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RESEARCH ARTICLE

ASSOCIATION OF KIDNEY FUNCTION BIOMARKERS, BLOOD MINERALS, AND BLOOD GLUCOSE WITH HYPERTENSION: A CROSS-SECTIONAL STUDY IN HADHRAMOUT, YEMEN

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Abstract

Hypertension is a major global health challenge and the most common comorbidity accompanying chronic kidney disease. In the Hadhramout coastal region of Yemen, it is among the most prevalent diseases. However, there is a lack of studies in this governorate assessing its physiological and biochemical impacts. Therefore, this study aimed to assess differences and correlations between kidney function biomarkers, blood minerals, blood glucose, and hypertension in Hadhramout, Yemen. A cross-sectional study of 60 participants (40 hypertensive patients and 20 healthy controls) were included. Blood samples were analyzed for fasting glucose, kidney function biomarkers (creatinine, urea, uric acid), and blood minerals (sodium, calcium). Demographic data and body mass index (BMI) were collected via a questionnaire. Hypertensive patients showed significantly higher levels of blood glucose, creatinine, urea, and uric acid compared to the control group, while no significant differences were observed in sodium and calcium levels. Demographically, hypertension was more prevalent in females (55%) and in the 60–69 age group (47.5%). Major risk factors included a family history of hypertension (75%) and anxiety (77.5%). Correlation analysis revealed a significant positive relationship between systolic blood pressure and BMI, alongside a significant negative correlation with sodium levels. Furthermore, diastolic blood pressure demonstrated a significant positive correlation with urea levels. In conclusion: Hypertension is associated with alterations in biochemical parameters, particularly kidney function markers, and glucose levels, as well as BMI, genetic predisposition, and specific electrolyte imbalances.

Keywords: Association; Biochemical parameters; BMI; Demographic characteristics; Hypertension; Kidney biomarkers; Risk factors.

1. Introduction

Hypertension is a major global health challenge and the most common comorbidity accompanying chronic kidney disease (CKD) and remains often poorly controlled in patients with CKD. Dietary sodium restriction is often overlooked, but can improve BP control, especially among patients treated with an agent to block the renin–angiotensin system [1-3]. Approximately 26% of the adults in the world are suffering from high blood pressure, and the percentage is expected to rise further in 2025, reaching 29.2% [4]**.** One of the global targets for chronic disease control is to reduce the prevalence of high blood pressure by 33% between 2010 and 2030 [5]. In Hadhramout coastal region, high blood pressure was among the ten most common diseases, according to health facility records, during the year 2019, as the number of infected patients reached 8849 case 4208 males and 4641 females [6]**.** The total number of cases during the first half of the year

2022 reached 988 cases in Ibn Sina General Hospital and 1021 case in Al-Shehr General Hospital, while 199 case in Al-Deis Al-Sharqiya Hospital. Although there are several studies conducted in different countries related to kidney function parameters and blood minerals in hypertensive patients. Despite extensive research on hypertension and its association with kidney function and electrolyte balance worldwide, there is a lack of region-specific data from Hadhramout, Yemen, particularly regarding the combined assessment of biochemical parameters and demographic risk factors. Therefore, this study aimed to evaluate differences and correlations between kidney function biomarkers, blood glucose, serum minerals, and hypertension, and to explore their association with demographic characteristics and risk factors. The goal was to clarify correlations among high blood pressure, kidney function, and blood mineral levels and to provide a reference for future research.

2. Materials and Methods

2.1 Study design, period and area

This was a cross-sectional analytical laboratory-based study, conducted during the period from December 2021 to March 2022. In Mukalla, Hadhramout Yemen.

2.2 Sample size and Exclusion Criteria

The study sample included 60 participants of both genders. They were divided into two groups:

Patient group: Included 40 hypertensive patients attending the internal medicine clinic at Ibn Sina Hospital in Mukalla, Hadhramaut Governorate. Eighteen cases were male and 22 were female, with ages ranging between 30 and 70 years.

