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Evaluation of Cardiac Complications Using Conventional Echocardiography among Children with End Stage Renal Disease

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ABSTRACT

Background: Children with chronic renal failure have an increased risk of mortality due to cardiovascular problems.

Objective: To evaluation of cardiac complications using conventional echocardiography among children with end stage renal disease.

Subject and Methods: This study was conducted on 40 children with chronic renal failure (17 males and 23 females), their age ranged from 8 years to 17 years, attending the Nephrology Unit of the Pediatric Hospital Zagazig University. All children were subjected to thorough history taking, complete detailed clinical examination and laboratory investigations. All cases and control were assessed by conventional echocardiography.

Results: using mitral and tricuspid inflow velocities peak early velocity (E), peak late velocity (A), E/A ratio, we found significant decreased E/A ratio in our cases predialysis than control group of both mitral and tricuspid inflow velocities; the E/A ratio of the mitral and tricuspid valves dropped considerably following dialysis, which has been linked to diminished compliance of the ventricle due to hypertrophy. Myocardial performance index (MPI) assessing global systolic and diastolic functions of both RV and LV showed statistically significant increased values in cases more than control but did not show significant difference after dialysis.

Conclusion: Major cardiac abnormalities are present in children with chronic renal failure (CRF), and they likely contribute to the high cardiovascular death rate seen in this population.

Keywords: End Stage Renal Disease, Conventional Echocardiography.

INTRODUCTION

End-stage renal failure (ESRF) is the last, catastrophic stage of chronic renal failure (CRF). Chronic kidney disease (CKD) encompasses the whole range and severity of renal disease and is a leading cause of morbidity and death in children globally **(1).** Forty percent of all deaths in people with end-stage renal disease can be attributed to cardiovascular problems **(2).** The onset of cardiovascular disease in CRF is influenced by a number of variables. The development of crucial and significant variables that contribute to the avoidable worsening of CVD in this patient population appears to begin early in the course of CKD **(2).** Cardiovascular complications may occur in patients with ESRD who don't have any cardiac abnormalities before starting dialysis **(3)**.

Ejection phase indices are the most used echocardiographic markers of left ventricular systolic performance. These indices are used to evaluate the efficiency with which the left ventricle pumps blood and are affected by the heart's preload, after load, and contractility. As it contracts and relaxes, the left ventricle pumps blood through the body, carrying oxygen-rich blood to the cells that need it. The ventricle's pumping efficiency may thus be measured in part by its stroke volume **(4).**

The purpose of this research was evaluation of cardiac complications using conventional echocardiography among children with end stage renal disease.

PATIENTS AND METHODS

This study was conducted on 40 children with chronic renal failure (17 male and 23 female), their age ranged
from 8 years to 17 years, attending the Nephrology Unit of the Pediatric Hospital Zagazig University. their data were collected pre and postdialysis, the proportion of boys to girls were nearly equal.

Inclusion Criteria: Diagnosed children with chronic renal failure and ongoing dialysis.

Exclusion Criteria: Refusal of the parents, and age more than 18.

Methodology:

All individuals enrolled in the trial underwent a thorough clinical evaluation (history, physical examination, etc.).

Full History

- Name, age, sex, date of admission.
- Chronology of symptoms.
- Co-existing medical Condition.
- Social and family history.

Clinical examination

- General: Wt, Ht, BMI.
- Neurological: level of consciousness, headache.
- Respiratory: tachypnea, rapid shallow breathing.
- Cardiovascular.

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Echocardiography was done to all patients. Assessment of left atrial volume index (LAVI): Left atrial volume was measured in two dimensions using apical four- and two-chamber transthoracic images. At the conclusion of ventricular systole, just prior to mitral valve opening, the left atrium was at its largest, hence the endocardial margins of the left atrium were traced in each of these perspectives. The result was a biplane volume estimated using a variant of Simpson's (the disc approach).

Ethical consent:

The study was authorised by Zagazig University's Ethical Institutional Review Board. The caregivers of all study participants provided written informed permission after being informed of our research's goals. The Declaration of Helsinki for human beings, which is the international medical association's code of ethics, was followed during the conduct of this study.

Statistical Analysis

The study was performed using a computer and the Statistical Package for the Social Sciences, version 20 (SPSS). The quantitative data were presented as means and standard deviations. The qualitative data were presented as percentages and frequency tables. The student's t test (T) was used to compare two sets of quantitative independent variables. The significance level of P 0.05 was chosen arbitrarily.

RESULTS

Table (1) shows that forty patients; their age ranged between 8 and 17 years were included in the study, their data were collected pre and postdialysis, the proportion of boys to girls were nearly equal.

