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Evaluation of the Relation between Dialysis Vintage, Cognitive Functions and Functional Status in CKD Patients

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Abstract

***Background:** Patients on haemodialysis are particularly vulnerable to cognitive impairment because of their advanced age, which inherently raises the risk of cognitive decline. Furthermore, stroke is frequently quite common in this population, which is a major factor in cognitive dysfunction. Cognitive impairment risk is further increased by cardiovascular risk factors, which are prevalent in haemodialysis patients. Haemodialysis also may be linked to cognitive problems because of blood pressure variations and it's effects on brain perfusion.*

***Aim:** To evaluate the relation between dialysis vintage, cognitive functions and functional status in CKD (chronic kidney disease) patients undergoing haemodialysis. We assessed cognitive function using Montreal Cognitive Assessment (MOCA) and the functional decline using Barthel Index (BI).*

***Methods:** Using a prospective observational study, the authors measured cognitive function and daily activity level in 60 haemodialysis patients between the age of 18 years and 80 years at Aarupadai Veedu Medical College. The study data for cognitive function and functional status was captured using Montreal cognitive assessment (MOCA) and Barthel index (BI), respectively.*

***Result:** This study suggests that as the vintage of dialysis increases, the Barthel Index score tends to decrease, implying a decline in the patient's functional status. The correlation was statistically significant, with a p-value of 0.001. The study demonstrated a strong association between longer dialysis vintage and lower MOCA scores. These findings suggest that individuals on dialysis for a longer duration are more likely to exhibit cognitive decline as measured by the MOCA scale. The statistical significance of this correlation was p <0.01.*

***Conclusion:** The study confirmed a strong positive relationship between a longer dialysis vintage and a higher risk of cognitive impairment. The study also showed a positive association between a decline in functional status and extended dialysis treatment.*

***Key words:** Cognitive function, functional status, dialysis vintage, MOCA, Barthel index.*

Introduction

Millions of people worldwide suffer from chronic kidney disease (CKD), with end-stage renal disease (ESRD) frequently requiring dialysis treatment in order to sustain life[1]. Dialysis is a useful treatment for the symptoms and side-effects of end-stage renal disease (ESRD); however, long-term dialysis exposure, sometimes known as "dialysis vintage," has been linked to a number of unfavourable health outcomes, such as reductions in cognitive function and general functional status[2]. Furthermore, decreased quality-of-life, greater reliance on others for daily tasks, and increased death rates have all been linked to cognitive impairment in people with chronic kidney disease (CKD)[3]. In addition to cognitive function, dialysis patients are at high-risk for physical functional decline, which encompasses mobility, self-care, and the ability to perform activities of daily living[4]. Older dialysis patients are more likely to experience functional impairment, and research indicates that a longer dialysis history is associated with worsening functional results[5]. Numerous factors, such as vascular disease, anaemia, and inflammation, which worsen neurocognitive deficits, influence the loss in cognitive and functional abilities in dialysis patients[6,7]. Furthermore, another risk factor for poor cognitive and physical results is the existence of frailty in dialysis patients, which frequently develops along with extended dialysis duration[8]. The precise processes by which dialysis vintage leads to a loss in

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cognition and functionality, however, are still being studied. Building on earlier research, this study intends to assess the association of dialysis vintage with cognitive function, and functional status in patients with chronic kidney disease (CKD). It also seeks to identify possible variables that may guide treatment measures aimed at enhancing patient outcomes.

The study was commenced after obtaining ethics clearance from the IEC of the institute.

Material and Methods

This prospective observational study was conducted in the Department of Nephrology at Aarupadai Veedu Medical College and Hospital, Puducherry, over a period of two months. The aim was to evaluate the relationship between dialysis vintage, cognitive function, and functional status in 60 chronic kidney disease (CKD) patients undergoing intermittent haemodialysis. The sample size of 60 was arrived based on the formula for cross-sectional studies. The participants were recruited consecutively as they arrived to the haemodialysis centre. Eligible patients were between 18 and 80 years old, had been on haemodialysis for at least three months, and provided informed consent. Patients with a history of psychological disorders, cerebral or cardiovascular injuries, acute illness, or those unwilling to participate were excluded from the study. Cognitive function was assessed using the *Montreal Cognitive Assessment (MoCA)*, a validated tool for detecting mild cognitive impairment, while functional status was measured using the *Barthel Index (BI)*, which evaluates a patient's ability to perform basic activities of daily living. Both assessments were conducted during dialysis sessions by trained personnel to ensure accuracy and minimise patient fatigue. Dialysis vintage, defined as the duration of time the patient had been undergoing haemodialysis, was recorded, and its relationship with cognitive and functional outcomes was analysed. The primary objective was to evaluate the correlation between the length of time on dialysis and declines in cognitive and functional status. The data analysis was performed using SPSS version 21.

