# Assessing the Impact of Hemodialysis Arteriovenous Access on Echocardiographic Findings in Chronic Kidney Disease Patients: A Cross-Sectional Study

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## Abstract:

***Background:*** **Chronic kidney disease (CKD) is an increasingly serious health problem. Between 2009 and 2019, it was the fifth leading cause of death. If not managed properly, CKD can progress to renal failure and is associated with complications such as early cardiovascular disease. The relationship between vascular access and cardiac function is complex, and its effect on cardiac output (CO) is not yet fully understood. High-flow access is defined as a blood flow rate (Qa) between 1000 and 1500 ml/min or greater than 20% of cardiac Output.** ***Aims:*** **Our study aimed to assess the relationship between arteriovenous access and echocardiographic findings in patients with CKD.** ***Subjects and Methods:*** **This comparative cross-sectional Study compared 75 CKD patients divided into three groups: hemodialysis patients with arteriovenous access, non-hemodialysis patients with arteriovenous access, and non-hemodialysis patients not having arteriovenous access. Patients were interviewed and clinically examined, and blood samples were collected. Using a transthoracic echocardiographic study, the study assessed the venous flow volume of the fistula and structural and functional echocardiographic findings.** ***Results:*** **Doppler venous flow was significantly higher in hemodialysis patients with arteriovenous access compared to non-hemodialysis patients with arteriovenous access, with concentric LVH being higher in the non-dialysis group. Using multivariate logistic regression analysis, gender, smoking, and diastolic dysfunctions were significantly associated with higher Doppler venous flow.** ***Conclusion:*** **we found a significant association between high-flow fistula and echocardiographic Changes In left ventricle hypertrophy (LVH), pulmonary hypertension (PHT), diastolic dysfunction, and left-sided valvular regurgitation.**

**Keywords:** LVH, high-flow fistula, diastolic dysfunction, PHT.

## Introduction

Chronic kidney disease (CKD) represents a major public health challenge in Egypt. It is defined by persistent structural or functional renal abnormalities lasting longer than three months and affects more than 10% of the global population. CKD has emerged as a leading cause of mortality, ranking fifth among the top causes of death between 2009 and 2019. Without appropriate management, CKD may progress to end-stage renal disease (ESRD) and is frequently associated with significant complications, most notably early cardiovascular disease (CVD). CVD remains the principal determinant of premature mortality among patients undergoing hemodialysis (HD), with cumulative mortality rates following a diagnosis of heart failure (HF) reported at 55%, 46%, and 57% at 12, 24, and 56 months, respectively [1, 2]. In Egypt, approximately 7.1 million individuals are

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affected by CKD, corresponding to an age-standardized prevalence of 106 cases per 1,000 populations [1].

HD remains a cornerstone therapy for patients with ESRD, necessitating reliable vascular access such as arteriovenous fistulas (AVFs). Currently, three primary types of vascular access are employed: HD catheters, native AVFs, and arteriovenous grafts (AVGs). Although AVFs are generally preferred due to their superior longevity and lower complication rates, they can significantly influence cardiac hemodynamics and may contribute to the development of high-output heart failure (HOHF) [3].

During HD, the prescribed blood flow (BF) through the dialysis circuit typically ranges from 300 to 400 mL/min. To minimize recirculation, the inflow BF to the access site must exceed this rate, often surpassing 500 mL/min. The creation of AVFs or AVGs markedly increases BF to the extremity—often by 10- to 50-fold—achieving rates between 500 and 2,000 mL/min or even higher in some cases. Considering that normal resting cardiac output (CO) ranges from 4 to 6 L/min, it becomes evident that such high-flow access can substantially impact systemic circulation [3].

During the creation of HD vascular access, a low-resistance venous pathway is surgically connected to arterial circulation. The AVF remains the preferred access modality for HD. Although adequate vascular access flow (Qa) is essential to ensure efficient dialysis, the optimal access should maintain sufficient pressure and flow to prevent thrombosis while preserving HD adequacy [2].

The contribution of vascular access to the development of high-output heart failure (HOHF) remains incompletely understood, and the mechanisms through which AVF influences CO are not yet fully elucidated. Elevated access flow has been associated with several complications, including HOHF, pulmonary hypertension (PHT), markedly dilated fistulas, central venous stenosis, dialysis-associated steal syndrome (DASS), and distal hypoperfusion ischemic syndrome [4, 5]. Although a universally accepted definition of high-flow access (HFA) is lacking, the Vascular Access Society defines HFA as a Qa between 1,000 and 1,500 mL/min or a Qa exceeding 20% of the total CO [5, 6].

