The Impact of Bone Mineral Biomarkers on Diastolic Cardiac Function in Children and Adolescents on Regular Hemodialysis

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ABSTRACT

Background: Chronic kidney disease (CKD) affects adults and children globally and is a critical health concern. Cardiovascular disease (CVD) was identified over ten years ago as a leading cause of death in children with advanced CKD. Numerous studies that evaluate cardiovascular risk, disease processes, and early markers of CVD in cases with CKD have been published as a result of this observation. Children with CKD have an exceptionally high prevalence of conventional and uremia-related CVD predisposing factors, much like adults do.

Objective: The aim was to study the impact of bone markers and other laboratory tests on diastolic cardiac functions in children and adolescent with CKD on regular hemodialysis.

Patients and Methods: A cross-sectional observational study was conducted on 40 patients with CKD on regular hemodialysis, from May 2022 to June 2023 in the Pediatric Nephrology and Cardiology Department at Sohag University Hospital.

Results: The commonest causes of CKD were congenital anomalies of the kidney and urinary tract (CAKUT) in 77.5% of patients. The mean age of patients was 14.18 ± 4.36 years. Evaluation of cardiac function showed that 57.5% of cases had diastolic dysfunction and 70% of cases had left ventricular hypertrophy (LVH). There was a statistically significant correlation between diastolic dysfunction with anemia and hyperparathyroidism ($p<0.05$). Hypertension was significantly accompanied by LVH ($p=0.045$).

Conclusion: Our study revealed that the most important factors affecting all parameters of diastolic function were anemia and hyperparathyroidism. Other factors affecting the diastolic function to a lesser extent were hypertension and residual kidney function (RKF). There was a substantial correlation between LVH and hypertension.

Keywords: CKD, Cardiovascular disease, Echocardiography, Hemodialysis.

INTRODUCTION

The diagnosis of CKD could be confirmed when the value of glomerular filtration rate (GFR) is less than 60 ml/min per 1.73m^2 over a period of more than three months [1]. The majority of occurrences of CKD in children under five years old are caused by CAKUT, as well as metabolic and genetic factors. On the other hand, in older children, glomerular and tubular diseases are frequently the cause [2].

Dialysis is used to treat patients with end stage renal disease (ESRD), which raises their risk of CVD. The two main problems that are often detected in hemodialysis cases are LVH and systolic or diastolic dysfunction, which are identified by echocardiography (ECHO) and significantly increase morbimortality [3].

The aim of this research was to study the association of bone markers and other laboratory tests with diastolic cardiac functions in children and adolescent with CKD on regular hemodialysis.

PATIENT AND METHOD

A cross-sectional observational study was conducted on 40 patients with CKD on regular hemodialysis, from May 2022 to June 2023 in the Pediatric Nephrology and Cardiology Department at Sohag University Hospital.

Inclusion criteria: Every patient (5–22 years old) receiving routine HD began dialysis when their GFR was ≤ 15 mL/min/1.73m^2, and each session lasted 3-5 hours.

Exclusion criteria: Patients suffering from primary cardiac conditions, such as cardio-myopathy, RHD and CHD.

Assessment of participants:

All patients in this study were subjected to the next:

1) History taking which included socio-demographic data; age, sex, previous growth and development of the child, and primary cause of ESRD and duration of dialysis.

2) Clinical examination which included:

a) Anthropometric measurements, such as height and weight, were used to evaluate a person's nutritional and developmental status.

b) BMI percentiles (<5%, 5%-85%, and >85%). Height and body mass index (BMI) (BMI; kg/m^2 of height) percentiles by age and gender were determined using tables given by the Centers for Disease Control and Prevention: BMI was measured by the next formula: BMI = weight (kg)/ height^2 (m^2).

c) Vital signs: in particular arterial blood pressure.

3) Routine laboratory investigation including:

a) CBC: Anemia was described as mean hemoglobin value less than 11 g/dl [4].

b) Blood urea nitrogen.

c) Serum creatinine (Ser Cr), serum albumin, serum electrolytes (calcium, potassium, and phosphorus), and intact parathormone hormone (iPTH).

d) The serum level of 25(OH) cholecalciferol (Vit. D) was determined in venous blood samples from all cases.

e) Single-pool Kt/V values were generated and utilized to assess dialysis adequacy and residual kidney function.

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4) Doppler Echo, tissue Doppler imaging, and M‑mode Echo:

All patients underwent echo with GE Vivid 6 to evaluate heart shape and function, which was conducted by skilled sonographers following a defined institutional protocol.

