

Hemodynamic and Body Weight Trajectories across Consecutive Hemodialysis Sessions in Patients with End-Stage Renal Disease

Authors:

Dr. N. Murugesan¹, Dr. Venkatram Murugesan², Dr. Sumathy Masanam Kasi³

¹Chief Nephrologist, East coast hospitals, Puducherry, ORCID: <https://orcid.org/0009-0008-6178-6920>

²Chief Nephrologist, East coast hospitals, Puducherry, ORCID: <https://orcid.org/0000-0002-3513-2279>

³Research Coordinator, East coast hospitals, Puducherry, ORCID: <https://orcid.org/0000-0003-3907-0420>

Corresponding Author:

Dr. Sumathy Masanam Kasi, Research Coordinator, East coast hospitals, Puducherry, ORCID: <https://orcid.org/0000-0003-3907-0420> Email: clinicalresearch@eastcoasthospitals.com

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ABSTRACT

Background: Hypertension represents one of the most pervasive and challenging clinical complications in patients with End-Stage Renal Disease (ESRD) undergoing maintenance hemodialysis, affecting 70% to 85% of this population globally. Unmanaged, persistent high blood pressure exponentially escalates the risk of catastrophic cardiovascular events, which remain the leading cause of mortality among dialysis patients. Re-evaluating diagnostic standards and management protocols is essential to mitigating cardiovascular risk and optimizing quality of care in this high-risk population. **Objective:** The primary aim was to evaluate short-term intra-individual fluctuations in body weight and blood pressure (BP) across five consecutive hemodialysis (HD) cycles. **Materials and Methods:** A prospective, single-center observational study was conducted over a one-month period. A non-probability convenience sampling technique was adopted to enroll adult participants under 75 years of age undergoing maintenance hemodialysis who completed five cycles. Patients presenting with acute hemodialysis indications, severe hemodynamic instability, active sepsis, or decompensated heart failure were excluded. Based on a monthly volume of 250 to 300 dialysis patients, a target sample size of $N = 30$ was determined following the application of eligibility criteria, in alignment with pilot study recommendations and the Central Limit Theorem. **Results:** Male participants constituted 63.3% ($n = 19$) of the cohort, while female participants accounted for 36.7% ($n = 11$). Pre-dialysis systolic blood pressure (SBP) demonstrated Grade 1 to Grade 2 hypertension across baseline cycles, peaking at Cycle 2 (156 ± 7.81 mmHg) before settling at 147.10 ± 8.26 mmHg by Cycle 5. Pre-dialysis diastolic blood pressure (DBP) remained elevated above 87 mmHg across all cycles, peaking at Cycle 3 (92.33 ± 4.49 mmHg). Pre-dialysis body weight remained highly stable prior to treatment sessions (55.42 to 55.46 kg). Ultrafiltration led to uniform, steady fluid removal across all five cycles. Intradialytic weight loss widened progressively from 2.0 kg (95% CI: 1.99 to 2.02) in Cycle 1 to 2.19 kg (95% CI: 2.08 to 2.30) in Cycle 5 ($t(29) = 41.092$, $p < 0.001$). Post-hoc pairwise comparisons with Bonferroni correction revealed that pre-dialysis baseline SBP remained statistically stable across Cycles 1 through 4 ($p < 0.05$); however, baseline SBP in Cycle 5 dropped significantly compared to Cycle 1 (Mean difference = 8.13 mmHg, $p < 0.005$), Cycle 2 (Mean difference = 8.90 mmHg, $p < 0.001$), and Cycle 3 (Mean difference = 6.57 mmHg, $p < 0.003$). Pre-dialysis baseline DBP decreased significantly by Cycle 5 relative to Cycle 2 (Mean difference = 4.33 mmHg, $p < 0.001$) and Cycle 3 (Mean difference = 4.96 mmHg, $p < 0.001$). **Conclusion:** Evaluating blood pressure and body weight trajectories across five consecutive hemodialysis cycles reveals critical intra-individual variability that isolated, single-point pre-dialysis metrics consistently fail to capture. Moving beyond static measurements toward short-term longitudinal profiling equips clinicians with actionable foresight to identify high-volatility phenotypes, refine dry-weight targets, optimize ultrafiltration strategies, and improve overall cardiovascular risk management in end-stage kidney disease.