Results

The study included a total of 60 patients undergoing haemodialysis. The majority of participants were male (73.3%), followed by females (26.7%). The age distribution was relatively diverse, with participants ranging from 21 to 80 years old. The most common age group was 41 - 50 years (33.3%), followed by 51 - 60 years (25.0%). The duration of dialysis vintage varied among participants, with the majority (25%) having been on dialysis for 0 - 6 months. The longest dialysis vintage recorded was 120 months (10 years). The most common dialysis frequency was twice a week (91.7%), followed by three times a week (8.3%). The functional status of the participants was assessed using the Barthel Index. The majority of participants (48.3%) fell within the 61 - 90 range, indicating moderate functional dependence. A smaller proportion (29%) exhibited severe functional dependence (21 - 60 range), while 35% demonstrated a high level of functional independence (91 - 100 range). Cognitive function was evaluated using the Montreal Cognitive Assessment (MoCA). The majority of participants (48.3%) scored within the 11 - 17 range, suggesting mild cognitive impairment. A smaller group (38.3%) scored between 18 - 25, indicating borderline cognitive impairment. Only a small percentage (3.3%) achieved scores above 25, indicating normal cognitive function. A correlation analysis was conducted to examine the relationship between dialysis vintage and functional status (Barthel Index) as well as cognitive function (MoCA score). Results indicated a significant negative correlation between dialysis vintage and Barthel Index scores ($r = -0.428$, $p < 0.001$), suggesting that longer dialysis duration was associated with decreased functional status. Additionally, a significant negative correlation was found between dialysis vintage and MoCA scores ($r = -0.501$, $p < 0.001$), indicating that individuals on dialysis for longer durations were more likely to exhibit cognitive decline.

Table I: Demographic and clinical characteristics.

Parameters	Value
Age (years)	49.5 ± 13.52
Gender	
Male	44 (73.33%)
Female	16 (26.67%)
Weight (kgs)	53.92 ± 11.38
Frequency	
2/week	55 (91.67%)
3/week	5 (8.33%)
Vintage	
Less than 1 year	30 (50%)
More than 1 year	30 (50%)
Vascular Access	
AVF	52 (86.67%)
Catheter	8 (13.33%)

Table II: Score distribution.

Parameter	Value
Barthel Index	
Independent	7 (11.7%)
Slightly dependent	21(35.0%)
Moderately dependent	29(48.3%)
Severely dependent	3(5.0%)
Montreal Cognitive Assessment Scale	
Normal	2(3.3%)

Mild cognitive function	23(38.3%)
Moderate cognitive function	29(48.3%)
Severe cognitive function	6(10.0%)

Table III: Correlation between dialysis vintage and Barthel index score.

Variable	Pearson Coefficient (r)	p-value
Dialysis Vintage and Barthel Index Score	-0.428**	**0.001**
Dialysis Vintage and MOCA Score	0.501**	**0.001**

***Correlation was significant at the 0.01 level (2-tailed), 95% C.I.*

Discussion

Our study demonstrates a significant relationship between dialysis vintage and both cognitive function and functional status in patients with chronic kidney disease (CKD). As the duration of dialysis increases, we observed a statistically significant decline in the Barthel Index score ($p = 0.001$), which implies a corresponding decrease in functional capacity. This association between dialysis vintage and functional decline is well-supported by existing literature, which has established that prolonged exposure to dialysis can lead to diminished physical performance due to a combination of factors, including cumulative physical stress, nutritional deficiencies, and chronic inflammation[9,10]. Given that the Barthel Index measures the ability to perform activities of daily living (ADLs), this decline suggests that patients who remain on dialysis for extended periods become increasingly dependent, which severely impacts their quality-of-life.

Functional decline in long-term dialysis patients is a multifactorial issue. Several studies have identified sarcopenia, frailty, and the cumulative effects of co-morbid conditions such as cardiovascular disease and diabetes as key contributors to the deterioration of functional status in dialysis patients[11,12]. Sarcopenia, in particular, has been noted to progress more rapidly in CKD patients due to chronic inflammation and oxidative stress, both of which are exacerbated by the dialysis process. Furthermore, frailty, which encompasses physical weakness, weight loss, and reduced endurance, is highly prevalent in CKD patients and is significantly associated with poor functional outcomes[13]. Thus, the decline in Barthel Index scores observed in our study reflects not only a deterioration in physical capacity but also the broader impact of these systemic factors on the ability to maintain independence.

