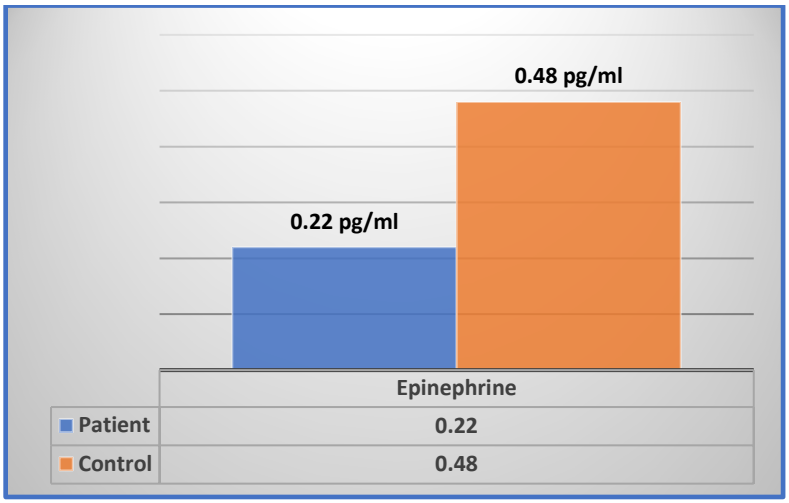

Figure 3. Epinephrine concentration. The serum level of Epinephrine was significantly lower in CKD group compared to control (P<0.001) (**Prepared by Authors, 2025**).

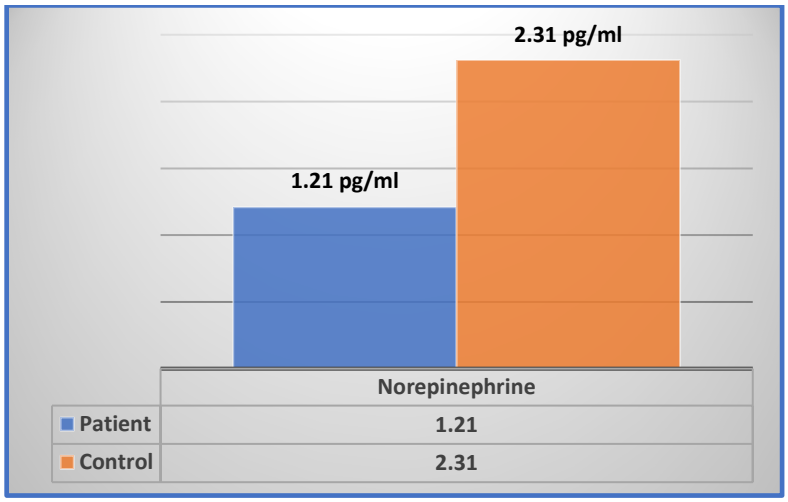

Figure 4. Norepinephrine concentration. The serum level of Norepinephrine was significantly lower in CKD group compared to control (P<0.001) (**Prepared by Authors, 2025**).