Keywords: End-Stage Renal Disease, Maintenance Hemodialysis, Blood Pressure Volatility, Ultrafiltration, Dry Weight Target, Longitudinal Trajectory

INTRODUCTION

Hypertension represents one of the most pervasive and challenging clinical complications in patients with End-Stage Renal Disease (ESRD) undergoing maintenance hemodialysis, affecting 70% to 85% of this population globally [1,2]. In developing regions such as India, the burden remains uniquely elevated, with national estimates indicating that approximately 75% of hemodialysis patients suffer from uncontrolled high blood pressure [3,4]. Despite its widespread prevalence, blood pressure control in dialysis units remains notoriously poor, presenting a persistent barrier to improving long-term patient outcomes [5,6].

The underlying pathophysiology of hypertension in ESRD is multifaceted and complex. Chronic fluid and sodium overload serve as the primary hemodynamic drivers, exacerbated by arterial stiffness, overactivation of the sympathetic nervous system, and underlying renal parenchymal decay [1,2,7,8]. Furthermore, inadequate dietary salt restriction and sub-optimal fluid compliance frequently compound these physiological mechanisms [9]. Left unmanaged, persistent high blood pressure exponentially escalates the risk of catastrophic cardiovascular events, which remain the leading cause of mortality among dialysis patients [10].

Adding to the clinical complexity, diagnosing and monitoring hypertension in hemodialysis remains a subject of considerable debate [5,6]. Significant variance in reported prevalence rates across clinical studies stems directly from methodological differences in blood pressure assessment specifically, whether measurements are obtained pre-dialysis, post-dialysis, or via out-of-clinic Ambulatory Blood Pressure Monitoring (ABPM) [9]. To establish diagnostic consistency, the National Kidney Foundation–Kidney Disease Outcomes Quality Initiative (KDOQI) clinical practice guidelines define hypertension in hemodialysis as a pre-dialysis blood pressure exceeding 140/90mmHg or a post-dialysis blood pressure exceeding 130/80mmHg [1].

Effective management requires a multi-pronged therapeutic strategy tailored to the unique hemodynamics of ESRD [11]. Core clinical priorities center on strict dietary sodium and fluid restriction, precise ultrafiltration to achieve true "dry weight," and the judicious selection of antihypertensive medications that are not excessively cleared during the dialytic procedure [1,9]. Re-evaluating these diagnostic standards and management protocols is essential to mitigating cardiovascular risk and optimizing quality of care in this high-risk population [10].

The primary aim was to evaluate short-term intra-individual fluctuations in body weight and blood pressure (BP) across five consecutive hemodialysis (HD) cycles.

MATERIALS AND METHODS

Study Design and Patient Selection

This prospective, single-center, observational study was conducted over a one-month period in the Department of Dialysis Services at a tertiary care teaching hospital in Puducherry, India. The study protocol received prior ethical approval from the Institutional Ethics Committee, and written informed consent was obtained from all participants in accordance with the principles of the Declaration of Helsinki [12].

A non-probability convenience sampling technique was adopted to enroll adult participants under 75 years of age undergoing maintenance hemodialysis who completed five cycles. Patients presenting with acute hemodialysis indications, severe hemodynamic instability, active sepsis, or decompensated heart failure were excluded. Based on a monthly volume of 250 to 300 dialysis patients, a target sample size of $N = 30$ was determined following the application of eligibility criteria. This sample size was chosen in alignment with pilot study recommendations [13,14] and the Central Limit Theorem

Clinical Evaluation and Data Collection

At baseline, comprehensive clinical evaluations were performed for all enrolled participants. Demographic characteristics, current symptoms, past medical histories, and chronic medication regimens were systematically documented. Baseline physical examinations were conducted alongside routine hematological and biochemical laboratory profiling.

Clinical and physiological monitoring was conducted across five consecutive, routinely scheduled hemodialysis sessions for each patient over the observation month. To maintain internal validity, all anthropometric and hemodynamic parameters were recorded using standard equipment calibrated daily per institutional biomedical maintenance protocols [14,15].

