ASSESSMENT OF BIOMARKERS OF RENAL FUNCTION IN LEPROSY PATIENTS IN OSSIOMO – OGAN, EDO STATE, NIGERIA

Authors:
ADEJUMO Babatunde Ishola Gabriel[1], IDEMUDIA Dennis Osadolor[1], UMAHI-OTTAH Grace[2], OYAKHIRE Fidelis Ohiremen[3], AIYEGBUSI Olufunke Victoria[4], DIMKPA Uchechukwu[5], ABDULRAHMAN Oladimeji Nasiru[6], AKHAUMERE Emmanuel Ojeideleko[7], UZOR Simon[8]

Authors' Affiliations:
[1].Department of Medical Laboratory Science, University of Benin,
[2.] Department of Physiology, Ebonyi State University, Abakaliki, Nigeria,
[3.] Department of Medical Laboratory Science, College of Health Sciences, Joseph Ayo Babalola University, Ikeji Arakeji, Osun State
[4.] Department of Nursing Science, College of Health Sciences, Joseph Ayo Babalola University, Ikeji Arakeji, Osun state
[5.] Department of Physiology, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria
[6.] Department of Medical Laboratory Science, College of Health Technology, Offa, Kwara State, [7.] Department of Chemical Pathology, National Hospital, Abuja.
[8.] Department of Medical Laboratory Science, Ebonyi State University, Abakaliki, Ebonyi State.

Correspondence:
Oyakhire F.O.,
Department of Medical Laboratory Science,
College of Health Sciences,
Joseph Ayo Babalola University,
Ikeji Arakeji,
Osun State, Nigeria
fooyakhire@jabu.edu.ng/oyakhirefidelis@yahoo.com
+234-706-547-7335
ORCID – 0000- 0002 – 2567 – 9684

Abstract

Background of study: Parameters such as blood-urea nitrogen, creatinine, uric acid, and electrolytes are good biomarkers of renal function, which could be considered as suitable prognostic indicators of renal diseases.

Aim: This study aimed at assessing the renal biomarkers of renal function in leprosy patients at Ossiomo-Ogan, Edo State, Nigeria.

Materials and methods: The study was conducted at the Leprosy Rehabilitation Centre, Ossiomo-Ogan, in Edo State, Nigeria, between April and December 2021. This study included 108 people between the ages of 18 and 60 (57 leprosy patients and 51 controls).Parameters such as urea, creatinine, chloride, potassium, sodium, and bicarbonate were assayed using standard methods. The data obtained were summarized using the mean and standard deviation. Comparative analysis was done using an independent sample t-test, while correlation tests were done using Pearson's bivariate correlation test. The level of significance was set at p 0.05.

Results: Serum levels of potassium and chloride were significantly elevated in leprosy patients compared with the controls ($p<0.05$). However, no significant differences were observed in sodium and bicarbonate between leprosy patients and controls ($p > 0.05$). Findings also indicated no significant differences in serum levels of urea ($p = 0.292$) and creatinine ($p = 0.790$) between leprosy patients and control subjects. Age, BMI, blood pressure parameters, urea, creatinine, and electrolytes in both leprosy patients and controls also indicated no significant correlation.

Conclusion: No significant difference in renal function was observed between leprosy patients and non-leprosy-affected individuals. However, the levels of serum urea and creatinine are high, which indicate renal involvement among the leprosy patients. There is a need to analyze renal biomarkers (urea, creatinine electrolytes) as part of routine medical examinations among leprosy patients to prevent renal failure.