A- Left ventricular mass (LVM) was determined using 2D directed M-mode echo measurements that met the American Society of Echo (ASE) guidelines. The indexed LVM was computed by dividing the LVM by height raised to a power of 2.7 (g/m2.7), according to **de Simone *et al.*** [5] formula.

B- Diastolic function was evaluated using Doppler echo and tissue Doppler imaging. Doppler echo was used to measure the early and late mitral inflow velocity (E and A, respectively). Tissue velocity imaging was performed in the 4 chamber view, with the mitral annular planes perpendicular to the ultrasound ray. A 5 mm pulsed TD sample was collected from the septal and lateral aspects of the mitral annulus, and the lateral aspect of the tricuspid annulus. Early diastolic (e′) (early diastolic filling velocity) and late peak diastolic myocardial (a′), and peak mitral annular velocities were determined at the medial and lateral mitral annuli using tissue Doppler. The e′/a′ ratio for both annuli was determined. The peak early mitral annular velocity (E′) was calculated by averaging the velocities at the medial and lateral annuli. Using these results, the E/E′ ratio (Doppler-derived peak early mitral inflow velocity to tissue Doppler-derived E′) was computed. Diastolic dysfunction was rated as follows: grade zero (no impairment in diastolic function), grade I (impaired relaxation, E/E′ ≤ eight), grade II (pseudo normal, E/E′ 9-12), and grade III (restrictive grade, E/E′ > 13) [6].

C- The left ventricular myocardial performance index (MPI), a global assessment of systolic and diastolic function, was calculated as the sum of isovolumic relaxation and contraction times divided by ejection time [6].

Ethical consideration:

Scientific and Ethical Committees of the Sohag Faculty of Medicine approved this study. Oral and written informed consent was obtained from parents of children included in the study as well as from adult participants. The Helsinki Declaration was adhered to at every stage of the investigation.

Statistical analysis

The STATA statistical software, version 14.2, was utilized to analyse the data. Mean±SD, median, and range were the figures used to depict quantitative data. The means of the two groups were compared using the student t-test. The Mann-Whitney test was performed when there was non-normal distribution of the data. Qualitative data were presented as frequency and percentage and were compared by Chi-Square test or Fisher's exact test. Using the STATA or Excel programs, graphs were created. Any P value less than 0.05 was deemed significant.

RESULTS

This study was conducted on forty cases with CKD on regular hemodialysis (19 males and 21 females) and their mean age was14.18 ± 4.36 years. The weight of patients ranged from 12 to 50 kg with a mean of 29.43 ± 10.22 kg and their height ranged from 90 to 160 cm with a mean of 127.73 ± 19.24 cm. 35 cases (87.5%) were short stature. Out of 40 patients, 52.5% were underweight and 2.5% were overweight with a mean BMI of 17.79 ± 3.6 kg/m^2 (ranged from 9.5 to 26.6 kg/m^2. More than half patients (57.5%) had positive history of consanguinity. Mean duration of dialysis (month) was 29.43±10.22, the mean of KT/V was 1.51±0.35, 11 cases were with residual kidney function and 29 cases were with no residual kidney function as shown in table 1.

Table (1): Demographic data and anthropometric measures and dialysis data among the studied cases

	Variable	Value
Age/years	Mean±SD (range)	14.18±4.36 15 (5:22)
Gender No. (%)	Female Male	21 (52.50%) 47.50 (%)
Weight	Mean±SD	29.43±10.21
Height	Mean±SD	127.73±19.23
	Short stature No. (%)	35(87.5%)
	Normal height No. (%)	5(12.5%)
BMI No. (%)	Underweight Normal Overweight	21 (52.50%) 18 (45.00%) 1 (2.50%)
Consanguinity No. (%)	Negative Positive	17 (42.50%) 57.50 (%)
Duration of dialysis (month)	Mean±SD	29.43±10.22
KT/V	Mean±SD	1.51±0.35
Residual kidney function No. (%)	No Yes	29 (72.50%) 11 (27.50%)

Table 2 shows that the commonest cause of CKD was CAKUT in 77.5% of patients followed by FSGN in 12.5%.