The control group: Included 20 healthy individuals (10 males and 10 females) from the same age group, who did not suffer from any symptoms of high blood pressure or any chronic disease. (were investigated in the same medicine clinic)

*** Exclusion Criteria:** Patients with a known history of chronic diseases other than hypertension (such as preexisting chronic kidney disease, thyroid disorders, or severe cardiovascular diseases), pregnant women, and patients on medications known to alter blood minerals or kidney functions were excluded. For the control group, any individual with a history of chronic illness or taking routine medications was excluded.

2.3 Study procedture

Patients were interviewed. A form was recorded about the condition of each case, and the blood samples were taken from them and analyzed in the laboratory, to find out some biochemical parameters related to kidney functions and blood minerals and comparison these parameters with those for the control group (healthy people).

2.4 Ethical considerations

This study did not involve therapeutic interventions; it was conducted in full compliance with international ethical standards and the Declaration of Helsinki. In the absence of a formal institutional ethics committee within the college, ethical approval was obtained through official administrative channels between the Faculty of Science at Hadhramaut University and the administration of Ibn Sina General Hospital, including its laboratory department. Furthermore, informed consent was secured from all participants prior to their enrollment; all individuals were thoroughly briefed on the study's objectives, procedures, and their right to voluntary participation.

2.5 Methods

2.5.1 Data Collection Tool

The informations related to the study were collected according to a questionnaire prepared for this purpose. The questionnaire included: patient name, age, gender, place of residence, educational level, weight, height, body mass index, systolic and diastolic pressure, number of years of the infection, anxiety, smoking, and infection from relatives.

2.5.2 Blood pressure Mesurement

The blood pressure of both groups: patients as well as the control (healthy) were measured in the internal medicine clinic using the Mercury Sphygmomanometer (German KD-METER Company). The blood pressure level was classified according to [7] as follows: Normal blood pressure: 120/80 mm Hg, pre-hypertension. Blood pressure: 120-139/80-89 mmHg, stage 1 hypertension: 140-159/90-99 mmHg, and stage 2 hypertension: < 160/100 mmH.

2.5.3. Body mass index (BMI)

Weight and height were measured using instrument (Zt - 120) from Health Scale Company (Germany), The Body mass index measurement has been approved according to [8]Body mass index = weight in kilograms/height in meters squared. The cases were divided according to the World Health Organization [9] into: people with underweight BMI < 18.5 kg/m^2, normal people BMI = 18.5-24.9 kg/m^2, overweight people = 25.0-29.9 kg/m^2 BMI and obese people 30.0 kg/m2≤ BMI.

2.5.4 Blood Samples Collecting

Three ml of venous blood were collected from hypertensive patients group as well as from the control group, using medical Disposable syringes (5cc) (Italy), which were placed in dry, clean tubes free of any anticoagulant (Plain tubes) (China). To perform

biochemical tests, the samples were left for 10 minutes at room temperature before it was placed in the centrifuge (HuMax 4k) from Human campany (Germany) to separate the serum from the blood, at a speed of 3000-4000 rotation/minute and for a period of time not exceeding five minutes, The separated serum was withdrawn using an automatic micro pipette (China), and then placed in Eppendorf plastic tubes (China) to conduct the the subsequent t tests.

2.5.5 Biochemical tests

The levels of glucose and creatinine, urea, and uric acid as indicator for kidney function were measured using enzymatic method. While the levels of minerals in the blood (sodium and calcium) were measured using colorimetric methods. It is an AU480 instrument manufactured by the American company Coulter Beckman, connected to a type of computer (DTX company, Japan) and for this purpose special diagnostic kits manufactured by the American company Beckman Coulter were used, according to the instructions listed on the kit of each examination.

2.6 Statistical Analysis

Data from the study samples were collected and statistically analyzed using SPSS Version 24. An independent samples t-test was used to compare the mean differences between the two study groups (hypertensive patients and healthy controls). The results were expressed as mean values ± standard deviation (SD), and statistical significance was set at a probability level of ($P < 0.05$). Furthermore, Pearson's correlation coefficient was used to measure the strength and direction of the linear relationships between blood pressure and other biochemical or demographic variables.

