ORIGINAL RESEARCH

Study to evaluate the association between IVC diameter and LVESD with all-cause mortality in patients undergoing hemodialysis at a Tertiary Care Hospital, North India

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ABSTRACT

Aim: The aim of the present study is to evaluate the association between IVC Diameter and LVESD with all-cause mortality in patients undergoing hemodialysis.

Methods: We conducted a hospital based single-center observational study. Patients above 18 years of age who attended the Nephrology and Cardiology departments and underwent chronic Hemodialysis treatment via functional AVA (arteriovenous access) at the HD unit of the tertiary care center for a period of one year were enrolled in this study. A total of 200 adult chronic HD patients who had functional AVA and those who underwent echocardiography examination were only enrolled in this study.

Results: The group of patients with high ivc diameter (IVCD) had a mean age of 64.5 ± 12.2 years, which was lower than the mean age of 66.0 ± 13.6 years for the group of patients with low IVCD. The majority of patients with high IVCD were male (63% male vs. 37% female), while among patients with low IVCD, 45% were male and 55% were female, respectively. There were no notable disparities in the use of antihypertensive drugs, oral antidiabetic medications, and anticoagulants between the two groups. There was no notable disparity in the aortic root and relative wall thickness between the two groups. Patients exhibiting high ivc diameter (IVCD) demonstrated significantly larger measurements in various cardiac parameters compared to those with low IVCD. These parameters include the interventricular septum, left atrium diameter, left ventricular end-diastolic diameter, left ventricular end-systolic diameter, left ventricular posterior wall, left ventricular mass, and left ventricular mass index. The statistical analysis showed that all of these differences were highly significant ($p < 0.001$). High ivc diameter (IVCD) individuals had significantly higher rates of all-cause death, cardiovascular mortality, and major adverse cardiovascular events (MACE) compared to low IVCD patients.

Conclusion: Increased risk of all-cause mortality, MACE-events, and poor survival in chronic HD patients is linked to dilated IVCD (≥1.5 cm). High IVCD and LVESD patients also have higher all-cause mortality and MACE. IVCD measures may reduce chronic HD mortality risk through fluid control with patient education or dry weight modifications.

Key words: Ivc diameter (IVCD), left ventricular end-systolic diameter (LVESD), Mortality, Major adverse cardiovascular events (MACE), Hemodialysis (HD)

INTRODUCTION

Death rates from cardiac disease are between 10 and 20 times higher in dialysis patients than in the general population [1]. Cardiac mortality and morbidity in dialysis patients usually result from cardiomyopathy and/or ischaemic heart disease. Cardiomyopathy may be manifest as concentric left ventricular hypertrophy (cLVH), left ventricular (LV) dilatation with compensatory hypertrophy [eccentric left ventricular hypertrophy (eLVH)], or systolic dysfunction. Cardiomyopathy is frequently observed in dialysis patients, and together with indices of LV geometry, are independent adverse predictors of mortality. Left ventricular mass (LVM) is prognostically dominant in

cLVH, whereas cavity size predicts outcome in patients with LV dilatation [2]. Dialysis patients have many risk factors for both volume and pressure overload. In end-stage renal disease (ESRD) treated by dialysis, fluid overload and arterial hypertension often contribute to a combination of eccentric and concentric hypertrophy, which maybe influenced both by inadequate volume and blood pressure (BP) control [3].