Body weight was measured immediately prior to vascular access cannulation (pre-dialysis) and within 10 minutes following blood re-infusion and line disconnection (post-dialysis). All weight measurements were obtained using a calibrated digital platform scale, recorded to the nearest 0.1 kg with patients wearing minimal attire and no footwear. Net ultrafiltration volume (fluid removed, Δ Weight) for each session was calculated as the arithmetic difference between pre-dialysis weight and post-dialysis weight:

Δ Weight (kg) = Pre-Dialysis Weight (kg) - Post-Dialysis Weight (kg)

Hemodynamic evaluations comprised non-invasive blood pressure (NIBP) tracking, specifically recording systolic blood pressure (SBP) and diastolic blood pressure (DBP) in a seated position using an automated NIBP monitor integrated into the hemodialysis

apparatus. Pre-dialysis blood pressure was measured after the patient had rested quietly for at least 10 minutes prior to cannulation. Post-dialysis blood pressure was recorded within 10 minutes following session completion. Mean arterial pressure (MAP) for both pre- and post-dialysis states was derived using the standard clinical formula [16,17]:

$$\text{MAP (mmHg)} = \text{DBP} + \frac{\text{SBP} - \text{DBP}}{3}$$

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows (Version 28.0; IBM Corp., Armonk, NY, USA). Continuous variables, including weight, SBP, DBP, and MAP, were assessed for normality using the Shapiro-Wilk test [18,19]. Normally distributed continuous data are presented as mean $\pm$ standard deviation (SD), whereas non-normally distributed data are expressed as median and interquartile range (IQR). Categorical demographic parameters are summarized using absolute numbers and percentages. Within-cycle differences (pre- versus post-dialysis) were evaluated using the paired-samples t-test. Serial variations in blood pressure and weight metrics across the five consecutive cycles were examined using repeated-measures analysis of variance (RM-ANOVA) with Mauchly's test for sphericity, applying Greenhouse-Geisser corrections where appropriate [6]. Statistical significance was defined as a two-tailed p-value less than 0.05.

The primary aim was to evaluate short-term intra-individual fluctuations in body weight and blood

pressure (BP) across five consecutive hemodialysis (HD) cycles. Evaluating these parameter trajectories over repeated, sequential sessions moves beyond population-level averages to expose critical patient-specific physiological phenotypes that routine, isolated pre-dialysis checks systematically miss.

RESULTS

Baseline Demographic and Clinical Characteristics

A total of 30 adult end-stage kidney disease (ESKD) participants (N = 30) completed the study protocol across five consecutive hemodialysis (HD) observation cycles without loss to follow-up. The study cohort presented with a mean age of 55.46 ± 8.02 years (range: 45 to 79 years), representing a predominantly middle-aged to older adult population. Male participants constituted 63.3% (n = 19) of the cohort, while female participants accounted for 36.7% (n = 11).

Intra-Individual Hemodynamic and Anthropometric Dynamics Across HD Cycles.

To evaluate short-term intra-individual fluctuations and acute intradialytic responses, paired-samples t-tests were conducted for pre- and post-dialysis Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Body Weight across five consecutive HD cycles (N = 30). Across all parameters and cycles, ultrafiltration and hemodialysis produced statistically significant intra-session reductions ($p < 0.001$ for all paired comparisons; Table 1).

Table 1: Longitudinal Changes in Blood Pressure and Body Weight Across Five Consecutive HD Cycles (N = 30)

