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Echocardiography Parameters During Long And Short Interdialytic Intervals In Hemodialysis Patients

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ABSTRACT
Background: In patients receiving haemodialysis (HD) cardiovascular disease is the leading cause of mortality. Most HD patients follow the typical schedule of three sessions per week, and thus remain outside dialysis for (~ 2 days in duration) short intervals and for a longer interval (~3 days) at the end of each week. **Objective:** Comparison between echocardiographic parameters during the 2- day (short) and 3-day (long) interdialytic intervals in prevalent HD patients. **Patients and Methods:** The study involved 30 stable prevalent HD patients on thrice weekly regimen. Echocardiography was done before and after the short and long interdialytic interval to study left and right ventricle functions and inferior vena cava (IVC) diameter. Patients' mean age was 56.23 ± 12.31 years (43.4% females and 56.7% males). **Results:** Comparison of echocardiographic measurements was done before and after dialysis between the short (2-days) and long (3-day) interdialytic interval groups (Group 1 Vs Group 2) we found that there were statistically highly significant differences among left pulmonary capillary wedge pressure (PCWP), IVC diameter and interdialytic weight change after dialysis session between the short and the long interdialytic interval patients' groups. The intradialytic weight gain (2.45 ± 1.13 vs 1.19 ± 0.78 kg), IVC diameter (11 ± 2.98 vs 9.62 ± 2.32) and PCWP (11.13 ± 2.3 vs 10.13 ± 1.55) increases were higher during the 3-day versus the 2-day interval ($P < 0.001$). There were no statistically significant differences between left ventricular (LV) systolic and diastolic dimensions, septum affection, ejection fraction, or pulmonary artery pressure. **Conclusion:** IVC, PCWP and intradialytic weight increase was higher during the 3-day versus the 2-day interval in post dialysis comparison. IVC, PCWP and intradialytic weight gain reflect degree of volume overload and their increase especially after interdialytic interval call for need to evaluate timing and frequency of prescribed HD regimens for some HD patients.
Keywords: Hemodialysis, Long interdialytic interval, Echocardiography.

INTRODUCTION
Cardiovascular disease is the leading cause of mortality in patients receiving hemodialysis (HD). Among these patients, serious arrhythmias and sudden cardiac arrests, rather than acute myocardial infarction or stroke, are the most frequent causes of cardiovascular death **(1)**. Patients on maintenance HD follow the typical schedule of three sessions per week, and thus remain outside dialysis for two short intervals (~ 2 days in duration) and for a longer interval (~3 days) at the end of each week **(2, 3)**.

Large-scale population studies have shown that mortality and cardiovascular-related hospitalizations in HD are not evenly distributed throughout the days of the week, they commonly occur within the last hours of the long (3-day) intradialytic interval and the following dialysis session **(2, 4, 5)**. Thus, there has been long concern that the 2-day interdialytic interval may unnecessarily increases the risk of death **(2, 6)**.

The clustering of death and cardiovascular events in the first week day suggest that extreme fluctuations in extracellular volume, accumulation of potentially toxic uremic solutes during the long interval, and the hemodynamic stress of the first haemodialysis session of the week may be implicated in myocardial disease and risk of death in these patients **(7)**. Although this link between the long interval and worsened cardiovascular outcomes has attracted increasing attention, few studies have examined the underlying mechanisms **(7)**. The exact pathophysiologic mechanisms underlying changes in cardiac function and sizing during intra- and inter-dialytic intervals are also obscure. Several factors could be involved, such as volume overload and acid-base and electrolyte shifts, as well as arterial and myocardial wall changes **(5)**. Only a handful of studies have examined cardiac function changes during interdialytic intervals and just one compared changes in echocardiographic indices of left and right ventricles during the 3-day and the 2-day intradialytic interval **(6, 7, 8)**.

The aim of this study was to to compare changes in echocardiographic parameters during the 2-day (short) and 3-day (long) interdialytic intervals of prevalent hemodialysis patients.

PATIENTS AND METHODS
The study was a cross-sectional study that included 30 regular HD at The Memorial Soad Kafafi Hospital, Misr University for Science and Technology. The study was conducted over 6- months period from September 2019 till February 2020.

The 30 studied patients were compared as two groups: Group 1 comprised the 30 HD patients who were studied before and after the 2- day (short) interdialytic interval, and **Group 2** comprised the same 30 HD patients who were studied before and after the 3-day (long) interdialytic interval.