Keywords: *leprosy, renal function, electrolytes.*

Introduction

Leprosy is also referred to as Hansen's disease. It is a chronic granulomatous infection generally caused by *Mycobacterium leprae* and *Mycobacterium lepromatosis*, both of which primarily affect the skin and peripheral nerves. The disease is diagnosed on the basis of three criteria: characteristic skin lesions in association with thickened nerves; a demonstration of acid-fast bacilli in slit skin smears; and the histopathology of skin biopsies[1.] Leprosy is of great concern in the medical community. This disease is not highly contagious, contrary to popular belief, and treatment is readily available[2.] Through awareness and early medical intervention, significant reduction of disability in the eyes, hands, and feet is possible. Relapses tend to be rare, but any damage caused by neuropathy is irreversible and may require lifelong care[3.] Many medical publications have extensively reported renal functional impairment in leprosy patients in the recent past[4–7.] The impairment has been alleged to be due to Erythema nodosum leprosum (ENL) [4.] Mitsuda and Ogawa[8] were the first workers to report renal lesions in leprosy. Glomeruli injury has been described in histology findings in leprosy patients, with progressive mesangial glomerulonephritis being the most common lesion[9–11.] Many other kinds of glomerulonephritis have also been described[12–15, 10, 16–20]. The exact pathogenesis of renal lesions in leprosy is still uncertain[21.] The bacteria do not seem to be directly involved in the renal lesions[8,] although they have been detected in the glomeruli and renal parenchyma of some patients[10, 11.] The glomerular lesion is probably caused by immune complexes, which develop during the reactional states, mainly in Erythema nodosum leprosum[21.]

The prevalence of glomerulonephritis has been reported as ranging from 6 to 50% in leprosy patients[22.] Amyloidosis, with an incidence ranging from 2 to 55%[22,] is attributed to chronic granulomatous reactions caused by Mycobacterium leprae[24] and manifested mainly by elevated proteinuria[24.] It may progress to chronic renal failure, which is one of the causes of death in leprosy[25.] Parameters such as blood-urea nitrogen, creatinine, uric acid, and electrolytes are good biomarkers of renal function, which could be considered as suitable prognostic indicators of renal diseases. Many works have been done on leprosy, but few have actually described renal involvement in the study area (Ossiomo-Ogan, Edo State, Nigeria), without a view on electrolyte renal handling and serum urea, hence the motivation and justification of this study.

The aim of this study, therefore, is to assess some renal biomarkers of renal function in leprosy patientsin Ossiomo-Ogan, Edo State, Nigeria.

Materials and methods

The study was conducted at the Leprosy Rehabilitation Centre, Ossiomo-OOgan, in Edo State, Nigeria, between April and December 2021. The center is located at a distance from the main village to prevent infected individuals from mixing up with the healthy, non-infected populace. The camp is provided with all the basic amenities such as water, electricity, and health care services to cater for the leprosy patients. The villagers at Ossiomo-Ogan are predominantly farmers and petty traders. The camp is secured, and all the activities surrounding the rehabilitation of the infected persons are done within the camp.

Study Design and Subject Selection

This is a case-control study design. The study subjects include both male and female leprosy patients, while male and female participants who have not been infected by leprosy or lived with leprosy patients served as controls. The leprosy subjects included those who were undergoing treatments and those who were newly diagnosed. The controls, however, were recruited from the healthy population within the village and its environs. This study included 108 people between the ages of 18 and 60 (57 leprosy patients and 51 controls).Excluded from this study were those who were not diagnosed with leprosy and those leprosy patients who have been certified free from the disease. The personal consent of individual participants was sought and obtained.

Questionnaire/Ethical Approval

An interviewer-administered, pre-tested, and structured questionnaire was used to collect data from the patients. The questionnaire consisted of questions designed to elicit details about their personal data, including age, sex, occupation, educational background, marital status, medications, alcohol consumption, smoking habit, duration of the disease, diet, physical activity, and exercise, as well as the history of underlying diseases. The Ethical Committee of the Ministry of Health, Edo State, and leaders of the center approved this study (File Number: HA-737/87; Date of Approval: April 15, 2021). The head of the center was also informed of the nature of the study, and his permission was sought and obtained before the commencement of the study.

Tobacco and alcohol intake

We assessed the alcohol intake and smoking history by recording the types of alcohol the participants consumed as well as the number of sticks of cigarettes smoked daily.