3. Results

3.1. Demographic characteristics

3.1.1 Distribution of samples under study according to gender

The study included examining 60 blood samples collected from two groups: hypertensive patients which included 40 cases, 18 males (45%) and 22 females (55%), while the healthy group (control) included 20 cases. 10 males (50%), and 10 females (50%).

3.1.2 Distribution of patient cases according to age:

The results in Figure 1 show that the 60–69 age group was the most common with 19 cases (47.5%), while the 30–39 age group was the least common with 3 cases (7.5%).

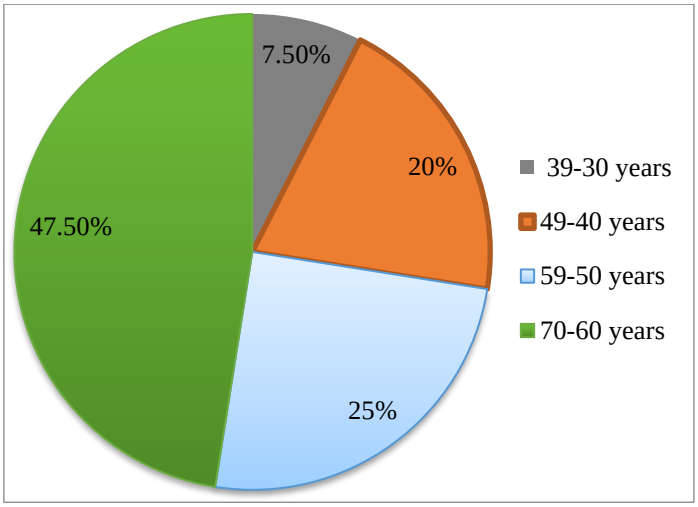

Fig. (1): Distribution of patient cases according to age

3.1.3 Distribution of patient cases according to educational level:

Figure 2 shows that illiteracy was the most common education level, with 17 individuals (42.5%).

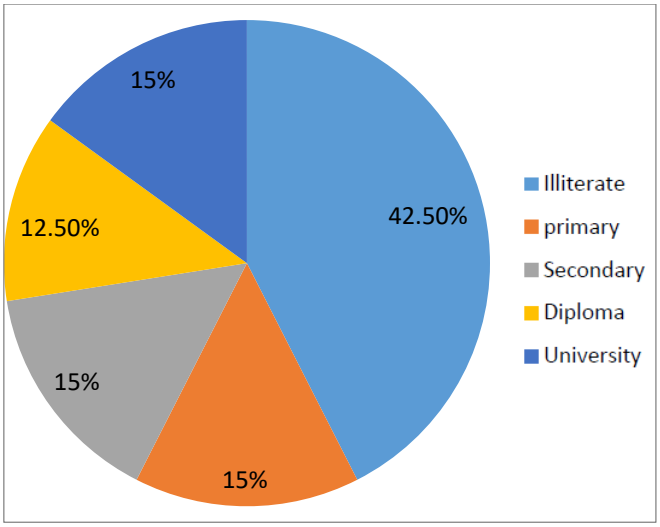

Fig. (2): Distribution of patient cases according to educational level) 1=Illiterate, 2= Primary school, 3= secondary school, 4= Diploma, 5= University).

3.2 Biochemical parameters related to glucose, kidney functions and minerals

Table 1 shows mean ± SD for glucose, creatinine, urea, uric acid, sodium, and calcium in both groups. Hypertensive patients had significantly higher blood glucose and significantly elevated creatinine, urea, and uric acid compared with controls. Mean sodium and calcium were lower in the hypertensive group, but these decreases were not statistically significant; the calcium value stayed within the test reference range, while the sodium value was close to the lower limit of its reference range.

