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Effect of Haemodialysis on Pulmonary Functions in Patients of End-Stage Renal Disease

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Abstract

***Introduction:** Chronic kidney disease (CKD) is an irreversible and progressive disorder marked by the gradual loss of kidney function, ultimately leading to end-stage renal disease (ESRD)[1]. CKD affects virtually all organ systems, with the respiratory system being one of the most impacted[3]. ESRD patients frequently experience a range of pulmonary complications such as pulmonary oedema, pleural effusion, acute respiratory distress syndrome, pulmonary fibrosis, calcification, pulmonary hypertension, haemosiderosis, pleural fibrosis, and sleep apnoea syndrome[4]. These respiratory issues significantly contribute to the overall morbidity.*

***Aim:** To determine effects of haemodialysis on pulmonary functions in patients with end-stage renal disease on haemodialysis.*

***Methods:** This hospital-based cross-sectional observational study examined 88 ESRD patients on maintenance haemodialysis at SN Medical College, Agra, from January 2023 to June 2024. All participants undergoing maintenance haemodialysis for >3 months were eligible for participation in study. Pulmonary function tests were conducted one hour before and after dialysis to assess the impact of haemodialysis on respiratory function.*

***Result:** The study included 88 ESRD patients on maintenance haemodialysis, with a mean age of 48.60 ± 10.98 years and a male predominance (52.30%). Post-haemodialysis, significant improvements were observed in pulmonary functions: FVC increased from 24.78 ± 7.69% to 58.95 ± 11.70%, and FEV1 from 36.12 ± 9.39% to 52.07 ± 10.70%. Our results suggest that performing haemodialysis in patients with end-stage renal disease (ESRD) improves pulmonary functions after dialysis sessions.*

***Conclusion:** Haemodialysis significantly enhances pulmonary function in ESRD patients, improving FVC, FEV1, and the FEV1/FVC ratio, highlighting its role in mitigating respiratory impairments.*

Introduction

Chronic kidney disease (CKD) is an irreversible and progressive disorder marked by the gradual loss of kidney function, ultimately leading to end-stage renal disease (ESRD)[1]. Patients with ESRD require renal replacement therapy through dialysis – either haemodialysis or peritoneal dialysis or kidney transplantation to survive[2]. CKD affects virtually all organ systems, especially in its advanced stages, with the respiratory system being one of the most impacted[3]. ESRD patients frequently experience a range of pulmonary complications such as pulmonary oedema, pleural effusion, acute respiratory distress syndrome, pulmonary fibrosis, calcification, pulmonary hypertension, haemosiderosis, pleural fibrosis, and sleep apnoea syndrome[4]. These respiratory issues significantly contribute to overall morbidity and reduced quality-of-life.

Haemodialysis improves pulmonary function by removing excess body fluid, reducing water content in the lungs, and decreasing pulmonary capillary permeability. This helps alleviate pulmonary oedema and pleural effusion, enhancing lung compliance and reducing airway resistance, thereby improving overall respiratory function in ESRD patients. This study investigates the short-term effects of haemodialysis on pulmonary function, using pulmonary function tests (PFTs) to assess the respiratory benefits in patients undergoing maintenance haemodialysis. The assessment of the role of haemodialysis in improving pulmonary function is pivotal and continues to be a field of research.

Material and Methods

The study was a hospital-based cross-sectional, observational study conducted at the Department of

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Medicine, SN Medical College, Agra, from January 2023 to June 2024. It involved 88 patients with end-stage renal disease who had been on maintenance haemodialysis for more than three months. Participants aged 18 - 75 years, of both sexes, who provided written informed consent and were clinically stable were included. Exclusion criteria included a history of smoking, chronic lung disease, infections, acute renal injury, heart failure, myopathies, arrhythmias, tuberculosis, or cirrhosis. Patients who were debilitated and unable to co-operate with spirometric maneuvers were also excluded. The study received ethics clearance from the Department of Medicine's Ethics Committee, and patients were free to withdraw at any time.