Measurement of Anthropometric Indices and Blood Pressure

Each participant's weight (in kilograms) and height (in meters) were measured. A weighing balance was utilized to measure weight in kilograms, and a stadiometer was used to measure height in meters. Body mass index (BMI) was calculated as the ratio of weight to square of height (kg/m^2). The normal range for BMI is taken as 18–25 kg/m^2.

Data Analysis

For continuous data, descriptive data was shown as mean and standard deviation, and for categorical variables, it was shown as a percentage. Comparative analysis between variables was done using an independent sample t-test. Correlation tests involving two variables were done using Pearson's bivariate correlation test. The test of significance was set at $p < 0.05$.

Sample Collection and Analysis

Five milliliters of blood were collected and dispensed into a plain container. The non-anticoagulated blood was allowed to clot, spun at 1500 rpm for 10 minutes, and the supernatant serum was separated into sterile tubes. The serum was stored at 20 C for up to 2 weeks prior to analysis. Analysis for urea and creatinine was done spectrophotometrically using commercially purchased reagents from the Fortres company in the United Kingdom. Electrolytes were analyzed using the ion-selective electrode method.

Results

Table 1 shows the demographics, lifestyle, and clinical characteristics of the study population. A total of 108 subjects were recruited for this study, including 51 uninfected controls and 57 patients living with leprosy. The mean age of the participants was 58.75 years (ranging from 22 to 96 years), with a SD of 14.72 years. The healthy control group indicated a significantly higher mean weight (62.58 ± 10.38 kg) compared with the leprosy patients (57.19 ± 10.50 kg). On the other hand, the leprosy patients indicated significantly greater age (63.65 ± 16.19 years vs. 53.29± 10.60 years) and SBP (136.17 ± 19.96 vs. 128.15 ± 11.94 mmHg) compared with the control. No significant differences were observed in mean height, BMI, or DBP between the two groups. Majority of the controls, 39.2%, were in the age group 50–59 yrs., while most of the leprosy patients, 59.6%, were in the age group 60 yrs. A greater percentage of the participants were female (controls: 64.7%; leprosy patients: 50.9%). All (100%) of the control subjects and 66.7% of the leprosy patients were married. The majority of the control group (52.9%) were employed, while most of the leprosy patients (45.6%) were retirees. Regarding their smoking and drinking habits, most of the participants were non-smokers (control, 90.2; leprosy, 87.7%) and non-alcoholics (control, 96.1%; leprosy, 71.9%). It is noteworthy that 9.8% of the controls were moderate smokers, 7% of the leprosy patients were mild smokers, and 5.3% were heavy smokers. Similarly, 7.8% of the controls were moderate drinkers; 19.3% of the leprosy patients were mild drinkers, while 5.3% were heavy drinkers. The majority of the participants (controls, 74.5 percent; leprosy patients, 66.7 percent) did not engage in any exercise. Most of the participants (controls, 80.4%; leprosy patients, 70.2%) were not on any form of medication.

Table 2 shows the mean levels of serum electrolytes among the study population. An independent sample t-test indicated that the leprosy patients had significantly higher mean serum levels of potassium (4.05 ± 0.62 vs. 3.81 ±0.39 mmol/L; $p < 0.05$) and chloride (104.45 ± 3.64 vs. 102.0 ± 2.50 mmol/L; $p < 0.001$) compared with the controls. In contrast, no significant differences were observed in sodium (136.17 ± 3.30 vs. 138.85 ± 14.75 mmol/L) or bicarbonate (22.29 ± 2.42 vs. 21.49 ± 2.94 mmol/L) between the control and leprosy patients.

Table 3 shows the distribution of the incidences of normal and abnormal statuses of the serum electrolytes among the study population. Data shows that an equal percentage (66.7%) of the control and leprosy patients had normal sodium levels.