LV dilatation in dialysis patients is commonly observed in states of chronic volume overload, whereas pressure overload leads primarily to an increase in LVM. According to Laplace's law, wall stress is directly proportional to pressure and LV internal radius, and inversely proportional to LV wall thickness. Volume overload results in an enlargement of ventricular chamber with increased wall thickness to counterbalance increased radius, so that radius/wall thickness ratio remains within normal limits. In states of pressure overload, the increase in wall tension is offset by a disproportionate increase in LV wall thickness at normal chamber radius, reflected on echocardiography as cLVH. There is ample evidence that a significant proportion of continuous ambulatory peritoneal dialysis (CAPD)patients demonstrate latent over hydration, because exact estimation of true dry body weight is difficult on clinical grounds alone. Measurement of the diameter of inferior vena cava (IVC) and its decrease on deep inspiration [collapsibility index (CI)] by echocardiography allows an accurate assessment of volume status in dialysis patients [4]. Echocardiography also allows cardiac structure and function to be assessed non-invasively. LV geometry may be classified into four groups on the basis of LVM and relative wall thickness (RWT): normal geometry (normal mass and normal RWT) (NG), concentric remodelling (normal mass and increased RWT) (CR), cLVH (increased mass and increased RWT) and eLVH (increased mass and normal RWT).

The aim of the present study is to evaluate the association between IVCD and LVESD with all-cause mortality in patients undergoing hemodialysis.

MATERIALS AND METHODS

This is a hospital based single-center observational cohort study. Adult patients who underwent chronic hemodialysis treatment via functional AVA at the hemodialysis unit of Sarojini Naidu Medical College and Hospital, Agra, North India over a period of one year (2023) were enrolled in the study.

INCLUSION & EXCLUSION CRITERIA

Adult chronic hemodialysis patients and who had echocardiography prior to hemodialysis in the cardiology department of Sarojini Naidu Medical College and Hospital, Agra were enrolled in the study. Patients who received hemodialysis via a tunneled cuffed catheter were excluded.

METHODOLOGY

These patients were divided into high IVCD and low IVCD groups according to a cut-off point of 1.5 cm. These patients with high or low IVCD were sub-grouped into high LVESD and low LVESD. The study was conducted among the patients who gave their consent prior to the study. The demographic and baseline clinical information of patients with chronic hemodialysis (HD) was documented at the time of study enrollment. The data collected encompassed various variables, including age, gender, height, weight, medical history of concurrent diseases, levels of serum total protein, serum albumin, aspartate aminotransferase (AST), alkaline phosphatase (alkaline-P), total bilirubin, serum cholesterol, serum triglyceride, fasting blood sugar, haemoglobin, serum platelet count, iron profile, serum aluminium, serum uric acid, sodium, potassium, ionised calcium, phosphate levels, HD efficiency (Kt/V), and intact parathyroid hormone (iPTH). During each hemodialysis (HD) session, blood samples were obtained following a fasting period of at least 8 hours. The Kt/V value was calculated using the Gotch and Sargent formula.5 The blood pressure and hypotension levels were measured during the first hemodialysis (HD) session, following the assessment of ivc diameter (IVCD) and left ventricular end-systolic diameter (LVESD). Additionally, data regarding conductivity, treatment duration, HD frequency, interdialytic weight increase, and ultrafiltration were also gathered during this HD session. The medications comprised antihypertensive, antidiabetic, antiplatelet, and anticoagulant medicines.

STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS version 24. Two-sided p-values < 0.05 were considered statistically significant.

RESULTS

Table 1: Baseline characteristics of chronic hemodialysis (HD) patients with functional arteriovenous access (AVA) between high and low IVCD groups

Variables	High IVCD	Low IVCD	*p* Value
	(*n* = 98)	(*n* = 102)	
Age (years)	64.5 ± 12.2	66.0 ± 13.6	0.007
Male (%)	62	44	0.002
Female (%)	36	58	
Height	164.6 ± 8.4	161.2 ± 8.4	0.005
Weight	62.8 ± 13.4	59.3 ± 12.8	0.095