Table (1): Biochemical parametrs (glucose and creatinine, urea, uric acid levels (kidney Functions indicators) and minerals (calcium and sodium) in study groups.

Parameter	Control Group (Mean ± SD)	Hypertensive Group (Mean ± SD)	P-value
Glucose (mg/dL)	88.35±8.79	109.18 ± 28.54	0.001
Creatinine (mg/dL)	0.44 ± 0.15	2.56 ± 0.94	0.001
Urea (mg/dL)	31.7 ± 8.33	69.4 ± 2.22	0.001
Uric Acid (mg/dL)	4.85 ± 1.12	8.08 ± 2.42	0.035
Sodium (mmol/L)	139.4 ± 3.32	135.9 ± 5.89	0.088
Calcium (mg/dL)	9.22 ± 0.73	9.09 ± 0.84	0.309
Weight (kg)	72.6 ± 8.11	77.7 ± 14.5	0.087
BMI	25.6 ± 1.97	30.1 ± 3.72	0.048
Arterial Pressure	98.7 ± 7.4	123.0 ± 11.2	0.001

3.3 Weight and Body Mass Index in the Study Groups

Table (1) presents a significant increase in the mean values of weight and body mass index in patients with hypertension compared to the healthy group.

Table No. (2) Reveals significant gender differences: females exhibited higher BMI, while males showed higher diastolic pressure Conversely, body weight remained statistically comparable.

Table (2): Weight and Body Mass Index and Mean of diastolic pressure according to gender in the patient group.

Parameter	Male Group (Mean ± SD)	Female Group (Mean ± SD)	P-value
Weight (kg)	74.9±10.19	76.9±15.02	0.118
BMI	27.4 ±3.8	30.3 ±3.7	0.018
Mean of diastolic pressure	130.0 ± 18.8	116.2 ± 13.2	0.030

3.4 Mean Arterial Pressure

Table No. 1 shows a significant increase in the value of Mean arterial pressure in patients with high blood pressure compared to the healthy group. Table (2) shows a non-significant increase in the average arterial pressure values in males compared to females in the patient group.

3.5 Frequency of Weight and Obesity in the Study Groups:

Table (3) illustrates the frequencies of weight and obesity in the study sample, where overweight appears to be the most frequent, while the least frequent is class three obesity.

3.6 Incidence from Kinship (Degree of Kinship, Anxiety and Smoking in in Hypertensive Patients

Table (3) illustrates Demographics and Risk Factors (Hypertensive Group Only) the Incidence from Kinship, Degree of Kinship, anxiety and calmness, Smokers and non- smoker in Hypertensive Patients. It was found that the number of hypertensive cases due to kinship reached 30 cases out of a total of 40 patients (75%). Overweight and Obese Class 1 were the most common. The degree of kinship in the genetic factor of a group of hypertensive patients in the study sample shows that first-degree relatives are predominant. And frequencies of both anxiety and calmness in hypertensive patients' group while the frequency of anxiety exceeded that of calmness, the anxiety occurring in 31 cases, while calmness was recorded in only 9 cases. According to Table 3, the smoking rate among hypertensive patients shows that 40% of the patients do not smoke, while 26.7% are smokers of the total patient group.

Table (3): Demographics and Risk Factors (Hypertensive Group Only)

Demographic Variable	Findings (Hypertensive Group Only)
Gender Distribution	55% Female, 45% Male
Age Group (Most Affected)	60–70 years (47.5%)
Age Group (Least Affected)	30–39 years (7.5%)
Education Level (Most Common)	Illiterate (42.5%)
Family History of Hypertension	Yes (75%)
First-Degree Relatives	70% First-degree relative success
Anxiety	77.5% had anxiety
Smoking Status	40% Non-smokers, 26.7% smokers
Weight Status	Overweight and Obese Class 1 most common

3.7 Correlative Relationships

The results of the mean arterial pressure levels were correlated with the obtained results in kidney function levels and body mass index. Table 4 indicates that there are significant positive correlation relationships between mean arterial pressure and kidney function. The table also shows a positive but not significant correlation between mean arterial pressure and body mass index.