Leprosy patients indicated a non-significantly higher percentage (86%) of those with normal potassium levels than the control group (82.4%). There were higher percentages of the controls with normal bicarbonate (37.3% vs. 24.6%) and chloride levels (92.2% vs. 75.4%) than the leprosy patients; however, none of these indicated statistically significant differences. More of the controls indicated 'abnormally low' levels of sodium (33.3% vs. 26.3%), potassium (17.6% vs. 10.5%), and chloride (3.9 vs. 1.8%) than the leprosy patients. In contrast, there were more leprosy patients with 'abnormally low' bicarbonate compared with the control group (71.9% vs. 62.7%). No significant percentage differences were observed between the two groups for all electrolytes. Higher incidences of 'abnormally high' sodium (7.0% vs. 0%), potassium (3.5% vs. 0%), bicarbonate (3.5% vs. 0%), and chloride (22.8% vs. 3.9% $p < 0.001$) were observed between the leprosy patients and the control.

Table 4 shows the correlation between serum urea, creatinine levels, and electrolytes among leprosy patients. Pearson's bivariate correlation test indicated no significant relationship between the serum urea level and sodium ($p = 0.861$), bicarbonate ($p = 0.561$), or chloride ($p = 0.331$) levels. In contrast, there was a significant negative correlation between serum urea and potassium levels. The higher the serum urea level of the leprosy patients, the higher their serum potassium concentration. On the other hand, there were no significant relationships between serum creatinine concentration and sodium ($p = 0.370$), potassium ($p = 0.455$), bicarbonate ($p = 0.373$), or chloride ($p = 0.259$).

Table 5 shows the correlation between age, BMI, electrolytes, urea, and creatinine among the leprosy patients. Pearson's bivariate correlation test indicated no significant correlation between age and sodium, potassium, bicarbonate, chloride, urea, and creatinine. Similarly, no significant correlations were observed between BMI and sodium, potassium, bicarbonate, chloride, urea, and creatinine, respectively.

Table 6 shows the correlation between SBP, DBP, electrolytes, urea, and creatinine among the leprosy patients. Pearson's bivariate correlation test indicated no significant correlation between SBP and sodium, bicarbonate, chloride, urea, and creatinine. Similarly, no significant correlations were observed between DBP and sodium, bicarbonate, chloride, urea, and creatinine. In contrast, there was a significant relationship between SBP and potassium ($p = 0.019$) as well as between DBP and potassium ($p = 0.05$).

Figure 1 shows the mean serum concentration of urea in the study population. An independent sample t-test indicated a lack of significant difference ($p = 0.292$) in the serum levels of urea between the control group (31.25 ± 9.13 mg/dl) and the leprosy patients (33.56 ± 11.73 mg/dl).

Figure 2 shows the mean serum concentration of creatinine in the study population. An independent sample t-test indicated no significant difference ($p = 0.790$) in the serum levels of creatinine between the control (0.82 ± 0.19 mg/dl) and the leprosy patients (0.81 ± 0.24 mg/dl).

Figure 3 shows the incidence of normal and abnormal serum levels of urea among the study population. Data indicated that all (100%) of the control patients and 91.2% ($n = 52$) of the leprosy patients had urea levels 50 mg/dl. On the other hand, 8.8% ($n = 5$) of the leprosy patients and none of the controls had an incidence of abnormally high urea levels (> 50 mg/dl).

Figure 4 shows the incidence of normal and abnormal serum levels of creatinine among the study population. Data indicated that all (100%) of the control patients and 96.5% ($n = 55$) of the leprosy patients had urea levels 1.4 mg/dl. On the other hand, 3.5% ($n = 2$) of the leprosy patients and none of the controls had an incidence of abnormally high urea levels (>1.4 mg/dl).