Comorbid condition			
Diabetes mellitus	46	36	0.080
Hypertension	76	77	0.941
Hyperlipidemia	55	44	0.082
Coronary artery disease	46	32	0.032
Cerebrovascular accident	2	2	1.000
PAD	24	20	0.316
Heart failure	22	15	0.132
COPD	5	12	0.084
Malignancy	9	11	0.6532
Lab data			
Total protein (g/dL)	6.9 ± 0.7	6.8 ± 0.4	0.042
Albumin (g/dL)	3.9 ± 0.2	3.9 ± 0.5	0.357
AST (IU/L)	16.4 ± 5.9	16.2 ± 5.2	0.702
Alkaline-P (IU/L)	76.4 ± 36.4	66.7 ± 24.6	0.032
Total bilirubin (mg/dL)	0.6 ± 0.3	0.5 ± 0.1	0.112
Cholesterol (mg/dL)	152.8 ± 32.6	164.6 ± 39.0	0.020
Triglyceride (mg/dL)	128.0 ± 84.9	146.2 ± 122.1	0.145
Fasting glucose (mg/dL)	114.4 ± 52.6	108.2 ± 48.0	0.316
Hb (g/dL)	10.3 ± 1.4	10.5 ± 1.3	0.145
Platelet (×1000/μL)	179.4 ± 54.0	201.8 ± 58.1	0.002
Fe (ug/dL)	76.9 ± 37.6	75.1 ± 29.4	0.832
TIBC (ug/dL)	245.5 ± 45.9	236.0 ± 45.1	0.072
Ferritin (ng/mL)	535.5 ± 320.4	573.2 ± 252.5	0.142
Transferrin saturation (%)	31.5 ± 13.9	32.2 ± 12.3	0.420
Al (ng/mL)	6.4 ± 3.1	7.0 ± 4.4	0.482
Uric acid (mg/dL)	6.1 ± 1.5	6.3 ± 1.6	0.220
Na (meq/L)	138.1 ± 2.9	137.9 ± 3.0	0.674
K (meq/L)	4.6 ± 0.6	4.7 ± 0.7	0.372
iCa (mg/dL)	4.5 ± 0.5	4.6 ± 0.5	0.364
P (mg/dL)	5.1 ± 1.3	5.1 ± 1.3	0.664
Kt/V (Gotch)	1.4 ± 0.2	1.4 ± 0.2	0.100
PTH (pg/mL)	327.6 ± 306.9	245.0 ± 250.9	0.012
HD parameters			
SBP	147.89 ± 23.96	140.52 ± 25.56	0.022
DBP	70.28 ± 13.99	66.30 ± 14.53	0.032
MAP	96.13 ± 15.34	91.02 ± 16.45	0.016
Hypotension during dialysis	35	40	0.412
Conductivity of HD	13.99 ± 0.12	13.95 ± 0.39	0.684
Treatment time of HD			<0.001
4 h	86	66	
3.5-4 h	2	4	
3.0-3.5 h	10	22	
Treatment frequency			0.916
TIW	103 (88)	111 (89.5)	
BIW	13 (11.1)	12 (9.7)	
QW	1 (0.9)	1 (0.8)	
Interdialytic weight gain (kg)	2.57 ± 1.23	2.45 ± 1.05	0.644
Ultrafiltration (L)	2.53 ± 1.13	2.41 ± 0.97	0.624
Medications			
Anti-HTN drugs			
ACEI/ARB	52	51	0.822
β-blocker	52	48	0.736
Calcium channel antagonist	57	60	0.622
Anti-diabetic agents			
OAD	29	27	0.670
Insulin and analogues	23	9	0.003
Antiplatelets	51	32	0.007