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Inclusion criteria: Clinically stable prevalent HD patients (dialysis for more than 6 months), good functioning AV fistula, adult (>18 years),dialysis 3 times/week, each for 4 hours using low flux membranes, bicarbonate dialysate, conventional heparin anticoagulation, dialysate flow 500 ml/min, blood flow was 250-350 ml/min and net ultrafiltration volume was determined according to the estimated dry weight of each patient and urea reduction ratio > 60 %.
Exclusion criteria: Patients of once weekly or twice weekly HD. Patients with temporary, permanent catheter or graft as vascular access. Unstable and debilitated patients e.g. decompensated heart failure or liver cell failure, uncontrolled hypertension and malignancy or active infection

All patients were subjected to all the following:
Full history taking and complete physical examination with emphasis on, demographic data (age, sex, body mass index, etiology of renal disease, associated comorbidities (DM, HTN, Heart Disease.), hemodialysis data including duration and frequency, intra-dialytic weight gain, vascular access.
Laboratory investigations: Blood samples were collected from each HD patient before the dialysis session. Biochemical measurements were done using standard laboratory techniques and included complete blood picture, blood urea, creatinine, sodium, potassium, corrected calcium, phosphorous, intact parathyroid hormone (iPTH), high-sensitivity C-reactive protein (hs-CRP), total cholesterol and s. albumin. iPTH was measured by a two-site chemiluminescence enzyme-labelled immunometric assay. hs-CRP was measured by particle-enhanced immunonephelometry (Behring).

Echocardiography: A complete trans-thoracic M-mode, 2-dimensional, and color Doppler echocardiographic examinations were performed using a Hewlett Packard Sonos 5500 ultrasound system with a 2.5 to 3.5 MHz transducer. All echocardiographic measurements were evaluated according to the recommendations suggested by the American Society of Echocardiography **[9].** Echocardiography was done before and after short (2-day inter-dialytic intervals) and long (3-day inter-dialytic intervals) with emphasis on left ventricular (LV) systolic and diastolic dimensions, septum affection, ejection fraction, pulmonary artery pressure, left pulmonary capillary wedge pressure (PCWP) and inferior vena cava (IVC) diameter. Echocardiography for measurement of IVC diameter was done with patient in supine position for at least 5 min just before the beginning of the dialysis session and one hour after the end of the session to allow vascular refilling after dialysis. Inferior vena cava diameter was measured at end-expiration (maximal diameter) and at end-inspiration (minimal diameter) at the entry of the hepatic veins as recommended by the American Society of Echocardiography guidelines and performed in the study by **Kutty *et al.* [10].**

Ethical consent:

An approval of the study was obtained from Ain Shams University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were presented as mean and standard deviation for quantitative parametric data and median and interquartile range for quantitative non-parametric data. Frequency and percentage will be used for presenting qualitative data. Suitable analysis will be done according to the type of data obtained. Student t test or Mann Whitney test was used to analyze quantitative data while chi square test and fisher exact test were used to analyze qualitative data. $P \leq 0.05$ was considered to be statistically significant.

RESULTS

The study included 17 (56.7%) males and 13 (43.3%) females with the mean age of 56.23 ± 12.31 (Table 1).

Table (1): Demographic data of the study population

Demographic data		**Total no. = 30**
Age	Mean ± SD	56.23 ± 12.31
	Range	28 – 75
Sex	Female	13 (43.3%)
	Male	17 (56.7%)
Weight (kgs)	Mean ± SD	76.43 ± 22.3
	Range	31 – 150
Height (cm)	Mean ± SD	171.5 ± 12.45
	Range	155– 195
Body mass index (kg/ m^2)	Mean ± SD	25.99 ± 6.75
	Range	16.4 – 43.8

The most common cause of ESRD was hypertension (46.7%) followed by DM (30%) (Table 2).

Table (2): Etiology of ESRD in the study population

Cause	Total no. = 30
Hypertension	14 (46.7%)
Diabetes mellitus	9 (30.0%)
Lupus nephritis	3 (10.0%)
Chronic glomerulonephritis	1 (3.3%)
Unknown etiology	1 (3.3%)
Obstructive Uropathy	1 (3.3%)
Adult Polycystic kidney	1 (3.3%)

Most of the study populations had associated comorbidities (Table 3).

