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Effectiveness of Hemodialysis in Chronic Renal Failure: A Comprehensive Analysis of Biochemical Parameters and Gender Influence

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Abstract

Background: Chronic renal failure (CRF) is a debilitating condition characterized by a gradual decline in kidney function, necessitating renal replacement therapies such as hemodialysis (HD).

Objective: This study aimed to evaluate the effectiveness of HD in improving serum levels of creatinine, uric acid, urea, and electrolytes (sodium, potassium, and chloride) in CRF patientsand investigate gender-related differences in treatment outcomes.

Methods: A total of 40 CRF patients (20 males and 20 females) aged 18-65 years, undergoing HD at a dialysis center in Zliten, Libya, were included in the study. Patients were divided into four groups: pre-dialysis males, post-dialysis males, pre-dialysis females, and post-dialysis females. Serum samples were analyzed for creatinine, uric acid, urea, sodium, potassium, and chloride levels using standard laboratory methods.

Results: HD significantly reduced serum levels of creatinine (62.58% in males, 66.04% in females), uric acid (73.23% in males, 75.14% in females), urea (69.76% in males, 74.53% in females), and potassium (30.76% in males, 34.27% in females). No significant gender-related differences were observed in treatment response for these parameters.However, serum sodium levels were not significantly affected in male patients but showed a slight reduction (1.63%) in female patients after HD. Serum chloride levels remained unaffected by HD in both genders. No significant changes were observed in blood hemoglobin percentage after HD.

Conclusion: HD effectively reduces serum levels of creatinine, uric acid, urea, and potassium, while maintaining electrolyte balance in CRF patients. Gender did not significantly impact treatment outcomes

Keywords: Chronic renal failure, hemodialysis, creatinine, uric acid, urea, electrolytes, biochemical parameters

Introduction

Chronic renal failure (CRF) is a debilitating condition characterized by progressive loss of kidney function, necessitating renal replacement therapy such as hemodialysis (HD) or transplantation(1). Monitoring biochemical markers such as urea, creatinine, and electrolytes is essential for assessing renal health and guiding treatment interventions(2, 3). While HD effectively removes metabolic waste products and maintains electrolyte balance, the influence of gender on treatment outcomes remains unclear. This study aimed to comprehensively evaluate the effectiveness of HD in CRF patients and investigate gender-related differences in treatment response.

Material and method

Study Design and Participants

This study was conducted on 40 chronic renal failure (CRF) patients (20 males and 20 females) aged 18-65 years undergoing hemodialysis (HD) treatment at the dialysis center in Zliten, Libya. The patients were randomly divided into four groups: Group 1 (G1) comprising control pre-dialysis male patients, Group 2 (G2) comprising post-dialysis male patients, Group 3 (G3) comprising control pre-dialysis female patients, and Group 4 (G4) comprising post-dialysis female patients.

Sample Collection and Preparation

Blood samples were collected from each group using sterile, clean, and dry test tubes. The tubes were positioned in a sloped orientation to facilitate coagulation at ambient temperature for 45 minutes. Following coagulation, serum was separated via centrifugation at 3000 revolutions per minute (rpm) for 10 minutes. The resultant clear serum was meticulously transferred into clean, dry vials and stored at -20°C until subsequent analysis for biochemical parameters.

Biochemical Analysis

The serum samples were analyzed for the following biochemical parameters using a VITROS 5600 system, which utilizes micro slide technology: serum urea, serum creatinine, serum uric acid, serum sodium, serum potassium, and serum chloride. The colorimetric determination of serum urea, creatinine, and uric acid was carried out using a spectrophotometer according to the method described by Owen et al. (1954), using specific kits (BIO-ADWIC, Egypt). The estimation of serum sodium, potassium, and chloride levels was conducted using the EasyLyte®PLUS REF 2121 system.

