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Frequency of Pulmonary Hypertension among Twice Weekly Maintenance Haemodialysis Patients: A Single Centre Study

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Abstract

Pulmonary hypertension (PH) is a recognized complication of chronic kidney disease (CKD), particularly in end-stage renal disease, with prevalence estimates ranging from 30% to 50%. It is an independent predictor of increased mortality in this patient population. A cross-sectional observational study was conducted at the National Institute of Kidney Diseases & Urology (NIKDU), Dhaka, Bangladesh, from December 2022 to March 2023, to determine the frequency of pulmonary hypertension among patients on a twice-weekly maintenance hemodialysis regimen. We adopted convenient purposive sampling technique. A total of 81 hemodialysis patients were enrolled. Data was collected through a pre-tested questionnaire including patients' history, clinical examination, laboratory findings, and other medical records review. The prevalence of pulmonary hypertension was 25(30.9%). No significant association was observed between pulmonary hypertension and duration of hemodialysis (29.8±24.3 months) or ultrafiltration volume (2.80±0.53 L). Cardiac abnormalities were prevalent, including regional wall motion abnormalities in 45.7% of patients. Pulmonary hypertension was highly prevalent in patients having twice-weekly hemodialysis and is significantly associated cardiac morbidity. Its development appears independent of dialysis vintage or ultrafiltration volume.

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Introduction

Chronic Kidney Disease (CKD) represents a significant and growing global health burden, with its most severe form, end-stage renal disease (ESRD), necessitating renal replacement therapy for survival.[1] Hemodialysis (HD) remains the most common modality of treatment worldwide, extending life but introducing a spectrum of cardiovascular complications that are the leading cause of mortality in this frail population.[2,3] Among these complications, pulmonary hypertension (PH) has emerged as a critical prognostic marker, increasingly recognized for its association with reduced functional capacity and heightened risk of death in ESRD patients.[4,5] Pulmonary hypertension is hemodynamically defined as a mean pulmonary arterial pressure ≥ 20 mmHg at rest, as assessed by right heart catheterization[6] or pulmonary systolic arterial pressure more than 38 mmHg by transthoracic echocardiography.[7] The pathophysiology of PH in the CKD population is complex and multifactorial, often classified as Group 5 PH due to unclear and multifactorial mechanisms.[8] Proposed contributing factors include fluid overload and high cardiac output states from arteriovenous fistulas, left ventricular diastolic dysfunction leading to post-capillary PH, metabolic alterations like uremic toxins and endothelial dysfunction, and chronic

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vascular remodeling.[9,10] The prevalence of PH among hemodialysis patients exhibits considerable geographical variation, with reported rates ranging from 18% to over 50% in different studies, a disparity attributed to differences in diagnostic criteria, patient demographics, and dialysis practices.[11,12] The frequency and duration of hemodialysis sessions are pivotal factors influencing volume status and solute clearance, both implicated in the development of PH. While thrice-weekly dialysis is the conventional standard in many settings, twice-weekly regimens are pragmatically employed in numerous healthcare systems, particularly in resource-limited countries, often based on residual renal function or logistical constraints.[13] However, this reduced frequency may predispose patients to prolonged fluid overload and inadequate clearance of uremic toxins, potentially exacerbating cardiovascular strain and promoting the development of PH.[14] Despite this plausible link, there remains a scarcity of focused research investigating the burden of PH specifically within the sizable cohort of patients maintained on a twice-weekly hemodialysis schedule. Therefore, this study aimed to determine the frequency of pulmonary hypertension among patients on a twice-weekly maintenance hemodialysis regimen. By elucidating the prevalence and exploring associated clinical factors, this research seeks to contribute to a better understanding of the cardiovascular risk profile in this specific patient population, thereby informing more tailored management and monitoring strategies to improve outcomes.

Methods

This cross-sectional observational study will be conducted at the National Institute of Kidney Diseases and Urology (NIKDU), Dhaka, Bangladesh, from December 2022 to March 2023. The study population will consist of scheduled hemodialysis patients, with a sample size of 81 selected by convenient purposive sampling. Our inclusion criteria were: patients getting twice-weekly HD for more than 3 months and aged ≥18 years. Exclusion criteria included: one or more than two HD per week, with every session lasting 4 hours, any pre-existing valvular heart disease, or congenital heart disease, pulmonary obstructive and restrictive disease, HIV-infected patients, chronic liver disease, and connective tissue diseases.