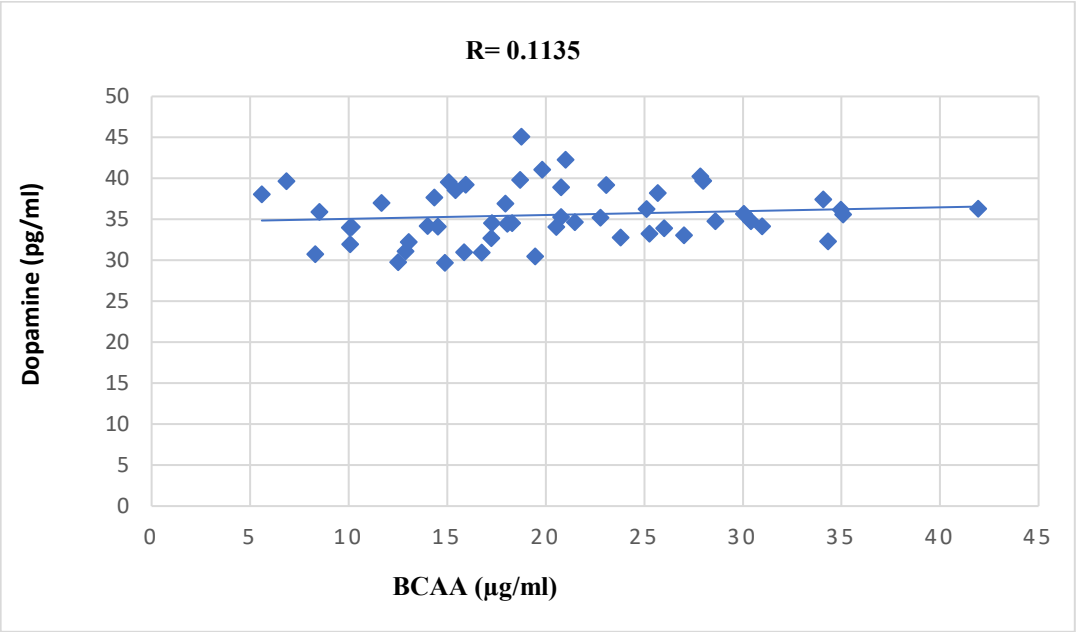

Figure 5. Linear correlation between BCAA level and Dopamine hormone level in CKD patients' blood serum. The correlation was positive (**Prepared by Authors, 2025**).

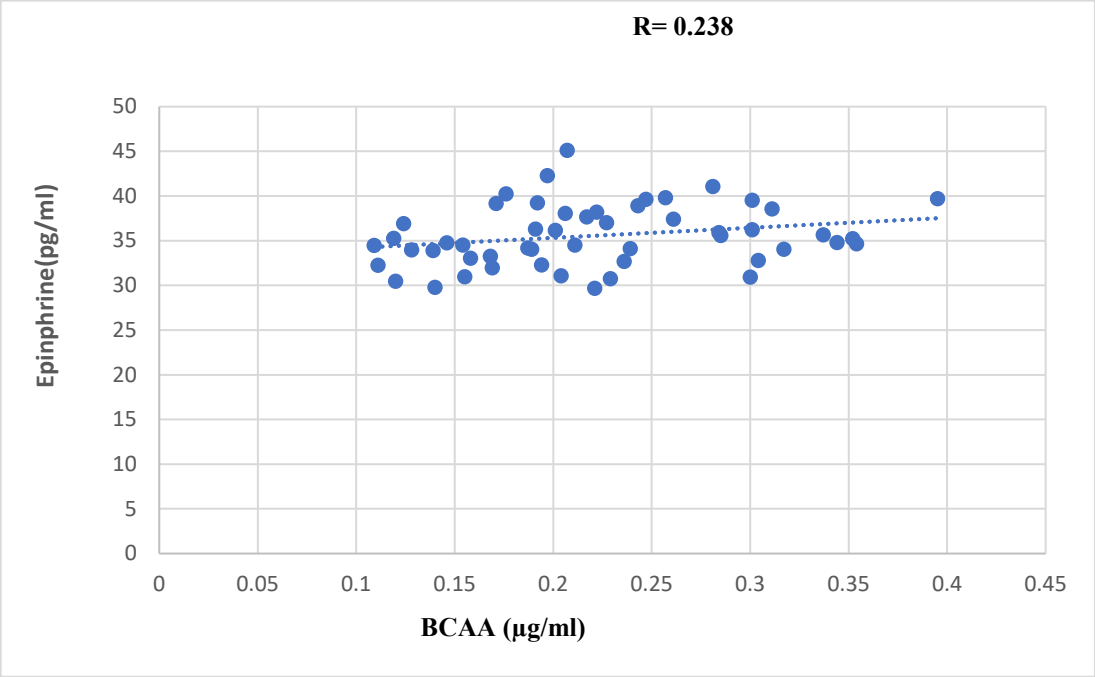

Figure 6. Linear correlation between BCAA level and Epinephrine hormone level in CKD patients' blood serum. The correlation was positive (**Prepared by Authors, 2025**).