Ethical Considerations

This study was conducted following the principles outlined in the Declaration of Helsinki and received approval from the Institutional Review Board (IRB) of Zliten Hospital. Prior to participation, all patients provided informed consent after being provided with detailed information about the study's purpose, procedures, potential risks, and benefits. Confidentiality of patient information was strictly maintained throughout the study, with data anonymized to ensure privacy.

Statistical Analysis

The obtained data were analyzed using SPSS software. One-way analysis of variance (ANOVA) was used to assess the level of significance for differences between the groups. A p-value < 0.05 was considered statistically significant.

Results

Serum Creatinine and Urea

Both male and female patients exhibited significantly higher pre-dialysis levels of urea (178.17 ± 34.31 mg/dL in males, 158.79 ± 40.78 mg/dL in females) and creatinine (11.85 ± 3.26 mg/dL in males, 10.01 ± 2.74 mg/dL in females) compared to their respective post-dialysis groups. HD led to substantial reductions in serum urea, with a mean decrease of 69.76% ± 7.73% in males and 74.53% ± 9.14% in females. Similarly, serum creatinine levels were markedly reduced after HD, with a mean reduction of 62.58% ± 12.49% in males and 66.04% ± 7.70% in females (Table 1).

Table 1. Effects of Hemodialysis on Serum Urea and Creatinine Levels in CRF Patients.

Group	Urea (mg/dL)	Reduction (%)	Creatinine (mg/dL)	Reduction (%)
G1 (Pre-dialysis Males)	178.17 ± 34.31	-	11.85 ± 3.26	-
G2 (Post-dialysis Males)	54.20 ± 18.43	69.76 ± 7.73	4.34 ± 1.37	62.58 ± 12.49
G3 (Pre-dialysis Females)	158.79 ± 40.78	-	10.01 ± 2.74	-
G4 (Post-dialysis Females)	40.83 ± 20.08	74.53 ± 9.14	3.50 ± 1.58	66.04 ± 7.70

Values are presented as mean ± standard deviation (SD). Reduction percentages represent the mean decrease in serum levels after hemodialysis compared to pre-dialysis levels.

G1: Control pre-dialysis male patients

G2: Post-dialysis male patients

G3: Control pre-dialysis female patients

G4: Post-dialysis female patients

Serum Uric Acid

Pre-dialysis uric acid levels were significantly higher in both male (G1: 7.01 ± 1.91 mg/dL) and female (G3: 6.48 ± 1.75 mg/dL) patients compared to their respective post-dialysis groups (G2: 1.85 ± 0.72 mg/dL; G4: 1.62 ± 0.74 mg/dL). HD significantly reduced serum uric acid levels, with a mean reduction of 73.23% ± 8.60% in males and 75.14% ± 8.19% in females (Table 2).

Table 2. Effects of HD on the serum uric acid level in CRF patients.

Group	Uric Acid (mg/dL)	Reduction (%)
G1 (Pre-dialysis Males)	7.01 ± 1.91	-
G2 (Post-dialysis Males)	1.85 ± 0.72	73.23 ± 8.60
G3 (Pre-dialysis Females)	6.48 ± 1.75	-
G4 (Post-dialysis Females)	1.62 ± 0.74	75.14 ± 8.19

Values are presented as mean ± standard deviation (SD). Reduction percentages represent the mean decrease in serum uric acid levels after hemodialysis compared to pre-dialysis levels.
G1: Control pre-dialysis male patients
G2: Post-dialysis male patients
G3: Control pre-dialysis female patients
G4: Post-dialysis female patients

Serum Electrolytes

HD effectively reduced serum potassium levels, with a mean reduction of 30.76% ± 4.85% in males and 34.27% ± 10.89% in females, indicating efficient management of hyperkalemia. Serum sodium levels were not significantly affected in male patients, while female patients experienced a slight reduction of 1.63% ± 2.03% post-dialysis. Interestingly, serum chloride levels remained relatively unchanged after hemodialysis in both genders (Table 3).