Table (3): Comorbidities in the study population

Co-morbidities	Total no. = 30
Free	5 (16.7%)
Positive	25 (83.3%)
Peripheral vascular disease	10 (33.3%)
Ischemic heart disease	13 (43.3%)
Hypertension	2 (6.7%)
Diabetes mellitus	1 (3.3%)
Chronic liver disease	1 (3.3%)
Osteoarthropathy	1 (3.3%)

The hemodialysis data of the study population : included 30 patients under regular HD for a period ranging from 8 months to 14 years with median duration of dialysis of 3 years. They were on 4 hours dialysis thrice weekly. Average weight gain ranged from 1-4 kg with mean increase in weight of 2.5 kg. All patients were dialyzed through AV fistula (Table 4).

Table (4): Hemodialysis data.

Hemodialysis data		Total no. = 30
Duration of HD (years)	Median (IQR)	3 (2 – 6)
	Range	0.8 – 14
Average weight gain (kg)	Mean ± SD	2.52 ± 0.75
	Range	1 – 4
Vas. Access	Right AVF	14 (46.7%)
	Left AVF	16 (53.3%)

Table (5) shows the laboratory results of the studied patients .

Table (5):laboratory results.

Result	Mean ± SD
Hemoglobin; gm/dl	9.88 ± 0.78
Creatinine; mg/dl	4.76 ± 1.2
Blood Urea; mg/dl	91.3 ± 6
Sodium; mEq/l	132.77 ± 3.24
Potassium; mEq/l	5.4 ± 0.5
S. Albumin; g/dl	3.46 ± 0.37
Corrected Calcium; mg/dl	8.95 ± 0.61
Phosphorus; mg/dl	4.32 ± 0.77
PTH; pg/ml (median (IQR)	390 (290-530)
Hs-CRP; mg/l (median (IQR)	9 (6-16)
T. Cholesterol; mg/dl	166 ± 5
Total iron (ug/dl)	62.3 ±3.19
TIBC(ug/dl)	310.7 ± 38.1
Transferrin saturation (Iron/TIBC x100)	20.07 ± 5.2
Ferritin (ng/ml) (median (IQR)	390.5 (225-554)

Table (6) shows the results of comparison between echocardiographic measurements before and after dialysis for the short (2-day) interdialytic interval group (Group I). There were statistically highly significant differences between left pulmonary capillary wedge pressure (PCWP) and inferior venacava (IVC)diameter.

Table (6): Comparison of ECHO parameters before and after dialysis for the 2-day (short) interdialytic interval patients (group 1)

		Group I		Test value	P-value	Sig.
		Pre	Post			
LV ESD	Mean ± SD	3.15 ± 0.37	3.09 ± 0.16	0.969	0.340	NS
	Range	2.8 – 4.9	2.8 – 3.3			
LV EDDV	Mean ± SD	4.84 ± 0.39	4.91 ± 0.14	-1.000	0.326	NS
	Range	2.9 – 5.1	4.7 – 5.1			
Septum	Mean ± SD	0.74 ± 0.11	0.73 ± 0.11	1.140•	0.264	NS
	Range	0.6 – 0.9	0.6 – 0.9			
Ejection Fraction (%)	Mean ± SD	52.83 ± 9.38	52.57 ± 9.63	1.000•	0.326	NS
	Range	35 – 75	35 – 75			
Pulmonary. Art. Pressure (mmgh)	Mean ± SD	21.27 ± 4.06	21.1 ± 4.19	1.542•	0.134	NS
	Range	16 – 35	16 – 35			
Lt. Pulmonary Capillary Pressure (PCWP)	Mean ± SD	14.45 ± 2.94	11.13 ± 2.3	**8.035•**	**0.000**	**HS**
	Range	8 – 21	6 – 16			
Inferior vena cava diameter (mm)	Mean ± SD	15.2 ± 5.12	11 ± 2.98	**7.004•**	**0.000**	**HS**
	Range	6 – 27	5 – 16			
	Present	8 (26.7%)	8 (26.7%)			
Interdialytic weight gain (kg)	Mean ± SD	–	1.19 ± 0.78	–	–	–
	Range	–	1 – 3.5			

LVEDD = LV end-systolic dimension; LVESD = LV ventricular end-diastolic dimension; *: Chi-square test; •: Paired t-test

Table (7) shows the results of comparison between echocardiographic measurements before and after dialysis for the long (3-day) interdialytic interval group (Group II). There were statistically highly significant differences between left PCWP and IVC diameter.