Anticoagulants	4	3	0.436

High IVCD patients (age 64.5 ± 12.2 years) were younger than low IVCD patients (66.0 ± 13.6 years). Most of the high IVCD patients were male (63% vs. 37% female) and among low IVCD patients, 45% were male and 55% were female, respectively. The mean height for high IVCD patients was 164.6 ± 8.4 cm, while low IVCD patients had a mean height of 161.2 ± 8.4 cm. The prevalence of coronary artery disease was greater among the high IVCD patients. Other comorbid diseases, except for cerebrovascular accidents, COPD, and malignancy, were more prevalent among high IVCD patients, but they were not statistically significant between groups. High IVCD patients had significantly higher systolic blood pressure, diastolic blood pressure, and mean arterial pressure than patients with low IVCD. The results were 147.89 ± 23.96 mmHg, 70.28 ± 13.99 mmHg, and 96.13 ± 15.34 mmHg in high IVCD patients and 140.52 ± 25.56 mmHg, 66.30 ± 14.53 mmHg, and 91.02 ± 16.45 mmHg in low IVCD patients, respectively. The ratio of HD treatment frequency revealed statistical significance between two groups ($p < 0.001$). The prevalence of insulin and analogues and antiplatelet medications was significantly higher in high IVCD patients compared to low IVCD patients. No significant difference of antihypertensive medications, oral antidiabetic medications, and anticoagulants were noted between two groups.

Table 2: Echocardiographic features of chronic hemodialysis (HD) patients with functional arteriovenous access (AVA) between high-and low-IVCD groups

Variables	High IVCD (n = 98)	Low IVCD (n = 102)	p Value
Aortic root (mm)	32.00 ± 4.36	33.17 ± 4.72	0.943
IVS (mm)	12.88 ± 5.02	11.33 ± 2.72	<0.001
LA diameter (mm)	45.04 ± 8.52	40.52 ± 8.00	<0.001
LVEDD (mm)	52.12 ± 7.53	48.82 ± 6.84	<0.001
LVESD (mm)	32.96 ± 9.11	28.32 ± 6.64	<0.001
LVPW (mm)	11.55 ± 3.16	10.52 ± 2.36	<0.001
LV mass (g)	268.02 ± 202.51	202.10 ± 79.23	<0.001
LVMI	162.66 ± 128.22	126.74 ± 45.28	<0.001
RWT (mm)	0.47 ± 0.17	0.44 ± 0.13	0.432

The two groups had similar aortic root and relative wall thickness. Patients with high IVCD had significantly higher interventricular septum, left atrium diameter, end-diastolic and end-systolic left ventricular diameters, posterior wall, mass, and mass index compared to those with low IVCD ($p < 0.001$).

Table 3: Outcomes of chronic HD patients with functional AVA between high-and low-IVCD groups

Inferior Vena Cava Diameter (IVCD)	Mortality	CV Mortality	MACE
Low	8	6	16
High	21	17	42
p Value	0.007	0.012	<0.001

MACE, all-cause mortality, and cardiovascular mortality were significantly higher in high IVCD patients than low IVCD patients. All-cause, cardiovascular, and MACE mortality were 21%, 17%, and 42% for high IVCD individuals. Low IVCD individuals had 8% all-cause, 6% cardiovascular, and 16% MACE mortality.

DISCUSSION

Although significant advancements have been achieved in renal care in recent decades, cardiovascular disease (CVD) continues to be a leading cause of illness and death in individuals with end stage renal disease (ESRD). It accounts for around 50% of fatalities [7,8]. The rate of cardiovascular death in patients 20 times higher than that in the general population [9]. The majority of individuals with HD have left ventricular hypertrophy (LVH), which is associated with cardiac myocyte death, fibrosis, capillary rarefaction, and ultimately, ischemic heart disease in the long run [10].

The group of patients with high ivc diameter (IVCD), with an average age of 64.5 ± 12.2 years, was younger compared to the group of patients with low IVCD, who had an average age of 66.0 ± 13.6 years. The majority of patients with high IVCD were male (63% male vs. 37% female), while among patients with low IVCD, 45% were male and 55% were female, respectively. High IVCD patients exhibited a higher prevalence of coronary artery disease. High IVCD patients had a notably higher prevalence of insulin and analogues as well as antiplatelet medicines, in comparison to low IVCD patients. There were no notable disparities in the use of antihypertensive drugs, oral antidiabetic medications, and anticoagulants between the two groups. There was no