Table (4): Correlations Between Blood Pressure and Biochemical Parameters

Variable 1	Variable 2	Correlation Coefficient (r)	P-value
Systolic BP	Glucose	0.314	0.015
Systolic BP	Creatinine	0.184	0.159
Systolic BP	Urea	0.168	0.199
Systolic BP	Uric Acid	0.067	0.612
Systolic BP	Sodium	-0.272	0.036
Systolic BP	Calcium	-0.170	0.193
Systolic BP	BMI	0.389	0.002
Diastolic BP	Glucose	0.018	0.538
Diastolic BP	Creatinine	0.242	0.063
Diastolic BP	Urea	0.295	0.022
Diastolic BP	Uric Acid	0.220	0.091
Diastolic BP	Sodium	0.006	0.963

Diastolic BP	Calcium	0.034	0.795
Diastolic BP	BMI	0.238	0.067

3.7.1 The Correlation between high blood pressure and kidney function parameters:

Table (4) showed that there is no statistically significant correlation between pressure Systolic and kidney functions parameters (creatinine, urea, and uric acid), where the values of the correlation coefficients r reached (0.184, 0.168, and 0.067, respectively), and the p-values reached (0.159, 0.199, 0.612), respectively. It is also noted that there is a positive significant correlation between diastolic pressure and urea, where as the correlation coefficient r reached (0.295) and p- value = 0.022 while there is no significant correlation between diastolic pressure and both creatinine and uric acid, where their correlation coefficients reached (0.242, 0.220) and their p- value reached 0.063, 0.091 respectively.

3.7.2 The correlation between high blood pressure and blood minerals

It is noted from Table (4) that there is a negative correlation between systolic pressure and sodium, where as the correlation coefficient r reached -0.272 and P-value = 0.036 on the other hand there is no significant correlation between systolic pressure and calcium, where the correlation coefficient reached r 0.170 and p-value = 0.193 ,as well asthere is no significant correlation between diastolic pressure and both sodium and calcium, whose correlation coefficients were 0.006, 0.034 as well as p-value = 0.963 , 0.795 Respectively.

The results of the levels of the arterial pressure average were linked with those results obtained in the kidney function levels, as Table 4 indicates the presence of positive significant correlations between the average of the arterial pressure and kidney function parameters.

3.7.3 The correlation between hypertension and body mass index:

Table 4 demonstrated a positive significant correlation between systolic pressure and body mass index, with a correlation coefficient (r) of 0.389 and a p-value of 0.002. In contrast, there was no significant correlation between diastolic pressure and body mass index, as evidenced by a correlation coefficient (r) of 0.238 and a p-value of 0.067.

4. Discussion

High blood pressure (hypertension) is defined as a chronic condition characterized by elevated arterial blood pressure, which increases the risk of cardiovascular and renal complications, and it is a chronic, non-contagious disease that has negative health consequences [10].

4.1 Demographic Determinants of Hypertension

The study reveals a higher prevalence of hypertension among females (55%) compared to males (45%), a trend consistent with established literature [11, 12]**.** This gender disparity is largely attributed to the age-related decline in estrogen and progesterone, hormones critical for maintaining vascular elasticity and regulating vasomotor tone; their depletion subsequently heightens vascular resistance [13]**.** Furthermore, hypertension was most prevalent in the 60–70 age demographic, reinforcing findings from Nigeria[14]. Socioeconomically, a significant illiteracy rate (47.5%) was observed among patients, mirroring data from Mosul, Iraq [15].

4.2 The effect of hypertension on the studied biochemical variables

4.2.1 The Effect of Hypertension on Blood Glucose Levels

The results of this study show a significant increase in fasting glucose levels among patients with hypertension compared to healthy individuals and this aligns with findings from [16], which indicated a significant differences in blood glucose concentrations between hypertensive patients and healthy controls. In India, [17] highlighted the connection between hypertension and diabetes, indicating that social, biological, cultural factors, and lifestyle choices may contribute to this association.