This study aimed to assess the relation between HD arteriovenous access and echocardiographic findings in CKD patients.

## Subjects and Methods

A comparative cross-sectional study was conducted at Suez Canal University hospitals in Ismailia, Egypt, from March 2025 to March 2024. 75 CKD patients aged »18 years (stages III, IV, V, and CKD-HD) were recruited from the dialysis unit, inpatient ward, and outpatient clinic and divided into 3 groups with 25 patients allocated to each group as follows:

Group A: CKD-HD with arteriovenous HD access (CKD-HD AVF).

Group B: CKD non-dialysis with arteriovenous access (CKD-ND AVF).

Group C: CKD non-dialysis without arteriovenous access (CKD-ND).

Exclusion criteria include patients with known cardiac disease (IHD, cardiomyopathy, HF), chronic liver disease, thyroid disease, and sepsis;

patients maintained on peritoneal dialysis; and those with temporary and long-term HD catheters.

Simple random sampling was adopted using the following equation; the estimated sample size was 25 participants in each group

$$n = 2\left[\frac{(Z_{\alpha/2} + Z_{\beta}) * \sigma}{\mu_1 - \mu_2}\right]^2$$

n= sample size

$Z_{\alpha/2}$ = 1.96 (is the critical value of the Normal distribution at α/2 for a confidence level of 95%, α is 0.05).

$Z_{\beta}$ = 0.84 (The critical value that separates the lower 20% of the Z distribution from the upper 80%).

σ = (0.5) the estimate of the standard deviation $\mu_1$ = (1.35) mean E/A ratio of left ventricle among non-AVF

$\mu_2$ = (0.92) mean E/A ratio of left ventricle among HD patients with AVF access [7, 8].

So, by the equation n= 22 patients, we will add 10% (≅3) to compensate for non-responders, and the sample size was **25 participants** in each group with a total sample size of **75 participants.**

All of the study population were interviewed to obtain history (Data collection tools: (each participant was subjected to a structured interview questionnaire which was fulfilled by the researcher) including demographic characteristics as gender, weight, height & BMI, age, residence, smoking, occupation, present illness and drug history.

Although Basic HD and vascular access information including number and type of previous accesses, date of creation of current vascular access, Access site, Access type, dialysis procedure data, number of sessions per week and its duration, hypotension or HTN related to session, interdialytic weight gain, Investigations includes Labs obtained from medical records of the patients (CBC, creatinine, urea, Na, K, Ca, Ph, uric acid, PTH, lipid profile).

Arteriovenous access Duplex was conducted in the radiology department; of Suez Canal University Hospital to assess the venous flow volume of AVFs, The average venous flow volume of an arteriovenous access ranges between 600 and 1000 as per KDOQI; an AVF as a VA can be defined as functional if it maintains a BF of at least 600 mL/min. On the other hand, VAS has been defined as a high-flow access as one with a flow (Qa) between 1000 and 1500 ml/min or a Qa that is >20% of the cardiac output (CO) [9, 5]. A conventional transthoracic echocardiographic study in the cardiology department of Suez Canal University Hospital assessed structural and functional echocardiographic findings.

The Ethical Committee at the Faculty of Medicine, Suez Canal University, Egypt, ethically approved this study (approval number: 5325, date: l6/5/2023). All patients gave their written informed consent before enrollment.

Data were fed to the computer and analyzed using IBM SPSS software package version 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Qualitative data were described using numbers and percentages. The Kolmogorov–Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). The significance

of the obtained results was judged at the 5% level, we used Chi-square test for categorical variables, to show the association between two or more categorical (nominal) variables. Monte Carlo correction for chi-square when more than 20% of the cells have an expected count of less than five. Analysis of variance [ANOVA] tests; to compare between more than two groups with parametric data. Kruskal-Wallis test which is a non-parametric equivalent to ANOVA used when ANOVA assumptions were violated to compare between more than two groups of skewed data.

## Results

This study was conducted on 75 CKD patients and divided into three groups: CKD-HD AVF includes 25 HD patients (CKD- HD AVF) with arteriovenous access; CKD-ND AVF includes 25 non-HD patients (CKD-ND AVF) with arteriovenous access; and CKD-ND includes 25 non -HD patients (CKD -ND) without arteriovenous access.

