



ORIGINAL ARTICLE

ASSOCIATION OF BODY MASS INDEX WITH HYPERTENSION AND DEMOGRAPHIC CHARACTERISTICS IN PATIENTS WITH END-STAGE RENAL DISEASE UNDERGOING MAINTENANCE HAEMODIALYSIS: A CROSS-SECTIONAL STUDY

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Background: End-stage renal disease (ESRD) is associated with a high burden of cardiovascular complications, particularly hypertension. Although body mass index (BMI) is an established indicator of nutritional status and cardiovascular risk, its association with hypertension among patients with ESRD undergoing maintenance haemodialysis remains inadequately studied in Pakistan. This study was conducted to determine the association of BMI with hypertension and demographic characteristics in patients with end-stage renal disease undergoing maintenance haemodialysis. **Methods:** This observational cross-sectional study was conducted in the Department of Nephrology, Holy Family Hospital, Rawalpindi, from Dec 2022 to Jun 2023 after ethical approval from CPSP. A total of 196 patients aged 18–75 years with ESRD undergoing maintenance haemodialysis for at least three months were recruited through non-probability consecutive sampling. Demographic characteristics, duration of ESRD, duration of haemodialysis, BMI, and blood pressure were recorded. Data were analysed using SPSS-25, and $p \leq 0.05$ was considered statistically significant. **Results:** Hypertensive patients had a higher mean age than non-hypertensive patients (51.2 ± 11.4 vs 43.5 ± 10.7 years). Males constituted 65.1% of hypertensive patients, while females were 34.9%. Underweight patients had a higher prevalence of hypertension than overweight patients. Mean systolic blood pressure was highest (166 ± 13 mmHg) in underweight patients and lowest (139 ± 7 mmHg) in obese patients. **Conclusion:** Body mass index was significantly associated with hypertension and haemodynamic parameters in patients with ESRD undergoing maintenance haemodialysis. Higher BMI was associated with relatively favourable cardiovascular profiles.

Keywords: Body mass index, End-stage renal disease, Hypertension, Maintenance haemodialysis

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INTRODUCTION

Chronic kidney disease (CKD) is defined as irreversible and progressive loss in structure and functions of kidneys persisting for more than 3 months.¹ It is commonly diagnosed by reduced glomerular filtration rate (GFR) or persistent albuminuria and can lead to end-stage renal disease (ESRD).² In ESRD the kidneys are unable to maintain normal metabolic and physiological homeostasis. The survival of an individual depends only on renal replacement therapy. Haemodialysis is the most widely used renal replacement therapy for patients of ESRD and plays an essential role in improving survival and quality of life.³ Due to increasing prevalence, associated cardiovascular complications and substantial healthcare burden chronic kidney disease has emerged as a major global public health problem. According to recent WHO and Global Burden of Disease (GBD) data, approximately 674–850 million people worldwide are affected by kidney disease, which is about 8–10% of the total global

population. According to a record, up to 2040 CKD will be the leading cause of years of life lost globally. Due to increase prevalence of hypertension, diabetes mellitus and obesity the burden of CKD is increasing day by day.

Diabetes mellitus and hypertension remain the leading causes of ESRD worldwide and are responsible for a major proportion of patients requiring long-term dialysis therapy.⁴ In low- and middle-income countries, limited access to early screening, healthcare facilities, and renal replacement therapies further contribute to increased morbidity and mortality associated with kidney disease.

In patients of maintenance haemodialysis, the most common complication is hypertension.⁵ It is defined as persistent elevation of systemic arterial blood pressure above 130/80 mmHg.⁶ In patients of ESRD, it is an important contributor to cardiovascular morbidity and mortality. Fluid overload, activation of renin-angiotensin-aldosterone system, endothelial dysfunction, increased sympathetic activity and arterial

stiffness are among the major mechanisms responsible for hypertension in dialysis patients.⁷ Poor blood pressure control is associated with left ventricular hypertrophy, heart failure, cerebrovascular disease and increased mortality. Cardiovascular disease therefore remains the leading cause of death in ESRD patients receiving maintenance haemodialysis.⁸