Table (1): Demographic data of the studied cases

Gender	**Frequency**	**Percentage**
Male	**17**	**42.5**
Female	**23**	**57.5**
Total	**40**	**100**
	Range	**Mean± SD**
Age (Years)	17- 8	12.3± 2.3
Dry weight (Kg)	20- 41	30.64± 5.5
Height (Cm)	157-110	130.7± 13.8

Table (2) shows the valvular regurge in tricuspid, mitral, and aortic valves before and after dialysis.

Table (2): Valvular regurgitation pre and post dialysis in studied cases

	Predialysis n=40		**Postdialysis n=40**	
	Freq	**%**	**Freq**	**%**
TR	10	25	7	17.5
MR	13	32.5	8	20
AR	5	12.5	3	7.5

Table 3 shows non-significant difference in systolic functions (FS% and EF) between diseased and control group. Also, non-significant difference between before and after dialysis.

Table (3): Comparison of LV systolic functions (FS%) fractional of shortening and (EF) ejection fraction measurements among control, cases pre and post dialysis.

Table (3a):

	Control n=20	**predialysis n= 40**	**t-value**	**P - value**
	Mean± SD	**Mean± SD**		
FS%	**36.2± 2.5**	**37.7± 4.2**	**1.4**	**0.16**
EF	**69.6± 5.8**	**66.1± 7.1**	**1.86**	**0.06**

Table (3b):

	Control n=20	**Postdialysis n=40**	**t-value**	**P-value**
	Mean±SD	**Mean± SD**		
FS%	**36.2±2.5**	**37±5.9**	**0.61**	**0.54**
EF	**69.6±5.8**	**67.5±6.2**	**1.25**	**0.21**

Table (3c):

	Predialysis n=40	**Postdialysis n=40**	**t-value**	**P-value**
	Mean± SD	**Mean± SD**		
FS%	**37.7±4.2**	**37±5.9**	**0.56**	**0.57**
EF	**66.1±7.1**	**67.5±6.2**	**0.9**	**0.33**

Tables 4 shows that mitral E and E/A values in diseased children is less than those of control both in pre and postdialysis cases and shows a significant decrease of E and E/A values in cases after dialysis. The Mitral A value was increased in diseased than in control and decreased non significantly after dialysis.

Table (4): Comparison of LV Diastolic functions (Mitral inflow velocity measurement) in control, cases before and after Dialysis:

Table (4a):

		Control n=20	**Predialysis n=40**	**t-valu**	**P-value**
Mitral (cm/sec.)		**Mean±SD**	**Mean±SD**		
		115.3±12.9	**90.4±5.5**	**12.9**	**< 0.001**
		62.9±9.2	**75.1±6.8**	**5.7**	**< 0.001**
	E/A	**1.85±0.2**	**1.42±0.1**	**14.3**	**< 0.001**

Table (4b):

		Control n=20	**Post-dialysis n=40**	**t-value**	**P-value**
Mitral (cm/sec.)		**Mean±SD**	**Mean±SD**		
	E	**115.3±12.9**	**85.3±5**	**11.8**	**< 0.001**
	A	**62.9±9.2**	**74.1±7.0**	**3.25**	**0.01**

	E/A	1.85±0.2	1.14±0.1	14.3	< 0.001

Table (4c):

		Predialysis n=40	Postdialysis n=40	t-value	P-value
		Mean±SD	Mean±SD		
Mitral (cm/sec.)	E	90.4±5.5	85.3±5	2.005	< 0.001
	A	75.1±6.8	74.1±7.0	0.64	< 0.46
	E/A	1.42±0.1	1.14±0.1	2.0	< 0.001

Tables 5 shows that tricuspid E and E/A values in diseased are less than those of control both in pre and postdialysis cases and shows significant decrease of E and E/A values in cases after dialysis.

Table (5): Comparison of RV diastolic functions (Tricuspid inflow velocity measurement) in control, cases before and after dialysis

Table (5a):

		Control n=20	Predialysis N=40	t-value	P-value
		Mean±SD	Mean±SD		
Tricuspid (cm/sec.)	E	110.5±11.6	82±7.2	16.1	< 0.001
	A	81.8±10.1	83.7±7.2	0.8	0.42
	E/A	1.37±0.2	1.02±0.14	13.7	< 0.001

Table (5b):

		Control n=20	Postdialysis N=40	t-value	P-value
		Mean±SD	Mean±SD		
Tricuspid (cm/sec.)	E	110.5±11.6	73.4±6.2	15.8	< 0.001
	A	81.8±10.1	81.1±4.8	0.4	0.69
	E/A	1.37±0.2	0.87±0.003	5.4	< 0.001

Table(5c):

		Predialysis n=40	Postdialysis N=40	t-value	P-value
		Mean±SD	Mean±SD		
Tricuspid (cm/sec.)	E	82±7.2	73.4±6.2	2.9	< 0.001
	A	83.7±7.2	81.1±4.8	1.8	0.06
	E/A	1.02±0.14	0.87±0.003	6.8	<0.001

Tables 6 shows that both LV and RV Tei index values in diseased; whether before or after HD are significantly higher than in control.