Parameter & HD Cycle	Pre-HD (Mean $\pm$ SD)	Post-HD (Mean $\pm$ SD)	Mean Diff (95% CI)	t- test	df	p-value
Systolic BP (mmHg)						
Cycle 1	155.23 $\pm$ 13.16	146.07 $\pm$ 11.98	9.17 (8.08, 10.25)	17.303	29	<0.001
Cycle 2	156.00 $\pm$ 7.81	147.20 $\pm$ 8.25	8.80 (7.48, 10.12)	13.590	29	<0.001
Cycle 3	153.67 $\pm$ 7.32	142.37 $\pm$ 6.35	11.30 (9.96, 12.65)	17.182	29	<0.001
Cycle 4	152.20 $\pm$ 8.08	139.40 $\pm$ 7.54	12.80 (10.11, 15.49)	9.746	29	<0.001
Cycle 5	147.10 $\pm$ 8.26	137.13 $\pm$ 7.59	9.97 (8.44, 11.49)	13.349	29	<0.001
Diastolic BP (mmHg)						
Cycle 1	89.47 $\pm$ 7.03	82.47 $\pm$ 6.98	7.00 (4.36, 9.64)	5.430	29	<0.001
Cycle 2	91.70 $\pm$ 5.69	82.40 $\pm$ 5.54	9.30 (8.46, 10.14)	22.679	29	<0.001
Cycle 3	92.33 $\pm$ 4.49	82.07 $\pm$ 4.44	10.27 (9.35, 11.18)	22.966	29	<0.001
Cycle 4	90.33 $\pm$ 5.18	79.60 $\pm$ 4.74	10.73 (9.82, 11.64)	24.149	29	<0.001
Cycle 5	87.37 $\pm$ 5.14	76.93 $\pm$ 5.14	10.43 (9.38, 11.49)	20.232	29	<0.001
Body Weight (kg)						
Cycle 1	55.46 $\pm$ 8.02	53.46 $\pm$ 8.03	2.01 (1.99, 2.02)	301.000	29	<0.001
Cycle 2	55.43 $\pm$ 8.01	53.40 $\pm$ 8.10	2.03 (1.90, 2.16)	32.269	29	<0.001
Cycle 3	55.45 $\pm$ 8.03	53.39 $\pm$ 8.00	2.06 (1.92, 2.21)	28.982	29	<0.001
Cycle 4	55.42 $\pm$ 7.98	53.32 $\pm$ 8.07	2.10 (1.93, 2.27)	25.143	29	<0.001
Cycle 5	55.46 $\pm$ 8.00	53.26 $\pm$ 8.07	2.19 (2.08, 2.30)	41.092	29	<0.001

Systolic Blood Pressure Dynamics

Pre-dialysis SBP demonstrated Grade 1 to Grade 2 hypertension across baseline cycles, peaking at Cycle 2 (156.00 ± 7.81 mmHg) before settling at 147.10 ± 8.26 mmHg by Cycle 5. Intra-session reductions in SBP were observed consistently across all treatments:

- **Cycle 1:** SBP decreased by 9.17 mmHg (95% CI: 8.08 to 10.25; $t(29) = 17.303$, $p < 0.001$).
- **Cycle 4 Peak Drop:** Intradialytic reduction peaked during Cycle 4, yielding a mean drop of 12.80 mmHg (95% CI: 10.11 to 15.49; $t(29) = 9.746$, $p < 0.001$).
- **Cycle 5 Optimization:** Post-HD SBP reached its nadir at Cycle 5 (137.13 ± 7.59 mmHg), transitioning mean post-HD pressure into the pre-hypertensive threshold.

Strong intra-individual correlations between pre- and post-HD SBP across cycles ($r = 0.577$ to 0.978 , $p < 0.001$) indicated that individual participant relative pressure ranks remained stable across sequential sessions.

Diastolic Blood Pressure Dynamics

Pre-dialysis DBP remained elevated above 87 mmHg across all cycles, peaking at Cycle 3 (92.33 ± 4.49 mmHg). Following dialysis, a parallel downward shift in vascular resistance occurred across all sessions:

- **Cycle 1:** DBP decreased by 7.00 mmHg (95% CI: 4.36 to 9.64; $t(29) = 5.430$, $p < 0.001$).
- **Cycles 3–5 Expansion:** The mean intradialytic DBP reduction expanded to >10 mmHg per session, peaking at Cycle 4 (10.73 mmHg, 95% CI: 9.82 to 11.64; $t(29) = 24.149$, $p < 0.001$).
- **Cycle 5 Normalization:** Post-HD DBP dropped below the 80 mmHg threshold in Cycles 4 and 5, reaching its lowest point in Cycle 5 (76.93 ± 5.14 mmHg).

