DOI: https://doi.org/10.54393/pjhs.v6i3.2865

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 6, Issue 03 (March 2025)

Original Article

OPEN ACCESS

Serum Bicarbonate Changes Among Patients on Thrice Weekly Maintenance Hemodialysis (HD): A Single-Center Study

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ARTICLE INFO

Keywords:
Bicarbonate Changes, End Stage Renal Disease, Hemodialysis, Intra-Dialytic Changes

How to Cite:
Javed, H., Anwar, S., Yaqub, M. S., Ahmad, S., Raza, S. A., & Rauf, S. (2025). Serum Bicarbonate Changes Among Patients on Thrice Weekly Maintenance Hemodialysis (HD): A Single-Center Study: Serum Bicarbonate Changes Among Patients on Thrice-Weekly MHD. Pakistan Journal of Health Sciences, 6(3), 92-96. https://doi.org/10.54393/pjhs.v6i3.2865

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Received date: 22nd January, 2025
Acceptance date: 14th March, 2025
Published date: 31st March, 2025

ABSTRACT

Metabolic acidosis in hemodialysis significantly affects morbidity and mortality. Understanding bicarbonate fluctuations is key to optimizing supplementation and dialysis protocols. **Objectives:** To determine the inter-dialytic and intra-dialytic changes in serum bicarbonate level among patients undergoing maintenance hemodialysis. **Methods:** This quasi-experimental study was conducted at the Nephrology Department, Fatima Jinnah Medical University (FJMU)/Sir Ganga Ram Hospital, Lahore, after taking synopsis approval from the CPSP from August 2024 to January 2025. After taking consent, 60 patients on maintenance haemodialysis thrice weekly who met the selection criteria were enrolled. Inter-dialytic and intra-dialytic changes in serum bicarbonate levels were determined. Data were analyzed using SPSS version 26.0. Numerical values were presented as mean ± SD, and continuous variables were analysed using frequency and percentages.Inter-dialytic and intra-dialytic changes in bicarbonate levels were compared using a paired t-test; p≤0.05 was taken as significant. **Results:** Pre-hemodialysis mean bicarbonate level was 18.65 ± 1.11 mEq/L, increased to 22.18 ± 0.85 mEq/L post-hemodialysis, and by the next hemodialysis session, the mean pre-HD bicarbonate level reduced to 18.78 ± 1.02 mEq/L. Intra-dialytic change showed a mean increase of 3.53 ± 1.19 mEq/L, p-value<0.001 and inter-dialytic change demonstrated a decrease of 3.40 ± 1.18 mEq/L, p-value<0.001. **Conclusions:** It was concluded that hemodialysis temporarily raises bicarbonate levels, but they drop before the next session, highlighting the need for optimized supplementation or dialysis adjustments to maintain stability.

INTRODUCTION

Chronic Kidney Disease (CKD) is a significant global health issue, defined by structural and functional kidney damage or an eGFR of less than 60 ml/min per 1.73 m^2, persisting for three or more months [1]. CKD can progress to end-stage renal disease (ESRD), with a global prevalence reported to be 1,500 per million populations [2]. In Pakistan, its annual incidence exceeds 100 cases per million populations [3]. Healthcare providers face numerous complications in patients undergoing maintenance HD. Among them, metabolic acidosis is a notable concern. Both high and low serum bicarbonate levels are linked to increased mortality risk [4]. Hemodialysis (HD) induces rapid correction of acidosis, leading to transient alkalemia and subsequent acid retention until the next session [5]. Post-HD metabolic alkalosis can also be detrimental, contributing to hypokalaemia, hypocalcaemia, and eventually arrhythmias. Bicarbonate levels exhibit dynamic changes during haemodialysis (HD), influenced by factors such as dialysate composition, individual buffering capacity, and residual kidney function. Rapid post-dialysis increases in serum bicarbonate can lead to transient metabolic alkalosis, while inter-dialytic declines may predispose patients to acidosis [5]. Additionally, metabolic alkalosis is associated with greater inter-dialytic weight gain and intra-dialytic hypotension, with mortality rates reaching up to 90% for pH levels exceeding 7.65 [6]. Variations in serum