Body mass index (BMI) is an anthropometric parameter commonly used to assess the composition of body and nutritional status. BMI is calculated as weight in kilograms divided by height in meters squared (Kg/m^2), and individuals are categorized as underweight ($\text{BMI} < 18.5 \text{ Kg/m}^2$), normal weight ($18.5\text{--}24.9 \text{ Kg/m}^2$), overweight ($25.0\text{--}29.9 \text{ Kg/m}^2$) and obese ($\geq 30.0 \text{ Kg/m}^2$).⁹ In the general population, elevated BMI is strongly associated with hypertension, diabetes mellitus, cardiovascular disease and increased mortality risk. Obesity contributes to increased cardiovascular workload, vascular dysfunction, insulin resistance and metabolic disturbances, thereby increasing the risk of chronic diseases.¹⁰ But its relationship with clinical outcomes in patients undergoing maintenance haemodialysis appears to be different. Recent studies have reported that BMI can influence cardiovascular risk, blood pressure control, and survival differently in patients with ESRD, giving rise to the concept of the 'obesity paradox'.¹¹ Despite increasing international evidence on this association, data from Pakistan regarding the relationship between BMI, hypertension, and demographic characteristics among maintenance haemodialysis patients remain limited. This study was conducted to determine the association of BMI with hypertension and demographic characteristics in patients undergoing maintenance haemodialysis.

METHODOLOGY

This observational cross-sectional study was conducted in the Department of Nephrology, Holy Family Hospital Rawalpindi over a period of six months from Dec 2022 to Jun 2023 after ethical approval from the College of Physicians and Surgeons Pakistan Ref No. CPSP/REU/NEP-2022-123-678. The objective of the study was to determine the association of BMI with hypertension and demographic characteristics in patients undergoing maintenance haemodialysis. A sample size of 196 patients was calculated using the WHO sample size calculator based on a confidence level of 95%, anticipated prevalence of hypertension among haemodialysis patients of 86.2%, and margin of error of 7%.¹² A non-probability consecutive sampling technique was employed to recruit participants. Patients aged 18–75 years of either gender undergoing maintenance haemodialysis for at least three months were included in the study. Patients with congestive cardiac failure, active malignancy, recent change in dry weight and those receiving peritoneal dialysis were

excluded. Written informed consent was obtained from all participants prior to enrolment and confidentiality of patients' information was maintained throughout the study.

After enrolment, demographic and clinical information including age, gender, duration of haemodialysis, body mass index and blood pressure status were recorded on a structured pro forma. BMI categories were classified according to the World Health Organization (WHO) classification as underweight ($< 18.5 \text{ Kg/m}^2$), normal weight ($18.5\text{--}24.9 \text{ Kg/m}^2$), overweight ($25.0\text{--}29.9 \text{ Kg/m}^2$), and obesity ($\geq 30.0 \text{ Kg/m}^2$).⁹ The association of BMI categories with hypertension and demographic variables including gender and duration of haemodialysis was evaluated.

All patients continued to receive standard haemodialysis treatment according to departmental protocols during the study period. Data analysis was performed using SPSS-25. Quantitative variables including age, BMI and duration of haemodialysis were presented as Mean $\pm$ SD, while categorical variables including gender, BMI categories and hypertension status were expressed as frequencies and percentages. Independent sample *t*-test was applied for comparison of quantitative variables, while chi-square test was used to assess association between categorical variables, and $p \leq 0.05$ was considered statistically significant.

RESULTS

A total of 196 patients with end-stage renal disease undergoing maintenance haemodialysis were included in the study, of whom 126 (64.3%) were hypertensive and 70 (35.7%) were non-hypertensive.

Table-1 summarizes the demographic and clinical characteristics of the study participants according to hypertension status.

The association between BMI categories and hypertension is presented in Table-2, while the comparison of haemodynamic parameters across BMI categories is shown in Table-3.

Table-4 presents the stratified analysis of hypertension according to gender and duration of maintenance haemodialysis.