Conventional Haemodialysis (HD) was performed using Fresenius Medical Care 4008-S machine, with four-hour sessions, a dialysate infusion rate of 500 mL/min, and blood flow rates between 300 and 350 ml/min. A bicarbonate buffer and a biocompatible membrane were used.

Detailed patient history, clinical examinations, and demographic data (age, sex, BMI, pre- and post-HD weight, smoking status, and presence of diabetes, hypertenison) were collected .GFR was measured using the Cockcroft and Gault formula. Fasting peripheral blood samples were obtained before midweek HD sessions for standard biochemical analyses. These analyses included CBC, serum bilirubin, albumin, ALT/AST, serum creatinine, urea, electrolytes, total protein, ferritin, calcium, phosphorus, intact parathormone (PTH), and haemoglobin. Pulmonary function tests, using a Medicaid Spirometer, were performed one hour before and after dialysis to measure FEV1, FVC, PEFR, and the FEV1/FVC ratio, categorizing lung functions into normal, restrictive, or obstructive pathologies. Additional data included ECG, abdominal ultrasonography, and chest X-ray PA view.

Data were organised in Excel and analysed with SPSS version 25.0 using descriptive and inferential statistics, including t-tests, ANOVA, and chi-square tests, with a significance level of $p < 0.05$. Results were presented in graphs and tables.

Results

In this study of 88 patients, majority were aged 41 - 50 years (36.3%), followed by 51 - 60 years (30.7%). The mean age was 48.60 ± 10.98 years. Most patients were male (52.3%), from lower socio-economic status (58.0%), and had hypertension (90.9%). 59.1% were of normal weight, 31.8% were overweight, and 9.1% underweight.

Most patients had been on haemodialysis for 1 to 5 years (51.13%).

Table I: Baseline characteristics of study participants.

Age Group (Years)	Frequency (n = 88)	Percentage	Mean±SD (Minimum - Maximum)
18 - 30	5	5.7%	48.60 ± 10.98 (20 - 70 years)
31 - 40	11	12.5%	
41 - 50	32	36.3%	
51 - 60	27	30.7%	
>60	13	14.8%	
Gender			
Male	46	52.3%	
Female	42	47.7%	
Socio-economic Status			
Lower	51	58.0%	
Middle	37	42.0%	
Hypertension			
Yes	80	90.9%	
No	8	9.1	
BMI (kg/m^2)	**Frequency (n = 88)**	**Percentage**	
Underweight (18.5)	8	9.1%	
Normal weight (18.5 - 22.9)	52	59.1%	
Overweight/obese (>22.9)	28	31.8%	
Duration of Haemodialysis			
3 Months - 6 Months	9	10.22%	
>6 Months - 1 Years	27	30.68%	
1 Year - 5 Years	45	51.13%	
>5 Years	7	7.95%	

Table II: Baseline anthropometric parameters of study participants.

Anthropometric Parameters	Mean±SD	Minimum	Maximum
Weight (in kg)	60.41 ± 7.88	45.6	88.0
Height (in cm)	163.7 ± 6.72	140.1	181.2
BMI (Kg/m^2)	22.60 ± 3.30	15.8	31.7

Table III shows mean of various pre-haemodialysis parameters.

Table III: Pre-haemodialysis Laboratory parameters.

