

Myocardial Functional Disorders in Hemodialysis Patient with Intradialytic Hypertension

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Abstract:

Background: Hemodialysis is the process of cleaning blood outside the body. It involves taking blood from a blood vessel and passing it through a synthetic filter, known as a dialyzer. Intradialytic hypertension (IDH) is a phenomenon where blood pressure increases during hemodialysis, and is associated with increased mortality. Majority of patients with IDH suffer and die from cardiovascular complications. **Aim of the work:** The aim of the work is to estimate the incidence of IDH among the hemodialysis patients, and to study myocardial functional disorders during hemodialysis in IDH patients. **Patient and Methods:** study was carried out in hemodialysis unit, internal medicine department of Benha University Hospital, where 100 patients were selected, conventional echocardiography was done immediately before and after HD, **Results:** incidence of IDH was 30%. Mean LVEDD significantly decreased post dialysis from 48.3 mm to 46.6 mm. P value was <0.001. Mean LVESD significantly decreased from 39 mm to 37.1 mm. P value was <0.001 Mean LAV significantly decreased from 50.6 mm³ to 40.8 mm³. P value was <0.001 Mean COP significantly decreased from 5.9 L/m to 5.6 L/m. P value was <0.001 Mean SV significantly decreased from 82.5ml to 69.5 ml. P value was <0.001 Mean LA diameter significantly decreased from 38.2 mm to 32.5 mm. P value was <0.001 in IDH patient **Conclusion:** IDH is a common alteration in the dialysis population with significant changes on ECHO parameter.

Keywords: Hemodialysis, IDH, LVH, echocardiographic changes

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Abbreviation :**CKD:** Chronic kidney disease**HD:** hemodialysis**IDH:** intradialytic HTN**HTN:** hypertension**LVH:** Left Ventricular Hypertrophy**GFR:** glomerular filtration rate

Introduction

Hemodialysis is the choice of renal replacement therapy for patients who need dialysis acutely and for many patients as maintenance therapy. It provides excellent, rapid clearance of solutes (1)

The adverse outcomes associated with large decreases in BP during hemodialysis are well known, but nephrologists should be aware of the clinical significance of increases in BP during hemodialysis (2).

Intradialytic hypertension is an increase in BP from pre to post-hemodialysis that has been shown to be associated with poor outcomes (3).

Numerous studies have explored the possible mechanisms responsible for intradialytic hypertension yielding potential interventions to consider improving outcomes in this high-risk group of patients (4), but very little data exist on the complex phenomenon of intradialytic hypertension although this complication has been recognized for many years (3).

Factors that might be involved in the pathogenesis of intradialytic hypertension include the following: extra cellular fluid volume overload, increased cardiac output, activation of the renin–angiotensin–aldosterone system (RAAS), activation of the sympathetic nervous system, endothelial cell dysfunction, peripheral vasoconstriction, fluctuations in electrolyte levels during dialysis, removal of antihypertensive medications by hemodialysis, and use of erythropoiesis-stimulating agents (5).

Cardiovascular diseases are common in patients with (ESRD) and are the main causes of morbidity and mortality. A large body of evidence has occurred indicating that a portion of this cardiovascular damage may be due to hemodialysis (6).

Patients and Methods

This comparative study was carried out in hemodialysis unit, internal medicine department of Benha University Hospital, between May 2018 to May 2019, on 100 selected patients.

Approval of ethical committee was obtained and all of patients were subjected to the following procedures after taking their consents.

I-History taking included:

Sex, Age (years), Age of starting of hemodialysis (years), UF volume and Blood flow rate.

II-Clinical examination:

1-Blood pressure measurement:-

Blood pressure was measured by sphygmomanometer. Measurements were obtained before hemodialysis, every 30 minutes during hemodialysis, and after hemodialysis.

