RESEARCH ARTICLE

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Rate of Blood Pressure Control among Hypertensive Patients with Hemodialysis in Sohag University Hospital

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Abstract

Background and Aim: Hypertension is a common comorbidity in hemodialysis patients, complicating cardiovascular management. While hemodialysis is known to affect blood pressure, the link between dialysis and hypertension control is not well understood. Our study investigates how hemodialysis affects blood pressure control in hypertensive patients and examines the frequency of cardiovascular events in this population.

Materials and Methods: This cross-sectional observational study included 57 hypertensive hemodialysis patients at Sohag University Hospital. Data collected included demographics, comorbidities, hemodialysis parameters, blood pressure (pre-dialysis, inter-dialysis, and post-dialysis), and incidence of cardiovascular events. Mean arterial pressure (MAP) was also calculated.

Results: The mean age of participants was 48.3 years (±15.18), with 73.68% male. The median hemodialysis duration was 36 months, and the median frequency was 3 sessions per week. A significant reduction in MAP was observed during dialysis on the first day compared to pre-dialysis ($P < 0.001$). Despite these improvements, 64.91% had uncontrolled hypertension, while 35.09% achieved control. Cardiovascular events were infrequent: cerebrovascular stroke (7.02%), myocardial infarction (1.75%), hypertensive urgency (14.04%), and pulmonary edema (1.75%); there were no significant differences between the controlled and uncontrolled hypertension groups.

Conclusion: Hemodialysis was associated with significant short-term, procedure-related blood pressure fluctuations across pre-dialysis, intradialytic, and interdialytic time points; however, sustained blood pressure control remained suboptimal, with most patients classified as uncontrolled. These findings highlight the limitations of relying solely on in-unit blood pressure measurements and support the need for more comprehensive monitoring strategies in hypertensive patients receiving hemodialysis.

Keywords: Hypertension, hemodialysis, cardiovascular events, mean arterial pressure, dialysis, chronic kidney disease, cardiovascular risk

INTRODUCTION

Hypertension is a prevalent comorbidity among patients undergoing hemodialysis and significantly contributes to the cardiovascular burden in this population.[1] Poor blood pressure (BP) control in hemodialysis patients is associated with an increased risk of adverse cardiovascular outcomes, including stroke and myocardial infarction (MI).[2]

The management of hypertension in patients undergoing hemodialysis is complicated by factors such as fluid overload, dialysis-induced hypotension, and the intermittent nature of treatment.[3] These factors contribute to difficulties in maintaining consistent BP control outside the dialysis sessions, leading to frequent fluctuations in BP.[4]

BP control is often suboptimal in hemodialysis patients despite antihypertensive medications. It has been noted that

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the effectiveness of these medications can vary significantly, with some patients experiencing inadequate control even with standard treatment regimens.[5]

In addition to BP fluctuations, the presence of other comorbidities, such as diabetes and cardiovascular disease, can complicate the management of hypertension in hemodialysis patients. Studies have shown that the presence of these comorbidities increases the risk of uncontrolled hypertension and poor cardiovascular outcomes.[6]

One of the key challenges in hemodialysis is determining the optimal timing for BP measurements, given the frequent fluctuations during dialysis and interdialytic periods. Previous studies have suggested that BP measurements taken immediately after dialysis may not accurately reflect the patient's typical BP.[7] This study aims to address this gap by evaluating BP control across multiple time points, including pre-dialysis, inter-dialysis, and post-dialysis.

METHODS

A cross-sectional observational study, with repeated BP measurements over a short, predefined period, was conducted among 57 hemodialysis patients at Sohag University Hospital in Egypt from May 2024 to May 2025. The study was approved by the Ethics Committee of Sohag University, and written informed consent was obtained from each participant (registration no: Soh-Med-24-03-08MS, date: 01.03.2024).

Inclusion and Exclusion Criteria

Hypertensive patients aged 18 years or older who were on hemodialysis were included in the study. Hypertension was defined by the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines (pre-dialysis BP >140/90 mmHg and/or post-dialysis BP >130/80 mmHg). Exclusion criteria included patients who refused to participate, patients who discontinued hemodialysis, end-stage renal disease patients not receiving hemodialysis, and patients with irregular hemodialysis schedules.