Pre-Haemodialysis	Mean±SD	Minimum	Maximum
Estimated GFR (mL/min/1.73 m^2)	8.34 ± 1.77	4.4	11.7
Fasting Blood Glucose (mg/dL)	110.75 ± 28.64	74	251
HB (g/dL)	9.08 ± 1.16	6.5	12.2

TLC Count (cells/µL)	7129.44 ± 2241.44	3088	13241
Platelet Count (lakhs/µL)	1.86 ± 0.89	1.0	5.1
Albumin (g/dL)	4.32 ± 0.73	3.3	6.6
Bilirubin (mg/dL)	0.53 ± 0.09	.4	.7
ALT (U/L)	41.15 ± 19.93	11.3	96.5
AST (U/L)	58.96 ± 11.98	30.7	85.1
Calcium (mg/dL)	9.10 ± 0.33	8.4	9.8
Phosphorus (mg/dL)	5.15 ± 0.86	3.2	6.6
Sodium (mmol/L)	138.14 ± 0.58	136.8	140.2
PTH (pg/mL)	568.33 ± 174.50	194.2	1014.3

Statistically significant pre-to-post-haemodialysis changes were observed in levels of serum urea and serum creatinine (Table IV). Urea decreased from 140.48 ± 19.69 mg/dL to 64.84 ± 12.89 mg/dL (p = 0.046), and creatinine decreased from 9.17 ± 1.13 mg/dL to 5.66 ± 1.12 mg/dL (p <0.001).

The mean bicarbonate level increased from 20.42 ± 1.01 mmol/L before haemodialysis to 27.61 ± 5.71 mmol/L after haemodialysis, though this change was not statistically significant (p = 0.207).

Table IV: Comparing effects of haemodialysis on kidney functions in patients of end-stage renal disease before and after haemodialysis.

Kidney Functions	Pre-Haemodialysis (Mean±SD)	Post-Haemodialysis (Mean±SD)	p-value
Urea (mg/dL)	140.48 ± 19.69	64.84 ± 12.89	**0.046**
Creatinine (mg/dL)	9.17 ± 1.13	5.66 ± 1.12	**0.000**
Bicarbonates (mmol/L)	20.42 ± 1.01	27.61 ± 5.71	0.207

Before haemodialysis, the mean forced vital capacity (FVC) was 24.78 ± 7.69%, which significantly improved to 58.95 ± 11.70% after treatment (mean difference: - 34.00%, t = - 19.40, p <0.001). Forced expiratory volume in one second (FEV1) also increased from 36.12 ± 9.39% to 52.07 ± 10.70% (mean difference: - 16.47%, t = - 12.13, p <0.001). The FEV1/FVC ratio improved from 69.22 ± 9.78 to 82.0 ± 7.00 (mean difference: - 12.76, t = - 8.72, p <0.001). Additionally, peak expiratory flow rate (PEFR) rose from 45.10 ± 12.24 L/min to 52.35 ± 10.24 L/min (mean difference: - 7.47 L/min, t = - 10.22, p <0.001). All changes were statistically significant, indicating improved pulmonary function post-haemodialysis.

Table V: Comparing effects of haemodialysis on pulmonary functions in patients of end-stage renal disease before and after haemodialysis

Pulmonary Functions	Pre-Haemodialysis	Post-Haemodialysis	Mean Difference	t value	p-value
FVC (%)	24.78 ± 7.69	58.95 ± 11.70	- 34.00 ± 16.43	- 19.40	**<0.001**
FEV1 (%)	36.12 ± 9.39	52.07 ± 10.70	- 16.47 ± 12.73	- 12.13	**<0.001**
FEV1/FVC	69.22 ± 9.78	82.0 ± 7.00	- 12.76 ± 13.71	- 8.72	**<0.001**
PEFR (L/min)	45.10 ± 12.24	52.35 ± 10.24	- 7.47 ± 6.86	- 10.22	**<0.001**