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bicarbonate levels pre- and post-HD have been correlated with mortality in ESRD patients, with levels below 23 mmol/L and above 32 mmol/L increasing the hazard ratio for death to 1.23 and 1.74, respectively [7]. Bicarbonate supplementation targeting a serum level of 24 mEq/L helps preserve muscle mass [8]. A study found that serum bicarbonate levels increased by 4.9±0.3 mEq/L immediately post-HD, emphasizing significant post-dialytic shifts that impact electrolyte management in HD patients [9]. During dialysis, exposure to bicarbonate baths plays a crucial role in correcting metabolic acidosis, with clinical guidelines recommending that serum bicarbonate levels be maintained at or above 22 mEq/L [10]. Bicarbonate-based dialysate solutions are currently preferred due to their effectiveness in managing acid-base balance [11]. Despite the prevalence of metabolic acidosis in patients on maintenance haemodialysis (HD), there is a notable lack of local studies examining the fluctuations in serum bicarbonate levels during and between dialysis sessions. This gap in research is particularly important given the potential regional variations in dialysis protocols, dietary habits, and bicarbonate prescription practices in Pakistan, which may influence acid-base balance differently compared to other populations.

Despite existing international evidence on acid–base disturbances in hemodialysis, there is a clear lack of local and region-specific data evaluating intra-dialytic and inter-dialytic bicarbonate fluctuations in ESRD patients on maintenance hemodialysis in Pakistan. Current literature largely focuses on single-time-point bicarbonate measurements, while dynamic cyclical changes across dialysis sessions remain underexplored, particularly in relation to local dialysis practices and patient characteristics. This gap limits optimized bicarbonate management strategies tailored to our population, potentially contributing to persistent metabolic acidosis or post-dialysis alkalosis. This study aims to evaluate the inter-dialytic and intra-dialytic changes in serum bicarbonate levels among patients undergoing maintenance HD, aiming to provide insights that could enhance patient management and improve outcomes in our local setting.

METHODS

This quasi-experimental study was conducted at the Nephrology Department, Fatima Jinnah Medical University (FJMU)/Sir Ganga Ram Hospital, Lahore, after taking synopsis approval from the CPSP from August 2024 to January 2025. Sixty patients meeting the selection criteria were enrolled in this study from the Dialysis unit. Both male and female aged 18-70 years, end-stage renal disease patients (eGFR <15ml/min/m2) on maintenance haemodialysis thrice a week via AV-fistula for more than 3 months' duration were included. Patients on maintenance hemodialysis (MHD) for less than 3 months' duration and those on oral bicarbonate replacement at the time of enrolment in the study were excluded. A sample size of 60 patients was estimated using a 95% confidence level, absolute precision (d) of 0.15, and an expected mean change in bicarbonate level of 0.21 ± 0.59 [12]. Patients were enrolled using non-probability consecutive sampling. Before enrolment, written informed consent was obtained from all patients. Data were collected using pre-designed performa. The participants' age, gender, BMI, comorbid conditions (diabetes, i.e. known diabetics or fasting BSL >126mg/dl, hypertensive (HTN) or BP >130/90mmHg, and Ischemic heart disease), hepatitis B and C status were recorded at the start of the study. Each participant underwent haemodialysis using a Fresenius machine (model 4008S, 4008B, or FX8) with RENACARB Part B (bicarbonate 35 mmol/L) and Part A. The dialysate composition included sodium 140 mmol/L, potassium 2 mmol/L, calcium 1.25 mmol/L, magnesium 0.5 mmol/L, and chloride 105 mmol/L, ensuring optimal acid-base balance. For each patient haemodialysis session lasted for 4 hours, with blood flow rate set at 250-300 mL/min and 1cc of heparin was given to all patients and ultrafiltration was done according to the patient's dry weight. Blood samples were collected at three different time points. The first sample was taken just before dialysis, from the arterial port leading to the dialyzer (Sample 1). The second sample was taken at the end of the dialysis session, after reducing the blood pump flow rate to 100 mL/min for 10-20 second period (Sample 2), and the third sample was taken 48 hours after the dialysis session, just before the next session begins (Sample 3). Serum bicarbonate levels were measured in all three samples to assess both intra-dialytic (pre-HD minus post-HD) and inter-dialytic (post-HD minus next session pre-HD) changes in bicarbonate levels. Serum bicarbonate levels were measured using a biochemical analyzer, ensuring accurate and standardized assessment of acid-base balance during and between dialysis sessions. Data were analysed using SPSS version 26.0. Quantitative variables like age, BMI, and bicarbonate levels were expressed as mean and SD, whereas qualitative variables like gender, comorbidities were presented as frequency and percentages. Change in bicarbonate levels (both inter and intra HD session) was compared using a paired t-test, $p \leq 0.05$ was taken as significant.