Table (2): CKD causes among the studied patients

Causes of CKD	No. (%)
- CAKUT	31 (77.50%)
-Focal segmental GS	5 (12.50%)
-Obstructive uropathy	3 (7.50%)
-Chronic interstitial nephritis	1 (2.50%)

As shown in table 3, mean left ventricular mass was (169.13±114.18), mean left ventricular mass index was (162.65±87.10), mean ejection fraction (%) was (60.43±13.52). 28 cases had left ventricular hypertrophy (23 cases (57.50%) had concentric LV hypertrophy and 5 cases (12.50%) had eccentric LV hypertrophy).

Table (3): Echo findings among the studied cases

Variable	Value
Left ventricular mass	
Mean±SD	169.13±114.18
Median (range)	144 (44:625)
LVM Index	
Mean±SD	162.65±87.10
Median (range)	152.5 (52:496)
LVM Index group No. (%)	
Normal	12 (30.00%)
Concentric hypertrophy	23 (57.50%)
Eccentric hypertrophy	5 (12.50%)
Myocardial performance index	
Mean±SD	0.31±0.22
Median (range)	0.25 (0.03:0.82)
Ejection fraction (%)	
Mean±SD	60.43±13.52
Median (range)	63 (6:80)
Mean E/E`	
Mean±SD	9.89±3.92
Median (range)	9.4 (1.19:19.07)
Mitral E velocity	
Mean±SD	0.87±0.23
Median (range)	0.83 (0.32:1.24)
Lateral mitral annulus E`	
Mean±SD	0.10±0.12
Median (range)	0.08 (0.03:0.83)
Septal mitral annulus E`	
Mean±SD	0.13±0.20
Median (range)	0.08 (0.06:1.06)
MV E/A ratio	
Mean±SD	1.25±0.39
Median (range)	1.21 (0.65:2.64)

Out of 40 patients, 57.5% had diastolic dysfunction (Table 4**).**

Table (4): Distribution of diastolic function in studied population.

Diastolic function	Number (%)
Normal diastolic function	17 (42.50%)
Diastolic dysfunction	23 (57.50%)

As shown in table (5), 20 cases had MR (mitral regurge), 11 cases had TR (tricuspid regurge), 14 cases had AR (aortic regurge), 3 cases had PR (pulmonary regurge), and 1 case had PHTN. Regarding status of mitral valve, half of cases had a normal mitral valve (50%), followed by mild MR (37.5%) as shown in figure (1).

Table (5): Status of heart valves among the studied cases

Variable	Number (%)
Mitral valve	
Normal	20 (50%)
Trivial MR	1 (2.5%)
Mild MR	15 (37.5%)
Moderate MR	3 (7.5%)
Severe MR	1 (2.5%)
Tricuspid valve	
Normal	29 (72.5%)
Mild TR	5 (12.5%)
Moderate TR	4 (10%)
Severe TR	2 (5%)
Aortic valve	
Normal	26 (65%)
Trivial AR	3 (7.5%)
Mild AR	6 (15%)
Mild AS	1 (2.5%)
Moderate AR	4 (10%)
Pulmonary valve	
Normal	36 (90%)
PHTN	1 (2.5%)
Mild PR	1 (2.5%)
Moderate PR	2 (5%)

