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Original Research Article

A Comparative Analysis of the Efficacy of Low-Temperature Dialysate Baths versus Sodium and Ultrafiltration Modelling to Reduce Intradialytic Hypotensive Episodes

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Abstract:

Background: Intradialytic hypotension (IDH) is a prevalent and significant complication in patients undergoing maintenance hemodialysis, affecting 20-30% of all dialysis treatments. The pathophysiology of IDH involves rapid fluid removal, impaired cardiovascular response, and dialysis process factors. Despite advances in dialysis technology such as sodium and ultrafiltration modeling, and low-temperature dialysate baths, a consensus on the most effective strategy to prevent IDH is still lacking.

Methods: This randomized control trial was conducted which included 60 participants with chronic kidney disease (CKD) undergoing maintenance hemodialysis. Participants were randomized into either the sodium and ultrafiltration modeling group or the low-temperature dialysate bath group. The study focused on monitoring medical history, baseline IDH frequency, blood pressure, heart rate, and IDH incidence. Statistical analysis was conducted using SPSS.

Results: The study population consisted of 60 participants with an average age of 52.3 years, predominantly male (60%), and with diabetic nephropathy as the most common cause of CKD (61.66%). The prevalence of IDH was 19.375%. There was no significant difference in the incidence of IDH episodes between the two treatment groups. Both interventions – sodium and ultrafiltration modeling and cooler temperature dialysate – were effective in preventing IDH, with comparable blood flow rates and mean duration of dialysis.

Conclusion: The study concludes that both sodium and ultrafiltration modeling and cooler temperature dialysate are viable and effective options for preventing IDH in patients prone to hypotension during hemodialysis. This underscores the need for personalized hemodialysis treatment strategies, particularly for patients with diabetes mellitus and longer dialysis durations.

Recommendations: Hemodialysis patients should use salt and ultrafiltration models and low-temperature dialysate baths to prevent IDH, according to the findings. Patient considerations include comorbidities, especially diabetic nephropathy, and dialysis length should determine the method. More research is needed on personalised IDH prevention and its long-term effects.

Keywords: Intradialytic Hypotension, Hemodialysis, Sodium Modeling, Ultrafiltration Modeling, Low-Temperature Dialysate.

Introduction

Intradialytic hypotension (IDH) remains a significant clinical challenge in the management of patients undergoing maintenance hemodialysis. IDH, characterized by a significant drop in blood pressure during dialysis sessions, affects approximately 20-30% of all dialysis treatments and is associated with increased morbidity and mortality in this population [1]. The pathophysiology of IDH is multifactorial, involving factors such as rapid fluid removal, impaired cardiovascular response, and the dialysis process itself [2].

Recent advancements in dialysis technology have led to the exploration of various strategies to mitigate the risk of IDH [3]. Among these, sodium and ultrafiltration modeling, and low-temperature dialysate baths have shown promise. Sodium modeling, which involves the adjustment of dialysate sodium concentration during hemodialysis, aims to reduce intradialytic hypovolemia and maintain blood pressure stability [4, 5]. On the other hand, low-temperature dialysate baths are believed to enhance vascular stability and reduce the risk of IDH by avoiding vasodilation associated with higher dialysate temperatures. Despite these advancements, there remains a lack of consensus on the most effective strategy to prevent IDH.

The aim of the study is to compare the effectiveness of sodium and ultrafiltration modeling versus low-temperature dialysate baths in preventing intradialytic hypotensive episodes (IDH) in patients with chronic kidney disease undergoing maintenance hemodialysis.

Methodology

Study Design: This study employed a randomized control trial design.

Study Setting: The research was conducted at Institute of Renal Sciences, Sir Ganga Ram Hospital, New Delhi, India, between August 2017 and December 2018.

Study Population: In the present study, the subjects with CKD undergoing maintenance Hemodialysis at least twice per week, for 3 months with at least one intradialytic hypotensive episode (as defined by KDOQI) per month were recruited in this study after fulfilling inclusion and exclusion criteria.