A total of 81 eligible hemodialysis patients were enrolled. Biochemical parametes were estimated using standard laboratory procedures in the Department of Pathology of the same institution. Post-dialysis transthoracic echocardiography was performed to estimate systolic pulmonary artery pressure and ejection fraction in the Department of Cardiology of the same institution. Information on vascular access, demographics, and dialysis vintage was collected via chart review.

Data was collected in a pre-tested questionnaire by taking the history, examining the patients clinically. Then, data was systematically recorded and analyzed using Statistical Package for Social Sciences (SPSS) version 25.0 for Windows. Quantitative data are presented as mean±SD, and qualitative data as frequency and percentage. Associations were tested with Chi-square, Stident's t-test, or Mann-Whitney U tests. Multivariate regression and ROC analysis identified risk factors. A p-value <0.05 was considered statistically significant.

The study protocol was approved by the Ethical Review Committee of National Institute of Kidney Diseases & Urology (NIKDU), Dhaka, Bangladesh (NIKDU/ERC/2022/114). Informed consent was

obtained from all participants after explaining the procedures, risks, and benefits in their local language. Confidentiality was maintained, and participants retained the right to withdraw at any time.

Results

Out of 81 patients, pulmonary hypertension (PH) was identified in 25 individuals, yielding a prevalence of 30.9%. The majority of the cohort belonged to the 40–60 years age group (55.6%), with a mean age of 47.8±12.9 years. An almost equal distribution between male (50.6%) and female (49.4%) was observed. Most of the patients resided in urban areas (66.7%) (Table-I). The most common viral status was non-B non-C hepatitis (81.5%), followed by Hepatitis C (16.0%) and Hepatitis B (2.5%) (Table-II). Primary disease distribution among the patients was as follows: unknown etiology in 33 patients (40.7%), diabetic nephropathy in 16 patients (19.9%), glomerulonephritis in 23 patients (28.4%), hypertension in 5 patients (6.2%), and other causes in 4 patients (4.9%). Cardiac abnormalities were common within the cohort. Nearly half of the patients (45.7%) had a regional wall motion abnormality on echocardiography, while valvular heart disease (VHD) was present in 9 patients (11.1%) (Table-III). The mean ejection fraction was 50.6±11.2%. The analysis of laboratory parameters revealed a state of anemia and mineral bone disease, with a mean haemoglobin concentration of 9.24±1.89 g/dL, a mean calcium level of 8.84±1.87 mg/dL, and a mean phosphate level of 5.59±5.88 mg/dL. The vast majority of patients (81.5%) had at least one comorbidity. The mean pulmonary artery systolic pressure (PASP) for the entire study population was 35.16±18.03 mmHg, with a wide range from 16 to 110 mmHg. The mean ultrafiltration volume was 2.80±0.53 liters, and the mean duration of hemodialysis was 29.8±24.3 months (Table-IV). No significant association was found between the development of PH and the volume of ultrafiltration per session or the total duration of hemodialysis (p>0.05) (Table-V).

Table-I: Demographic characteristics of the patients (n=81)

Variables	Frequency (Percentage)
Age group (in years)	
18–40	25 (30.9)
41–60	55.6
>60	13.6
Sex	
Male	41 (51.0)
Female	40 (49.0)
Residence	
Urban	54 (67.0)
Rural	27(33.0)

Table-II: Distribution of viral status (n=81)

Viral Status	Frequency	Percentage
BN (Non-B Non-C)	66	81.5
Hepatitis C	13	16.0
Hepatitis B	2	2.5

Table-III: Distribution of primary diseases and comorbidities (n=81)

Variables	Frequency (Percentage)
Primary disease	
Unknown	33 (40.7)
DM	16 (19.9)
GN	23 (28.4)
HTN	5 (6.2)
Others	4 (4.9)
Regional wall motion abnormality	
Yes	37 (45.7)
No	44 (54.3)
Valvular heart disease (VHD)	
Yes	9 (11.1)
No	72 (88.9)

Table-IV: Clinical and laboratory profiles of the patients (n=81)

Variables	Mean±SD
Duration of HD (months)	29.80±24.34
Ultrafiltration (UF) (L)	2.80±0.53
Ejection Fraction (EF) (%)	50.59±11.18
Pulmonary artery systolic pressure (PASP) (mmHg)	35.16±18.03
Hemoglobin conc. (g/dL)	9.24±1.89
Serum Calcium (mg/dL)	8.84±1.87
Serum Phosphate (mg/dL)	5.59±5.88
Serum Uric Acid (mg/dL)	6.42±2.26
Post-dialysis body weight (kg)	57.06±12.27