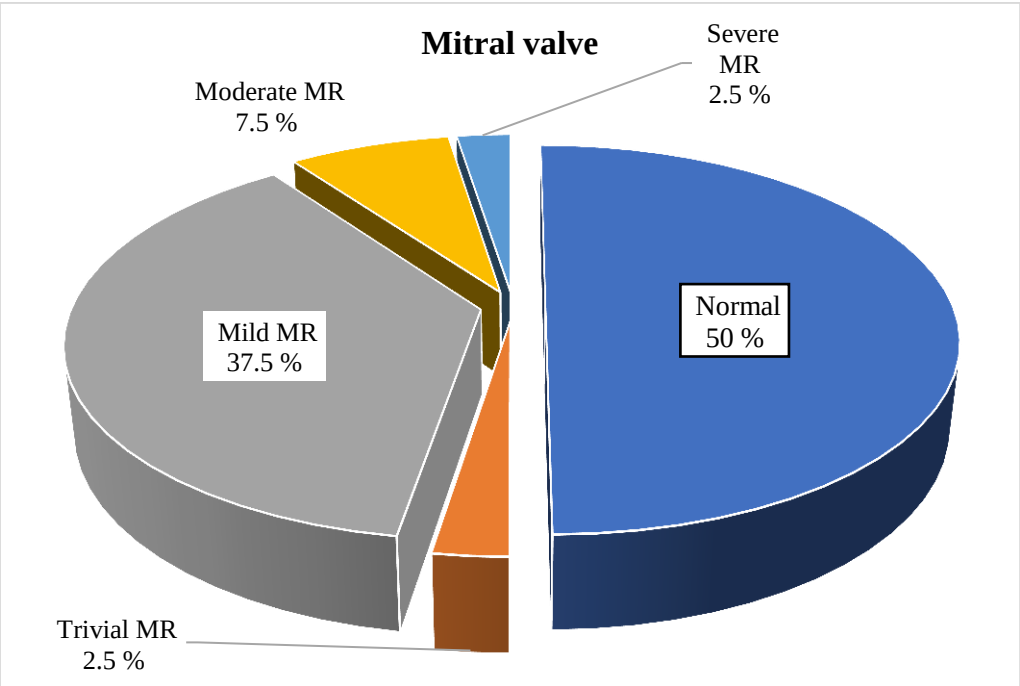

Figure (1): Distribution of the studied patients based on status of mitral valve.

As shown below in table (6), there was no statistically significant relationship between diastolic function and age, gender, consanguinity, weight, height, BMI, causes of CKD, duration of dialysis (month), KT/V, and residual kidney function.

Table (6): Comparison between patient with normal diastolic function and those with diastolic dysfunction as regard demographic data, anthropometric measures and causes of CKD and dialysis data

Variable (Mean±SD) or number (%)	Normal diastolic function N=17	Diastolic dysfunction N=23	P value
Age/years	15.06±4.42	13.52±4.29	0.28
Gender			
Female	10 (58.82%)	11 (47.83%)	0.49
Male	7 (41.18%)	12 (52.17%)	
Weight	31.35±9.63	28.0±10.61	0.29
Height	132.3±18.63	124.3±19.3	0.19
BMI	17.64±3.51	17.90±3.74	0.82
BMI groups			
Underweight	9 (52.9%)	12 (52.1%)	0.68
Normal	8 (47.06%)	10 (43.48%)	
Overweight	0 (0%)	1 (4.35%)	
Consanguinity			
Negative	6 (35.29%)	11 (47.83%)	0.43
Positive	11 (64.71%)	12 (52.17%)	
Causes of CKD			
-CAKUT	12 (70.59%)	19 (82.61%)	0.52
-Focal segmental GS	3 (17.6%)	2 (8.7%)	
-Obstructive uropathy	1 (5.88%)	2 (8.7%)	
-Chronic interstitial nephritis	1 (5.88%)	0 (0%)	
Duration of dialysis (month)	67.76±59.79	63.04±46.2	0.92
KT/V	1.45±0.28	1.55±0.39	0.34
Residual kidney function			
No	10 (58.82%)	19 (82.61%)	0.15
Yes	7 (41.18%)	4 (17.39%)	

Table (7) demonstrates that there was no statistically significant relationship between diastolic function and MCV (mean corpuscular volume), Ca, phosphorus, 25 (OH) cholecalciferol of the studied patients. In contrast, there was statistically significant correlation between diastolic dysfunction and anemia and PTH, 33 cases were anemic, 22 cases of them had diastolic dysfunction.

Table (7): Comparison between patient with normal diastolic function and those with diastolic dysfunction as regard vital signs and investigation

	Variable	Normal diastolic function N=17	Diastolic dysfunction N=23	P value
Systolic blood pressure	Mean±SD	119.41±15.19	119.1±16.21	0.96
Diastolic blood pressure	Mean±SD	80.59±8.99	78.70±11.40	0.46
Hypertension	Normotensive	6 (35.29%)	8 (34.78%)	
	Hypertensive	11 (64.71%)	15 (65.22%)	0.97
Anemia	No	6 (35.29%)	1 (4.35%)	**0.03**
	Yes	11 (64.71%)	22 (95.65%)	
MCV	Mean±SD	83.86±8.82	85.19±5.47	0.56
Ca	Mean±SD	9.58±1.75	9.41±1.45	0.75
Phosphorus	Mean±SD	4.78±1.37	4.99±2.34	0.87
PTH	Mean±SD	246.84±248.06	596.2±1160.9	**0.04**
25(OH) cholecalciferol	Mean±SD	31.71±36.32	29.84±20.90	0.43
Vit D insufficiency	No	3 (17.65%)	8 (34.78%)	
	Yes	14 (82.35%)	15 (65.22%)	0.23

There was significant statistically difference between cases with normal diastolic function and cases with diastolic dysfunction regarding the LVM index group, more than 50% of cases with normal diastolic dysfunction (52.9%) had normal LVM index in comparison to 13.04% of cases with diastolic dysfunction. While 78.2% of cases with diastolic dysfunction had concentric hypertrophy in comparison to 29.4% of cases with normal diastolic dysfunction, as shown in figure (2).