For each hemodialysis treatment, we calculated the change in systolic blood pressure from pre- to post-dialysis. Intradialytic hypertension is defined as an increase in systolic blood pressure ≥ 10 mmHg from pre- to post-dialysis in an individual treatment. Individual patients who had a change in systolic blood pressure from pre- to post-dialysis $\geq +10$ mmHg when averaged throughout the entire study period were defined as having persistent intradialytic hypertension.

2- Pulse rate (beat per min)

III-Laboratory investigation:

1- Biochemical tests:

Serum albumin, serum creatinine, serum K, serum Na, HCO₃, PTH, Ferritin, Ca, P, WBC. Hemoglobin, Hct (%), CRP and Mg .

2- Imaging

ECG and Echocardiographic Assessment:

Conventional echocardiography was done immediately before and after HD with the use of a PHILIPS EPIC7 (Philips healthcare, Sanjon, Canada) echocardiography machine with a transducer (3.5 MHz).

All echocardiographic data were calculated based on the American Society of Echocardiography Guidelines

Statistical methods

Data management and statistical analysis were done using SPSS vs.25. (IBM, Armonk, New York, USA).

Numerical data were summarized as mean and standard deviation or median and range. Categorical data were summarized as numbers and percentages.

Comparisons between SBP and DBP at different times were done using repeated measure ANOVA. Different parameters were compared pre and post dialysis using paired t test.

Correlation analysis was done using Spearman's correlation. "r" is the correlation coefficient. It ranges from -1 to +1. -1 indicates perfect negative correlation, +1 indicates perfect positive correlation and 0 indicates no correlation.

All P values were two sided. P values less than 0.05 were considered significant.

Results

- Mean age of the whole study group was (46 ± 14) years old, 52% of study population were males while 48% were females.
- Diastolic blood pressure increased in 31% of patients {(5)-(20)} and decreased in 26% of patients {(-5) - (-15)}. No changes were recorded in 43 % of patients. **(Table 1)**
- In those with increased SBP post dialysis, mean SBP was 128 pre dialysis and 138 at 120 minutes and 143 post-dialysis. Median percent change was 13.2% and ranged from 6.7% to 27.3%. In those with decreased SBP post-dialysis, mean SBP was 132 mm Hg pre dialysis and 121 mm Hg at 120 minutes and 109 mm Hg post dialysis. Median percent change was -15.4% and ranged from -23.1% to -8.3%. In those with no change in systolic blood pressure, mean SBP was 129 mmHg pre dialysis at 120 minutes and post dialysis. **(Table 2)**
- Mean serum Ca^{++} level was 7.67 ± 0.3 mg/dl in intradialytic HTN patient, and 7.40 ± 0.58 mg/dl in non-intradialytic HTN patient. There was no significant differences in serum Ca^{++} level between intradialytic HTN patient and non-intradialytic HTN patient (p value was

0.936). Mean serum P level was 5.3 ± 0.75 mg/dL in intradialytic HTN patient, and 5.31 ± 0.70 mg/dL in non-intradialytic HTN patient. There was no significant differences in serum P level between intradialytic HTN patient and non-intradialytic HTN patient (p value was 0.676). Mean serum PTH level was 381.6 ± 127.47 pg/mL in intradialytic HTN patient. Mean serum PTH level was 355.26 ± 117.15 pg/mL in non-intradialytic HTN patient. There was no significant differences in serum PTH level between intradialytic HTN patient and non-intradialytic HTN patient (p value was 0.433). Mean serum Mg level was 2.26 ± 0.16 mg/dL in intradialytic HTN patient. and 2.256 ± 0.16 mg/dL in non-intradialytic HTN. There was no significant differences in serum Mg level between intradialytic HTN patient and non-intradialytic HTN patient (p value was 0.530). No significant differences in serum albumin, serum creatinine, serum K^+ , serum Na^+ , serum HCO_3^- , serum ferritin, O_2 saturation, WBCs count, hemoglobin level, hematocrit level, serum CRP level between intradialytic HTN patient and non-intradialytic HTN patient. **(Table 3)**