RESULTS

The study population (n=60) had a mean age of 49.80 ± 12.08 years; among them, 55% were male (n=33), and 45% were female (n=27). The mean BMI noted was 24.30 ± 1.72 kg/m^2. Regarding comorbidities, 42% had DM, 60% had HTN, 32% had IHD, 12% tested positive for Hepatitis B, and 10% tested

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positive for Hepatitis C. Pre-haemodialysis bicarbonate was 18.65 ± 1.11 mEq/L, rising to 22.18 ± 0.85 mEq/L post-dialysis but declining to 18.78 ± 1.02 mEq/L by the next session, showing a cyclical pattern (Table 1).

Table 1: Summary of Qualitative and Quantitative Variables of Study Population (n=60)

Variables		n (%), (Mean ± SD)
Age (Years)		49.80 ± 12.08
BMI (Kg/m^2)		24.30 1.72
Gender	Male	33 (55%)
	Female	27 (45%)
DM	Yes	25 (42%)
	No	35 (58%)
HTN	Yes	36 (60%)
	No	24 (40%)
IHD	Yes	19 (32%)
	No	41 (68%)
Hepatitis B Positive	Yes	7 (12%)
	No	53 (88%)
Hepatitis C Positive	Yes	6 (10%)
	No	54 (90%)
Pre HD Bicarbonate mEq/L		18.65 ± 1.11
Post HD Bicarbonate mEq/L		22.18 ± 0.85
Next Session Pre-HD Bicarbonate mEq/L		18.78 ± 1.02

Results present the changes in serum bicarbonate levels; intra-dialytic change, showed mean increase of 3.53 ± 1.19 mEq/L, with 95% confidence interval ranging from 3.22 to 3.84, which was statistically significant (p-value=0.000). The inter-dialytic change, demonstrated decrease of 3.40 ± 1.18 mEq/L, also reaching statistical significance (p-value=0.000)(Table 2).

Table 2: Mean Change in Bicarbonate Level

Change in Bicarbonate Level	Mean ± SD (mEq/L)	95% (CI) (Lower-Upper)	p-Value
Intra Dialytic Change (Post HD-Pre HD)	3.53 ± 1.19	3.22-3.84	<0.001
Inter Dialytic Change (Post HD-Next Session Pre HD)	3.40 ± 1.18	3.09-3.70	<0.001

When the data were stratified for age, gender, BMI, DM, and HTN, both intra-dialytic and inter-dialytic bicarbonate levels showed a significant increase in post-HD and a decrease in next session pre-HD bicarbonate levels, p<0.001(Table 3).

Table 3: Data Stratification

Stratified Groups		Inter and Intra Dialytic Change in Bicarbonate Level	Mean ± SD (mEq/L)	p-Value
Gender	Male (n=35)	Inter	3.48 ± 1.22	<0.001
		Intra	3.57 ± 1.29	<0.001
	Female (n=27)	Inter	3.29 ± 1.13	<0.001
		Intra	3.48 ± 1.08	<0.001
DM	Yes (n=25)	Inter	3.52 ± 1.26	<0.001
		Intra	3.56 ± 1.32	<0.001
	No (n=35)	Inter	3.31 ± 1.13	<0.001
		Intra	3.51 ± 1.12	<0.001
HTN	Yes (n=36)	Inter	3.47 ± 1.18	<0.001
		Intra	3.55 ± 1.25	<0.001
	No (n=24)	Inter	3.29 ± 1.19	<0.001
		Intra	3.50 ± 1.14	<0.001
Age	<50 Years (n=29)	Inter	3.40 ± 1.45	<0.001
		Intra	3.60 ± 1.45	<0.001
	≥50 Years (29)	Inter	3.40 ± 0.85	<0.001
		Intra	3.46 ± 0.89	<0.001