Data Collection

Patient data were collected, including age, sex, duration of hemodialysis, and comorbidities such as diabetes, ischemic heart disease (IHD), liver cirrhosis (LC), lupus nephritis, epilepsy, schizophrenia, rheumatic heart disease, and dilated cardiomyopathy. A full physical exam was conducted, including vital sign measurements (pulse, BP, and temperature).

Blood Pressure Measurement and Control

BP control was assessed according to KDOQI guideline thresholds. Controlled hypertension was defined as BP values consistently below target levels (pre-dialysis <140/90 mmHg and post-dialysis <130/80 mmHg) during the monitoring period, while patients exceeding these thresholds at one or more measurements were classified as having uncontrolled hypertension. BP monitoring frequency, antihypertensive medications, and patients' awareness of their BP target ranges were also recorded. BP measurements were taken over three days.

- Trained nursing staff obtained BP measurements using a calibrated automated sphygmomanometer, with patients seated and at rest for at least 5 minutes. Pre-dialysis and post-dialysis measurements were recorded within 5 minutes before initiation and within 5 minutes after completion of the dialysis session, respectively.
- Day 1 (dialysis day): BP pre-dialysis, inter-dialysis, and post-dialysis.
- Day 2 (interdialytic day): BP was measured twice (AM and PM), in accordance with guidelines recommending increased out-of-clinic BP monitoring, such as home BP monitoring or ambulatory BP monitoring.
- Day 3 (dialysis day): BP measured pre-dialysis, inter-dialysis, and post-dialysis.

Hemodialysis Protocol

Hemodialysis was performed using 1.8-2.2 m^2 high-flux synthetic membranes (Helixon®) and a blood flow rate of 300 mL/min. The bicarbonate-based dialysate had a flow rate of 500 mL/min and contained sodium at 106 mmol/L before bicarbonate addition, adjusted to a final concentration of 140 mmol/L after $NaHCO_3$ supplementation; potassium (2 mmol/L), calcium (1.5 mmol/L), magnesium (0.50 mmol/L), bicarbonate (33 mmol/L), and chloride (111 mmol/L). Sessions were conducted three times weekly for 4 hours.

Complications

Complications, including strokes, MIs, pulmonary edema, and hypertensive urgencies, were documented. Hypertensive urgency was defined by an systolic BP ≥180 mmHg and/or diastolic BP ≥110 mmHg without end-organ damage.

Statistical Analysis

It was performed using SPSS version 26. Normality was assessed using the Shapiro-Wilk test. Parametric data were analyzed using paired t-tests, while non-parametric data were analyzed using the Wilcoxon test. Comparisons of mean arterial pressure (MAP) across multiple time points were exploratory. Qualitative data were expressed as frequencies and percentages and were analyzed using the chi-square test. A *P*-value of < 0.05 was considered significant.

RESULTS

Fifty-seven hypertensive patients undergoing hemodialysis participated, with ages ranging from 21 to 80 years (mean: 48.3±15.18). Of these, 42 (73.68%) were male and 15 (26.32%) were female. The median hemodialysis duration (interquartile range) was 36 months (18-72), with 3 sessions per week (3-3) and a session length of 4 hours (4-4) (Table 1).

Regarding comorbidities, 9 (15.79%) patients had diabetes mellitus (DM), 6 (10.53%) had IHD, and none had LC. Lupus nephritis was present in 3 patients (5.26%), whereas epilepsy, schizophrenia, rheumatic heart disease, and dilated cardiomyopathy each was found in 1 patient (1.75%) (Table 2).

The MAP was significantly lower during dialysis and post-dialysis on the 1st dialysis day, on the 2nd day (dialysis-free AM), and during dialysis and post-dialysis on the 3rd day, compared to the 1st day pre-dialysis ($P < 0.001$). No significant difference was observed between the 1st day pre-dialysis and either the 2nd day (dialysis-free PM) or the 3rd day pre-dialysis (Table 3).

Out of the 57 patients, 20 (35.09%) had controlled hypertension, while 37 (64.91%) had uncontrolled hypertension. Regarding antihypertensive medications, 30 (52.63%) patients were using calcium channel blockers, 40 (70.18%) patients were on beta blockers, 8 (14.04%) patients were on alpha-2 agonists, 1 (1.75%) patient was on an alpha-1 blocker, 19 (33.33%) patients were using angiotensin blockers, 12 (21.05%) patients were taking diuretics, and 1 (1.75%) patient was on an angiotensin-converting enzyme (ACE) inhibitor.