Table 3. Effects of Hemodialysis on Serum Electrolyte Levels in CRF Patients

Group	Sodium (mEq/L)	Reduction (%)	Potassium (mEq/L)	Reduction (%)	Chloride (mEq/L)	Reduction (%)
G1 (Pre-dialysis Males)	134.01 ± 4.52	-	5.42 ± 0.77	-	104.09 ± 3.81	-
G2 (Post-dialysis Males)	134.20 ± 2.92	0.20 ± 2.54	3.75 ± 0.57	30.76 ± 4.85	104.21 ± 2.33	0.18 ± 2.53
G3 (Pre-dialysis Females)	133.92 ± 3.61	-	5.03 ± 0.85	-	102.27 ± 2.26	-
G4 (Post-dialysis Females)	131.69 ± 2.92	1.63 ± 2.03	3.25 ± 0.41	34.27 ± 10.89	102.03 ± 2.31	-0.22 ± 1.60

Values are presented as mean ± standard deviation (SD). Reduction percentages represent the mean decrease in serum levels after hemodialysis compared to pre-dialysis levels.
G1: Control pre-dialysis male patients
G2: Post-dialysis male patients
G3: Control pre-dialysis female patients
G4: Post-dialysis female patients

Blood Hemoglobin

Although there was a slight increase in Hb% after HD in both males (G1: 9.60% ± 1.82%; G2: 10.14% ± 2.07%) and female (G3: 9.94% ± 1.38%; G4: 10.16% ± 1.48%) patients, the differences were not statistically significant (Table 4).

Table 4. Effects of Hemodialysis on Blood Hemoglobin Percentage in CRF Patients.

Group	Hemoglobin (%)	Change (%)
G1 (Pre-dialysis Males)	9.60 ± 1.82	-
G2 (Post-dialysis Males)	10.14 ± 2.07	5.81 ± 8.77
G3 (Pre-dialysis Females)	9.94 ± 1.38	-
G4 (Post-dialysis Females)	10.16 ± 1.48	2.75 ± 11.10

Values are presented as mean ± standard deviation (SD). Change percentages represent the mean increase in blood hemoglobin percentage after hemodialysis compared to pre-dialysis levels.
G1: Control pre-dialysis male patients

G2: Post-dialysis male patients
G3: Control pre-dialysis female patients
G4: Post-dialysis female patients

Discussion

The present study evaluated the effectiveness of HD in improving various biochemical parameters in CRF patients. The results demonstrated that HD significantly reduced serum levels of creatinine, uric acid, urea, and potassium in both male and female patients, which is consistent with findings from previous studies.

Creatinine, a byproduct of muscle metabolism, is primarily eliminated by the kidneys. In CRF, impaired kidney function leads to elevated serum creatinine levels, which can have detrimental effects on various organs, including the cardiovascular system (4). The significant reduction in serum creatinine levels observed after HD (62.58% in males and 66.04% in females) indicates the effective removal of this waste product from the bloodstream, reflecting an improvement in renal clearance.

Similar findings have been reported by other studies, with HD leading to a reduction in serum creatinine levels ranging from 50% to 70% (2, 5). For instance, a study conducted on CKD patients undergoing HD demonstrated a notable decrease in creatinine levels from baseline to six weeks post-HD, indicating the effectiveness of the treatment in removing creatinine (6). Additionally, another study highlighted a substantial drop in creatinine concentrations during the fourth week of dialysis compared to the first week, emphasizing the role of dialysis in eliminating toxic waste products like creatinine from the bloodstream (7). Therefore, HD effectively helps in lowering serum creatinine levels, contributing to the management of CKD patients. HD membranes play a crucial role in removing creatinine through a combination of adsorption and diffusion (8).