- Twenty eight 28 percentage of patients showed LVH, 20% showed Rt VH, 16% showed inverted T wave and pathological Q while 12% showed inverted T wave only. **(Table 4)**
- Mean LVEDD significantly decreased post dialysis from 48.3 mm to 46.6 mm, (p value was <0.001). Mean LVESD significantly decreased from 39 mm to 37.1 mm (p value was <0.001). Mean LAV significantly decreased from 50.6 mm³ to 40.8 mm³. (p value was <0.001). Mean COP significantly decreased from 5.9 L/m to 5.6 L/m. (p value was <0.001). Mean SV

significantly decreased from 82.5ml to 69.5 ml (p value was <0.00). Mean LA diameter significantly decreased from 38.2 mm to 32.5 mm (p value was <0.001) in patients with intradialytic HTN. **(Table 5)**

- Mean LVEDD significantly decreased post dialysis in intradialytic HTN patient and non-intradialytic HTN patient (p value 0.046). Mean LAV significantly decreased post dialysis in intradialytic HTN patient and non-intradialytic HTN patient (p value 0.026). **(Table 6)**

Table (1): Diastolic blood pressure status post dialysis

		n (%)
DBP status	Increased {(5)-(20) mmHg}	31 (31.0)
	Decreased {(-5) - (-15) mmHg }	26 (26.0)
	No change	43 (43.0)

Table (2): SBP in pre dialysis and post dialysis patient

		SBP (mmHg)
I. In those with increased SBP		
Pre (110-150 mmHg)	Mean ±SD	128 ±10
120 minutes (120-160 mmHg)	Mean ±SD	138 ±10
Post (130-160 mmHg)	Mean ±SD	143 ±8
% change	Median (range)	13.2 (6.7 - 27.3)
II. In those with decreased SBP		
Pre (120-160 mmHg)	Mean ±SD	132 ±9
120 minutes (110-150 mmHg)	Mean ±SD	121 ±9
Post (100-140 mmHg)	Mean ±SD	109 ±8
% change	Median (range)	-15.4 (-23.1 - - 8.3)
III. In those with ISO SBP		
Pre (120-140 mmHg)	Mean ±SD	129 ±7
120 minutes (120-140 mmHg)	Mean ±SD	129 ±7
Post (120-140 mmHg)	Mean ±SD	129 ±7
% change	Median (range)	0 (0 -0)

Table (3): Laboratory findings in patient with intradialytic HTN and non-intradialytic HTN

Laboratory findings	Mean and Standard Deviation	patient with intradialytic HTN	Patient non intradialytic HTN	P value
Serum albumin (gm/dl)	Mean \pm SD	3 \pm 0.8	2.974 \pm 0.62	0.467
Serum creatinine (mg/dL)	Mean \pm SD	8 \pm 3.25	9.30 \pm 2.92	0.808
Serum K ⁺ (mEq/L)	Mean \pm SD	5.2 \pm 0.544	5.119 \pm 0.73	0.248
Serum Na ⁺ (mEq/L)	Mean \pm SD	136.13 \pm 2.52	136.62 \pm 2.73	0.519
HCO ₃ (mEq/L)	Mean \pm SD	17.8 \pm 1.71	17.40 \pm 1.39	0.672
Serum Ca ⁺⁺ (mg/dl)	Mean \pm SD	7.67 \pm 0.3	7.40 \pm 0.58	0.936
Serum P ⁺ (mg/dL)	Mean \pm SD	5.3 \pm 0.75	5.31 \pm 0.70	0.676
Serum PTH (pg/mL)	Mean \pm SD	381.6 \pm 127.47	355.26 \pm 117.15	0.433
Serum Ferritin(ng/mL)	Mean \pm SD	124.93 \pm 45.47	113.06 \pm 35.03	0.904
O ₂ saturation (%)	Mean \pm SD	92.70 \pm 1.643	92.96 \pm 1.38	0.740
Serum WBC _s (m/mm ³)	Mean \pm SD	7646.67 \pm 3958.9	8031.43 \pm 4060.97	0.222
Serum Hemoglobin(g/dl)	Mean \pm SD	8.637 \pm 0.694	8.493 \pm 0.69	0.367
Serum Hematocrit (%)	Mean \pm SD	23.30 \pm 2.12	23.069 \pm 1.69	0.891
Serum CRP(mg/l)	Mean \pm SD	8.80 \pm 8.31	9.34 \pm 8.43	0.384
Serum Mg(mg/dL)	Mean \pm SD	2.26 \pm 0.16	2.256 \pm 0.16	0.530