Table-1: Demographic and clinical characteristics of haemodialysis patients according to hypertension status

Variable	Hypertensive (n=126)	Non-Hypertensive (n=70)	Test value	p
Age (Yrs, Mean $\pm$ SD)	51.2 $\pm$ 11.4	43.5 $\pm$ 10.7	<i>t</i> = 4.08	0.001
Male Gender [n (%)]	82 (65.1)	36 (51.4)	χ^2 = 4.11	0.037
Female [n (%)]	44 (34.9)	34 (48.6)	χ^2 = 3.76	0.044
Mean BMI (Kg/m^2)	24.1 $\pm$ 3.8	27.3 $\pm$ 4.2	<i>F</i> = 3.92	0.002
Duration of Haemodialysis (Yrs)	2.8 $\pm$ 1.5	1.9 $\pm$ 1.1	<i>F</i> = 2.76	0.006

Statistical Test Applied: Independent sample *t*-test and Chi-square test

Table-2: Distribution of BMI categories among hypertensive and non-hypertensive patients

BMI Category	Hypertensive n (%)	Non-Hypertensive n (%)	χ^2	p
Underweight	20 (83.3)	4 (16.7)	6.18	0.029
Normal Weight	68 (87.2)	10 (12.8)	8.94	0.011
Overweight	28 (37.8)	46 (62.2)	10.36	0.002
Obese	10 (50.0)	10 (50.0)	5.81	0.041

Table-3: Comparison of haemodynamic parameters across BMI categories (One-way ANOVA)

BMI Category	Mean±SD				p
	SBP (mmHg)	DBP (mmHg)	Pulse Pressure	Heart Rate	
Underweight	166±13	101±8	65±7	97±5	0.001
Normal Weight	154±10	94±6	60±5	91±4	0.008
Overweight	142±8	85±5	57±4	84±3	0.003
Obese	139±7	82±4	57±3	81±3	0.001

Table-4: Stratification of hypertension according to duration of haemodialysis and gender

Variable	Hypertensive n (%)	Non-Hypertensive n (%)	χ^2	p
Male	82 (69.5)	36 (30.5)	4.28	0.039
Female	44 (56.4)	34 (43.6)	3.62	0.047
Duration of Dialysis				
<1 year	46 (76.7)	14 (23.3)	6.91	0.018
1-3 years	52 (60.5)	34 (39.5)	4.83	0.033
>3 years	28 (56.0)	22 (44.0)	3.95	0.049

DISCUSSION

The present study evaluated the association of body mass index with hypertension and demographic characteristics among patients undergoing maintenance haemodialysis. Hypertension remains one of the most important cardiovascular complications in end-stage renal disease patients and contributes significantly to increased morbidity and mortality.⁷ The findings of the present study demonstrated significant associations between BMI categories, blood pressure parameters and demographic variables among haemodialysis patients.

In our study, the mean age of hypertensive patients on haemodialysis was 51.2±11.4 years as compared to non-hypertensive patients with mean age 43.5±10.7 years. These findings indicate that hypertension was more among older haemodialysis patients. The reason behind this can be that increasing age is associated with vascular rigidity, endothelial dysfunction and decreased arterial compliance, all of this leads to elevated blood pressure especially in ESRD patients.¹³ Similar observations have been reported in previous nephrology studies by Bae *et al*, where advanced age was associated with poor blood pressure control and increased cardiovascular complications in dialysis patients.¹⁴ Male predominance was also observed among hypertensive patients in our study, with 65.1% males of hypertensive cases compared to 51.4% among non-hypertensive patients, whereas females represented 34.9% and 48.6% of hypertensive and non-hypertensive groups respectively. Similar gender-based differences have been reported in previous studies

evaluating cardiovascular risk factors in ESRD populations by Mohamud *et al*.¹⁵ The higher prevalence of hypertension among male haemodialysis patients can be due to increased prevalence of cardiovascular risk factors, smoking, sedentary lifestyle and negligence regarding health and living standard common in males.¹⁶ In our results a significant association between duration of haemodialysis and hypertension was seen. Hypertensive patients had a relatively longer duration of dialysis compared to non-hypertensive patients. Due to prolonged haemodialysis following changes can happen: alteration in morphology of blood vessels, i.e., arterial calcification, persistent fluid overload and activation of neuro-hormonal pathways leading to hypertension. Progressive cardiovascular remodelling and increased arterial stiffness are the other common pathologies, which may explain the higher prevalence of hypertension in patients undergoing prolonged dialysis therapy.^{17,18}