Uric acid, a metabolic waste product derived from purine metabolism, accumulates in the blood due to diminished renal excretion in CRF (9). Elevated serum uric acid levels are associated with an increased risk of gout, nephrolithiasis, and cardiovascular complications (10, 11). The substantial decrease in serum uric acid levels (73.23% in males and 75.14% in females) after HD suggests efficient clearance of this compound, which is essential to prevent these complications. Similar reductions in serum uric acid levels have been reported in other studies, ranging from 60% to 80% (12, 13). The initiation of HD leads to a notable decline in serum uric acid levels, indicating the effectiveness of this treatment modality in managing uric acid levels in patients with CRF and gout. Additionally, discontinuation of urate-lowering therapies (ULTs) post-HD may be considered appropriate in this patient population (12).

Urea, another waste product derived from protein metabolism, is also primarily excreted by the kidneys. Accumulation of urea in the blood (uremia) can lead to various symptoms, including fatigue, nausea, and cognitive impairment (14). The significant reductions in serum urea levels observed after HD (69.76% in males and 74.53% in females) indicate effective removal of this toxic metabolite from the body, alleviating the symptoms associated with uremia. HD decreases serum urea levels through the process of removing excess urea and other waste products from the blood (15). Studies have shown that HD adequacy plays a crucial role in reducing blood urea levels, with a significant correlation between HD adequacy and urea reduction (16). Furthermore, research has demonstrated a significant decrease in serum uric acid levels post-dialysis in patients with CRF, highlighting the effectiveness of HD in managing uremic toxins like uric acid (2). Overall, HD is an effective method for reducing serum urea levels in patients with kidney dysfunction.

Potassium, an essential electrolyte, is primarily excreted by the kidneys. In CRF, impaired kidney function can lead to hyperkalemia, which can have severe consequences, including cardiac arrhythmias and muscle weakness (17). The substantial decrease in serum potassium levels (30.76% in males and 34.27% in females) after HD suggests effective management of hyperkalemia, reducing the risk of associated complications. HD plays a crucial role in managing potassium levels in the body of patients with end-stage renal disease. Patients undergoing maintenance HD often experience fluctuations in serum potassium levels due to reduced renal potassium excretion (18, 19). Studies have shown that pre-dialysis potassium concentrations can rise between dialysis sessions, leading to hyperkalemia, especially before the first dialysis of the week (19, 20). Conversely, post-dialysis potassium levels may drop, potentially causing hypokalemia, particularly after the last dialysis of the week (21). Additionally, adherence to a dietary pattern rich in potassium, like the DASH diet, has been associated with lower serum potassium levels in HD patients, highlighting the impact of dietary interventions on potassium balance during HD (22).

Interestingly, HD did not significantly affect serum sodium or chloride levels in male patients, and only a slight reduction in sodium levels was observed in female patients. This finding suggests that the dialysis process effectively maintains the balance of these electrolytes within normal ranges, which is crucial for maintaining proper fluid balance, nerve function, and muscle contractions (23). However, it is essential to monitor these electrolyte levels closely and adjust dialysate compositions accordingly to prevent imbalances. Lower serum chloride levels have been associated with increased mortality in chronic HD patients (24). In contrast, hyperchloremia can contribute to metabolic acidosis in HD patients, affecting acid-base balance (25). Studies have shown that chloride dialysate concentration influences metabolic acidosis control, with lower chloride concentrations improving standard base excess and decreasing the strong ion gap [(26)]. Additionally, in pre-dialysis chronic kidney disease patients, low serum chloride levels were linked to higher mortality and cardiovascular events, highlighting chloride as a potential prognostic indicator in CKD (24). Overall, HD plays a crucial role in regulating chloride levels, impacting patient outcomes and metabolic balance.

The lack of significant changes in blood hemoglobin percentage after HD indicates that the dialysis process did not substantially alter red blood cell counts or hemoglobin levels in these patients. However, anemia is a common complication in CRF, affecting approximately 80% of patients. Its management often requires additional interventions, such as erythropoietin therapy or iron supplementation, in conjunction with HD (27).

The reductions in serum creatinine, uric acid, urea, and potassium levels after HD were comparable between male and female patients, with no statistically significant differences observed between the genders. The only notable difference between genders was observed in serum sodium levels, where a significant reduction of 1.63% ± 2.03% was seen in female patients after HD, while no significant change was observed in male patients. However, for other electrolytes, such as serum chloride levels, no significant gender-related differences were observed. Additionally, the changes in blood hemoglobin percentage after HD were not significantly different between males and females.