Table 1 shows Socio-demographic characteristics among the studied groups, As there was a tendency to have e a higher age in the non-HD group than in the other groups ($p < 0.001$).While, There was a statistically significant difference between CKD-HD AVF, CKD-ND AVF & CKD-ND regarding smoking ($p=0.008$).

Table 2 shows Distribution of comorbidities among the studied groups where DM was encountered as the most prevalent comorbidity y in all groups, followed by hypertension, where most patients did not require pharmacologic glycemic control when compared to hypertension, which requires single or multiple drugs.

Table 3 shows Distribution of Echocardiographic functional and structural parameters among the studied groups which revealed CLVH was significantly higher in CKD-ND. There was a significant difference between CKD-HD AVF, CKD-ND AVF & CKD-ND groups regarding the aortic valve ($p<0.001$) and mitral valve ($p=0.013$) while regarding the tricuspid valve, there is no significant difference noticed between the three groups ($p>0.05$). There was a statistically significant difference between CKD-HD AVF, CKD-ND AVF & CKD-ND groups regarding DD ($p<0.001$) as grade I diastolic dysfunctions were significantly higher in CKD-ND and grade II were common in both CKD-HD and CKD-ND group.

Table 4 shows Distribution of Doppler venous flow and echocardiographic parameters as participants of our study who had PHT, LVH, left-side heart valve regurge, or diastolic dysfunctions showed significant elevation in Doppler venous flow compared to non-higher Doppler venous flow.

Table 5 demonstrates Multiple Logistic regression analysis for factors associated with higher Doppler venous flow, using multivariate logistic regression analysis to evaluate significant factors associated with higher Doppler venous flow. Female Gender, smoking, and Diastolic dysfunctions were significantly associated with higher Doppler venous flow.

**Table 1. Socio-demographic characteristics among the studied groups.**

| | | CKD-HD AVF (No.= 25) | | CKD-ND AVF (No.= 25) | | CKD-ND (No.= 25) | | Test value | P-value |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | | |
| Gender | Female | 13 | 52.0% | 9 | 36.0% | 11 | 44.0% | $X^2$= 1.299 | 0.522 |
| | Male | 12 | 48.0% | 16 | 64.0% | 14 | 56.0% | | |
| Age (years) | Mean± SD | 29.36± 8.47 | | 45.92± 22.29 | | 61.20± 13.68 | | Kw= 24.59 | <0.001** p1=0.106, p2<0.001 p3=0.014 |
| Residency | Rural | 13 | 52.0% | 10 | 40.0% | 14 | 56.0% | $X^2$= 1.387 | 0.500 |
| | Urban | 12 | 48.0% | 15 | 60.0% | 11 | 44.0% | | |
| Occupation | Not working | 18 | 72.0% | 13 | 52.0% | 15 | 60.0% | $X^2$= 2.136 | 0.344 |
| | Working | 7 | 28.0% | 12 | 48.0% | 10 | 40.0% | | |
| Smoking | Non-smoker | 22 | 88.0% | 15 | 60.0% | 14 | 56.0% | $X^2$= 13.702 | $0.008^{MC**}$ |
| | Smoker | 3 | 12.0% | 8 | 32.0% | 4 | 16.0% | | |
| | X-smoker | - | - | 2 | 8.0% | 7 | 28.0% | | |

*P value >0.05: Not significant, *P value <0.05 is significant, **p<0.01 is highly significant. $X^2$: Chi-Square test, Kw: Kruskal Wallis Test, P1: P-value between CKD-HD AVF Vs CKD-ND AVF, p2: P-value between CKD-HD AVF Vs CKD-ND, P3: P-value between CKD-ND AVF Vs CKD-ND*

**Table 2. Distribution of comorbidities among the studied groups**

| | | CKD-HD AVF (No.= 25) | | CKD-ND AVF (No.= 25) | | CKD-ND (No.= 25) | | Test value | P-value |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | | |
| Diabetes | Yes | – | – | 6 | 24.0% | 7 | 28.0% | $X^2$= 8.002 | $0.018^{MC*}$ |
| DM duration (Years) | Mean± SD | - | | 9.67± 8.02 | | 9.40± 7.60 | | $^{Z}_{MWU}$= 0.338 | 0.561 |
| DM treatment | No treatment | 25 | 100.0% | 23 | 92.0% | 20 | 80.0% | $X^2$= 10.56 | $0.051^{MC}$ |
| | Insulin | – | – | – | – | 3 | 12.0% | | |
| | Oral hypoglycemic | – | – | 2 | 8.0% | 1 | 4.0% | | |
| | Insulin+ Oral hypoglycemic | – | – | – | – | 1 | 4.0% | | |
| HTN | Yes | 13 | 52.0% | 14 | 56.0% | 22 | 88.0% | $X^2$= 8.595 | 0.014* |
| HTN Duration (Yrs) | Mean± SD | 5.0± 4.12 | | 6.2± 3.46 | | 11.13± 10.56 | | Kw= 2.359 | 0.307 |
| HTN treatment | No treatment | 12 | 48.0% | 11 | 44.0% | 3 | 12.0% | $X^2$= 16.57 | $<0.001^{MC**}$ |
| | Single drug | 10 | 40.0% | 12 | 48.0% | 10 | 40.0% | | |
| | Combined drugs | 3 | 12.0% | 2 | 8.0% | 12 | 48.0% | | |