Four (7.02%) patients experienced cerebrovascular strokes (CVS), 1 (1.75%) patient experienced a MI, 8 (14.04%) patients experienced hypertensive urgency, and 1 (1.75%) patient experienced pulmonary edema. There were no significant differences in age, sex, hemodialysis duration, number of dialysis sessions, or session duration between the controlled and uncontrolled hypertension groups. Comorbidities, including DM, IHD, LC, lupus nephritis, epilepsy, schizophrenia, rheumatic heart disease, dilated cardiomyopathy, and lifestyle factors, were also similar across groups. No LC cases were observed.

The controlled hypertension group had significantly lower MAP than the uncontrolled group at several time points: 1st day during dialysis and post-dialysis; 2nd day (dialysis-free AM and PM); and 3rd day during dialysis and post-dialysis ($P < 0.001$) (Table 4).

Table 1. Demographic data and hemodialysis characteristics of the studied patients

		(n=57)
Age (years)	**Mean ± SD**	48.3±15.18
	Range	21-80
Sex	**Male**	42 (73.68%)
	Female	15 (26.32%)
Hemodialysis duration (months)	**Median**	36
	IQR	18-72
Dialysis sessions (weeks)	**Median**	3
	IQR	3-3
Session duration (hours)	**Median**	4
	IQR	4-4

SD: Standard deviation, IQR: Interquartile range

Table 2. Comorbidities of the studied patients

		(n= 57)
DM	**Yes**	9 (15.79%)
	No	48 (84.21%)
IHD	**Yes**	6 (10.53%)
	No	51 (89.47%)
LC	**Yes**	0 (0%)
	No	57 (100%)
Others	**Lupus nephritis**	3 (5.26%)
	Epilepsy	1 (1.75%)
	Schizophrenia	1 (1.75%)
	Rheumatic heart disease	1 (1.75%)
	Dilated cardiomyopathy	1 (1.75%)
	No	50 (87.72%)

DM: Diabetes mellitus, IHD: Ischemic heart disease, LC: Liver cirrhosis

Table 3. Mean arterial pressure (mmHg) of the studied patients

			(n=57)	*P*-value
1st day (dialysis)	**Pre-dialysis**	**Mean ± SD**	112.92±12.75	
		Range	83.33-133.33	
	During dialysis	**Mean ± SD**	108±12.59	**<0.001***
		Range	83.33-130	
	Post-dialysis	**Mean ± SD**	96.7±13.18	**<0.001***
		Range	80-120	
2nd day (dialysis free)	**AM**	**Mean ± SD**	103.6±11.5	**<0.001***
		Range	83.33-123.33	
	PM	**Mean ± SD**	111.4±10.18	0.086
		Range	93.33-130	
3rd day (dialysis)	**Pre-dialysis**	**Mean ± SD**	113.1±11.05	0.783
		Range	93.33-133.33	
	During dialysis	**Mean ± SD**	105.9±12.34	**<0.001***
		Range	83.33-133.33	
	Post-dialysis	**Mean ± SD**	100±11.94	**<0.001***
		Range	80-123.33	

*: Significant as $P \leq 0.05$. *P*-value compared to pre-dialysis at 1st day, SD: Standard deviation

There were no significant differences in the use of antihypertensive medications (calcium channel blockers, beta blockers, alpha-2 agonists, alpha-1 blockers, angiotensin blockers, diuretics, or ACE inhibitors) between the controlled and uncontrolled hypertension groups (Table 5). Likewise, the incidence of complications such as CVS, MI, hypertensive urgency, and pulmonary edema did not differ significantly between the groups (Table 6).