Table 1. Demographics, Lifestyles and Clinical Characteristics of the Study Population

Characteristics	Control (n = 51) Mean ± SD or n (%)	Leprosy Patients (n = 57) Mean ± SD or n (%)	Total (n = 108) Mean ± SD or n (%)
Weight (kg)	62.58 ± 10.38	57.19 ± 10.50*	59.74 ± 10.74
Height (meters)	1.64 ± 0.15	1.61 ± 0.13	1.62 ± 0.14
BMI (kg/m2)	23.69 ± 7.42	22.24 ± 5.03	22.92 ± 6.29
SBP (mmHg)	128.15 ± 11.94	136.17 ± 19.96*	132.38 ± 17.06
DBP (mmHg)	78.09 ± 5.76	77.22 ± 7.65	77.63 ± 6.81
Age (years)	53.29 ± 10.60	63.65 ± 16.19	58.75 ± 14.72
<40	2 (3.9)	0 (0)	2 (1.9)
40 – 49	13 (25.5)	15 (26.4)	28 (25.9)
50 – 59	20 (39.2)	8 (14.0)	28 (25.9)
=60	16 (31.4)	34 (59.6)	50 (46.3)
Sex			
Males	18 (35.3)	28 (49.1)	46 (42.6)
Females	33 (64.7)	29 (50.9)	62 (57.5)
Marital Status			
Single	0 (0)	19 (33.3)	19 (17.6)
Married	51 (100)	38 (66.7)	89 (82.4)
Occupational Status			
Employed	27 (52.9)	4 (7.0)	31 (28.7)
Unemployed	14 (27.5)	21 (36.8)	35 (32.4)
Retired	9 (17.6)	26 (45.6)	35 (32.4)
Self Employed	1 (2.0)	6 (10.5)	7 (6.5)
Smoking Status			
Non-Smokers	46 (90.2)	50 (87.7)	96 (88.9)
Smokers	5 (9.8)	7 (12.3)	12 (11.1)
Alcoholic Status			
Non-Drinkers	49 (96.1)	41 (71.9)	90 (83.3)
Drinkers	2 (3.9)	16 (28.1)	18 (16.7)
Exercise Status			
Non-Exercisers	38 (74.5)	38 (66.7)	76 (70.4)
Exercisers	13 (25.5)	19 (33.3)	32 (29.6)
Medication			
No	41 (80.4)	40 (70.2)	81 (75.0)
Yes	10 (19.6)	17 (29.8)	32 (25.0)

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; * Significant difference between control and leprosy patients.

Table 2. Mean Levels of Serum Electrolytes among the Study Population

Variables	Control (n = 51)	Leprosy Patients (57)	t-Statistics	P-Value
Sodium (mmol/L)	136.17 ± 3.30	138.85 ± 14.75	-1.27	0.207
Potassium (mmol/L)	3.81 ± 0.39	4.05 ± 0.62	-2.35	0.021
Bicarbonate (mmol/L)	22.29 ± 2.42	21.49 ± 2.94	1.53	0.128
Chloride (mmol/L)	102.0 ± 2.50	104.45 ± 3.64	-4.03	<0.001

Table 3. The Incidence of Normal and Abnormal Statuses of the Serum Electrolytes among the Study Population

Electrolytes	Control (n = 51)	Leprosy Patients (n = 57)	P - Value
Sodium			
Normal	34 (66.7)	38 (66.7)	1.00
Abnormally Low	17 (33.3)	15 (26.3)	0.362
Abnormally High	0 (0)	4 (7.0)	-
Potassium			
Normal	42 (82.4)	49 (86.0)	0.758
Abnormally Low	9 (17.6)	6 (10.5)	0.194
Abnormally High	0 (0)	2 (3.5)	-
Bicarbonate			
Normal	19 (37.3)	14 (24.6)	0.128
Abnormally Low	32 (62.7)	41 (71.9)	0.439
Abnormally High	0 (0)	2 (3.5)	-
Chloride			
Normal	47 (92.2)	43 (75.4)	0.188
Abnormally Low	2 (3.9)	1 (1.8)	0.414
Abnormally High	2 (3.9)	13 (22.8)	<0.001

Normal ranges: Sodium, 135 – 147 mmol/L; Potassium, 3.5 – 5.0 mmol/L; Bicarbonate, 23 – 29 mmol/L; Chloride, 98 – 106 mmol/L.