Inclusion Criteria: Patients aged 18 years and above with chronic kidney disease (CKD) undergoing maintenance hemodialysis were included.

Exclusion Criteria: Patients with acute kidney injury, unstable cardiovascular status, or those who had undergone dialysis for less than 3 months were excluded.

Randomization and Grouping: Participants were randomly assigned to one of two groups:

- Sodium and Ultrafiltration Modeling Group: This group received individualized sodium and ultrafiltration profiles based on their pre-dialysis sodium levels and fluid status.
- Low-Temperature Dialysate Bath Group: Participants in this group underwent hemodialysis with a dialysate temperature set lower than the standard temperature, typically around 35°C.

Data Collection: Demographic data, medical history, and baseline IDH frequency were collected. Blood pressure, heart rate, and incidence of IDH were monitored and recorded at the beginning, both during and after each dialysis session, every 30 minutes.

Statistical Analysis: Statistical software such as SPSS was utilized for data analysis. Demographic information was compiled using descriptive statistics. Using either Fisher's exact test or the Chi-square test, the incidence of IDH episodes between the two groups was examined.

Ethical Considerations: Ethical approval was obtained from the ethical committee. Informed consent was taken from all participants.

Results

Sixty patients with chronic kidney disease receiving hemodialysis (HD) for maintenance were included in the study. 30 patients each were allocated into 2 groups: Group 1 (low-temperature dialysate) and Group 2 (sodium and ultrafiltration modelling).

Table 1: Demographic data of the study population

Description	Data
Mean Age	52.3 years (37 to 59 years)
Gender Distribution	
Males	60%
Females	40%
Leading Cause of CKD	Diabetic Nephropathy (61.66%)

The frequency of IDH in the study was 19.375%. Before randomization, there were 128 episodes of IDH in 480 sessions. After randomization, the occurrence of IDH was slightly higher in the low-temperature group compared to the sodium and ultrafiltration modeling group, but this difference was not statistically significant.

The average age of the study group was 52.3 yrs, with an age range of 37 to 59 years. Approximately 60% of the study population were males, and 40% were females. The gender distribution was similar in both groups.

Table 2: Mean ± SD of Age among study population (unpaired t test)

	GROUP	N	Mean	SD	SE	P value
Age	Low temperature dialysate	30	54.28	10.656	1.507	0.954
	Sodium & UF modeling	30	52.16	9.913	1.402	

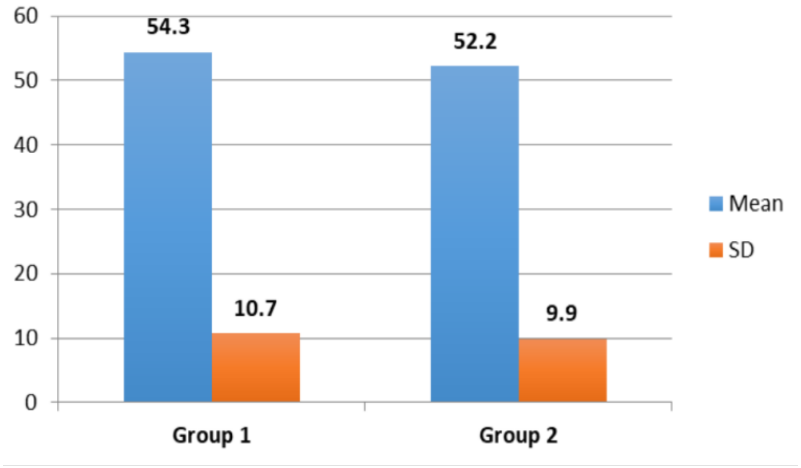

Figure 1: Age distribution among study groups

The most common cause of CKD in the study population was diabetic nephropathy, accounting for 61.66% of the patients. The incidence of diabetic nephropathy was similar in both groups.

The mean blood flow rate was 240.80 ± 29.83 ml/min in the low-temperature dialysate group and 238.80 ± 28.77 ml/min in the sodium and ultrafiltration modeling group. The mean duration of dialysis was 3.1 years in the low-temperature dialysate group and 2.7 years in the sodium and ultrafiltration modeling group.