Table 4. Differences in mean arterial pressure (mmHg) between the studied patients

		Controlled hypertension (n=20)	Uncontrolled hypertension (n=37)	*P*-value
1st day (dialysis free)	**During dialysis**	94.83±7.05	115.05±8.56	**<0.001***
	Post-dialysis	84.67±3.96	103.24±11.72	**<0.001***
2nd day (dialysis free)	**AM**	94.83±8.41	108.38±10.11	**<0.001***
	PM	101.83±8.2	116.58±6.87	**<0.001***
3rd day (dialysis)	**Pre-dialysis**	102.17±8.04	119.01±7.32	**<0.001***
	During dialysis	95.5±10.39	111.53±9.35	**<0.001***
	Post-dialysis	89.67±9.61	105.59±9.03	**<0.001***

*: Significant as $P \leq 0.05$

DISCUSSION

This study examined hypertensive patients undergoing hemodialysis; BP was assessed on three consecutive days (pre-dialysis, inter-dialysis, and post-dialysis), and measurements were also taken in the morning and evening on dialysis-free days. The participants' ages ranged from 21 to 80 years, with a mean age of 48.3±15.18 years. The study population was predominantly male, with 42 (73.68%) males and 15 (26.32%) females, consistent with Skonieczny et al.[8] study, in a retrospective single-center study on 222 hemodialysis patients, reported that 62.4% of their cohort was male, with a mean age of 66.2 years. This difference may be attributed to geographical and environmental factors, as well as the different demographic characteristics of the study populations.

Beyond descriptive comparisons, the observed BP variability may reflect complex interactions between volume status, sympathetic activation, arterial stiffness, and dialysis-related hemodynamic shifts.

Regarding hemodialysis parameters, our study found that the median duration was 36 months, with 3 sessions per week, each session lasting 4 hours. These results align with those of Skonieczny et al.[8], who reported a median dialysis duration of 45.1 months and an average of 720 minutes per week. Tsikliras et al.[9] indicated a dialysis vintage of 35 months, which is close to our findings. In contrast, Nongnuch et al.[10] reported a longer dialysis duration of 42 months in a study of 531 patients undergoing hemodialysis.

Table 5. Differences in anti-hypertensive medications between the studied patients

	Controlled hypertension (n=20)	Uncontrolled hypertension (n=37)	*P*-value
Ca channel blockers	9 (27.27%)	21 (26.92%)	0.872
Beta blocker	14 (41.18%)	26 (32.91%)	
Alpha 2 agonist	1 (2.94%)	6 (7.59%)	
Alpha 1 blocker	0 (0%)	1 (1.27%)	
Angiotensin blocker	5 (14.71%)	15 (18.99%)	
Diuretic	4 (11.76%)	8 (10.13%)	
ACE inhibitor	0 (0%)	1 (1.28%)	

Ca: Calcium, ACE: Angiotensin-converting enzyme

Table 6. Differences in complications between the studied patients

	Controlled hypertension (n=20)	Uncontrolled hypertension (n=37)	*P*-value
CVS	2 (10%)	2 (5.41%)	0.606
MI	0 (0%)	1 (2.7%)	1
HTN urgency	3 (15%)	5 (13.51%)	1
Pulmonary edema	0 (0%)	1 (2.7%)	1

CVS: Cerebrovascular stroke, MI: Myocardial infarction, HTN: Hypertension

Regarding comorbidities, our study identified 9 (15.79%) patients with DM, 6 (10.53%) with IHD, and 3 (5.26%) with lupus nephritis, which is comparable to the results reported by Tsikliras et al.[9], who found that 21.6% of their patients had DM, and 30.2% had coronary artery disease. However, the prevalence of comorbidities varies across studies. For example, Skonieczny et al.[8] found that 34.1% of their patients had DM and 65.9% had cardiovascular disease, while Rootjes et al.[11] reported 27.1% prevalence of diabetes. These variations may be attributed to differences in sample populations, diagnostic criteria, and regional healthcare practices.

Our study found significant differences in MAP between groups with controlled and uncontrolled hypertension. Specifically, MAP was significantly lower on the 1st dialysis day, the 2nd day (dialysis-free AM), and the 3rd day, compared with pre-dialysis MAP on the 1st dialysis day ($P < 0.001$). These findings are consistent with the dialysis-related BP fluctuations described in the literature, where BP decreases post-dialysis due to fluid removal and tends to rise between dialysis sessions as fluid accumulation occurs.[11] Rootjes et al.[11] similarly observed significant post-dialysis reductions in MAP compared to pre-dialysis values, supporting our findings. Furthermore, Skonieczny et al.[8] reported significant reductions in systolic and diastolic BP post-dialysis, aligning with our results.