Table (4): ECG rhythm and findings in whole study population

		n (%)
ECG (Rhythm)	Sinus	90 (90.0)
	Tachyarrhythmia	10 (10.0)
ECG (finding)	Inverted T wave	12 (12.0)
	Inverted T wave & pathological Q	16 (16.0)
	LVH	28(28.0)
	RT VH	20 (20.0)
	Normal	24 24.0)

Table (5): Echo parameters pre and post dialysis in patient with intradialytic HTN.

				P value
LVEDD (mm)	Pre	Mean ±SD	48.3 ±4.1	<0.001
	Post	Mean ±SD	46.6 ±.3	
	% change	Median (range)	-4.2 (-10.2 - 17.2)	
LVESD (mm)	Pre	Mean ±SD	39 ±6.2	<0.001
	Post	Mean ±SD	37.1 ±6.1	
	% change	Median (range)	-4.7 (-9.0 - -1.3)	
EF	Pre	Mean ±SD	53.1 ±5.2	0.330
	Post	Mean ±SD	52.7 ±5.3	
	% change	Median (range)	-7 (-15.5 - 20.7)	
LAV (mm³)	Pre	Mean ±SD	50.6 ±9.7	<0.001
	Post	Mean ±SD	40.8±10.7	
	% change	Median (range)	-21.1 (-33.6 - -4.8)	
COP (L/min)	Pre	Mean ±SD	5.9 ±1.3	<0.001
	Post	Mean ±SD	5.6 ±1.3	
	% change	Median (range)	-6.2 (-13.9 - -2.7)	
SV (ml)	Pre	Mean ±SD	82.5 ±17.8	<0.001
	Post	Mean ±SD	69.5 ±17	
	% change	Median (range)	-14.1 (-32.9 - 5.6)	
LA Diameter (mm)	Pre	Mean ±SD	38.2 ±4.3	<0.001
	Post	Mean ±SD	32.5 ±4.2	
	% change	Median (range)	-13.5 (-36.4 - -6.8)	

Table (6): Echo parameters pre and post dialysis in patient with intradialytic HTN and non-intradialytic HTN.