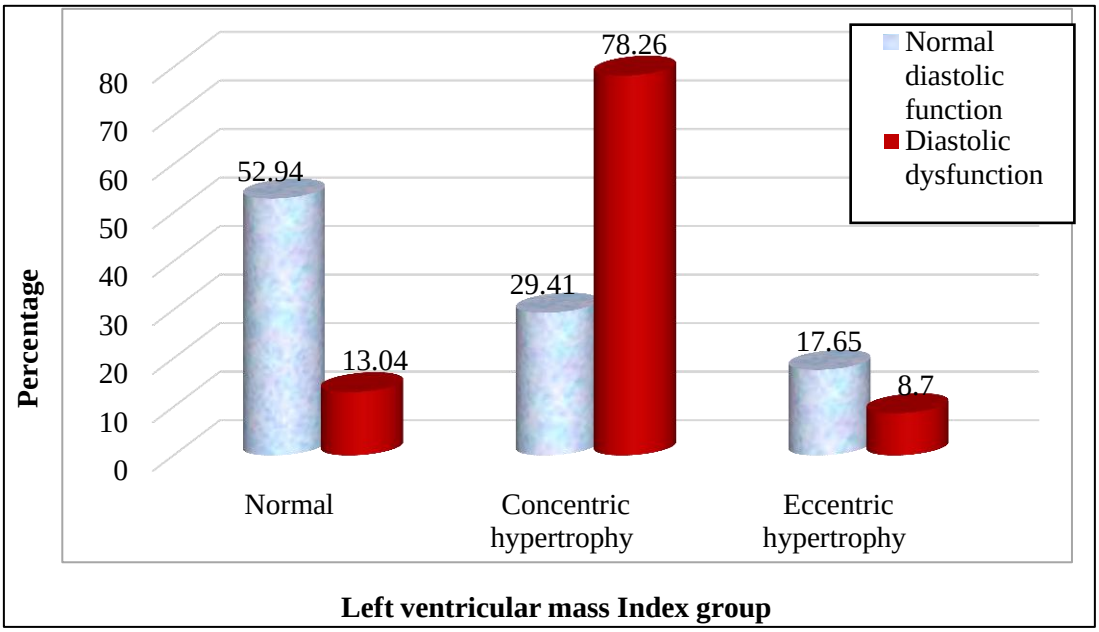

Figure (2): Comparison between patients with normal diastolic function and those with diastolic dysfunction as left ventricular mass index group.

Moreover, cases with diastolic dysfunction showed significant increase in mean E/E` in comparison to normal diastolic dysfunction (11.89±3.41 and 7.18±2.82), as shown in figure (3).