Table 4. Bivariate Correlation between Serum Urea, Creatinine Levels and Electrolytes among Leprosy Patients

VARIABLES	R (*p-value*)	VARIABLES	R (*p-value*)
Urea vs. Sodium	0.024 (*0.861*)	Creatinine vs. Sodium	0.121 (*0.370*)
Urea vs. Potassium	-0.327 (*0.013*)	Creatinine vs. Potassium	-0.101 (*0.455*)
Urea vs. Bicarbonate	0.079 (*0.561*)	Creatinine vs. Bicarbonate	0.120 (*0.373*)
Urea vs. Chloride	-0.131 (*0.331*)	Creatinine vs. Chloride	-0.152 (*0.259*)

Abbreviation: R = Correlation Coefficient

Table 5. Correlation between Age, BMI, Electrolytes, Urea and Creatinine among the Leprosy Patients

VARIABLES	R (*p-value*)	VARIABLES	R (*p-value*)
Age vs. Sodium	0.028 (*0.836*)	BMI vs. Sodium	-0.180 (*0.181*)
Age vs. Potassium	-0.066 (*0.627*)	BMI vs. Potassium	0.094 (*0.489*)
Age vs. Bicarbonate	-0.144 (*0.286*)	BMI vs. Bicarbonate	-0.016 (*0.908*)
Age vs. Chloride	-0.078 (*0.562*)	BMI vs. Chloride	-0.112 (*0.405*)
Age vs. Urea	0.189 (*0.158*)	BMI vs. Urea	0.095 (*0.481*)
Age vs. Creatinine	0.008 (*0.951*)	BMI vs. Creatinine	0.050 (*0.713*)

Abbreviations: BMI = Body Mass Index; R = Correlation Coefficient

Table 6. Correlation between Blood Pressure Parameters, Electrolytes, Urea and Creatinine among the Leprosy Patients

VARIABLES	R (*p-value*)	VARIABLES	R (*p-value*)
SBP vs. Sodium	0.009 (*0.991*)	DBP vs. Sodium	0.011 (*0.934*)
SBP vs. Potassium	0.310 (*0.019**)	DBP vs. Potassium	0.259 (*0.05**)
SBP vs. Bicarbonate	-0.022 (*0.872*)	DBP vs. Bicarbonate	-0.137 (0.311)
SBP vs. Chloride	0.061 (*0.652*)	DBP vs. Chloride	-0.018 (*0.895*)
SBP vs. Urea	0.161 (*0.233*)	DBP vs. Urea	0.154 (*0.253*)
SBP vs. Creatinine	0.203 (*0.129*)	DBP vs. Creatinine	0.114 (*0.397*)

* Significant correlation. Abbreviations: SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; R = Correlation Coefficient