	Intradialytic HTN patient.			Non intradialytic HTN patient.			P value
LVEDD (mm)	Pre	Mean ±SD	48.3 ±4.1	Pre	Mean ±SD	59.64 ±2.13	0.363
	Post	Mean ±SD	46.6 ±3	Post	Mean ±SD	58.48 ±2.11	0.046
	% change	Median (range)	-4.2 (-10.2 - 17.2)	% change	Median (range)	-1.1 (-2 - 0.7)	-
LVESD (mm)	Pre	Mean ±SD	39 ±6.2	Pre	Mean ±SD	39.39 ±1.82	0.696
	Post	Mean ±SD	37.1 ±6.1	Post	Mean ±SD	39.54 ±1.87	0.644
	% change	Median (range)	-4.7 (-9.0 - -1.3)	% change	Median (range)	-0.3 (-0.2 - -1.3)	-
EF	Pre	Mean ±SD	53.1 ±5.2	Pre	Mean ±SD	60.55 ±2.14	0.272
	Post	Mean ±SD	52.7 ±5.3	Post	Mean ±SD	61.05 ±2.16	0.188
	% change	Median (range)	-7 (-15.5 - 20.7)	% change	Median (range)	-0.5 (0.2 + 1.4)	-
LAV (mm ³)	Pre	Mean ±SD	50.6 ±9.7	Pre	Mean ±SD	26.740 ±1.887	0.054
	Post	Mean ±SD	40.8±10.7	Post	Mean ±SD	24.80±1.99	0.026
	% change	Median (range)	-21.1 (-33.6 - -4.8)	% change	Median (range)	-1.9 (-1.4-2.5)	-
COP (L/min)	Pre	Mean ±SD	5.9 ±1.3	Pre	Mean ±SD	7.67 ±0.93	0.931
	Post	Mean ±SD	5.6 ±1.3	Post	Mean ±SD	6.80 ±0.97	0.873
	% change	Median (range)	-6.2 (-13.9 - -2.7)	% change	Median (range)	-0.4 (-1.7 - -0.2)	-
SV (ml)	Pre	Mean ±SD	82.5 ±17.8	Pre	Mean ±SD	115.4 ±7.77	0.341
	Post	Mean ±SD	69.5 ±17	Post	Mean ±SD	110.40 ±7.80	0.682
	% change	Median (range)	-14.1 (-32.9 - 5.6)	% change	Median (range)	-5 (-0.5 - 5.5)	-
LA Diameter (mm)	Pre	Mean ±SD	38.2 ±4.3	Pre	Mean ±SD	45.19 ±2.20	0.982
	Post	Mean ±SD	32.5 ±4.2	Post	Mean ±SD	42.96 ±2.37	0.792
	% change	Median (range)	-13.5 (-36.4 - -6.8)	% change	Median (range)	-2.2 (-2.8 - -0.8)	-

Discussion:

CKD is a global public health problem with a rising prevalence. Low glomerular filtration rate is associated with higher risk for kidney failure requiring dialysis, as well as with cardiovascular disease (CVD), hypertension, anemia, and other metabolic complications (7).

Echocardiography is an established method for the assessment of left ventricular (LV) and right ventricular function. LV diastolic dysfunction is an important cause of cardiac morbidity in ESRD patients. Diastolic dysfunction appears to be the initial LV dysfunction and might even precede left ventricular hypertrophy (LVH) (8).

LVH is very frequent in patients with intradialytic hypertension and the left ventricular mass index further progressively increases after the beginning of hemodialysis therapy (9).

Our study showed that there was statistically significant difference in systolic and diastolic blood pressures after hemodialysis as SBP increase in 30% of patient. SBP increased in from (128 ± 10 to 143 ± 8) and DBP from (78 ± 4 to 87 ± 4) in 30 % of patients.

The prevalence of intradialytic hypertension was provided by an analysis

of 438 dialysis patients participating in the Crit-Line Intradialytic Monitoring Benefit (CLIMB) study, in which 13.2% of participants exhibited intradialytic rise in systolic BP (SBP) >10 mm Hg. (3)

Patients with intradialytic hypertension tended to be older, received more antihypertensive drugs, had lower dry weight and lower interdialytic weight gain as compared with those without intradialytic hypertension. (3)

In a subsequent analysis from the US Renal Data System Dialysis Morbidity and Mortality Wave II cohort showed that 213 of 1718 patients (12.2%) experienced intradialytic hypertension, defined as increase in SBP >10 mm Hg from pre to post dialysis. (3)

Mg is reported to be involved in regulation of blood pressure where Mg can change vascular tone result in increased blood pressure (10).

Mg serum is associated with endothelial dysfunction, increased reactivity, increased contractility, vascular remodeling and inflammation, and increased blood pressure (11).

In our study serum Mg level was (2.3 ± 0.2 mg/dL) with no significant correlation in patient with intradialytic HTN. This is in

agreement with where serum Mg level was (3 ± 0.5 mg/dL). and **(12)** where the mean serum magnesium level of 3.61 mg/dl.