Strong correlation coefficients ($r = 0.849$ to 0.920 , $p < 0.001$ for Cycles 2–5) confirmed uniform participant responsiveness across cycles.

Body Weight and Ultrafiltration Trajectory

Pre-dialysis body weight remained highly stable prior to treatment sessions (55.42 to 55.46 kg). Ultrafiltration led to uniform, steady fluid removal across all five cycles. Intradialytic weight loss widened progressively from 2.01 kg (95% CI: 1.99 to 2.02) in Cycle 1 to 2.19 kg (95% CI: 2.08 to 2.30) in Cycle 5 ($t(29) = 41.092$, $p < 0.001$). Near-perfect intra-individual correlations ($r =$

0.998 , $p < 0.001$) across all cycles demonstrated consistent individual fluid removal patterns.

Longitudinal Pre-Dialysis Trajectory (Repeated Measures ANOVA)

To evaluate, long-term trends in baseline pre-intervention values across the 5-cycle time series, one-way repeated measures ANOVAs were executed.

1. **SBP Baseline Progression:** Mauchly's test indicated a violation of sphericity ($\chi^2(9) = 71.44$, $p < 0.001$), requiring Greenhouse-Geisser correction ($\epsilon = 0.414$). There was a statistically significant main effect of cycle on baseline SBP, $F(1.66, 48.03) = 12.60$, $p < 0.001$, $\eta_p^2 = 0.303$, indicating that 30.3% of the total variance in baseline SBP was attributable to cycle progression. Multivariate repeated measures testing confirmed a significant overall effect across evaluation cycles ($\Lambda = 0.378$, $F(4, 26) = 10.704$, $p < 0.001$, $\eta_p^2 = 0.622$).

Polynomial Within-Subjects Trend Analysis:

- **Linear Trend:** A significant linear downward trajectory ($F(1, 29) = 15.02$, $p < 0.001$, $\eta_p^2 = 0.341$) reflected a systematic baseline SBP decline from Cycle 1 (155.23 ± 13.16 mmHg) to Cycle 5 (147.10 ± 8.26 mmHg).
 - **Quadratic Trend:** A significant quadratic component ($F(1, 29) = 13.49$, $p < 0.001$, $\eta_p^2 = 0.318$) identified a curvilinear deceleration pattern. Pre-dialysis SBP remained relatively plateaued across Cycles 1 through 3 (155.23 to 153.67 mmHg) before dropping across Cycles 4 and 5 (152.20 to 147.10 mmHg).
2. **DBP Baseline Progression:** Sphericity was likewise violated ($\chi^2(9) = 55.53$, $p < 0.001$; $\epsilon = 0.565$). A statistically significant main effect was confirmed, $F(2.26, 65.59) = 5.56$, $p < 0.004$, $\eta_p^2 = 0.161$. Within-subjects contrasts showed a strong quadratic trend ($F(1, 29) = 14.32$, $p < 0.001$), characterized by an initial slight rise in baseline DBP from Cycle 1 (89.47 mmHg) to Cycle 3 (92.33 mmHg), followed by a notable decline through Cycle 5 (87.37 mmHg).

Pairwise Post-Hoc Comparisons (Bonferroni Adjusted)

To pinpoint where significant longitudinal shifts occurred between cycles, post-hoc pairwise comparisons with Bonferroni correction were performed (Table 2).

Table 2: Bonferroni-Adjusted Post-Hoc Pairwise Comparisons for Baseline Pre-Intervention SBP and DBP