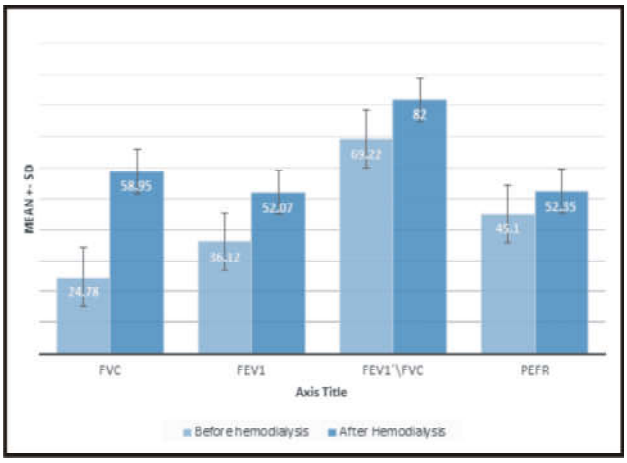

Fig. 1: *Mean pulmonary functions before and after haemodialysis.*

Pre-haemodialysis, no significant correlations were found between pulmonary function parameters across age groups. Post-haemodialysis. The FEV1/FVC ratio showed a significant improvement across age groups, indicating better pulmonary function after haemodialysis (p <0.05). Other parameters also showed improvement, but the differences were not statistically significant.

Table VI: Comparing effects of haemodialysis on pulmonary functions in patients of end-stage renal disease before and after haemodialysis with age.

Age (years)		N	Pulmonary Functions			
			FEV1 Mean±SD	FVC Mean±SD	FEV1/FVC Mean±SD	PEER Mean±SD
Pre-	≤30	5	41.06 ± 2.64	29.34 ± 2.20	72.22 ± 12.08	48.02 ± 5.91
Haemodialysis	31 - 40	11	39.93 ± 10.86	27.91 ± 11.70	70.64 ± 5.70	47.50 ± 14.25
	41 - 50	32	35.74 ± 9.59	24.09 ± 7.22	69.0 ± 11.90	44.70 ± 13.42
	51 - 60	27	34.89 ± 10.73	23.90 ± 7.63	69.0 ± 9.75	44.50 ± 11.40
	>60	13	34.49 ± 4.65	23.88 ± 5.59	67.88 ± 6.15	44.14 ± 12.16
	Total	88	36.12 ± 9.39	24.78 ± 7.69	69.22 ± 9.78	45.10 ± 12.24
p-value			0.399	0.364	0.918	0.930
Post-	≤30	5	59.94 ± 6.94	68.26 ± 3.72	88.30 ± 7.68	59.78 ± 5.04
Haemodialysis	31 - 40	11	55.41 ± 7.63	64.24 ± 14.96	85.85 ± 6.40	57.77 ± 11.18

	41 - 50	32	52.78 ± 11.42	59.56 ± 11.94	84.12 ± 4.86	52.39 ± 12.40
	51 - 60	27	50.64 ± 12.01	56.42 ± 9.57	79.70 ± 6.58	49.86 ± 6.88
	>60	13	47.45 ± 7.11	54.68 ± 11.74	75.88 ± 7.22	49.98 ± 8.78
	Total	88	52.07 ± 10.70	58.95 ± 11.70	82.0 ± 7.00	52.35 ± 10.24
p-value			0.144	0.071	**<0.001**	0.087

Table VII: Correlation of pulmonary function Pre-haemodialysis and Post-haemodialysis.

Pre-haemodialysis		Post-haemodialysis			
		FVC	FEV1	FEV1/FVC	PEFR
FVC	Pearson's Correlation Co-efficient	-0.036	-0.142	-0.017	0.140
	p-value	0.736	0.188	0.874	0.193
FEV1	Pearson's Correlation Co-efficient	0.035	0.395**	0.004	**0.045**
	p-value	0.747	0.000	0.973	0.678
FEV1 / FVC	Pearson's Correlation Co-efficient	0.159	0.061	0.075	**0.011**
	p-value	0.138	0.575	0.489	0.918
PEFR	Pearson's Correlation Co-efficient	0.208	-0.247*	0.024	0.864**
	p-value	0.052	**0.020**	0.827	0.000

**Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*

Discussion

End-stage renal disease (ESRD) progresses from chronic kidney disease (CKD) and necessitates renal replacement therapy, such as haemodialysis (HD) or peritoneal dialysis (PD), to sustain life[5]. Haemodialysis, which involves extracorporeal blood filtration, is essential for managing ESRD while patients await a kidney transplant. CKD patients often face respiratory issues, and dialysis can sometimes improve pulmonary functions.