In our study serum Ca level was (7.5 ± 0.5 mg/dl), serum PO^4 level was (5.5 ± 1.5 mg/dl) and serum PTH level was (363 ± 120 pg/ml) with no significant correlation in patient with intradialytic HTN.

As the glomerular filtration rate (GFR) decreases, serum phosphorus increase, followed by a decrease in the serum activated vitamin D level. As a consequence, the serum calcium level decreases.**(13)**

In our study HCO_3 was (18 ± 1 mEq/L). This is in agreement with **(14)** where HCO_3 was 21.9 mEq/L among 56,385 patients who received hemodialysis from 2001–2003.

Patients on chronic hemodialysis are at greater risk of morbidity and mortality as compared with the general populations.

LVH on ECG is significant as it is independently associated with adverse cardiovascular outcomes **(15)**.

Our study was done on 100 HD patients showing sinus rhythm in 90% of patients and sinus tachyarrthmia in 10% of patients. There was inverted T wave in 12% of patients, left ventricular hypertrophy in 28% of patients, right ventricular

hypertrophy in 20% of patients, normal findings in 24% of patients. This is in agreement with study done by **(16)** as LVH was found in 27.6% of all patients on HD.

Our study showed that there was statistically significant decrease in LVESD from (39 ± 6.2 mm) to (37.1 ± 6.1 mm) (p value < 0.001) , LVEDD from (48.3 ± 4.1 mm) to (46.6 ± 3 mm) (p value < 0.001) , LA diameter from (38.2 ± 4.3 mm) to (32.5 ± 4.2 mm) (p value < 0.001) in patient with IDH .This is in agreement with **(17)** where they studied 84 patients on regular hemodialysis (HD) with IDH (mean age of 45.3 ± 14.5 years). Standard echocardiographic measurements were obtained and Left ventricle and left atrium diameter were significantly decreased after HD. Also, **(18)** study demonstrated that Left ventricular end-diastolic dimension (LVEDD) decreased from 40.3 ± 4.2 mm (mean \pm standard deviation) mm to 36.1 ± 4.6 mm in patient with IDH. Our study showed that there was statistically significant decrease in COP from (5.9 ± 1.3 L/m) to (5.6 ± 1.3 L/m) (p value < 0.001) , SV from (82.5 ± 17.8 ml) to (69.5 ± 17 ml) (p value < 0.001) , LA volum from (50.6 ± 9.7 mm³) to (40.8 ± 10.7 mm³) (p value < 0.001) in patient with IDH .This is in agreement with **(19)** as

COP decrease from (6.47 ± 0.9 L/m) to (5.47 ± 0.8 L/m) (p value < 0.001) In Ercan et al ., (2016) LA volum decrease from (36.7 ± 21.7 mm³) to (29.5 ± 10.0 mm³) (p value < 0.001) and this agreement with our study . In (20) LA volum decrease from (36.7 ± 21.7 mm³) to (29.5 ± 10.0 mm³) (p value < 0.001) and this agreement with our study . In (21)SV decrease from (57.3 ± 30.1 ml) to (56 ± 29.1 ml) and this agree with our study. In non-intradialytic HTN Our study showed that there was statistically significant decrease in LVESD from (39.39 ± 1.82 mm) to (39.54 ± 1.87 mm) (p value <0.011) , LVEDD from (59.64 ± 2.13 mm) to (58.48 ± 2.11 mm) (p value <0.001) , SV from (115.4 ± 7.77 ml) to (110.40 ± 7.80 ml) (p value <0.001) , LA diameter from (45.19 ± 2.20 mm) to (42.96 ± 2.37 mm) (p value <0.001) , , LA volume from (26.740 ± 1.887 mm³) to (24.80 ± 1.99 mm³) (p value <0.001) in non-intradialytic HTN patient. This is in agreement with (22) where they studied 166 patients on regular hemodialysis, and found a decrease in LVESD from (36.7 ± 7.2 mm) to (36.4 ± 6.4 mm) (p value <0.011). LVEDD from (56.6 ± 6.5 mm) to (54.8 ± 6.5 mm) (p value <0.001), SV from (99.8 ± 22.9 ml) to (93.7 ± 27.8 ml) (p value <0.001).