Table (7): Comparison of ECHO parameters before and after dialysis for the 3-day (long) interdialytic interval patients (group 2)

		Group II		Test value	P-value	Sig.
		Pre	Post			
LV ESD	Mean ± SD	3.1 ± 0.16	3.1 ± 0.16	0.000•	1.000	NS
	Range	2.8 – 3.3	2.8 – 3.3			
LV EDDV	Mean ± SD	4.91 ± 0.14	4.91 ± 0.14	0.000•	1.000	NS
	Range	4.7 – 5.1	4.7 – 5.1			
Septum	Mean ± SD	0.73 ± 0.11	0.73 ± 0.11	0.000•	1.000	NS
	Range	0.6 – 0.9	0.6 – 0.9			
Ejection Fraction (%)	Mean ± SD	52.63 ± 9.76	52.63 ± 9.76	0.000•	1.000	NS
	Range	35 – 75	35 – 75			
Pulmonary. Art. Press. (mmgh)	Mean ± SD	21.17 ± 4.19	21.17 ± 4.19	0.000•	1.000	NS
	Range	16 – 35	16 – 35			
Lt. pulmonary.Capillary Pressure (PCWP)	Mean ± SD	12 ± 2.26	10.13 ± 1.55	**5.577•**	**0.000**	**HS**
	Range	8 – 17	8 – 15			
Inferior vena cava diameter (mm)	Mean ± SD	11.8 ± 3.45	9.62 ± 2.32	**5.709•**	**0.000**	**HS**
	Range	6 – 20	6 – 14			
	Present	7 (23.3%)	8 (26.7%)			
Interdialytic weight gain (kg)	Mean ± SD	–	2.45 ± 1.13	–	–	–
	Range	–	1.5– 4.5			

*: Chi-square test; •: Paired t-test

Table (8) shows the results of comparison of echocardiographic measurements before dialysis between (Group I Vs Group II). There were statistically highly significant differences between left pulmonary capillary wedge pressure and IVC diameter

Table (8): Comparison between Group I and Group II regarding ECHO parameters predialysis.

		Predialysis		Test value	P-value	Sig.
		Group I	**Group II**			
LVESD	Mean ± SD Range	3.15 ± 0.37 2.8 – 4.9	3.1 ± 0.16 2.8 – 3.3	0.966	0.342	NS
LVEDDV	Mean ± SD Range	4.84 ± 0.39 2.9 – 5.1	4.91 ± 0.14 4.7 – 5.1	-1.000	0.326	NS
Septum	Mean ± SD Range	0.74 ± 0.11 0.6 – 0.9	0.73 ± 0.11 0.6 – 0.9	1.000•	0.326	NS
Ejection Fraction (%)	Mean ± SD Range	52.83 ± 9.38 35 – 75	52.63 ± 9.76 35 – 75	0.722•	0.476	NS
Pulmonary. Art. Press. (mmgh)	Mean ± SD Range	21.27 ± 4.06 16 – 35	21.17 ± 4.19 16 – 35	0.769•	0.448	NS
Lt.pulmonary.Capillary pressure	Mean ± SD Range	14.45 ± 2.94 8 – 21	12 ± 2.26 8 – 17	**13.155•**	**0.000**	**HS**
Inferior vena cava diameter (mm)	Mean ± SD Range	15.2 ± 5.12 6 – 27	11.8 ± 3.45 6 – 20	**9.597•**	**0.000**	**HS**
	Present	8 (26.7%)	7 (23.3%)			

*: Chi-square test; •: Paired t-test

Table (9) shows the results of comparison of echocardiographic measurements after dialysis between (Group I Vs Group II). There were statistically highly significant differences among PCWP,IVC and interdialytic weight gain.

Table (9): Comparison between Group I and Group II regarding ECHO parameters post-dialysis.