Table (6): Myocardial performance index (Tei index) among control, cases before and after dialysis groups:

Table (6a):

	Control n=20	Predialysis n=40	t-value	P-value
	Mean±SD	Mean±SD		
Tei LV	0.34±0.04	0.51±0.05	12.2	< 0.001
Tei RV	0.35±0.02	0.48±0.05	12.2	< 0.001

Table (6b):

	Control	Postdialysis		
	n=20	n=40	t-value	P-value
	Mean±SD	Mean±SD		
Tei LV	0.34±0.04	0.50±0.03	15.4	< 0.001
Tei RV	0.35±0.02	0.46±0.04	9.9	< 0.001

Table (6c):

	Predialysis n=40	Postdialysis n=40	t-value	P-value
	Mean±SD	Mean±SD		
Tei LV	0.51±0.05	0.50±0.03	1.19	0.23
Tei RV	0.48±0.05	0.46±0.04	1.69	0.09

Tables 7 shows significant increase in both lateral and medial (septal) mitral E/E′ values in diseased than control group. Also, both lateral and medial mitral E/E′ showed significant decrease after dialysis.

Table (7): Comparison of Mitral E/E′ among control, cases before and after dialysis

Table (7a):

		Control n=20	Predialysis n=40	t-value	P-value
		Mean±SD	Mean±SD		
Mitral	Lateral	6.8±0.6	8.8±1.3	13.8	< 0.001
	Medial	5.9±0.2	8.0±1.0	15.1	<0.001

Table (7b):

		Control n=20	Post-dialysis n=40	t-value	P-value
		Mean±SD	Mean±SD		
Mitral	Lateral	6.8±0.6	7.1±1.0	11.2	< 0.001
	Medial	5.9±0.2	7.1±1.3	3.5	0.01

Table (7c):

		Predialysis n=40	Post-dialysis n=40	t-value	P-value
		Mean±SD	Mean±SD		
Mitral	Lateral	8.8±1.3	7.1±1.0	16.2	<0.001
	Medial	8.0±1.0	7.1±1.3	7.3	0.01

Tables 8 shows significant increase of both medial (septal) and lateral tricuspid E/E′ of diseased than control. Also shows significant decrease of both lateral and medial tricuspid E/E′ after dialysis.

Table (8): Comparison of tricuspid E/E′ among control, cases before and after dialysis

Table (8a):

		Control n=20	Predialysis n=40	t-value	P-value
		Mean±SD	Mean±SD		
Tricuspid	Lateral	6.1±0.32	7.9±0.6	11.1	<0.001
	Medial	6.5±0.25	8.4±1.0	13.2	<0.001

Table (8b):

	Control n=20	Postdialysis n=40	t-value	P-value

		Mean±SD	Mean±SD		
Tricuspid	**Lateral**	**6.1±0.32**	**7.0±0.6**	**6.2**	**0.01**
	Medial	**6.5±0.25**	**7.5±1.0**	**4.2**	**0.01**

Table (8c):

		Predialysis n=40	Postdialysis n=40	t-value	P-value
		Mean±SD	Mean±SD		
Tricuspid	**Lateral**	**7.9±0.6**	**7.0±0.6**	**8.4**	**0.01**
	Medial	**8.4±1.0**	**7.5±1.0**	**6.2**	**0.01**

DISCUSSION

Significant cardiac abnormalities in children with end-stage renal disease certainly contribute to the increased cardiovascular morbidity and mortality seen in this population. Because they lack adult habits like smoking, high blood pressure, and high glucose levels, children provide a great research population for this condition [(5)].

There is conflicting evidence about whether or not hemodialysis alters diastolic or systolic ventricular function in adults. In youngsters, there is a dearth of information about ESRD. Shortening fraction, ejection fraction, and velocity of circumferential fibre shortening are all measures of echocardiographic left ventricular systolic function that have been shown to be normal in the vast majority of adult and some pediatric investigations [(6)].

Systolic time intervals have been utilised in several papers to evaluate left ventricular systolic function. However, **Morris *et al.*** [(7)] discovered that a small percentage of their patients (17%) showed aberrant systolic time intervals and a decreased shortening fraction combined with clinical indications of congestive heart failure.