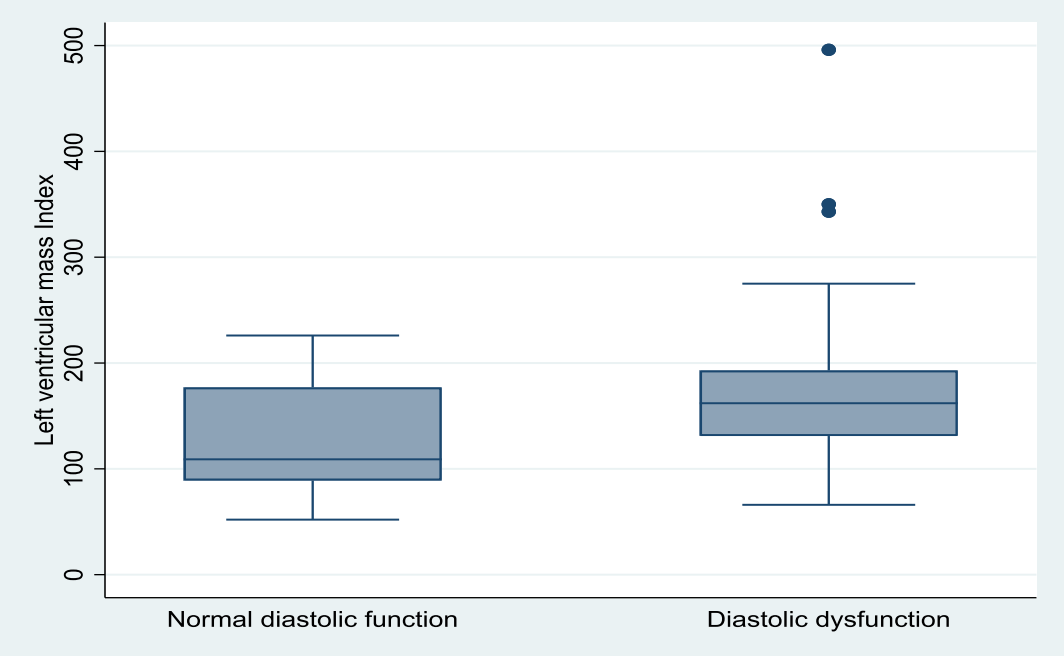

Figure (3): Comparison between patients with normal diastolic function and those with diastolic dysfunction as mean E/E`.

Table (8) shows that there was no statistically significant correlation between blood pressure and MPI, EF, but there was statistically significant correlation between blood pressure and LVM, LVMI, mean E/E`, and septal mitral annulus E`.

Table (8): Comparison between normotensive and hypertensive patients as regard echo findings

Variable (Mean±SD) Or number (%)	Normotensive N=14	Hypertensive N=26	P value
LVM	113.93±69.17	198.85±123.39	**0.01**
Left ventricular mass Index	124.21±49.81	183.35±96.30	**0.045**
LVMI group -Normal -Concentric hypertrophy -Eccentric hypertrophy	 6 (42.86%) 6 (42.86%) 2 (14.29%)	 6 (23.08%) 17 (65.38%) 3 (11.54%)	 0.36
MPI	0.32±0.22	0.31±0.22	0.99
Ejection fraction	60.07±16.79	60.62±11.76	0.45
Mean E/E	8.09±3.9	10.85±3.65	**0.03**
Mitral E velocity	0.87±0.28	0.87±0.21	0.99
Lateral mitral annulus E`	0.14±0.2	0.08±0.03	0.11
Septal mitral annulus E`	0.22±0.32	0.08±0.01	**0.002**
MV E/A ratio	1.12±0.30	1.31±0.42	0.18

Table (9) indicates that there was no significant correlation between RKF and LVM, LVMI, MPI, EF, but there was statistically significant correlation between RKF and MV E/A ratio.

Table (9): Comparison between patients with and without residual kidney function as regards echo findings

Variable	No Residual kidney function N=29	Residual kidney function N=11	P value
LVM Mean±SD	 160.4±111.5	 192.09±123.3	 0.41
LVMI Mean±SD	 162.4±88.79	 163.27±86.6	 0.95
LVMI group Normal Concentric hypertrophy Eccentric hypertrophy	 8 (27.59%) 18 (62.07%) 3 (10.34%)	 4 (36.36%) 5 (45.45%) 2 (18.18%)	 0.61
MPI Mean±SD	 0.31±0.22	 0.32±0.21	 0.77
Ejection fraction (%) Mean±SD	 60.17±13.39	 61.09±14.48	 0.60
Mean E/E` Mean±SD	 9.66±3.61	 10.49±4.79	 0.56
Mitral E velocity Mean±SD	 0.84±0.23	 0.96±0.23	 0.14
Lateral mitral annulus E` Mean±SD	 0.11±0.14	 0.10±0.04	 0.42
Septal mitral annulus E` Mean±SD	 0.12±0.18	 0.16±0.25	 0.85
MV E/A Ratio Mean±SD	 1.15±0.32	 1.49±0.47	 **0.02**

DISCUSSION

The current study was conducted among 40 cases with CKD on regular hemodialysis (19 males and 21 females) and their ages ranged from 5 to 22 years with a mean age of 14.18 ± 4.36 years. Regarding socio-demographic characteristics, our results were nearly similar to the study that was conducted by **El-Gamasy and Mawlana** [7] who conducted the study among children and adolescents with ESRD and revealed that the mean of their age was 13.7 ± 3.9 years with a ranges of (10-18) years [7]**.** Also, our results were in line with a study that was done by **Ali *et al.*** [8] who reported that the range of age of cases suffering from ESRD on regular HD regime for at least 3 months was from 4 to 18 years old.