Overall, these results suggest that gender does not play a major role in influencing the efficacy of HD in reducing serum levels of creatinine, uric acid, urea, and potassium in CRF patients. However, it is important to note that the study had a relatively small sample size, and further research with larger cohorts may be needed to confirm these findings and explore any potential gender-specific effects on other biochemical parameters or clinical outcomes.

It is important to note that the effectiveness of HD may vary among individuals due to factors such as the underlying cause of renal failure, comorbidities, and individual response to treatment. Regular monitoring of biochemical parameters and adjustment of dialysis regimens are crucial for optimizing patient outcomes (28). Additionally, HD should be accompanied by appropriate dietary and lifestyle modifications, as well as management of comorbidities, to achieve optimal results (29).

Future studies with larger sample sizes and longer follow-up periods may provide further insights into the long-term effects of HD on various biochemical parameters and clinical outcomes in CRF patients. Additionally, investigating the impact of different dialysis modalities, such as peritoneal dialysis or hemodiafiltration, on these parameters could provide valuable information for tailoring treatment strategies to individual patient needs.

Conclusion

HD emerges as an effective treatment modality for managing CRF by facilitating the removal of metabolic waste products and maintaining electrolyte balance. Gender did not significantly impact treatment outcomes, highlighting the importance of individualized treatment plans tailored to each patient's specific needs. Future studies with larger cohorts are needed to validate these findings and elucidate potential gender-related differences in treatment response.

Acknowledgments

References

1. Ammirati AL. Chronic kidney disease. Revista da Associação Médica Brasileira. 2020;66:s03-s9.
2. Putra RN, Perangin-angin VAB, Ferdinand S, Tandanu E. Description of Serum Urea and Creatinine Levels Pre Hemodialysis and Post Hemodialysis at Royal Prima Hospital in Chronic Kidney Disease. Archives of The Medicine and Case Reports. 2021;2(2):118-22.
3. Madhavan Unny N, Zarina A, Beena V. Fluid and Electrolyte Balance. Textbook of Veterinary Physiology: Springer; 2023. p. 193-211.
4. Webster AC, Nagler EV, Morton RL, Masson P. Chronic kidney disease. The lancet. 2017;389(10075):1238-52.
5. Shekhar S, Singh RR, Sinha R, Tripathy S. Effect of haemodialysis on renal profile in chronic renal failure patients at a tertiary care centre. International Journal of Biochemistry Research & Review. 2021;8(1):57-61.
6. Albalawi AM, Dera, A. A., Rajagopalan, P., Maqsood, S., Kashif, F. S., & Mansoor, N. The effect of Dialysis on Biochemical Parameters in Chronic Renal Failure Patients: A Cross-sectional Study. International Journal of Biochemistry Research & Review. 2023;32(2):32–7.
7. Devagourou A, Sharma KK, Yadav RK, Gupta VP, Kalaivani M. An experimental study to evaluate the effect of low-intensity intradialytic exercises on serum urea, creatinine, and fatigue of chronic kidney disease patients undergoing hemodialysis. Saudi Journal of Kidney Diseases and Transplantation. 2021;32(5):1253-9.
8. Saiful S, Imanda MR, Mardiana L, Khairi K, Rahmi R, Raharjo Y, editors. Adsorptive hemodialysis membrane for creatinine removal. AIP Conference Proceedings; 2023: AIP Publishing.
9. Maiuolo J, Oppedisano F, Gratteri S, Muscoli C, Mollace V. Regulation of uric acid metabolism and excretion. International journal of cardiology. 2016;213:8-14.
10. Ndrepepa G. Uric acid and cardiovascular disease. Clinica chimica acta. 2018;484:150-63.