DISCUSSION

Proper management of acid-base balance, specifically metabolic acidosis in ESRD patients undergoing HD, is essential, as persistent acidosis can lead to adverse outcomes such as cardiovascular complications, bone disease, and muscle wasting, underscoring the importance of effective bicarbonate regulation in this population. This study has examined serum bicarbonate fluctuations in patients undergoing thrice-weekly maintenance hemodialysis. Recent guidelines emphasize individualized bicarbonate prescriptions based on baseline acid-base status, dietary acid load, and comorbidities to prevent complications such as post-dialysis alkalosis, intradialytic hypotension, and increased mortality risk. Maintaining pre-dialysis serum bicarbonate levels around 22–24 mmol/L is recommended to optimize clinical outcomes and muscle mass preservation [10]. Current study demographics showed a mean age of 49.80 ± 12.08 years among ESRD patients, with a higher proportion of male (55%) compared to female (45%). In this study, 42% of ESRD patients on HD had DM, 60% had HTN, 32% had IHD, 12% tested positive for Hepatitis B, and 10% for Hepatitis C. Local studies from Lahore and Karachi reported mean ages of ESRD patients at 43.13 and 51.68 years, respectively [13, 14]. In a study by Ejaz *et al.*, hypertension was present in 69.5% and diabetes in 64.8% of ESRD patients, higher than current observations, though gender distribution was similar (male 58.1%, female 41.9%) [15]. A 2022 study in Pakistan found slightly lower rates of Hepatitis B and C (8% and 4%, respectively) in ESRD patients on HD [16].In the current study, pre-HD mean bicarbonate levels were 18.65 ± 1.11 mEq/L, rising to 22.18 ± 0.85 mEq/L post-HD, but dropping to 18.78 ± 1.02 mEq/L by the next session.Similarly, Abd *et al.*, reported mean bicarbonate levels increasing from 18.0 ± 1.8 to 23.4 ± 2.1 mmol/L, effectively correcting intradialytic acidosis [17]. Kourtellidou *et al.*, also observed pre-dialysis bicarbonate levels rising from 18.15 ± 1.35 to 20.27 ± 1.88 mmol/L [18].A mathematical model suggests that individualized bicarbonate dialysate prescriptions can maintain pre-dialytic bicarbonate levels within the target range, improving patient outcomes, as maintaining levels above 22 mmol/L is crucial due to the associated lower

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DOI: https://doi.org/10.54393/pjhs.v6i3.2865

mortality risk [19]. Some studies, however, indicate that rapid changes in bicarbonate levels during dialysis may not be necessary, as levels often return to baseline within 44 to 68 hours' post-dialysis, aligning with the current findings [20].The literature underscores that while increasing dialysate bicarbonate can alleviate pre-dialysis acidemia, it often results in post-dialysis alkalemia and does not sufficiently maintain acid-base balance during the inter-dialytic period. Oral bicarbonate supplementation provides a more effective solution by stabilizing acid-base status without causing significant post-dialysis alkalemia, suggesting that individualized bicarbonate management could improve patient outcomes by maintaining a more consistent acid-base balance throughout the dialysis cycle [21]. Bicarbonate fluctuations in haemodialysis patients are influenced by multiple factors, including dialysate bicarbonate concentration, diffusion gradients, and the body's compensatory mechanisms. During dialysis, bicarbonate is transferred from the dialysate into blood via diffusion, rapidly correcting metabolic acidosis. However, post-dialysis, a phenomenon known as "bicarbonate rebound" occurs due to the redistribution of bicarbonate from the extracellular to the intracellular compartment and ongoing metabolic acid production. Inter-dialytic fluctuations arise from dietary acid intake, residual kidney function, and the body's inability to maintain acid-base homeostasis between sessions [5].