In our study, overweight patients showed lower prevalence of hypertension than underweight and normal-weight patients. Underweight patients showed hypertension in 75.0% cases, whereas overweight patients demonstrated hypertension in only 40.5% cases. A statistically significant association was observed between BMI categories and hypertension status. These findings support the concept of reverse epidemiology frequently described in nephrology literature. Several mechanisms have been proposed to explain this paradoxical relationship. Higher BMI in dialysis patients may reflect improved nutritional reserves, greater muscle mass and better tolerance to chronic catabolic stress. In patients of ESRD its very common to experience protein-energy wasting, chronic inflammation, anorexia and metabolic disturbances that contribute to poor nutritional status.¹⁹ In underweight patients due to malnutrition and reduced physiological reserve, cardiovascular instability and poor blood pressure regulation is very common.²⁰ Study of Motofealea *et al*¹⁹ has also suggested that overweight patients on haemodialysis may exhibit relatively better survival and cardiovascular outcomes due to improved haemodynamic stability and enhanced tolerance to dialysis-related stress.

The present study further evaluated haemodynamic parameters across BMI categories. Underweight patients demonstrated the highest systolic and diastolic blood pressure values, with mean systolic blood pressure of 166±13 mmHg and mean diastolic blood pressure of 101±8 mmHg. In comparison with overweight and obese patients showed relatively lower blood pressure values. Mean systolic blood pressure decreased to 142±8 mmHg in overweight patients and 139±7 mmHg in obese patients. Similarly, diastolic blood pressure declined from 101±8 mmHg in underweight patients to 82±4 mmHg in obese patients. These findings indicate improved haemodynamic

stability among patients with higher BMI. In patients with increased BMI, pulse pressure and heart rate decreased that showed improvement of cardiovascular system in overweight and obese haemodialysis patients.²¹ All these observed relationship between BMI and blood pressure may be influenced by several physiological factors. Overweight patients may have increase in intravascular volume buffering capacity and better nutritional reserve, decrease chances of fluctuations in haemodynamic status during dialysis sessions.¹¹ Chronic inflammation and protein-energy wasting are more commonly observed in underweight ESRD patients leading to endothelial dysfunction and cardiovascular instability. Similar findings have been reported in study of Kang *et al*²² evaluating obesity paradox in dialysis populations, where higher BMI was associated with improved cardiovascular tolerance and reduced mortality risk.

Stratification analysis in the present study demonstrated higher prevalence of hypertension among patients undergoing dialysis for less than one year, i.e., 76.7% of patients. This may be related to inadequate fluid control and incomplete cardiovascular compliance during early dialysis periods. Hypertension gradually decreased among patients who were on dialysis since long, possibly due to improved fluid management and treatment optimization with passage of time.⁵

LIMITATIONS & RECOMMENDATIONS

- It was a single-centre cross-sectional study, further multi-centre prospective studies are recommended.
- Dietary habits, inflammatory markers, dialysis adequacy parameters and antihypertensive medication compliance were not evaluated that should be focused in future.
- BMI was not accurately differentiated between adipose tissue and lean body mass in ESRD patients that can be considered.
- Our study did not assess the duration of end-stage renal disease before initiation of maintenance haemodialysis, which can influence the observed association between body mass index and hypertension. It is recommended to be focused on in further studies.

CONCLUSION

This study demonstrated a significant association between body mass index and hypertension among patients undergoing maintenance haemodialysis. Underweight and normal-weight patients exhibited comparatively higher blood pressure levels and greater haemodynamic instability than overweight and obese patients. Higher body mass index was associated with relatively improved cardiovascular tolerance and favourable haemodynamic parameters, supporting the concept of reverse epidemiology in end-stage renal disease patients.

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Authors approved the draft and are accountable in ensuring that questions related to accuracy or integrity of the work are duly investigated and resolved.

TA: Idea conception and data collection

AM: Drafting the work, data analysis

AT: Drafting the work, data analysis

IM: Interpretation of data

SJ: Data acquisition and data analysis

MAA: Manuscript writing

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