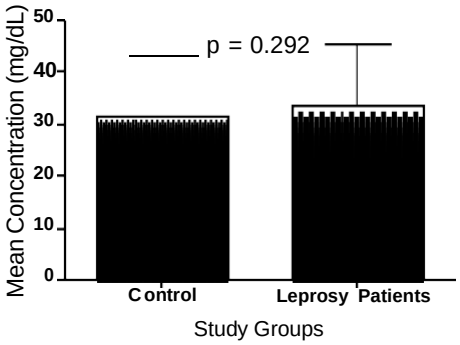

Figure 1. Mean Serum Concentration of Urea among the Study Population

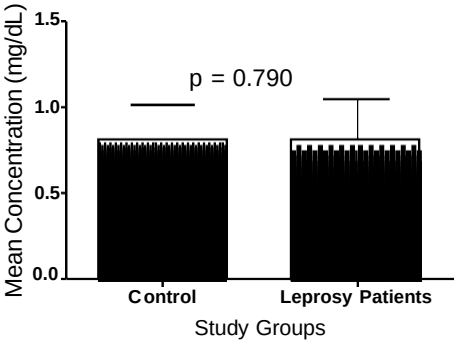

Figure 2. Mean Serum Concentration of Creatinine among the Study Population

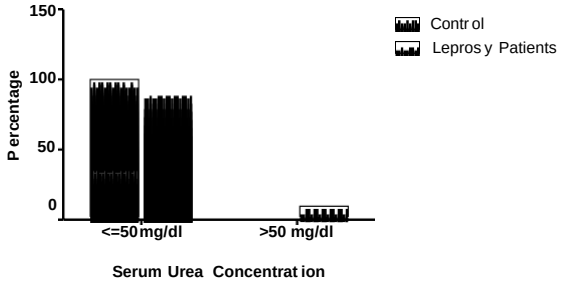

Figure 3. Incidence of Normal and Abnormal Serum Level of Urea among the Study Population.

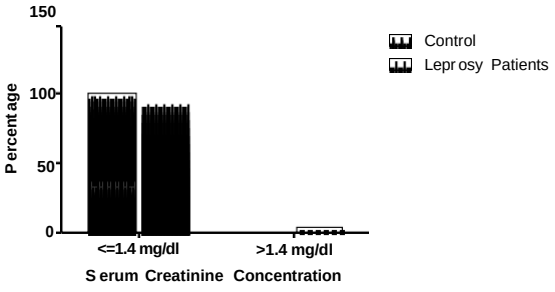

Figure 4. Incidence of Normal and Abnormal Serum Level of Creatinine among the Study Population.

Discussion

Leprosy is a multisystem infectious disease that can involve the kidneys in a variety of ways[11.] The exact pathogenesis of renal lesions in leprosy is still unclear[26]. Mycobacterium leprae does not appear to be directly involved in the creation of renal lesions[27], although it has been detected in the renal parenchyma of some patients, including the glomeruli[10,11]. Glomerular lesions are probably mediated by immunocomplexes [17, 26]. It has been ascertained by some workers [27] that leprosy can occur at any age, and they also suggested that the development of the disease depends on the host immune response[28–31]. In this study, the mean age of the participants was 58.75 years (ranging from 22 to 96 years). This is in agreement with some workers who opined that individuals aged 50–60 years are mostly affected by leprosy[32]. Umahi-Ottah et al.[3] recorded 60 years and above, while another study by Reibel et al.[34] indicated that the age group of 20–64 years was mostly affected. We also discovered in this study that more females, 33 (64.7%), were infected than males, 18 (35.3%). This result agrees with many authors: Umahi-Ottah et al. (50.9%)[33], Montnegro et al.[35], Date and Johny[14];Kirsztajn et al.[23];Ponce et al.[36]; Silva Junior and Daher[37]; Phadnis et al.[38]; Margarido-Marchese et al.[31] who all found a higher prevalence of leprosy tilted towards females. In contrast, Salgado et al.[9] reported that males were more affected by leprosy than females. The reason for higher susceptibility in females may be due to immunocomplexes, which are implicated in the development of the disease.

From this study, 8.8% (n = 5) of leprosy patients have an abnormal urea level greater than 50 mg/dL. This agrees with the results of previous works by Nadeem et al. [4] and Kanwar et al.[41]. They found raised levels of urea in up to 53% of leprosy patients in their works. da Silva Jnr and Daher [27] in their study found 20 (62.5% of the total) leprosy patients with a urea value above 40 mg/ dl. Some previous workers—Nadeem et al.[40]; Bajaj et al.[2]; Thomas et al.[7]; and Mittal et al.[20]—failed to observe any significant rise in urea level even in the reactionary state of leprosy. Also, in this study, 3.5% (n = 2) of leprosy patients have abnormal creatinine values above >1.4 mg/dL.

This agrees with the results obtained by other workers. According to daSilva Jnr and Daher [27], creatinine levels above 1.4 mg/dl were recorded in 6 (18.75%) leprosy patients in their study. Singh et al. [25] found that 9.33% of leprosy patients exhibited increased creatinine levels. Date et al. [19] reported raised serum creatinine (2 out of 8) among reactional lepromatous patients.