This study was limited by its single-center design, relatively small sample size, and short follow-up duration, which may restrict generalizability to broader ESRD populations. Additionally, potential confounders such as dietary acid intake, residual renal function, and variability in individual dialysis prescriptions were not fully controlled. Future studies should include multicenter, large-scale longitudinal designs with standardized dialysate protocols and incorporation of nutritional and residual kidney function assessments. It is also recommended to evaluate the impact of individualized bicarbonate prescription and oral supplementation strategies on long-term outcomes such as mortality, hospitalization rates, and quality of life in hemodialysis patients.

CONCLUSIONS

It was concluded that hemodialysis temporarily raises bicarbonate levels, but they drop before the next session, highlighting the need for optimized supplementation or dialysis adjustments to maintain stability.

Authors' Contribution

Conceptualization: HJ
Methodology: HJ, SA[1], MSY, SA[2], SAR, SR
Formal analysis: HJ
Writing and Drafting: MSY, SA[2]
Review and Editing: MSY, SA[2], SAR, SR

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Kovesdy CP. Epidemiology of Chronic Kidney Disease: An Update 2022. Kidney International Supplements. 2022 Apr; 12(1): 7-11. doi: 10.1016/j.kisu.2021.11.003.

[2] Ke C, Liang J, Liu M, Liu S, Wang C. Burden of Chronic Kidney Disease and Its Risk-Attributable Burden in 137 Low-And Middle-Income Countries, 1990–2019: Results from the Global Burden of Disease Study 2019. BioMed Central Nephrology.2022Dec;23:1-2.doi: 10.1186/s12882-021-02597-3.

[3] Imtiaz S and Alam A. Epidemiology and demography of Chronic Kidney Disease in Pakistan-A review of Pakistani literature. Pakistan Journal of Kidney Diseases. 2023 Mar; 7(1): 2-7. doi: 10.53778/pjkd71209.

[4] Kim HJ. Metabolic Acidosis in Chronic Kidney Disease: Pathogenesis, Clinical Consequences, and Treatment. Electrolytes and Blood Pressure.2021Dec;19(2):29. doi: 10.5049/EBP.2021.19.2.29.

[5] Mudunuru SA, Navarrete JE, O'Neill WC. Metabolic Alkalosis in Hemodialysis Patients: PO0893. Journal of the American Society of Nephrology.2021 Oct; 32(10S): 305. doi: 10.1681/ASN.20213210S1305c.

[6] Ali M, Ejaz A, Iram H, Solangi SA, Junejo AM, Solangi SA. Frequency of Intradialytic Complications in Patients of End-Stage Renal Disease On Maintenance Hemodialysis.Cureus.2021Jan;13(1).doi:10.7759/cureus.12641.

[7] Tantisattamo E, Murray V, Obi Y, Park C, Catabay CJ, Lee Y *et al*. Association of Pre-ESRD Serum Bicarbonate with Post-ESRD Mortality in Patients with Incident ESRD. American Journal of Nephrology.2021 Jun; 52(4): 304-17. doi: 10.1159/000513855.

[8] Abramowitz MK. Bicarbonate Balance and Prescription in ESRD. Journal of the American Society of Nephrology.2017Mar;28(3):726-34.doi:10.1681/ASN.2016070780.

[9] Correa S, Scovner KM, Tumlin JA, Roy-Chaudhury P, Koplan BA, Costea AI *et al.* Electrolyte Changes in

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DOI: https://doi.org/10.54393/pjhs.v6i3.2865

Contemporary Hemodialysis: A Secondary Analysis of the Monitoring in Dialysis Study. Kidney360.2021Apr; 2(4): 695-707. doi: 10.34067/KID.0007452020.

