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Echocardiographic Findings in Children of Chronic Kidney Disease

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Patients with Chronic Kidney Disease (CKD) are at significantly increased risk for both morbidity and mortality from cardiovascular disease (CVD). Determining the spectrum of echocardiographic abnormalities in these patients can help in reduction of morbidity and mortality from CKD.
Materials and Methods: This cross-sectional study was held on department of Pediatric Nephrology, Dhaka Shishu Hospital, Dhaka, during July 2018 to December 2018 (Six months). A total of thirty-six children with chronic kidney disease with creatinine clearance <60ml/min/1.73 m2 and age ranged from 2 to 16 years on supportive treatment and hemodialysis were included. In control group equal number of age and sex matched healthy children without any preexisting renal or cardiovascular diseases were included. Both study group and control group were assessed for cardiovascular findings by echocardiography.
Results: The mean age was 9.09±3.01 years (mean±SD) in case group and 7.85±3.69 years (mean±SD) in control group. Regarding sex, 22 patients (61.1%) in the case group were male and 14 (38.9%) were female. In this study, in CKD patients significant (p<0.001) difference was

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observed in following cardiac parameters, left ventricular end diastolic diameter (LVEDD) (38.34 vs 34.52), left ventricular end systolic diameter LVESD (26.64 vs 20.75), interventricular septal thickness (IVS) (9.34 vs 7.27), left ventricular posterior wall thickness (LVPWT) (8.36 vs 7.46), ejection fraction (EF) (56.68% vs 70.36%), fractional shortening (FS) (31.88% vs 38.30%) and peak early diastole velocity/peak atrial filling velocity (E/A ratio) (1.15 vs 1.45) when compared to control group. Most common cardiac abnormality in children with chronic kidney disease were left ventricular systolic dysfunction (44.4%), mild pulmonary hypertension (30.6%) and left atrial dilatation (27. 8%).

Conclusion: Left ventricular systolic dysfunction was the commonest echocardiographic findings in CKD children. There was also significant difference in diastolic function between study and control group.

Keywords: Chronic kidney disease; echocardiography; risk factors; child.

1. INTRODUCTION

Chronic kidney disease (CKD) encompasses a spectrum of different pathophysiologic processes associated with abnormal kidney function and a progressive decline in glomerular filtration rate (GFR) [1]. It is an important cause of morbidity and mortality in children worldwide [1,2]. Scientific and technologic improvements during the second half of the 20th century provided renal replacement therapy as a life-sustaining option for many individuals who otherwise may have died [2,3]. In the past 2 decades, the incidence of the chronic kidney disease in children has steadily increased. The Kidney Disease Outcomes Quality Initiative (KDOQI) working group of the National Kidney Foundation (NKF) defined chronic kidney disease as evidence of structural or functional kidney abnormalities (abnormal urinalysis, imaging studies, or histology) that persist for at least 3 months, with or without a decreased glomerular filtration rate (GFR), as defined by a GFR of less than 60 ml/min per 1.73 m^2 [2,3] Patients with CKD are at significantly increased risk for both morbidity and mortality from cardiovascular disease (CVD) [4]. Patients on dialysis have a 10 to 30 fold increased risk for cardiovascular mortality compared with the general population. CVD is the single most important cause of death among patients receiving long-term dialysis, accounting for 44% of overall mortality [5-8]. Coronary artery disease including myocardial infarction, congestive heart failure (CHF) and pericardial disease are the common manifestations of major cardiovascular abnormalities in the End stage renal disease (ESRD) [4,9]. Heart failure accounts for 15%, myocardial infarction for about 10% and pericarditis for about 3% of dialysis associated mortality [10-18]. Sudden cardiac death may be related to the high prevalence of left ventricular dysfunction secondary to the LVH in dialysis patients [19,20]. The known common cardiac abnormalities in ESRD are increase in LV cavity size, thickened LV posterior wall, thickened interventricular septum, region wall motion abnormality, decrease in LV compliance, pericardial effusion and calcific/sclerotic valves [21,22]. Changes in cardiac structure and function detected by echocardiography are common in patients with CKD undergoing hemodialysis, and have been recognized as key outcome predictors [23,24]. This study is intended to find out the echocardiographic abnormalities and cardiovascular risk assessment in CKD in children of Bangladesh. This effort was to help target key patient population at risk by quantifying the extent of the problem, and by facilitating an assessment of the impact of intervention.

2. MATERIALS AND METHODS

It was a cross sectional study done on department of Pediatric Nephrology, Dhaka Shishu Hospital, Dhaka, six months from the day of approval. All children aged 2 to 16 years with chronic kidney disease (GFR<60ml/min/1.73m^2) got treatment from the Department of Pediatric Nephrology of Dhaka Shishu Hospital, Dhaka were enrolled in the study. Equal number of age and sex matched healthy control were also enrolled. The patient or the guardian who refused to participate in the study, children under 2 years and above 16 years of age and GFR ≥60 ml/min/1.73m^2 and known case of any preexisting cardiac diseases were excluded from this study. Patients were approached for participation either in the inpatient or outpatient setting after taking informed written consent. Children with chronic kidney disease getting treatment or follow up, who fulfilled the inclusion criteria were enrolled in the study. Demographic

data regarding information about age, relationship of respondent to child, parental education status and socio-economic status were collected from guardian or parents [25-29]. Medical data regarding diagnosis, treatment status, follow up were obtained from the patient's medical record [33-34]. Demographic and medical data regarding risk factors taken. For checking cardiac status, clinical examination done. Patients with already known cardiac disease were excluded. The purpose of study was explained to all the patients. Echocardiography was done by consultant cardiologist of cardiology department of Dhaka Shishu Hospital. All findings were noted and record was kept. Left ventricular systolic function was taken as LVEF and fractional shortening (FS). E/A ratio showed diastolic dysfunction. E is peak early diastole velocity and A is peak arterial filling velocity of left ventricle across mitral valve. E/A ratio less than 0.75 and more than 1.8 was considered as diastolic dysfunction. LVH was diagnosed when interventricular septum thickness or left ventricular posterior wall thickness ≥12 mm.