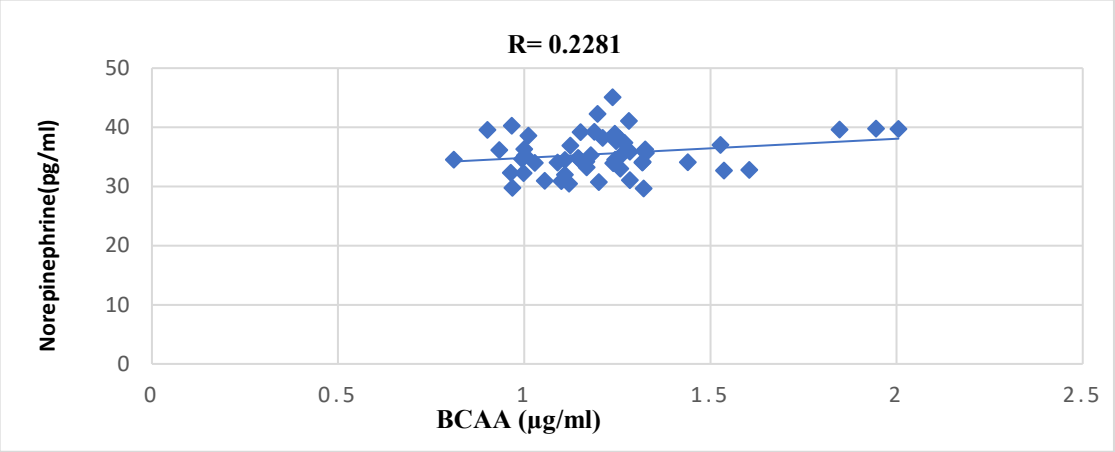

Figure 7. Linear correlation between BCAA level and Norepinephrine hormone level in CKD patients' blood serum. The correlation was positive (**Prepared by Authors, 2025**).

4. Discussions

Globally, CKD is one of the main causes of mortality. This disease has a long, slow course lasting several months. Patients typically do not show any signs or symptoms until their glomerular filtration rate (GFR) reaches 15 cm³/min or less **(29)**. Therefore, it is important to find alternative biochemical variables that can be used as a cognitive marker for this disease, in addition to traditional biochemical tests. Since CKD significantly affects the body's metabolic balance, and among these effects is a decrease in the concentration of BCAAs in the blood **(30)**. Therefore, our current study included measuring the concentration levels of branched-chain amino acids and catecholamine hormones (epinephrine, norepinephrine, and dopamine) in the blood serum of patients with CKD to monitor the decline in kidney function in these patients. According to the study's findings, individuals with CKD had significantly lower levels of BCAAs in their serum (P<0.005). Low levels of these acids are considered to be characteristic changes in the blood of chronic kidney patients for several main reasons: 1) increased rate of decomposition of BCAAs to enhance the formation of glutamate **(31)**, 2) increased muscle absorption of BCAAs in cases of chronic malnutrition, and 3) increased oxidation of these acids, albeit to a lesser degree, to be used as raw materials for the formation of glucose **(32)**. More precisely, all of these factors combine to reduce the concentration of BCAAs in the blood, which may be an indicator of a deterioration in the patient's general condition. This indicates that a disorder in muscle protein metabolism leads to excessive protein breakdown in skeletal muscles, which leads to increased utilization of BCAAs as an energy source, which increases the activity of branched-chain aminotransferase (BCAT) enzymes in the muscles, which increases BCAA consumption **(33)**. The pathophysiological states of metabolic acidosis and systemic inflammation facilitate enhanced proteolytic processes and heightened activity associated with CKD, culminating in an elevated demand for branched-chain amino acids as precursors for the biosynthesis of acute-phase proteins and components of the immune system **(34)**. This is consistent with the results of Kumar et al **(35)**, Klerk et al **(36)**, Cano et al **(37)** and Seshadri Reddy et al **(38)**. Catecholamine hormones are important neurohormones in the human body **(39)**, performing a fundamental and indispensable function in regulating circulatory stability **(40)**. These hormones have a profound impact on cardiac function and also significantly influence renal physiology, particularly the proximal and distal nephron segments. Furthermore, these hormones play a significant role in modulating renal blood flow dynamics **(41)**. The study showed that the decreased concentration of catecholamines such as epinephrine, norepinephrine and dopamine in patients with CKD is attributed to a number of complex physiological and pathological causes, including impaired catecholamine synthesis in the adrenal gland due to a disturbance in hormonal balance (such as HPA axis dysfunction), which affects the adrenal gland that produces catecholamines **(42)**. The accumulation of uremia (urea and other toxins) negatively affects the cells of the adrenal medulla **(43)**. The imbalance in the availability of essential amino acids for synthesis, as low concentrations of BCAAs and tyrosine, the essential amino acid for catecholamine synthesis, affects the body's ability to produce dopamine, norepinephrine, and epinephrine **(44)**. CKD patients suffer from autonomic neuropathy due to damage to the sympathetic nerves (sympathetic nerve dysfunction), which leads to a disruption in the transmission of nerve signals that stimulate the secretion of catecholamines **(45)**. CKD reduces the effectiveness of catecholamine synthesis enzymes, thereby affecting the activity of enzymes responsible for converting tyrosine to dopa and then to dopamine, such as Tyrosine Hydroxylase, Dopa Decarboxylase and Dopamine β-hydroxylase **(46)**. Normally, the kidneys regulate catecholamine levels partly through filtration or reabsorption. In CKD this balance is disrupted, potentially leading to abnormal accumulation or loss of catecholamines in the urine **(47)**. This is consistent with results of Al-Salihi et al **(48)** and Kuczera et al **(49)** by studying the relationship between BCAA concentration and catecholamine concentrations