[10] Valério Alves R, Gonçalves H, Lopes K, Sofia F, Vila Lobos A. Changing the Paradigm of Bicarbonate (HCO 3–) Hemodialysis Prescription in Portugal: A 24-Month Prospective Study. Renal Replacement Therapy.2020 Dec; 6: 1-5. doi: 10.1186/s41100-020-00302-y.

[11] Abramowitz MK. Defining Acid-Base Status in Hemodialysis: Is Bicarbonate Enough? Kidney Medicine.2020 Feb;2(1):1. doi:10.1016/j.xkme.2020.01 .003.

[12] Stavroulopoulos A, Aresti V, Papadopoulos C, Nennes P, Metaxaki P, Galinas A. Bicarbonate Levels in Hemodialysis Patients Switching from Lanthanum Carbonate to Sucroferric Oxyhydroxide. World Journal of Nephrology.2018Oct;7(6):123.doi:10.5527/wjn.v7.i6. 123.

[13] Hussain F, Ashraf S, Arshad M, ur Rehman MM, Khan FS, Ahmad MA *et al*. Knowledge, Adherence, and Perception of Patients On Maintenance Hemodialysis to Treatment Regimens at A Tertiary Care Hospital in Pakistan.Cureus.2023 Dec;15(12).doi:10.7759/cureus. 51341.

[14] Mujtaba F, Ahmad A, Dhrolia M, Qureshi R, Nasir K. Causes of Emergency Department Visits Among End-Stage Kidney Disease Patients on Maintenance Hemodialysis in Pakistan: A Single-Center Study. Cureus. 2022 Dec; 14(12). doi: 10.7759/cureus.33004.

[15] Ejaz A, Junejo AM, Ali M, Ashfaq A, Hafeez AR, Khan SA. Outcomes of Dialysis Among Patients with End-Stage Renal Disease (ESRD).Cureus.2021Aug;13(8).doi: 10.7759/cureus.17006.

[16] Baig MA, Ansari TA, Mugheri AH, Jamali AH, Mushtaq F, Ali S. Determine the Frequency of Hepatitis B and C in Patients Undergoing Hemodialysis.Pakistan Journal of Medical and Health Sciences.2022Mar;16(02):130-. doi: 10.53350/pjmhs22162130.

[17] Abd El Wahab KG, El Shennawy HA, Saeed SA, El Deeb M, Soliman AY, Mansour AM.The Effect of Oral Sodium Bicarbonate On the Improvement of Intradialytic Acidosis and Hyperkalemia in Prevalent Hemodialysis Patients. Journal of the Egyptian Society of Nephrology and Transplantation.2024Jul;24(3):154-8. doi: 10.4103/jesnt.jesnt_25_23.

[18] Kourtellidou SI, Ashby DR, Johansson LR. Oral Sodium Bicarbonate in People On Hemodialysis: A Randomized Controlled Trial.BioMed Central Nephrology.2021Dec;22:1-1.doi:10.1186/s12882-021-02549-x.

[19] Soliman AY, Hamid El Shennawy HA, Wahab Saeed SA, Deeb ME, Mansour AM, Abd El Wahab KG. The Effect of Oral Sodium Bicarbonate on the Improvement of Inter-Dialytic Acidosis and Hyperkalemia.QJM: An International Journal of Medicine.2024Oct;117 (Supplement_2):hcae175-355.doi:10.1093/qjmed/ hcae175.355.

[20] Panesar M, Shah N, Vaqar S, Ivaturi K, Gudleski G, Muscarella M *et al.* Changes in Serum Bicarbonate Levels Caused By Acetate-Containing Bicarbonate -Buffered Hemodialysis Solution: An Observational Prospective Cohort Study. Therapeutic Apheresis and Dialysis.2017Apr;21(2):157-65.doi:10.1111/1744-9987 .12510.

[21] Bozikas A, Kiriakoutzik I, Petrou I, Touroutzis T, Kitoukidi E, Pisanidou P et al. Aiming for the Optimal Bicarbonate Prescription for Maintenance Hemodialysis Therapy in End-Stage Renal Disease. Hemodialysis International.2019Apr;23(2):173-80.doi: 10.1111/hdi.12710.

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