**Table 2. Distribution of comorbidities among the studied groups**

| | | CKD-HD AVF (No.= 25) | | CKD-ND AVF (No.= 25) | | CKD-ND (No.= 25) | | Test value | P-value |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | | |
| Others | Stroke | _- | -_ | -_ | -_ | 2 | 8.0% | $X^2$= 1.299 | $0.002^{MC**}$ |
| | SLE | 2 | 8.0% | _- | -_ | -_ | -_ | | |
| | Vasculitis | 1 | 4.0% | _ | _ | _ | _ | | |

*P value >0.05: Not significant, *P value <0.05 is significant, **p<0.01 is highly significant.*
*$X^2$: Chi-Square test, MC: Monte-Carlo correction, Kw: Kruskal Wallis Test*
*P1: P-value between CKD-HD AVF Vs CKD-ND AVF, p2: P-value between CKD-HD AVF Vs CKD-ND, P3: P-value between CKD-ND AVF Vs CKD-ND.*

**Table 3. Distribution of Echocardiographic functional and structural parameters among the studied groups**

| | | CKD-HD AVF (No.= 25) | | CKD-ND AVF (No.= 25) | | CKD-ND (No.= 25) | | Test Value | P-value |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | No. | % | | |
| EF | Mean± SD | 63.40± 6.50 | | 63.44± 6.71 | | 62.26± 6.43 | | Kw= 1.219 | 0.544 |
| FS | Mean± SD | 35.98± 6.5 | | 33.48± 4.52 | | 32.73± 4.86 | | Kw= 4.101 | 0.129 |
| LV | Normal | 13 | 52.0% | 12 | 48.0% | 7 | 28.0% | $X^2$= 14.75 | $0.012^{MC*}$ |
| | CLVH | 9 | 36.0% | 6 | 24.0% | 18 | 72.0% | | |
| | Dilated | 3 | 12.0% | 5 | 20.0% | - | - | | |
| | ELVH | - | - | 2 | 8.0% | - | - | | |
| Aortic Valve | Normal | 22 | 88.0% | 21 | 84.0% | 11 | 44.0% | $X^2$= 12.409 | $0.003^{MC**}$ |
| | Aortic regurge | 3 | 12.0% | 4 | 16.0% | 14 | 56.0% | | |
| Mitral Valve | Normal | 6 | 24.0% | 12 | 48.0% | 7 | 28.0% | $X^2$= 25.796 | $<0.001^{MC**}$ |
| | Mitral regurge | 17 | 68.0% | 13 | 52.0% | 18 | 72.0% | | |
| | Calcification | 2 | 8.0% | - | - | - | - | | |
| Tricuspid Valve | Normal | 11 | 44.0% | 10 | 40.0% | 6 | 24.0% | $X^2$= 2.431 | 0.297 |
| | Tricuspid regurge | 14 | 56.0% | 15 | 60.0% | 19 | 76.0% | | |
| PAP | Normal | 24 | 96.0% | 23 | 92.0% | 22 | 88.0% | $X^2$= 1.087 | $0.863^{MC}$ |
| | PHT | 1 | 4.0% | 2 | 8.0% | 3 | 12.0% | | |
| DD | No | 13 | 52.0% | 15 | 60.0% | 3 | 12.0% | $X^2$= 20.49 | $<0.001^{MC**}$ |
| | Grade I | 5 | 20.0% | 10 | 40.0% | 16 | 64.0% | | |
| | Grade II | 7 | 28.0% | - | - | 6 | 24.0% | | |