4.2.2 The effect of high blood pressure on biochemical parameters related to kidney functions: Creatinine, urea and Uric Acid

Current study findings indicate a significant rise in the mean levels of creatinine, urea, and uric acid in the blood of patients with high blood pressure compared to healthy controls, with a probability level of < 0.001. These results align with the research conducted by [18, 19]**.**

The results of this study indicated a significant increase in uric acid levels among hypertensive patients compared to healthy controls ($p < 0.05$). This finding aligns with [20] study, which also reported a significant rise in uric acid among hypertensive individuals. This increase may be attributed to alterations in renal processing of urate.

4.2.3 The Impact of Hypertension on Serum Sodium and Calcium Levels

This study observed non-significant decreases in mean serum sodium (Na) and calcium (Ca) levels among hypertensive patients. Regarding sodium, these results align with findings from Italy[21], suggesting that while clinical levels may appear reduced, hypertension and elevated vascular risk are often driven by high dietary sodium intake, particularly when coupled with low potassium consumption[22]. Similarly, the observed non-significant decline in calcium levels is consistent

with research indicating no direct correlation between serum concentrations and blood pressure [23].

4.3 Physiological Parameters: BMI and MAP

The study revealed a significant elevation in Body Mass Index (BMI) and Mean Arterial Pressure (MAP) among hypertensive patients compared to healthy controls. The BMI findings align with global data from Italy [24], the United States [25], Ethiopia [26], and Pakistan [27]. Notably, research in China [28] further underscores that increased BMI correlates with hypertension and heightened risks of complications, such as stroke. This positive correlation between BMI and blood pressure may be attributed to high dietary intake of hydrogenated fats[29] .

4.4. Risk Factors for Hypertension

The analysis identified several critical risk factors, primarily obesity, genetics, psychological distress, and smoking. In this study, 26.7% of patients were overweight, a finding consistent with [30], while research in New York [31] confirms that childhood obesity significantly elevates adult hypertension risk. Genetic predisposition also emerged as a primary driver; the high prevalence of positive family history among participants aligns with evidence that genetic variations and familial data are robust predictors of blood pressure levels[32]. Specifically, while this study noted a significant genetic link, previous reports have documented family history rates ranging from 57.5% [12] to 75% [33]. Furthermore, 77.5% of hypertensive subjects exhibited anxiety, supporting the established correlation between psychological disorders and sympathetic nervous system dysfunction [16]. Regarding lifestyle habits, 40% of the patient cohort were smokers. While this exceeds the smoking prevalence reported in some regional studies [12].

4.5. Correlation Analysis between Blood Pressure and studied Parameters

The statistical analysis revealed diverse correlations between blood pressure (BP) and the studied variables. A significant positive correlation was established between systolic blood pressure (SBP) and blood glucose levels, whereas diastolic blood pressure (DBP) exhibited no such association, a result that converges with findings reported in Poland [34]. In terms of renal function, DBP was significantly correlated with urea levels, whereas no significant correlations were observed with creatinine or uric acid. These results align with previous studies conducted in Sudan [35] and India [36], although the present study diverges from the literature by finding no positive correlation between SBP and creatinine. Furthermore, an investigation into electrolyte balance indicated a significant negative correlation between SBP and sodium levels—consistent with findings in Iraq [23] and Korea [37]. Neither sodium nor calcium exhibited significant correlations with DBP. Notably, elevated sodium levels, particularly in geriatric populations, are known to impair microvascular circulation. Additionally, mean arterial pressure (MAP) was significantly correlated with kidney function parameters, echoing the results of [37]and [38].

In summary, the present study demonstrates that hypertension in the Hadhramout region is strongly linked to significant alterations in kidney function biomarkers, blood glucose levels, and specific electrolyte imbalances. These biochemical shifts underline the systemic impact of elevated blood pressure and emphasize the necessity for comprehensive clinical monitoring. Addressing these metabolic and renal changes early on is essential for improving patient outcomes and preventing long-term complications.