Bajaj et al.[2] reported significantly increased serum creatinine in reactive cases but not significantly elevated levels in quiescent or uncomplicated leprosy patients. Savas et al.[42] reported significantly higher urea and creatinine levels, respectively, in their works. They attributed the higher results to the higher mean age of their leprosy patients. In our study, the mean age was 58.75 years, which seems not to be very high. The 3.5% abnormal creatinine level recorded may be due to a few participants aged above 70 years, an age that may be responsible for immunocomplex susceptibility. In contrast, a study by Kirsztajn et al.[23] indicated that no obvious alteration of renal function was detected in the analysis of serum creatinine. Also contrasting the above authors, Thomas et al.[7] and Gutman et al. [6] have reported normal serum creatinine levels in reactive leprosy cases. However, from this present study, the mean urea and creatinine concentrations of leprosy patients were not statistically significant when compared with the controls.

The mean level of potassium and chloride is higher in leprosy patients when compared with the controls in this study (Table 2). Leprosy patients indicated a non-significantly higher percentage (86%) of those with normal potassium levels than the control group (82.4%). There were higher percentages of the controls with normal bicarbonate (37.3% vs. 24.6%) and chloride levels (92.2% vs. 75.4%) than the leprosy patients; however, none of these indicated statistically significant differences. More of the controls indicated 'abnormally low' levels of sodium (33.3% vs. 26.3%), potassium (17.6% vs. 10.5%), and chloride (3.9 vs. 1.8%) than the leprosy patients. In contrast, there were more leprosy patients with 'abnormally low' bicarbonate compared with the control group (71.9% vs. 62.7%). No significant percentage differences were observed between the two groups for all electrolytes. Higher incidences of 'abnormally high' sodium (7.0% vs. 0%), potassium (3.5% vs. 0%), bicarbonate (3.5% vs. 0%), and chloride (22.8% vs. 3.9; p 0.001) were observed between the leprosy patients and the control. This is in contrast with previous works by Savas et al. [42], who reported normal sodium and potassium levels among the leprosy patients.

There is no significant relationship between serum urea level and sodium ($p = 0.861$), bicarbonate ($p = 0.561$), or chloride ($p = 0.331$) levels in this study. In contrast, there was a significant negative correlation between serum urea and potassium levels. The higher the serum urea level of the leprosy patients, the higher their serum potassium concentration. On the other hand, there were no significant relationships between serum creatinine concentration and sodium ($p = 0.370$), potassium ($p = 0.455$), bicarbonate ($p = 0.373$), or chloride ($p = 0.259$) (Table 4).

Also from the results obtained in this study, there was no significant correlation between age and sodium, potassium, bicarbonate, chloride, urea, and creatinine. Similarly, no significant correlations were observed between BMI and sodium, potassium, bicarbonate, chloride, urea, and creatinine, respectively (Table 5). There is no significant correlation between SBP and sodium, bicarbonate, chloride, urea, and creatinine. Similarly, no significant correlations were observed between DBP and sodium, bicarbonate, chloride, urea, and creatinine. In contrast, there was a significant relationship between SBP and potassium ($p = 0.019$) as well as between DBP and potassium ($p < 0.05$) (Table 6). Reasons for the above results may be attributed to the fact that none of the leprosy patients has been diagnosed with a renal abnormality, unlike the work done earlier on reactive and uncomplicated cases by some workers[27, 42, 43]. The caveat in the study was the non-inclusion of a urine sample in the parameters analyzed, which will be clarified in further study.

Conclusion

From this study, the levels of serum urea and creatinine are high, which indicate renal involvement among the leprosy patients. There is a need to always analyze renal biomarkers (urea, creatinine electrolytes) as part of routine medical examinations among leprosy patients to prevent renal failure, which is the cause of death among them.

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