*P value >0.05: Not significant, *P value <0.05 is significant, **p<0.01 is highly significant.*
*$X^2$: Chi-Square test, MC: Monte-Carlo correction, Kw: Kruskal Wallis Test*
*P1: P-value between CKD-HD AVF Vs CKD-ND AVF, p2: P-value between CKD-HD AVF Vs CKD-ND, P3: P-value between CKD-ND AVF Vs CKD-ND LV: left ventricle, CLVH: Concentric left ventricle hypertrophy, ELVH: Eccentric left ventricle hypertrophy.*

| Table 4. Distribution of Doppler venous flow and echocardiographic parameters | | | | | | |
|---|---|---|---|---|---|---|
| | | Doppler venous flow | | | Test value | P-value |
| | | Mean | ± | SD | | |
| LV | Normal | 804.00 | ± | 120.26 | F= 10.056 | <0.001** |
| | CLVH | 1133.33 | ± | 413.12 | | |
| | Dilated | 1420.00 | ± | 44.72 | | |
| | ELVH | 1150.00 | ± | - | | |
| Aortic Valve | Normal | 1084.60 | ± | 235.69 | T= 2.052 | 0.046* |
| | Aortic regurge | 1296.29 | ± | 351.66 | | |
| Mitral Valve | Normal | 1062.11 | ± | 286.41 | F= 3.598 | 0.035* |
| | Mitral regurge | 1293.36 | ± | 345.08 | | |
| | Calcification | 1000.00 | ± | 261.88 | | |
| Tricuspid Valve | Normal | 1138.00 | ± | 444.59 | T= 1.441 | 0.804 |
| | Tricuspid regurge | 1221.17 | ± | 481.21 | | |
| PAP | Normal | 1093.38 | ± | 438.10 | T= 2.307 | 0.025* |
| | PHT | 1691.33 | ± | 364.41 | | |
| Diastolic dysfunctions | No | 1049.33 | ± | 331.20 | F= 4.076 | 0.023* |
| | Grade 1 | 1186.00 | ± | 427.12 | | |
| | Grade 2 | 1480.57 | ± | 327.16 | | |

*P value >0.05: Not significant, *P value <0.05 is significant, **p<0.01 is highly significant.*
*T: Independent Samples T Test, F: One- Way ANOVA Test, LV: left ventricle, CLVH: Concentric left ventricle hypertrophy, ELVH: Eccentric left ventricle hypertrophy, PAP: pulmonary artery pressure*

| Table 5. Multiple Logistic regression analysis for factors associated with higher Doppler venous flow. | | | | |
|---|---|---|---|---|
| Parameters | B | Wald | P-value | Odds ratio (OR) |
| Gender | 3.263 | 5.672 | .017 | 26.116 |
| Smoking | .729 | 5.005 | .025 | 2.073 |
| Primary kidney disease | -.489- | .280 | .597 | .613 |
| Type of previous access | .105 | .025 | .875 | 1.111 |
| Site | 2.026 | 2.355 | .125 | 7.582 |
| LV | -21.287- | 2.225 | .136 | .000 |
| Aortic Valve | -165.157- | 3.726 | .054 | .000 |
| Mitral Valve | 39.250 | 3.569 | .059 | 14.000 |
| Diastolic dysfunctions | 49.027 | 3.932 | .047 | 19.000 |
| Weight (kg) | 1.983 | 2.901 | .089 | 7.262 |
| Hemoglobin (g/dl) | -18.568- | 2.663 | .103 | .000 |
| TAGs (mg/dl) | -.211- | 2.097 | .148 | .810 |
| LDL (mg/dl) | .905 | 3.625 | .057 | 2.472 |
| EF | 1.681 | 2.126 | .145 | 5.369 |
| FS | 5.203 | 3.820 | .051 | 11.775 |
| Hemoglobin (g/dl) | 3.151 | 3.525 | 0.060 | 23.368 |
| LDL (mg/dl) | 0.023 | .603 | 0.438 | 1.023 |

*B: regression coefficient*

## Discussion

CKD is highly prevalent and has become a major public health concern in Egypt, as untreated CKD can progress to kidney failure that is irreversible, progressive, and associated with higher cardiovascular risk, High flow access is associated with complications like HOHF, PHT, mega fistula, central vein stenosis, dialysis-associated steal syndrome, or distal hypo perfusion ischemic syndrome.

The study aimed at predicting the cardiac outcome in CKD and CKD-HD patients through assessment of the relation between HD arteriovenous access and structural and functional cardiac abnormalities based on measuring Doppler venous flow of an arteriovenous access and echocardiographic findings in CKD patients.