		Post-dialysis		Test value	P-value	Sig.
		Group I	**Group II**			
LV ESD	Mean ± SD Range	3.09 ± 0.16 2.8 – 3.3	3.1 ± 0.16 2.8 – 3.3	-1.000•	0.326	NS
LV EDDV	Mean ± SD Range	4.91 ± 0.14 4.7 – 5.1	4.91 ± 0.14 4.7 – 5.1	0.000•	1.000	NS
Septum	Mean ± SD Range	0.73 ± 0.11 0.6 – 0.9	0.73 ± 0.11 0.6 – 0.9	0.000•	1.000	NS
Ejection fraction	Mean ± SD Range	52.57 ± 9.63 35 – 75	52.63 ± 9.76 35 – 75	-1.000•	0.326	NS
Pulmonary. Art. Press. (mmgh)	Mean ± SD Range	21.1 ± 4.19 16 – 35	21.17 ± 4.19 16 – 35	-1.000•	0.326	NS
Lt.pulmonary.Capillary Pressure (PCWP)	Mean ± SD Range	11.13 ± 2.3 6 – 16	10.13 ± 1.55 8 – 15	**2.458•**	**0.020**	**S**
Inferior vena cava diameter (mm)	Mean ± SD Range	11 ± 2.98 5 – 16	9.62 ± 2.32 6 – 14	**3.858•**	**0.001**	**HS**
	Present	8 (26.7%)	8 (26.7%)			
Interdialytic weight gain (kg)	Mean ± SD Range	1.19 ± 0.78 1 – 3.5	2.45 ± 1.13 1.5–4.5	**7.644•**	**0.000**	**HS**

*: Chi-square test; •: Paired t-test

DISCUSSION

The study population included 17 (56.7%) males and 13 (43.3%) females. They were of middle age with a mean age of 56.23 ± 2.31 years. The main cause of ESRD was hypertension (46.7%) followed by diabetes mellitus (30%). Most of these patients had associated comorbidities (83.3%) mainly in form of vascular disease (76%). **Afifi *et al.*** [11], reported that the mean age of HD patients in Egypt increased from 45.6 years in 1996 to 49.8 years in 2008. Hypertension is the main cause of ESRD with 36.6% prevalence and diabetes is the second most common cause. These figures still away from developed countries as mean age in United State was 61.1 years and the main cause of ESRD is diabetes according to **USRDS** [12].

In the present study, several intra- and inter-group comparisons were made between echo parameters (2- day group and 3- day group). These include comparison of ECHO parameters between pre- and post-dialysis in the short interdialytic interval patients (Group 1). Comparison of ECHO parameters between pre- and post-dialysis in the long interdialytic interval patients (Group 2). Comparison between Group 1 and Group 2 regarding ECHO parameters pre-dialysis. Comparison between Group 1 and Group 2 regarding ECHO parameters post-dialysis.

The main findings of the present study were the statistically highly significant differences between left PCWP and IVC diameter before and after dialysis session in the short interdialytic interval patients (2-days) and the long interdialytic interval patients (3-days). In addition ,interdialytic weight gain .However, the intradialytic weight gain (2.45 ± 1.13 vs 1.19 ± 0.78 kg), inferior vena cava diameter (11 ± 2.98 vs 9.62 ± 2.32) and PCWP (11.13 ± 2.3 vs 10.13 ± 1.55) increase were higher during the 3-day versus the 2-day interval ($P < 0.001$).

Sato *et al.* [13] reported that PCWP is more sensitive to estimate the change in body weight during HD than any other parameters such as natriuretic peptides and can reflect a substantial amount of excess fluid. A high PCWP in patients receiving dialysis almost always results from a combination of volume overload and LV dysfunction [7].

IVC measurement is known to correlate with central venous pressure among critically ill and healthy adult patient and was reported as useful to assess fluid overload in HD patients [14].

According to a DOPPS report, a relative interdialytic weight gain (IDWG) of at least 5.7% elevated the risk for mortality, and an IDWG of at least 4% elevated the risk for fluid overload hospitalization [15]. Interdialytic weight gain and cardiac chamber dilatation are associated in patients receiving HD, indicating that recurrent stretching of cardiac chambers between sessions results in long-term cardiac remodeling [16].

Excess inter-dialytic volume accumulation could be one important mechanism for intermittent increase of cardiovascular risk in conventional HD patients. Prospective studies showed that higher interdialytic weight gain is associated with higher pre-dialysis BP, higher ultrafiltration rates, symptomatic intra-dialytic hypotension and elevated risk of cardiovascular mortality [17, 18].

High ultrafiltration rates to control volume overload in dialysis patients are related to sub-clinical myocardial stunning and micro-vascular ischemia, factors that can promote adverse cardiac remodeling. This explains why aggressive ultrafiltration per se was also associated with increased risk of cardiovascular events [18].