Parameter Comparison	Mean Difference	Standard Error (SE)	p-value (Bonferroni)	95% CI of Difference
Systolic Blood Pressure (mmHg)				
Cycle 1 vs. Cycle 2	-0.77	1.84	1.000	-6.28 to 4.74
Cycle 1 vs. Cycle 3	1.56	1.91	1.000	-4.15 to 7.28
Cycle 1 vs. Cycle 4	3.03	2.12	0.812	-3.31 to 9.38
Cycle 1 vs. Cycle 5	8.13*	2.10	0.005	1.85 to 14.42
Cycle 2 vs. Cycle 3	2.33	1.38	0.985	-1.80 to 6.46
Cycle 2 vs. Cycle 4	3.80	1.45	0.134	-0.54 to 8.14
Cycle 2 vs. Cycle 5	8.90*	1.71	<0.001	3.77 to 14.03
Cycle 3 vs. Cycle 4	1.47	1.41	1.000	-2.75 to 5.69
Cycle 3 vs. Cycle 5	6.57*	1.56	0.003	1.89 to 11.24
Cycle 4 vs. Cycle 5	5.10	1.50	0.018	0.61 to 9.59
Diastolic Blood Pressure (mmHg)				
Cycle 1 vs. Cycle 2	-2.23	1.17	0.652	-5.73 to 1.27
Cycle 1 vs. Cycle 3	-2.86	1.34	0.395	-6.88 to 1.15
Cycle 1 vs. Cycle 4	-0.86	1.13	1.000	-4.25 to 2.52
Cycle 1 vs. Cycle 5	2.10	1.12	0.690	-1.25 to 5.45

Cycle 2 vs. Cycle 3	-0.63	0.93	1.000	-3.42 to 2.16
Cycle 2 vs. Cycle 4	1.37	0.99	1.000	-1.60 to 4.34
Cycle 2 vs. Cycle 5	4.33*	0.99	0.001	1.37 to 7.30
Cycle 3 vs. Cycle 4	2.00	0.88	0.298	-0.65 to 4.65
Cycle 3 vs. Cycle 5	4.96*	1.09	0.001	1.70 to 8.23
Cycle 4 vs. Cycle 5	2.96	0.94	0.034	0.14 to 5.79

* p < 0.05 level (adjusted for multiple comparisons).

Summary of Pairwise Differences

Post-hoc pairwise comparisons with Bonferroni correction revealed that for pre-dialysis baseline SBP, levels remained statistically stable across Cycles 1 through 4 ($p < 0.05$). However, baseline SBP in Cycle 5 dropped significantly compared to Cycle 1 (Mean difference = 8.13 mmHg, $p < 0.005$), Cycle 2 (Mean difference = 8.90 mmHg, $p < 0.001$), and Cycle 3 (Mean difference = 6.57 mmHg, $p < 0.003$).

For pre-dialysis baseline DBP, pressure levels peaked at Cycle 3 (92.33 ± 4.49 mmHg) before decreasing significantly by Cycle 5 relative to Cycle 2 (Mean difference = 4.33 mmHg, $p < 0.001$) and Cycle 3 (Mean difference = 4.96 mmHg, $p < 0.001$). These findings confirm that while acute within-session reductions occur immediately during every cycle, cumulative baseline improvements materialize primarily during the later treatment cycles.

DISCUSSION

The core finding of this investigation highlights the significant clinical limitation of relying on isolated, single-point pre-dialysis parameters to gauge hemodynamic stability in end-stage kidney disease (ESKD). Standard clinical guidelines, such as the KDOQI Clinical Practice Guidelines for Hemodialysis Adequacy and European Renal Best Practice recommendations, emphasize strict monitoring of fluid status, dry weight targets, and ultrafiltration rates to minimize cardiovascular risk [1,9]. However, single-point blood pressure (BP) and static interdialytic weight gain (IDWG) figures remain intrinsically vulnerable to single-session noise, situational anxiety, and acute volume swings. By rigorously applying parametric evaluation frameworks (3,4) across five consecutive hemodialysis (HD) cycles, the present study establishes

a robust methodological foundation that filters out episodic volatility to capture authentic, short-term physiological trajectories [7,9].

A key narrative emerging from sequential intra-individual tracking is the identification of hidden hypertensive burden and vascular resistance shifts. Conventional clinical paradigms often assume that interdialytic or post-dialysis BP remains proportionally lower than elevated pre-dialysis readings [5,6]. While our cohort demonstrated consistent, statistically significant intra-session drops in both SBP and DBP across all five cycles ($p < 0.001$), longitudinal tracking revealed important baseline trends specifically, a quadratic trajectory where baseline pre-dialysis SBP plateaued before significantly declining by Cycle 5 ($p < 0.005$). In clinical practice, evaluating trajectories across multiple sessions prevents the systematic under-recognition or over-treatment of transient spikes, distinguishing between acute volume removal and true baseline hemodynamic stabilization [6,9].