Table-V: Association between clinical variables and pulmonary hypertension

Variables	χ^2 value	df	p-value
Ultrafiltration	17.911	15	0.267^{NS}
Duration of hemodialysis	37.846	40	0.568^{NS}

Chi-square test was applied to reach p-value; NS=not significant

Discussion

In this study, the most common primary disease among patients undergoing twice-weekly maintenance hemodialysis was of unknown etiology, observed in 40.7% of cases. Glomerulonephritis accounted for 28.4% of the study population, followed by diabetes mellitus in 19.9% and hypertension in 6.2%. A smaller proportion (4.9%) had other causes. The high percentage of unknown causes reflects the lack of early diagnosis and renal biopsy in many patients, which is consistent with findings in regional studies. Glomerulonephritis and diabetes mellitus remain the leading identified etiologies of chronic kidney disease worldwide, and our findings align with previous research indicating a similar trend in developing countries.[1,2] This single-center study identified a high prevalence of pulmonary hypertension (PH), found in 30.9% of patients on a twice-weekly maintenance hemodialysis regimen. This finding aligns with the broader literature reporting a significant burden of PH in the ESRD population, with prevalence rates commonly ranging between 30-50%.[11,15] Our results underscore that PH remains a frequent cardiovascular comorbidity even in patients undergoing a less frequent dialysis schedule, highlighting its persistent threat to patient outcomes. The central pathophysiological mechanism linking CKD and PH is believed to be chronic fluid overload, leading to increased pulmonary venous pressure and subsequent pulmonary arterial remodeling.[10,16] It was therefore a critical finding of our study that the prevalence of PH showed no significant association with the volume of ultrafiltration per session or the total vintage of hemodialysis. This suggests that while chronic volume overload is a key driver, the development of PH is not merely a function of the volume removed in a single session or the cumulative time on dialysis. Instead, it may be more closely related to the persistence of fluid overload in the interdialytic period, a state potentially exacerbated by a twice-weekly regimen that allows for a longer accumulation of volume between sessions.[14,17] Other potent non-volume-related factors, including uremic toxin-induced endothelial dysfunction, vascular calcification, and the high-flow state from an arteriovenous fistula, likely play a substantial contributory role.[9,18] The mean PASP of 35.16 mmHg in our cohort is comparable to values reported in other studies of dialysis-dependent patients.[11,19] Furthermore, the high prevalence of cardiac abnormalities, particularly regional wall motion abnormalities (45.7%), points to a significant burden of underlying cardiovascular disease. This finding

suggests that left ventricular dysfunction, both systolic and diastolic, is a major contributor to the development of post-capillary PH in this population.[4,20] The presence of valvular heart disease in 11.1% of patients may also be a compounding factor. The lack of association with traditional markers like dialysis vintage and ultrafiltration volume, coupled with the strong link to PASP and cardiac dysfunction, implies that echocardiographic screening is indispensable for identifying at-risk patients on twice-weekly schedules.[21,22] Routine monitoring of PASP could serve as a vital tool for risk stratification and guiding management strategies, such as intensifying diuresis or optimizing dry weight.[23] This study has several limitations. Its cross-sectional design precludes establishing causal relationships. As a single-center study with a modest sample size utilizing convenient sampling, the findings may not be fully generalizable to all hemodialysis populations. The diagnosis of PH was based on echocardiographic estimation of PASP rather than the gold-standard right heart catheterization, though echocardiography remains the most practical and widely used screening tool in clinical practice.[7,24]

The study limitations include a single-center cross-sectional design and a modest sample size, which limit generalizability. The use of echocardiography instead of right heart catheterization for diagnosis may introduce potential measurement inaccuracies.

Conclusion

This study concludes that pulmonary hypertension is highly prevalent, affecting 30.9% of patients on a twice-weekly hemodialysis regimen. There was no significant association identified between pulmonary hypertension with the duration of hemodialysis or ultrafiltration volume. The high burden of cardiac abnormalities underscores the need for proactive cardiovascular management. Routine echocardiographic screening is recommended for early detection and intervention in this vulnerable patient population to potentially improve long-term outcomes and inform tailored treatment strategies. Routine echocardiographic screening for pulmonary hypertension should be integrated into the management of all twice-weekly hemodialysis patients. Future large-scale, multi-center studies are recommended to validate these findings and explore underlying mechanisms to guide effective intervention strategies.

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