11. Ferraro PM, Curhan GC. Serum uric acid and risk of kidney stones. American Journal of Kidney Diseases. 2017;70(2):158-9.
12. Alkilany R, Einstadter D, Antonelli M. Urate-lowering therapy for patients with gout on hemodialysis. International journal of rheumatic diseases. 2022;25(7):769-74.
13. Yahia SH. Measurement of Serum Uric Acid, Calcium and Phosphate Pre and Post Hemodialysis. Age. 2019;50(24):79.
14. Rosner MH, Reis T, Husain-Syed F, Vanholder R, Hutchison C, Stenvinkel P, et al. Classification of uremic toxins and their role in kidney failure. Clinical Journal of the American Society of Nephrology. 2021;16(12):1918-28.
15. Atta A, Khan MN, Muhammad P, Zubair M, Khan AS, Khan Y. Estimation of Urea Reduction Ratio in Dialysis Patients Per Session and Adequacy of Dialysis. Pakistan Journal of Medical & Health Sciences. 2022;16(05):1247-.
16. Agustiyowati THR. The Influence of Hemodialysis Adequacy on the Blood Urea Value. KnE Life Sciences. 2019:152–7-–7.
17. Sarnowski A, Gama RM, Dawson A, Mason H, Banerjee D. Hyperkalemia in chronic kidney disease: links, risks and management. International Journal of Nephrology and Renovascular Disease. 2022:215-28.
18. Shibata S, Uchida S. Hyperkalemia in patients undergoing hemodialysis: Its pathophysiology and management. Therapeutic Apheresis and Dialysis. 2022;26(1):3-14.
19. Kovesdy CP. Fluctuations in plasma potassium in patients on dialysis. Nephrology Dialysis Transplantation. 2020;35(11):2021-.
20. Kacharam S, Lynch MR, Shemin D, Abuelo JG. Should serum potassium levels be routinely checked after the last dialysis of the week and before the first dialysis of the week? Hemodialysis International. 2021;25(1):142-4.
21. Garagarza C, Valente A, Caetano C, Ramos I, Sebastião J, Pinto M, et al. Potassium Intake—(Un) Expected Non-Predictor of Higher Serum Potassium Levels in Hemodialysis DASH Diet Consumers. Nutrients. 2022;14(10):2071.
22. Garagarza, Cristina Valente, Ana Caetano C, Ramos, Inês, Sebastião J, et al. MO904: Potassium Intake Does Not Predict High Serum Potassium Levels in Haemodialysis Dash Diet Consumers. Nephrology Dialysis Transplantation. 2022;37(Supplement_3):gfac083.6.
23. Bergeron MF. Muscle cramps during exercise-is it fatigue or electrolyte deficit? Current Sports Medicine Reports. 2008;7(4):S50-S5.
24. Valga F, Monzon T, Vega-Diaz N, Santana A, Moscol G, Ruiz-Santana S, et al. Serum chloride as a marker of cardiovascular and all-cause mortality in chronic hemodialysis patients: 5-Year follow-up study. nefrologia. 2023;43:47-56.
25. Libório AB, Noritomi DT, Martins de Castro MC. Chloride, but not unmeasured anions, is correlated with renal bone disease markers. Journal of Nephrology. 2007;20(4):474-81.
26. Marques F, Libório A, Daher E. Effect of chloride dialysate concentration on metabolic acidosis in aintenance hemodialysis patients. Brazilian Journal of Medical and Biological Research. 2010;43:996-1000.
27. Shiferaw WS, Akalu TY, Aynalem YA. Risk factors for anemia in patients with chronic renal failure: a systematic review and meta-analysis. Ethiopian journal of health sciences. 2020;30(5).

28. Rada O-A, Ostan M, Almăjan F, Fericean ML. Changes in the values of serum biochemical parameters of patients undergoing dialysis. Research Journal of Agricultural Science. 2021;53(2).
29. Kalantar-Zadeh K, Fouque D. Nutritional Management of Chronic Kidney Disease. The New England journal of medicine. 2018;378(6):584-5.