5. Study Limitations

While this study provides valuable local insights into the biochemical alterations associated with hypertension in the Hadhramout region, it has certain limitations. First, the study was conducted with a relatively small sample size of 60 participants, which may limit the generalizability of the findings. Second, due to the cross-sectional design, it is only possible to establish associations between hypertension and the measured biochemical parameters; causality cannot be determined. Third, the sample was collected from a single setting (Ibn Sina Hospital in Mukalla) using a convenience sampling method, which might not fully represent patients from rural areas. Finally, although major risk factors were recorded, other influential lifestyle factors such as precise daily dietary sodium intake and physical activity levels were not quantitatively assessed. Future multicenter, longitudinal studies with larger cohorts are recommended to validate these findings.

Conflict of interest

The author declares that there is no conflict of interest.

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مقالة بحثية

ارتباط المؤشرات الحيوية لوظائف الكلى ومعادن الدم وجلوكوز الدم مع ارتفاع ضغط الدم: دراسة مقطعية في حضرموت، اليمن

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المُلخّص

يُعد ارتفاع ضغط الدم تحدياً صحياً عالمياً كبيراً وأكثر الأمراض المصاحبة لمرض الكلى المزمن شيوعاً. وفي منطقة ساحل حضرموت باليمن، يُصنف كأحد أكثر الأمراض انتشاراً. تفتقر المحافظة للدراسات المتخصصة التي تقيم ارتباطه بالمتغيرات الفسيولوجية والبيوكيميائية. لذلك، هدفت هذه الدراسة إلى تقييم الاختلافات والارتباطات بين المؤشرات الحيوية لوظائف الكلى والمعادن في الدم وسكر الدم وارتفاع ضغط الدم في حضرموت، اليمن. أُجريت دراسة مقطعية شملت 60 متطوعاً، بواقع 40 مريضاً بارتفاع ضغط الدم و20 فرداً سليماً كمجموعة ضابطة. تم تحليل عينات الدم لقياس جلوكوز الدم الصائم، والمؤشرات الحيوية لوظائف الكلى (الكرياتينين، اليوريا، حمض اليوريك)، ومعادن الدم (الصوديوم والكالسيوم). كما تم جمع البيانات الديموغرافية وحساب مؤشر كتلة الجسم (BMI) عبر استبيان. أظهر مرضى ارتفاع ضغط الدم مستويات أعلى بكثير من سكر الدم والكرياتينين واليوريا وحمض اليوريك مقارنة بالمجموعة الضابطة، بينما لم تُلاحظ فروق ذات دلالة إحصائية في مستويات الصوديوم والكالسيوم. ديموغرافياً، كان المرض أكثر انتشاراً بين الإناث (55%) وفي الفئة العمرية 60-69 عاماً (47.5%). وشملت عوامل الخطر الرئيسية التاريخ العائلي للمرض (75%) والقلق (77.5%). وكشف تحليل الارتباط عن علاقة طردية معنوية بين الضغط الانقباضي ومؤشر كتلة الجسم، وعلاقة عكسية معنوية مع مستويات الصوديوم. كما ارتبط الضغط الانبساطي طردياً وبشكل معنوي مع مستويات اليوريا. يستنتج من الدراسة أن ارتفاع ضغط الدم يؤثر بشكل كبير على المعلمات الكيموحيوية، خاصة جلوكوز الدم ومؤشرات وظائف الكلى، ويرتبط ارتباطاً وثيقاً بمؤشر كتلة الجسم، والاستعداد الوراثي، واختلالات محددة في معادن الدم.

الكلمات المفتاحية: ارتباط؛ ارتفاع ضغط الدم؛ الخصائص الديموغرافية؛ عوامل الخطر؛ المؤشرات الحيوية للكلى؛ المعايير البيوكيميائية؛ مؤشر كتلة الجسم.

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