(epinephrine, norepinephrine, and dopamine) in the blood of those suffering from long-term renal illness, a linear correlation coefficient (r) was found. This suggests a causal relationship between low BCAA concentration and catecholamine concentrations (epinephrine, norepinephrine, and dopamine) **(50, 51)**. This is because low BCAA concentrations in chronic kidney disease negatively affect the balance of other amino acids, leading to an increase in some other acids, which increases competition for brain transmitters and affects the availability of tyrosine **(52, 53)**. Tyrosine is the primary precursor for the synthesis of neurohormones (epinephrine, norepinephrine, and dopamine), which are important hormones in the body and are an indicator of their concentration in the body **(48)**. It is also an indicator of chronic kidney disease. It shows that the linear correlation coefficient (r) for the BCAA in the blood serum and hormones (epinephrine, norepinephrine, and dopamine) in CKD patients is positive.

5. Conclusion

This study highlights hypertension as an important factor influencing tumor aggressiveness, with a correlation observed between hypertension and advanced cancer stage as well as higher tumor grade. Additionally, early menarche and smoking are linked to negative histopathological features. While hypertension did not have a significant impact on survival rates, trends in cumulative hazard suggest it may have prognostic importance, indicating the need for further research. These findings support the integration of hypertension management and lifestyle interventions into breast cancer treatment protocols to help reduce disease progression.

6. Declarations

6.1 Acknowledgments

We are grateful to the doctors and nurses at Al-Nasiriya Teaching Hospital for their life-saving efforts, as well as the laboratory assistants for their technical assistance in obtaining blood samples from patients.

6.2 Ethical Considerations

This study obtained ethical approval, with all patients providing written consent for the use of their data in clinical research. The study adhered to the principles outlined in the latest version of the Declaration of Helsinki. Ethical approval was obtained from the Thi-Qar Health Directorate, the Training and Human Development Center of University of Thi-Qar (Approval No. REC0774803, dated July 22, 2024).

6.3 Authors' Contributions

Writing - preparation of the original draft, A.H.M., M.A.A. and H.M.A.; writing - review and editing, A.H.M. The authors read and approved the final manuscript.

6.4 Conflict of Interest

The authors declare no conflict of interest.

6.5 Fund or Financial Support

This research was not funded by any public, commercial, or not-for-profit funding agency.

6.6 Using Artificial Intelligence Tools (AI Tools)

The researchers refrained from employing artificial intelligence instruments.

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