Table 3: Statistical data comparing the two study groups

Parameter	Low-Temperature Group	Sodium and Ultrafiltration Group
Blood Flow Rate (ml/min)	240.80 ± 29.83	238.80 ± 28.77
Mean Years of Dialysis Duration	3.1 years	2.7 years

Both interventions (sodium and ultrafiltration modeling and cooler temperature dialysate) were found to be effective options for the prevention of IDH in hypotension-prone patients. The average number of IDH episodes for each patient did not significantly differ between the two groups.

Discussion

The study conducted to evaluate the number of intradialytic hypotensive (IDH) episodes in patients undergoing maintenance hemodialysis under two different protocols- low temperature dialysate and sodium and ultrafiltration modeling- revealed several key findings that align with and contribute to the existing body of literature on IDH.

A notable result of the study is the incidence of IDH, which was observed to be 19.3% in this study cohort. This incidence rate is slightly higher but comparable to the 18% reported by [6]. This similarity in incidence rates across different studies suggests a degree of consistency in the occurrence of IDH among diverse patient populations undergoing hemodialysis. The demographic data from the study underscores known risk factors for IDH. The average age of the participants was 52.3 yrs, with a majority being male (60%). This aligns with findings from studies by [6] and [7] which also identified older age as a risk factor for IDH. Interestingly, while literature often cites female gender as a higher risk factor for IDH, this study found a greater prevalence of males in the IDH population, which is more in line with the study by Pavan et al. [6].

A critical aspect of the study was the focus on comorbidities, particularly diabetic nephropathy, which was the most prevalent cause for CKD in the study population. This finding is consistent with research by Pavan et al. [6] and Ebrahimi et al. [7], emphasizing the increased risk for IDH in diabetic patients. The connection between diabetes and IDH highlights the need for careful monitoring and specialized dialysis strategies for patients with diabetic nephropathy. Another significant observation was related to dialysis duration. The study noted thatlonger dialysis duration is a crucial risk factor for IDH, which corroborates with the findings of Pavan et al. [6] and emphasizes the need for personalized treatment duration to minimize the risk of IDH.

Regarding the dialysis parameters, the study found that the mean blood flow rates were comparable between the two groups, and the mean ultrafiltration removed per session was within the recommended "safe zone" of less than 3% of body weight. This adherence to recommended practices suggests a standardization in the dialysis procedure that could help in minimizing the risk of IDH.

One of the key comparisons made in the study was between the effectiveness of the two dialysis protocols in managing IDH. The study found no significant difference in the incidence of IDH between patients treated with low temperature dialysate and those with sodium and ultrafiltration modeling. This finding aligns with studies by Ebrahimi et al. [7] and Dheenan and Henrich [8], suggesting that both dialysis methods are equally effective in managing IDH in patients undergoing maintenance hemodialysis.

Conclusion

The study concluded that both sodium and ultrafiltration modeling and cooler temperature dialysate could be used as options for the prevention of IDH in patients prone to hypotension. The study's findings highlight the importance of individualizing hemodialysis treatment strategies to prevent IDH, especially in patients with diabetes mellitus and those with a longer duration of dialysis.

Limitations: Limited period for follow-up. The assessment of the combined effect of both modalities in the same group of patients was not possible.

Recommendations: Based on the findings, it is recommended that both sodium and ultrafiltration modeling and low-temperature dialysate baths be considered effective strategies for preventing IDH in hemodialysis patients. The choice of strategy should be individualized based on patient-specific factors such as comorbidities, particularly diabetic nephropathy, and dialysis duration. Further research is encouraged to explore personalized approaches for IDH prevention and to investigate the long-term outcomes of these interventions.

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List of Abbreviations:

IDH - Intradialytic Hypotension
CKD - Chronic Kidney Disease
HD - Hemodialysis
KDOQI - Kidney Disease Outcomes Quality Initiative
LVH - Left Ventricular Hypertrophy
UF - Ultrafiltration

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