In our study, the mean age of participants was (45.92± 22.29) years, 52% were females, 88% were non-smokers while, in CKD-ND AVF, the mean age of participants was (29.36± 8.47) years, 64% were males, 60% were non-smokers, In CKD-ND, the mean age of participants was (61.20± 13.68) years, 54% were females, 56% were non-smokers, this is slightly close to study by Robinson, et al that found The mean age of the participants was (48± 7.44) years, 66.4% of patients were male [10]. Also, another study found that the mean age was (51± 6.94) years, and 43 % were females [11]. In the study by Saleh & et al out of 100 patients 60% were males with a mean age of 48 years, and the study population comprised 34 females [5].

Regarding primary kidney disease In the CKD-HD AVF group, 60% was unknown, and 28% had obstructive uropathy while in the CKD-ND AVF group, unknown primary kidney disease was 24%, DKD 8%, polycystic kidney 32%, while CKD-ND group 48% was unknown and 32% was hypertensive glomerulopathy. In the CKD-HD AVF group, none of the patients was diabetic, 52% were hypertensive with a mean duration of 5 years, in the CKD-ND AVF group 24% were diabetic with a mean duration of 9 years, and 56% were hypertensive with a mean duration of 6 years, while in CKD-ND group, 28% were diabetic with mean duration 9 years, and 88% were hypertensive with a mean duration of 11 years.

According to the 2020 registry data of the Egyptian Society of Nephrology and Transplantation (ESNT), HTN remains the leading cause of ESRD in Egypt, accounting for approximately 41% of cases. DM follows as the second most common cause, representing 13%, while the third most frequent category is ESRD of unknown etiology. The high proportion of unknown causes likely reflects limited patient awareness, delayed referral to nephrology services, and gaps in data documentation. These findings differ from global registry trends and may be attributed to the incomplete participation of dialysis units in the ESNT registry, as well as limited public and provider awareness [12].

In 2022, Manzur-Pineda and his colleagues found that 98% of the ESRD patients had a medical history of essential HTN, 69% were diabetic, 22% had coronary artery disease, and 19% had congestive HF which is different from our study results [13].

In our study, Participants of our study who had PHT, LVH, left-side heart valve regurge, or diastolic dysfunctions showed significant elevation in Doppler venous flow compared to normal cases.

Another study found that the incidence of cardiovascular events was significantly higher in the high-flow group compared to the low-flow group at the one-year follow-up which was similar to our finding [11].

Additionally, previous research reported that patients with HF exhibited significant enlargement of LV dimensions and volumes, as well as markedly increased LA volume, compared with the non-HFA group. These findings are consistent with the results of our study, which demonstrated that higher-flow AVFs are more frequently associated with CLVH than lower-flow accesses [5].

Our study revealed no significant differences in EF and FS among the three groups, likely due to excluding participants with known cardiac diseases. However, Robinson et al. reported that AVF presence was associated with worse diastolic function in pretransplant CKD-HD patients, which is consistent with our findings [10].

A comprehensive study in 2023 reported increased PAP following AVF creation, with a 10-year follow-up, aligning with our finding of significantly higher Doppler venous flow in patients with PHT [14]. However, another study, predominantly involving African American participants, found that AVF creation was associated with reduced or stable PAP measurements in the ESRD population. This discrepancy might be attributed to improved volume status, though the study lacked information on AVF BF measurements and ultrafiltration rates during HD [13].

In our study, the CKD-ND group is associated with increased incidence of CLVH in comparison to CKD-ND AVF and CKD-HD AVF groups while keeping in mind that the CKD-ND group was associated with a higher age group and longer duration of chronic illnesses predominantly DM and HTN which consistent with Bansal et al study that reported Mean left ventricular mass index did not change significantly from advanced CKD to ESRD; however, EF declined during this transition period. Although left ventricular mass index is fixed by advanced stages of CKD, EF decline during more advanced stages of CKD may be an important contributor to CVD and mortality after dialysis [15].

## Conclusion

In Conclusion, There is a significant association between High-flow AVF and Echocardiographic changes in terms of LVH, PHT diastolic dysfunctions, and left-side valve regurge.

## Limitations:

This study's findings are limited by a small sample size (75 patients), being conducted at a single center, potentially limiting the applicability of the results to other populations and hospitals, and the potential influence of unaccounted confounding factors such as differences in patients' comorbidities and medications. Larger, multicenter studies are needed to validate and confirm the relationship between AVF characteristics and its cardiac consequences in hemodialysis patients.

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