In agreement with our results the study by **Tsilonis *et al.*** [8] compared changes in echocardiographic indices during the 3-day and the 2-day intradialytic interval. preformed echocardiographic recordings at the start and end of the 3- and 2-day interdialytic intervals on 41 stable patients on standard thrice-weekly HD therapy. During both intervals studied, elevations in cardiac output, stroke volume, LV mass index, and peak early diastolic velocities of the LV were evident whereas LV ejection fraction did not change , they found interdialytic weight gain (3.0 ± 1.7 vs 2.4 ± 1.3 kg) and IVC diameter increase (0.54 ± 0.3 vs 0.25 ± 0.3) were higher during the 3-day versus the 2-day interval, and also reported that interdialytic increases in left and right atrial volume, RV systolic pressure and tricuspid regurgitation peak gradient were also significantly greater during the 3- versus the 2-day interval suggesting increased pulmonary circulation and right ventricle loading over the 3-day period.

On the other hand, in our study there were no statistically significant differences between LV systolic and diastolic dimensions, septum affection, ejection fraction, or pulmonary artery pressure before and after dialysis session in either short or long interdialytic groups.

In contrary to our findings the study by **Braunschweig *et al.*** [19] used continuous central hemodynamic monitoring with an implantable monitoring, found LV filling pressure and RV systolic pressure increased gradually during the interdialytic periods and attained higher values after the 3-day than the 2-day interval.

Obokata *et al.* [6] performed comparison among 80 HD patients on thrice weekly schedule using echocardiogram at 3 different interdialytic intervals (IDTs) (just after HD, after short 1 day interval, and after long 2 day interval). Measurements were repeated after 2-minute handgrip stress to evaluate cardiac reserve. They found that there were no differences in resting cardiovascular function measured by echocardiography at 3 different IDTs. However, exercise-induced after load mismatch was most pronounced in individuals after the long IDT compared to other IDTs. These findings could explain why cardiovascular events are highest on the day after the long IDT compared to other IDTs in dialysis patients[6].

Overall, these findings suggested that atrial enlargement; an expression of diastolic dysfunction and volume overload, during the long interval in HD patients imposes a hemodynamic burden to RV function and cardio-pulmonary circulation and explain the more frequent occurrence of pulmonary edema toward the end of the 3-day interval and a mechanistic factor for the heightened risk toward the end of this period [8]. Moreover, right atrial dilatation may trigger serious arrhythmias and cardiac arrest; the most common causes of death in hemodialysis [1]. In the long-term, exposure of RV to elevated pulmonary pressure may result in compensatory RV hypertrophy, which deteriorates LV filling capacity via interventricular interaction, leading to further LV diastolic dysfunction [20], along with the evidence of increased morbidity and mortality toward the end of the long interval, call for detailed heart imaging studies to examine whether these intradialytic and interdialytic alterations translate into long-term consequences in cardiac function and whether they mediate the day-of-week mortality pattern in conventional dialysis [7].

Most cardiovascular diseases can be minimised by addressing behavioural risk factors such as volume overload, which can be monitored through patient education, assessing the optimal dry weight and the regular follow up by ECHO. Also, it will be more valuable to consider establishing HD day after day instead of long intradialytic period especially for high risk cardiac patients.

Study Limitation:

This study has several limitations. It was based on a group of patients treated in a single hospital. The sample size was relatively small. In addition, the observational cross-sectional study design is another limiting factor. Further studies including large number are needed. There is also a need to evaluate timing and frequency of prescribed hemodialysis regimens and long-term consequences of different interdialytic intervals. Additional research to study hard outcomes of more frequent dialysis is warranted. Properly designed randomized trials to study cost-effectiveness and real world analyses of dialysis patterns are needed in order to elucidate the best frequency of HD for the benefit of our patients.

CONCLUSION

The intermittent nature of conventional thrice weekly dialysis and the consequent wide fluctuations in volume status and metabolic parameters during the dialysis-free periods may pre-dispose patients to several complications. There were significant differences on comparing left PCWP and IVC diameter not only before and after dialysis session in the short interdialytic interval patients (2- days) but also before and after dialysis session in the long interdialytic interval patients (3- days). There were highly significant differences on comparing IVC diameter, PCWP, and intradialytic weight between short and long interdialytic intervals specifically post dialysis.