Furthermore, evaluating short-term body weight fluctuations concurrently with real-time BP responses across five sequential cycles provides crucial mechanistic insight into fluid dynamics versus underlying vascular adaptation. When intra-individual BP volatility occurs independently of significant IDWG changes, the primary driver shifts from simple volume overload to altered vascular reactivity, arterial stiffness, and autonomic dysfunction [5,6]. Moreover, broader demographic and systemic factors, including gender disparities in dialysis practices and vascular access, significantly influence fluid management and hemodynamic stability in hemodialysis populations [20,21].

From a practical perspective, capturing short-term intra-individual variability offers immediate translational

value [6]. Session-to-session trajectory profiling equips clinicians with actionable foresight to transition from reactive fluid removal to prospective cardiovascular risk management. Identifying high-volatility phenotypes over consecutive cycles enables precise refinement of dry-weight targets, tailored adjustment of ultrafiltration profiles, and strategic timing of antihypertensive administration [1,5,6,22]. Ultimately, moving beyond isolated static metrics toward longitudinal, short-term trajectory analysis is vital to mitigating chronic cardiovascular remodeling and optimizing survival in hemodialysis populations [10].

Strengths and Limitations

A principal strength of this study lies in its multi-session longitudinal design. Evaluating parameter trajectories across five consecutive HD cycles substantially mitigates single-session interference, situational white-coat spikes, and transient fluid shifts that frequently confound cross-sectional or single-cycle hemodialysis studies. By leveraging five sequential measures per individual, this design increases statistical power and observational stability, enabling a more reliable characterization of true intra-individual variability and short-term hemodynamic trends [19]. Furthermore, testing data for normal distribution across repeated measures ensured rigorous statistical modeling of parameter fluctuations [19].

Despite these strengths, several limitations warrant consideration. First, while observing five consecutive HD cycles effectively captures short-term intra-individual variance, this temporal window may not fully reflect long-term seasonal or multi-month hemodynamic fluctuations driven by gradual vascular remodeling or progressive loss of residual kidney function. Second, ambulatory interdialytic blood pressure monitoring was not conducted between sessions, limiting direct comparison between in-center post-dialysis readings and out-of-hospital blood pressure profiles. Finally, unmeasured confounders, such as inter-individual variations in dietary sodium intake, dialysate sodium prescriptions, and precise timing of antihypertensive medication adherence across treatment days, could contribute to session-to-session variability. Future multi-center studies with extended observation windows across larger cohorts are recommended to validate these trajectories.

CONCLUSION

Evaluating blood pressure and body weight trajectories across five consecutive hemodialysis cycles reveals critical intra-individual variability that isolated, single-point pre-dialysis metrics consistently fail to capture. Identifying session-to-session patterns such as baseline pressure stabilization over sequential cycles independent of fluid removal exposes underlying vascular dynamics

that single readings obscure. Moving beyond static pre-dialysis measurements toward short-term longitudinal profiling enables clinicians to optimize dry-weight targets, refine ultrafiltration strategies, and improve cardiovascular risk management in end-stage kidney disease.

Declarations

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. No financial or personal relationships with people or organizations have inappropriately influenced the actions or data presented in this study.

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This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The study was conducted using existing institutional resources and clinical records from the East Coast Hospitals Medical Records Department.

Ethical Statement and Informed Consent

Patient Anonymity and Confidentiality: The authors declare that the patient's identity has been strictly anonymized throughout this report. All identifying information, including name, specific date of birth, and hospital identification numbers, has been removed or de-identified to ensure complete privacy in accordance with the ethical standards of the Institutional Ethics Committee and the Declaration of Helsinki. (Protocol No.EC/NEW/INSG/2024/4589/EIMS/2026/37),

Informed Consent: Written informed consent was obtained from the patient for the publication of this case report and any accompanying images or clinical data. The patient was briefed on the educational and research-driven purpose of this documentation. A copy of the written consent is available for review by the Editor-in-Chief of this journal upon request.

Use of Data: The clinical data and diagnostic findings presented herein are utilized exclusively for research and educational purposes to advancement of medical science.

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