Cognitive decline, as indicated by lower Montreal Cognitive Assessment (MOCA) scores, was also significantly associated with longer dialysis vintage ($p = 0.01$). This finding is consistent with previous research that has highlighted the increased prevalence of cognitive impairment in CKD patients, particularly those who have been on dialysis for extended periods[14]. Several mechanisms have been proposed to explain the cognitive decline in CKD patients, particularly those on long-term dialysis. One of the most widely accepted explanations involves the chronic exposure to uraemic toxins, which accumulate due to reduced renal clearance and contribute to neurotoxicity. Uraemic toxins, such as indoxyl sulfate and p-cresyl sulfate, are known to induce oxidative stress and inflammation, which can damage the blood-brain barrier and lead to neuronal injury[15]. This is further compounded by the presence of traditional cardiovascular risk factors, such as hypertension, diabetes, and dyslipidemia, which are prevalent in CKD patients and are themselves linked to cognitive decline[16,17]. Moreover, the process of dialysis itself, while essential for maintaining life in end-stage renal disease (ESRD) patients, may exacerbate these issues by contributing to fluctuations in blood pressure and cerebral perfusion, thereby increasing the risk of cerebrovascular events.

Another potential contributor to cognitive decline in dialysis patients is anaemia, which is common in CKD due to the kidney's reduced ability to produce erythropoietin. Anemia can lead to cerebral hypoxia, which has been associated with both cognitive impairment and an increased risk of dementia in older adults[18]. Additionally, CKD patients often experience metabolic imbalances, such as disturbances in calcium and phosphate homeostasis, which may contribute to vascular calcification and cognitive dysfunction[19]. Our findings suggest that these factors may interact to accelerate cognitive decline in patients with prolonged dialysis vintage, further emphasizing the need for early intervention to mitigate these risks.

In addition to physical exercise, maintaining proper nutritional status is also crucial for preventing functional decline in dialysis patients. Malnutrition is highly prevalent in CKD patients due to a combination of factors, including reduced appetite, metabolic acidosis, and protein-energy wasting, all of which can contribute to muscle loss and frailty. Nutritional interventions, such as dietary supplementation with protein and amino acids, have been shown to improve muscle mass and physical performance in CKD patients and should be considered as part of a comprehensive strategy to mitigate functional decline[20]. Similarly, cognitive interventions, such as structured cognitive training programs, may help to slow the progression of cognitive impairment in dialysis patients, particularly those who are at high-risk for dementia[21].

While our study provides valuable insights into the relationship between dialysis vintage, cognitive function, and functional status, there are several limitations that should be acknowledged. First, our study is cross-sectional

in nature, which limits our ability to establish causality between dialysis vintage and the observed declines in cognitive and functional abilities. Longitudinal studies are needed to confirm these findings and to better understand the temporal relationship between dialysis duration and cognitive and functional outcomes. Second, while we used the Barthel Index and MOCA to assess functional and cognitive status, respectively, these tools may not capture the full range of impairments experienced by CKD patients. Future research should consider the use of more comprehensive assessments, such as the Instrumental Activities of Daily Living (IADL) scale, which evaluates higher-order functional abilities, and domain-specific cognitive tests that can provide a more detailed understanding of cognitive decline[22].

Another limitation of our study is the potential for selection bias, as patients with severe cognitive or functional impairments may be less likely to participate in the study or may have discontinued dialysis. This could result in an underestimation of the true prevalence of cognitive and functional decline in long-term dialysis patients. Additionally, we did not control for certain co-morbid conditions, such as depression and anxiety, which are common in CKD patients and may influence both cognitive function and quality-of-life[23]. Future studies should include a more comprehensive assessment of psychological factors to better understand their role in the observed declines.

Conclusion

Our study highlights a significant association between dialysis vintage and both cognitive function and functional status in patients with chronic kidney disease (CKD). As the duration of dialysis increases, patients experience notable declines in both cognitive performance and functional capacity, as measured by the Montreal Cognitive Assessment (MOCA) and the Barthel Index, respectively. These findings are consistent with existing literature and underscore the multifaceted nature of the challenges faced by long-term dialysis patients, including sarcopenia, frailty, chronic inflammation, and exposure to uraemic toxins.

The observed declines in cognitive and functional abilities reflect the cumulative impact of prolonged dialysis on both physical and mental health. The interplay of factors such as nutritional deficiencies, anaemia, metabolic imbalances, and co-morbid conditions further exacerbates these issues. Consequently, there is a critical need for comprehensive, multidisciplinary approaches to address these challenges. Strategies should include regular monitoring of cognitive and functional status, targeted nutritional and cognitive interventions, and management of comorbid conditions.

Given the limitations of our cross-sectional study, future research should employ longitudinal designs to better understand the temporal dynamics between dialysis vintage and cognitive and functional outcomes. Additionally, more comprehensive assessment tools and considerations of psychological factors are necessary to capture the full spectrum of impairments and to develop effective strategies for improving the quality-of-life in long-term dialysis patients. Ultimately, our findings emphasize the importance of early intervention and holistic care to mitigate cognitive and functional decline and enhance patient outcomes in the CKD population.

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