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REFERENCES

1. **Saran R, Li Y, Robinson B *et al.* (2016):** US Renal Data System 2015 Annual Data Report: Epidemiology of kidney disease in the United States. Am J Kidney Dis., 67: 7–8.
2. **Foley R, Gilbertson D, Murray T *et al.* (2011):** Long interdialytic interval and mortality among patients receiving hemodialysis. N Engl J Med., 365: 1099-1107.
3. **Banshodani M, Kawanishi H, Fukuma S *et al.* (2017):** The impact of hemodialysis schedules on the day of the week of hospitalization for cardiovascular and infectious diseases, over a period of 20 years. PLoS One, 12 (7): 577-82.
4. **Zhang H, Schaubel D, Kalbfleisch J *et al.* (2012):** Dialysis outcomes and analysis of practice patterns suggests the dialysis schedule affects day-of-week mortality. Kidney Int., 81: 1108-1115.
5. **Georgianos P, Sarafidis P, Sinha A *et al.* (2015):** Adverse effects of conventional thrice-weekly hemodialysis: is it time to avoid 3-day interdialytic intervals?. Am J Nephrol., 41 (4-5): 400-408.
6. **Obokata M, Negishi K, Marwick T *et al.* (2015):** Comparison of different interdialytic intervals among hemodialysis patients on their echocardiogram-based cardiovascular parameters. Am Heart J., 169 (4): 523-30.
7. **Loutradis C, Sarafidis P, Papadopoulos C *et al.* (2018):** The Ebb and Flow of Echocardiographic Cardiac Function Parameters in Relationship to Hemodialysis Treatment in Patients with ESRD. Am Soc Nephrol., 5: 1372-1381.
8. **Tsilonis K, Sarafidis P, Kamperidis V *et al.* (2016):** Echocardiographic parameters during long and short interdialytic intervals in hemodialysis patients. Am J Kidney Dis., 68: 772–781,
9. **Henry W, DeMaria A, Gramiak R *et al.* (1980):** Report of the American society of echocardiography committee on nomenclature and standards in two-dimensional echocardiography. Circulation, 62: 212–217.
10. **Kutty S, Li L, Hasan R *et al.* (2014):** Systemic venous diameters, collapsibility indices, and right atrial measurements in normal pediatric subjects. J Am Soc Echocardiogr., 27: 155–62.
11. **Afifi A, El Setouhy M, El Sharkawy M *et al.* (2004):** Diabetic nephropathy as a cause of end-stage renal disease in Egypt: a six-year study. East Mediterr Health J., 95: 620–626.
12. **US Renal Data System USRDS 2013 Annual Data Report (2013):** National Institutes of Health, National Institute of Diabetes and Digestive and Kidnay Diseases; Bethesda. https://www.nih.gov/about-nih/what-we-do/nih-almanac/national-institute-diabetes-digestive-kidney-diseases-niddk

13. **Sato H, Kawasaki M, Tanaka R *et al.* (2020):** Relationships among pulmonary capillary wedge pressure, dry weight and natriuretic peptide in patients undergoing hemodialysis: a three-dimensional speckle tracking echocardiography study. J Echocardiogr., 18 (3): 160-168.
14. **Torterüe X, Dehoux L, Macher M *et al.* (2017):**: Fluid status evaluation by inferior vena cava diameter and bioimpedance spectroscopy in pediatric chronic hemodialysis. BMC Nephrology, 18: 373-77.
15. **Wong M, McCullough K, Bieber B *et al.* (2017):** Interdialytic Weight Gain: Trends, Predictors, and Associated Outcomes in the International Dialysis Outcomes and Practice Patterns Study (DOPPS). Am J Kidney Dis., 69 (3): 367–79.
16. **Ozdogan O, Kayikcioglu M, Asci G *et al.* (2010):** Left atrial volume predicts mortality in low-risk dialysis population on long-term low-salt diet. Am Heart J., 159: 1089–1094.
17. **Kalantar-Zadeh K, Regidor D, Kovesdy C *et al.* (2009):** Fluid retention is associated with cardiovascular mortality in patients undergoing long-term hemodialysis. Circulation, 119: 671–679.
18. **Flythe JE, Curhan GC, Brunelli SM**. Disentangling the ultrafiltration rate mortality association: the respective roles of session length and weight gain. Clin J Am Soc Nephrol., 8: 1151–1161.
19. **Braunschweig F, Kjellström B, Söderhäll M *et al.* (2006):** Dynamic changes in right ventricular pressures during haemodialysis recorded with an implantable haemodynamic monitor. NDT., 21: 176–183.
20. **Majos E, Dąbrowski R, Szwed H (2013):** The right ventricle in patients with chronic heart failure and atrial fibrillation. Cardiol J., 20: 220–226.