Patients with ESRD who have preexisting cardiac illness or who undergo prolonged and severe hemodynamic overload may have impaired systolic function. Although systolic function indices are typically normal or even elevated in individuals with ESRD who have no history of heart illness, diastolic filling is commonly changed in those on dialysis [(8)].

In our study ESRD cases have normal conventional left ventricular systolic function as evidenced by ejection fraction and fraction of shortening (66.1±7.1, 37.7±4.2 vs 69.6±5.8, 36.2±2.5, respectively) between cases with ESRD and control respectively. Also, we observed no significant change of EF and FS% after dialysis.

This observation is in keeping with previous reports of **Johnstone *et al.*** [(9)] who found that heart function and structure were evaluated using echocardiography in children and young adults with chronic renal failure, patients on chronic hemodialysis, and transplant recipients; they discovered no significant difference in systolic function between the groups, but only abnormalities in diastolic function.

In individuals with end-stage renal failure, peak inflow velocity measurements in the fast early (E) falling phase of diastole and the later atrially driven phase have been interpreted as evidence of aberrant ventricular diastolic function (A). Typically, the E/A ratio is lowered by decreasing the peak E wave velocity and increasing the peak A wave velocity. Most researchers explain this to the ventricle's decreased compliance as a result of hypertrophy; however, this explanation is overly simple because these indices are not accurate indicators of ventricular compliance [(5)].

Also contributing to impaired diastolic function in hypertrophied myocardium is lusitropic abnormalities (delayed relaxation), which arise from impaired calcium re-uptake by the sarcoplasmic reticulum. Temporarily extending the action potential is achieved by prolonging cytosolic calcium. Arrhythmias are encouraged by conduction anomalies related to fibrosis and hypertrophy, and delayed after-depolarization is a contributing factor [(10)].

Diastolic dysfunction in both ventricles may be caused by increased myocardial stiffness. Recent evidence indicates that uremia is associated with increased myocardial collagen content, also known as diffuse intermyocardiocytic fibrosis. Thus, fibrosis appears to be related to the decreased diastolic function [(10)]. Despite the existence of diastolic dysfunction, the E/A ratio can be restored to normal or even to an enhanced value by increasing preload in these people, a shift in Doppler pattern known as pseudo normalization[(11)].

Graham and colleagues [(12)] have found a considerable decrease in A velocity after a reduction in preload; however, this decrease in A velocity was considerably smaller than the decrease in E velocity, resulting in a decrease in the E/A ratio. Consequently, the idea that preload reduction might reveal diastolic dysfunction in such patients remains sound.

In accordance with all the above studies and findings, in the current study, on comparing ESRD cases with control, we found that the peak mitral E wave velocity was significantly decreased mean value (90.4±5.5) and the A wave velocity increased significantly with mean value (75.1±6.8) so that E/A ratio was also decreased than in control (P<0.001). The mean value of mitral E/A was (1.42±0.1) predialysis, which decreased post dialysis to (1.14±0.1). There was a significant post dialysis change in the E/A (P = < 0.001). Also mean value of tricuspid E/A ratio predialysis was (1.02±0.14) decreased post dialysis (0.87±0.003) with (P value < 0.001); thus reflecting diastolic impairment of the left and right ventricular function. Moreover, our results demonstrated that both mitral and tricuspid inflow velocities were markedly affected by preload changes; this was supported by **Garadah *et al.*** [(13)], and **Alarrayed *et al.*** [(14)] who reported that the net fluid loss (preload reduction) is directly proportional with reduction of early diastolic filling E and E/A ratio of the LV.

In our study, E′ of the lateral tricuspid show significant change postdialysis (12.2±1.8 vs 11.1±1.69, P=0.01) and A′ of the lateral tricuspid annulus (11.7±1.1 vs 10.2±1.4, P< 0.001) decreased significantly after HD so that lateral tricuspid E′/A′ ratio decreased significantly postdialysis (1.05±0.21 vs 1.01±0.28, P= 0.011).

No significant changes in both medial (septal) mitral and medial tricuspid E′/A′ velocities were observed after dialysis, this is in concordance with **Graham *et al.*** [12] about preload independence of septal mitral annulus.

So, in conclusion about myocardial annular tissue velocity in our study, we found that lateral mitral and lateral tricuspid E′/A′ were load dependent, while septal mitral and septal tricuspid E′/A′ were load independent so it may be used as a good diagnostic parameter of diastolic dysfunction in our cases.

CONCLUSION

Significant cardiac abnormalities are a known risk factor for the increased cardiovascular mortality in children with CRF. so routine cardiac evaluation should be part of the management protocols in order to detect and revise factors associated with increased morbidity to improve survival and quality of life of these children. MPI assessing global function of both RVand LV were load independent in our cases but taking into consideration weight reduction in our cases is limited; about 1 Kg.

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