Our results agree with the findings of (23) and (24) who found that LV end-diastolic and end systolic size significantly decreased along with a decrease in volume after HD. This is also in agreement with (25) study where there was a decrease in LVESD from (48.7 ± 28.1 ml) to (38.7 ± 24 ml) (p value <0.011), LVEDD from (132.7 ± 47.2 ml) to (112.6 ± 40.1 ml) (p value <0.001), LA diameter from (41.8 ± 7.5 mm) to (39.3 ± 8 mm) (p value <0.001), LA volume from (23.8 ± 6.95 mm³) to (21.7 ± 6.7 mm³) (p value <0.001) in non-intradialytic HTN patient .

Conclusion

IDH is a common (prevalence 30%) alteration in the dialysis population. This alteration predicts a high death risk. Volume and sodium overload, endothelial dysfunction, overactivity of the RAS and SNS all play a role in this alteration. There was significant decrease in LVEDD, LVESD, LAV, COP, SV and LA diameter in HD patient with IDH.

References

1. Flythe J. E., Inrig J. K., Shafit., Chang T. I., Cape K., Dinesh, et al . (2013). Association of intradialytic blood pressure variability with increased all-cause and cardiovascular mortality in patients treated with long-term hemodialysis.

- American Journal of Kidney Diseases, 61(6),966-974
2. Daugirdas J. T., Black P.G., Ing T.S. (2007) In "Handbook of Dialysis". 4th ed. Philadelphia, PA:Lippincott Williams & Wilkins, a Wolter Kluwer Business,;
 3. Park J., Rhee C. M., Sim J. J., Kim Y. L., Ricks J., Streja, et al (2013). A comparative effectiveness research study of the change in blood pressure during hemodialysis treatment and survival. *Kidney international*, 84(4), 795-802.
 4. Inrig JK, Patel UD, Toto RD and Szczech LA. Association of blood pressure increases during hemodialysis with 2-year mortality in incident hemodialysis patients: a secondary analysis of the Dialysis Morbidity and Mortality Wave 2 Study. *Am J Kidney Dis.* 2009;54:881–890. doi: 10.1053/j.ajkd.2009.05.012.
 5. Davenport, A. Response to “The long forgotten salt factor”. *Kidney Int.* 74, 964–965 (2008).
 6. Krapf, R. & Hulter, H. N. Arterial hypertension induced by erythropoietin and erythropoiesisstimulating agents (EsA). *Clin. J. Am. Soc. Nephrol.* 4, 470–480 (2009).
 7. Muntner P, Judd SE, Gao L, Gutiérrez OM, Rizk DV, McClellan W, et al (2013). Cardiovascular risk factors in CKD associate with both ESRD and mortality. *J Am Soc Nephrol*; 24:1159–1165.
 8. Agarwal R (2013) B-type natriuretic peptide is not a volume marker among patients on hemodialysis. *Nephrol Dial Transplant* 28(12):3082–3089
 9. Foley R. N., Curtis B. M., Randell E. W., & Parfrey P. S. (2010). Left ventricular hypertrophy in new hemodialysis patients without symptomatic cardiac disease. *Clinical Journal of the American Society of Nephrology*, 5(5), 805-813.
 10. Grober U, Schmidt J and Kisters K (2015). Magnesium in prevention and therapy. *Nutrients*;7:8199-8226.
 11. Pakfetrat M, Roozbeh J, Malekmakan N, Nasab M and Nikoo M.. Is there an association between intradialytic hypotension and serum magnesium changes?. *Hemodialysis International* 2010;14:492-497.
 12. Amit Naik, Rakesh.S. Jagat, P and Dhurvey. Study of serum magnesium level in Acute kidney injury and Chronic kidney disease and its clinical correlation with other biochemical parameters. *Journal of Evolution of Medical and Dental Sciences.* 2015; 4: 12928-32.
 13. Group KDIGO-MUW. KDIGO (2017) clinical practice guidelines update for the diagnosis, evaluation, prevention, and treatment of chronic kidney disease-mineral and bone disorder (CKD-MBD). *Kidney Int Suppl* 2017; 7:1-59.
 14. Wu DY, Shinaberger CS, Regidor DL, McAllister CJ, Kopple JD and Kalantar-Zadeh K (2006).: Association between serum bicarbonate and death in hemodialysis patients: Is it better to be acidotic or alkalotic? *Clin J Am Soc Nephrol* 1: 70–78
 15. Weiner DE, Tighiouart H, Vlagopoulos PT, Griffith JL, Salem DN, Levey AS, et al. Effects of anemia and left ventricular hypertrophy on cardiovascular disease in patients with chronic kidney disease. *J Am Soc Nephrol* 2005;16(6):1803–10.
 16. Chijioke A , Makusidi AM and Kolo PMb (2012). Electrocardiographic abnormalities among dialysis naïve chronic kidney disease patients in Ilorin Nigeria. *Ann Afr Med*;11(1):21–6.
 17. Gerede D. M., Turhan S., Kaya C. T., Ozcan O. U., Goksuluk H., VurgunV. K., etal ., (2015).