In our study, 20 patients (35.09%) had controlled hypertension, whereas 37 patients (64.91%) had uncontrolled hypertension. This rate of uncontrolled hypertension aligns with the findings of AL-Ramahi and Amr[12], who highlighted poor BP control in the majority of their cohort. Santos et al.[13] found similar results, with 36 patients achieving controlled BP and 35 having uncontrolled BP.

Regarding antihypertensive medications, our study showed that 30 (52.63%) patients were on calcium channel blockers, 40 (70.18%) were on beta blockers, 8 (14.04%) were on alpha-2 agonists, 1 (1.75%) was on an alpha-1 blocker, 19 (33.33%) were on angiotensin blockers, 12 (21.05%) were on diuretics, and 1 (1.75%) was on an ACE inhibitor. These findings are consistent with Skonieczny et al.[8], who reported the use of beta blockers in 74.1% of patients and calcium channel blockers in 52.9%. Kauric-Klein[14] also found similar usage patterns, with 79.7% of patients on beta blockers and 55% on calcium channel blockers. However, Resmiati et al.[15] reported different patterns, with 74.1% of patients using non-dihydropyridine calcium channel blockers, and only 5.2% using beta blockers. These discrepancies could be due to variations in the availability of medications across regions.

No statistically significant differences in complications were observed between the controlled and uncontrolled hypertension groups; however, the low event rates and modest sample size render the study underpowered to detect meaningful differences in rare cardiovascular outcomes.

Complications in our study were consistent with those reported in the literature. We observed that 4 (7.02%) patients experienced CVS, 1 (1.75%) patient suffered from MI, 8 (14.04%) patients had hypertensive urgencies, and 1 (1.75%) patient had pulmonary edema. These findings are in line with Sánchez-Perales et al.[16], who reported MI in 1.58% of patients, and Agarwal[17], who found an acute MI rate of 3.2/1000 patient years. Sarafidis et al.[18] also noted the high prevalence of hypertension in patients on dialysis, a significant factor contributing to cardiovascular morbidity.

Persistent hypertension despite treatment may be related to inadequate dry-weight assessment, sympathetic overactivity, suboptimal timing of antihypertensive medications, and dialysis adequacy, all of which were not fully captured in the present study.

Study Limitations

This single-center, cross-sectional study with a modest sample size has limited generalizability and does not allow assessment of long-term BP control, antihypertensive effectiveness, or cardiovascular outcomes. BP monitoring was restricted to a three-day period and relied mainly on in-unit measurements rather than ambulatory or home BP monitoring, which limited the accurate estimation of the true BP burden and failed to capture usual interdialytic variability influenced by fluid intake, dietary sodium, and differences in ultrafiltration.

Key determinants of BP in hemodialysis patients—including ultrafiltration volume, interdialytic weight gain, dry-weight adjustments, antihypertensive drug dosing, timing, and adherence—were not systematically assessed, limiting mechanistic and causal interpretation. The exploratory design, absence of a formal power calculation, low event rates, lack of multivariable adjustment, and uncorrected multiple comparisons further restrict statistical inference, while effect sizes and confidence intervals are not routinely reported.

CONCLUSION

This study demonstrates marked short-term BP variability in hypertensive patients undergoing hemodialysis, characterized by transient intradialytic and post-dialytic reductions, yet a high overall prevalence of uncontrolled hypertension. These findings suggest that pre- or post-dialysis BP measurements alone are insufficient to characterize the true BP burden. More comprehensive assessment approaches—ideally incorporating interdialytic, ambulatory, or home BP monitoring—along with individualized volume and antihypertensive management are needed to improve BP evaluation and control in this population.

Ethics

Ethics Committee Approval: The study was approved by the Ethics Committee of Sohag University (registration no: Soh-Med-24-03-08MS, date: 01.03.2024).

Informed Consent: Written informed consent was obtained from each participant.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.G., H.A.H., H.A.M., Concept: H.A.H., A.N.E., Design: A.G., H.A.H., Data Collection or Processing: H.A.M., A.N.E., Analysis or Interpretation: A.G., H.A.H., H.A.M., A.N.E., Literature Search: A.G., A.N.E., Writing: A.G., H.A.M., A.N.E.

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