notable disparity in the aortic root and relative wall thickness between the two groups. Due to the intermittent nature of hemodialysis (HD) treatments, HD patients are susceptible to intradialytic hypotension and have severe hemodynamic effects. As a result, these patients are particularly prone to impaired Vaso regulation, compromised microcirculation, reduced peripheral arterial compliance, and increased risk of demand myocardial ischemia [11]. Fluid overload resulting from fluid retention and chronic inflammation in patients undergoing chronic hemodialysis can result in pulmonary congestion, acute pulmonary edema, hypertension, left ventricular hypertrophy, and heart failure.[12] These conditions are associated with increased risk of cardiovascular morbidity and mortality. Hence, excessive accumulation of fluid in the body may also serve as a significant contributing factor to the development of cardiovascular complications and increased risk of death in patients undergoing hemodialysis [13,14].

Furthermore, excessive fluid accumulation is also linked to a heightened risk of cardiovascular death in individuals undergoing hemodialysis [15]. Managing fluid status is a major clinical problem in patients undergoing HD therapy. Intravascular volume can be estimated using IVCD in patients with end-stage kidney disease (ESKD) who are undergoing hemodialysis (HD). IVC Diameter has been found to be correlated with fluid status in adult HD patients [4,16,17].

Patients exhibiting high ivc diameter (IVCD) demonstrated significantly larger measurements in various cardiac parameters compared to those with low IVCD. These parameters include interventricular septum, left atrium diameter, left ventricular end-diastolic diameter, left ventricular end-systolic diameter, left ventricular posterior wall, left ventricular mass, and left ventricular mass index. The statistical significance of these differences was observed with a p-value of less than 0.001 for all measurements. High ivc diameter (IVCD) individuals had significantly higher rates of all-cause death, cardiovascular mortality, and major adverse cardiovascular events (MACE) compared to low IVCD patients. The overall mortality rate, specifically due to cardiovascular causes, and the rate of major adverse cardiovascular events (MACE) were 21%, 17%, and 42% respectively for individuals with substantial ivc diameter (IVCD). The mortality rate among individuals with low IVCD was 8% for all causes, 6% for cardiovascular causes, and 16% for major adverse cardiovascular events (MACE). Chronic fluid overload in patients with end-stage kidney disease (ESKD) substantially increases the stress on the heart, leading to the development of left ventricular hypertrophy (LVH) and enlargement of the left ventricle over a period of time. Assessing the size of the heart is crucial for evaluating how well the ventricles are working. Ejection fraction (EF) and fractional shortening (FS) are the primary measures used to evaluate left ventricular systolic function. LVESD is employed to calculate FS [18]. Reduced ejection fraction (EF) in end-stage kidney disease (ESKD) patients is linked to an increased likelihood of cardiovascular death and mortality [19]. A LVESD (left ventricular end-systolic diameter) of 19 mm or greater has been identified as an independent risk factor for higher rates of all-cause death and cardiovascular mortality in patients with mitral regurgitation [20]. Nevertheless, there is a scarcity of research on the correlation between LVESD and cardiovascular mortality as well as all-cause mortality in individuals with chronic HD. The present investigation revealed that an elevated left ventricular end-systolic diameter (LVESD) has a combined influence on major adverse cardiovascular events (MACE) and the risk of mortality from any cause in chronic hemodialysis (HD) patients with ivc diameter (IVCD).

CONCLUSION

Increased risk of all-cause mortality, MACE-events, and poor survival in chronic HD patients is linked to dilated IVCD (≥1.5 cm). High IVCD and LVESD patients also have higher all-cause mortality and MACE. IVCD measures may reduce chronic HD mortality risk through fluid control with patient education or dry weight modifications. LVESD can also be used to assess heart function and reduce MACE risk in these patients.

CONFLICT OF INTEREST: None to be declared.

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