Regarding their physical assessment, the weight of patients ranged from 12 to 50 kg with a mean of 29.43 ± 10.21 kg and their height ranged from 90 to 160 cm with a mean of 127.73 ± 19.24 cm, 35 cases (87.5%) were short stature. Calculation of BMI showed that 52.5% of cases were underweight and 2.5% of cases were overweight with a mean BMI of 17.79 ± 3.6. kg/m^2 (ranged from 9.5 to 26.6 kg/m^2). Our study is in agreement with study that was conducted by **Zaki *et al.*** [9] who discovered that dialysis patients had a growth deficiency in anthropometric measures when compared to healthy controls.

Our result had recorded that the most frequent causes of CKD were congenital kidney and urinary tract abnormalities (77.5%), followed by FSGN (12.5%), obstructive uropathy (7.5%), and chronic interstitial nephritis (2.5%). Our estimations concurred with those of **El-Gamasy and Mawlana** [7]**,** who discovered that congenital kidney and urinary tract defects accounted for the majority of cases (33.3%) and **Hafez and Ahmed** [10] who found that the indications for hemodialysis were polycystic kidney (36%), glomerulonephritis (20%), nephrocalcinosis (16%), obstructive uropathy (16%), and unknown cause (12%). The current study showed that the mean of KT/V was 1.51 ± 0.35, which was in accordance with **Adnan *et al.*** [11] who found that the mean of Kt/v was 1.3 ± 0.1**.**

Our study showed that there was association between residual renal function (RRF) as 82.6% of cases with diastolic dysfunction showed loss of RRF but the difference was statistically insignificant. Also, there was statistically insignificant difference between RRF and LV mass (P-value > 0.05). This wasn't in accordance with a study done by **Raikou *et al.*** [12] who found that the loss of RRF was significantly accompanied by LVH (P=0.007) and diastolic dysfunction (P=0.001) in HD patients**.** Also, our results weren't in agreement with a study done by **Ahsan *et al.*** [13] who discovered significance difference between cases with preserved RRF and cases without preserved RRF based on diastolic dysfunction (P=0.001). The difference in significance could be explained by our small sample size.

The present study has found that diastolic dysfunction did not exhibit a statistically significant relationship with sex distribution, age, consanguinity, weight, height, or BMI. Such outcomes are reliable with those of **El-Gamasy and Mawlana** [7]**,** who found that the diagnosis of cardiac disease didn't vary significantly between age and sex-defined groups. Also, our findings were in agreement with **Ali *et al.*** [14]**,** who found that there was no significant difference in age (p=0.58), gender (p=0.58), consanguinity (p=0.18), weight (p=0.9), height (p=0.7), and BMI (p= 0.89) when comparing group A (with normal diastolic dysfunction) with group B (with diastolic dysfunction). Moreover, our estimates were in line with **Patange *et al.*** [15] who found the same results as age, gender, and BMI did not differ statistically significantly (p value wasn't significant). However our results weren't in agreement with the results obtained by **Chavers *et al.*** [16] who reported that cardiac findings were more common in female and more common in age between 10-15 years old.

The current study's findings showed that there was a statistically negligible difference between normal diastolic function cases and diastolic dysfunction cases according to association with hypertension as 26 of studied patients (65 %) were hypertensive, 65.22% of diastolic dysfunction cases had hypertension and 34.78% were normotensive. Our findings are consistent with **El-Gamasy and Mawlana** [7]**,** who found that patients with hypertension were more likely to be diagnosed with cardiac disease (75% versus 58%, P<0.001).

According to LV mass, there was a statistically significant difference (P < 0.05) between instances of hypertension and normotensive patients in the current study. This runs counter to a research by **Moustafa *et al.*** [17] that found no evidence of a significant relationship between LVH and HTN. According to our findings, blood pressure and LVMI were significantly correlated, which is consistent with findings from **Sinha *et al.*** [18], who also revealed a substantial correlation between BP and indexed LVMI.

The current study had shown that there was a statistically significant relation between normal diastolic function cases and diastolic dysfunction cases according to presence of anemia (p=0.03). 95.65% of cases with diastolic dysfunction were anemic. However, there was statistically insignificant difference between cardiac and non-cardiac cases according to Ca and phosphorus level (P > 0.05).

This contradicts the findings of **Moustafa *et al.*** [17]**,** who demonstrated that there was no meaningful relationship between anemia and LVMI. Furthermore, our estimates disagreed with those of **Ali *et al.*** [14]**,** who found a statistically significant correlation between anemia and diastolic dysfunction in pre-

dialytic children. However, our results agreed with the results of **McNiece *et al.* [19] and Radoui *et al.* [20]** who demonstrated that there was a correlation between anemia with diastolic dysfunction and LVMI.