- Effects of hemodialysis on Tei Index: comparison between flow Doppler and tissue Doppler imaging. *Echocardiography*, 32(10), 1520-1526.
18. Kudoh A and Yasuo M .(2014).The dual effects of hemodialysis on cardiac function assessed by pulsed Doppler echocardiography. *Japanese circulation journal* ; 52(1) : 13-20.
19. Krupička J., Janota T., Kasalova Z., & Hradec, J. (2009). Natriuretic peptides-physiology, pathophysiology and clinical use in heart failure. *Physiological research*, 58(2).
20. Ene-Iordache, B., Perico, N., Bikbov, B., Carminati, S., Remuzzi, A., Perna, etal. (2016). Chronic kidney disease and cardiovascular risk in six regions of the world (ISN-KDDC): a cross-sectional study. *The Lancet Global Health*, 4(5), e307-e319.
21. Michael J. Germain , Jyovani JOUBERT, Daniel O'GRADY, Brian H. NATHANSON, Yossi CHAIT, Nathan W LEVIN,(2018) Original Article Cardiovascular Comparison of stroke volume measurements during haemodialysis using bioimpedance cardiograph and echocardiography *Haemodialysis International*2018;22:201–208
22. London, G. M., Pannier, B., Guerin, A. P., Blacher, J., Marchais, S. J., Darne, B.,etal. (2001). Alterations of left ventricular hypertrophy in and survival of patients receiving hemodialysis: follow-up of an interventional study. *Journal of the American Society of Nephrology*, 12(12), 2759-2767.
23. Galetta F, Cupisti A, Franzoni F, Femia FR, Rossi M, Bar-sotti G etal 2005: Left ventricular function and calciumphosphate plasma levels in uraemic patients.*J Intern Med*258: 378–384, 2005
24. Hung, K. C., Huang, H. L., Chu, C. M., Chen, C. C., Hsieh, I. C., Chang, S. T.,etal . (2004). Evaluating preload dependence of a novel Doppler application in assessment of left ventricular diastolic function during hemodialysis. *American journal of kidney diseases*, 43(6), 1040-1046.
25. Ersbøll, M., Raja A. A., Warming P. E., Nielsen, T. L., Plesner, L. L., Dalgaard, M., etal. (2019). Changes in left ventricular filling parameters before and after dialysis in patients with end stage renal disease. *The international journal of cardiovascular imaging*, 1-9.

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