Our study assessed the impact of haemodialysis on pulmonary function in ESRD patients, finding that the most affected age group was 41 - 50 years, with a mean age of 48.60 years The majority of participants were male (52.3%), coming from lower socio-economic backgrounds (58.0%), and had hypertension (90.9%). which was comparable to other studies like Yilmaz *et al*[6] who found the mean age of the study population to be 49.51 years and 51.8% were male in their study and Momeni *et al*[7] who reported the mean age as 42.40 years with 30 out of 50 patients being male. Most patients had a normal BMI, with some classified as overweight or underweight. Majority of patients were receiving haemodialysis for 1 - 5 years (51.13%). Mane *et al*[8] reported that out of 103 participants, 46 (44.66%) had been receiving haemodialysis for the preceding one to three years, whereas 41 (39.81%) had been receiving it for the preceding six to twelve months. Sharma *et al*[9] found that only 10% of the patients had been receiving haemodialysis for less than six months, whereas 45 patients (90%) were receiving it for 6 months-3 years.

We observed significant improvements in biochemical parameters post-haemodialysis, including notable decreases in urea and creatinine levels and an increase in bicarbonate levels, though the latter was not statistically significant.

Mane *et al*[10] reported that prior to haemodialysis, the mean urea was 140.48 mg/dL; this improved to 64.84 mg/dL. Before haemodialysis, the mean creatinine was 9.17 mg/dL; it was later improved to 5.66 mg/dL. In contrast, Steinhorst *et al*[11] noted a notable increase in renal function following 40 haemodialysis sessions.

Spirometric measures also showed significant post-dialysis improvements in FEV1(36.12% *versus* 52.07%), FVC (24.78% *versus* 58.95%), FEV1/FVC (69.22 *versus* 82.00) and PEFR (45.10 L/min *versus* 52.35 L/min) when compared from Pre-haemodialysis to Post-haemodialysis. Momeni *et al*[12] reported an increase in FEV1 and a significant decrease in FEV1/FVC after haemodialysis. Similarly, Hasan *et al*[13] observed that after haemodialysis, patients FEV1\FVC showed statistically significant improvements. Sharma *et al*[14] also showed similar findings in their study.

Our findings indicate a general decline in pulmonary function with increasing age, with younger CKD patients showing more pronounced improvements in pulmonary function post-haemodialysis, although the differences were not statistically significant ($p > 0.05$), except for the FEV1/FVC ratio, which showed a highly significant improvement ($p < 0.05$). Notably, FEV1 had a strong positive correlation with itself post-haemodialysis, but no significant correlations were found between FEV1 and other parameters. Before haemodialysis, PEFR exhibited a significant negative correlation with FEV1 and a significant positive correlation with itself (PEFR). After haemodialysis, PEFR continued to show a significant positive correlation with itself but no significant correlations with other parameters (FVC, FEV1/FVC).

Our results suggest that haemodialysis can positively impact pulmonary function in ESRD patients, supporting some studies while differing from others. The observed improvements in respiratory parameters may be attributed to reduced fluid overload and alleviated respiratory symptoms associated with renal failure. The discrepancies in findings across studies highlight the need for further research to comprehensively understand the effects of haemodialysis on respiratory health. Overall, haemodialysis appears beneficial in enhancing pulmonary function, offering potential relief from respiratory issues related to kidney failure.

Conclusion

Our study found that haemodialysis significantly improves both biochemical and spirometric parameters in ESRD patients. While pulmonary function declines with age, haemodialysis appears to benefit younger patients more, though not statistically significant. Overall, haemodialysis enhances pulmonary function, particularly for FVC, FEV1, FEV1/FVC ratio, and PEFR.

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