Additionally, our results were consistent with those of **El-Gamasy and Mawlana [7],** who displayed that there was no significant difference in blood calcium or serum phosphorus ($p>0.05$) and a significant difference in Hb level between cardiac and non-cardiac cases ($p>0.05$). The current results on the relationship between phosphorus levels and diastolic dysfunction did not agree with those of **Ali *et al.* [14],** who found a highly statistically significant relationship between diastolic dysfunction and hyperphosphatemia, and contradicting the findings of **Galetta *et al.* [21],** who showed a significant positive connection between elevated CVD and hyperphosphatemia in their uremic cases receiving continuous hemodialysis.

In addition, our findings disagreed with those of **Strózecki *et al.* [22],** who found that elevated serum phosphate levels in CKD had a significant correlation with an increased risk of developing secondary hyperparathyroidism and elevated calcium x PO_4 that results in extravascular metastatic calcification, both of which are linked to an increased risk of cardiac morbidity and mortality in CKD. Contrasting to **El-Gamasy and Mawlana [7],** who found no statistically significant difference in PTH between children receiving dialysis who were cardiac and those who were not ($P >0.05$), our study revealed a significant correlation between diastolic function and PTH ($P=0.04$). Our results, however, were consistent with those of **Ali *et al.* [14],** who displayed a statistically significant correlation between PTH level and diastolic dysfunction.

Moreover, the current study was in accordance with **Adnan *et al.* [11],** who recorded that significant statistical differences were identified between the CVD and non-CVD individuals in the Ca^+ x PO_4^+ product, however there were significant differences between the CVD and non-CVD cases in PTH and Hb.

Our study indicated that there was statistically insignificant difference between cases with normal diastolic function and cases with diastolic dysfunction on regular dialysis according to D insufficiency. Our findings weren't in line with **Ali *et al.*[14]** who reported that there was highly statistically significant difference between the pre-dialytic studied groups according to vit D insufficiency and Ca level.

We had reported that there was 42.5% of cases with normal diastolic function and 57.5% of cases with diastolic dysfunction. This is nearly comparable to the results of **Adnan *et al.* [11],** which showed that 64% of patients had mild impairment in diastolic and systolic functions. The current study showed that there was statistically insignificant difference between cases with preservation of RRF and cases without RRF regarding LVM. Concentric hypertrophy represented 62.07% of cases without preservation of RRF followed by normal 27.59%. Also, there was insignificant decrease in mean E/E` among cases without preservation of RRF in comparison to cases with preservation of RRF. Our findings weren't similar to **Mitsnefes *et al.*[23]** who has found that regarding LVH, there was a statistically significant difference between the two renal disease groups and the control individuals. Concentric remodeling and LVH were very common in children with CRI, but eccentric LVH was the most frequent abnormal geometric pattern in dialysis cases. LVH was present in 21% of CRI patients and 41% of dialysis patients. Children with CRI who were receiving continuous dialysis showed anomalies in their diastolic function, as evidenced by considerably lower E′ ($P < 0.001$) and a significantly greater E/E′ ratio compared to the controls ($P<0.001$). Compared to children with CRI, dialysis patients exhibited worse diastolic function ($P<0.001$) and greater E/E′ ratio ($P < 0.001$) [23]. However, this was consistent with **Hafez and Ahmed [10]** study, that has found lower E/A ratio and higher E/E` ratios in hemodialysis cases than in controls**.**

STUDY LIMITATIONS

One of the study's limitations was the tiny cohort of pediatric patients. There was no normalization of the tissue Doppler indications of diastolic dysfunction to an age-independent z-score. The fact that our analysis was cross-sectional rather than case-control is another evident study weakness.

CONCLUSION

The results emphasized that the most factors affecting all parameters of diastolic function are anemia and hyperparathyroidism, other factors are affecting the diastolic function to a lesser extent are hypertension and residual kidney function. Hypertension was significantly associated with left ventricular hypertrophy.

RECOMMENDATIONS

- While providing juvenile dialysis patients with routine care, it should be advised to test for heart disorders on a regular basis, diagnose them early, and monitor any complications.
- In pediatric patients with ESRD, echocardiography is the best diagnostic modality for the early identification of heart disorders.

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