Fractional shortening (s) calculated as

FS (%) = (LVDd-LVDs) x 100 Normal range being 25% to 45%

LVDd: Left ventricle internal diameter in diastole
LVDs: Left ventricle internal diameter in systole

Ejection fraction calculated as

LVEF (%) = (LVVd-LVVs) x 100
Normal= 59.2%±6%

LVVd: Left ventricle volume in diastole
LVVs: Left ventricle volume in systole

The data from patients was collected on a proforma.

Data was collected by preformed questionnaires. Data was processed and analyzed by using the SPSS Windows (version 20.0) programs. P value < 0.05 was considered statistically significant.

3. RESULTS

This cross sectional study was carried out with an aim to determine the echocardiographic findings and cardiovascular risk factor assessment in different stages of CKD in children in Bangladesh. A total of 36 children age ranged from 2-16 years with chronic kidney disease receiving treatment from Dhaka Shishu Hospital and equal number age and sex matched control were included in this study.

Table 1 shows the average age was 9.09±3.01 years in case group and 7.85±3.69 years in control group. Male Female ratio in case is 1.5**:**1 vs 0.8**:**1 in control. Most of the study cases 61.1% vs 86.1% control were from rural . In socio-economic status 25% were from poor socioeconomic, 47.2% were from lower middle socioeconomic class in cases group, on the other hand 19.4% were from poor socioeconomic class, 72.2% were from lower middle socioeconomic class in control group. In case group, 44.4% father were businessman & 91.7% mother were housewife whereas 94.4% mother in control group were housewife. In both case and control groups 25% were non immunized.

Table 2 shows higher percentage of stage 3 in 2-5 years (100%) and higher percentage of stage 5 in 5-10 years (46.7%). The difference was statistically significant between stage and age group (P=0.010).

Table 3 shows in WAZ 52.8% of case were <3rd percentile, 30.6% were 3rd -50th percentile and 16.7% >50th percentile On the other hand in control 2.8%, 36.1% and 61.1% respectively (p= .001). In HAZ 55.6% case were <3rd percentile 30.6% 3rd -50th percentile and 13.9% were >50th percentile but in control group it was 13.9%, 47.2% and 38.9% respectively (p= .001). BMI shows 88.9% of case were underweight and 11.1% were within normal weight and 30.6% control were underweight and 69.4% were within normal weight which is also statistically significant.

Table 4 shows 33.3% cases were normotensive and 63.9% had stage 2 hypertension but all were normotensive in control group. The difference is statistically significant between two groups (P=0.001).

Table 5 shows statistically significant difference in hemoglobin and serum parathyroid level between stage 3,4,5. Hemoglobin level is significantly low and parathyroid hormone is high in stage 5 CKD.

This Table 6 shows there is statistically significant difference between case and control among all recorded echocardiographic parameters eg LVEDD, LVESD, IVS, LVPWT, EF(%), FS(%), E/A ratio.

Table 1. Demographic characteristics of case and control (n=72)

Characteristics	Case (n=36)		Control (n=36)		P value
	No	%	No	%	
Mean age (years±SD)	9.09±3.01		7.85±3.69		0.122
Sex					
Male	22	61.1	16	44.4	0.157
Female	14	38.9	20	55.6	
Male**:** Female	1.5**:**1		0.8**:**1		
Residence					
Rural	22	61.1	31	86.1	0.031
Urban	12	33.3	3	8.3	
Urban slum	2	5.6	2	5.6	
Socio-economic					
Poor	9	25.0	7	19.4	0.093
Lower middle	17	47.2	26	72.2	
Upper middle	8	22.2	3	8.3	
Father occupation					
Service holder	6	16.7	5	13.9	0.084
Businessman	16	44.4	8	22.2	
Others: (Farmers,Shopkeeper)	14	38.9	23	63.9	
Mother's occupation					
House wife	33	91.7	34	94.4	0.643
Service holder	3	8.3	2	5.6	
Immunized status					
Immunized	22	61.1	25	69.4	0.478
Partially immunized	5	13.9	2	5.6	
Non immunized	9	25.0	9	25.0	

P value reached from chi square test

Table 2. Age distribution of study patients according to stage of CKD (n=36)

Age group	Number	Stage 3		Stage 4		Stage 5		P value
		No	%	No	%	No	%	
2-5	6	2	100	0	00	4	13.3	
5-10	16	0	00	2	50.0	14	46.7	0.010
10-16	14	0	00	2	50.0	12	40.0	

P value reached from chi square test

Table 3. Anthropometry of study patients and control (n=72)

Anthropometry	Case (n=36)		Control (n=36)		P value
	No	%	No	%	
WAZ					
<3rd percentile	19	52.8	1	2.8	0.001
3rd -50th percentile	11	30.6	13	36.1	
>50th percentile	6	16.7	22	61.1	
HAZ					
<3rd percentile	20	55.6	5	13.9	0.001
3rd -50th percentile	11	30.6	17	47.2	
>50th percentile	5	13.9	14	38.9	
BMI					
Under weight (<18.5)	32	88.9	11	30.6	0.001
Normal (18.5-24.9)	4	11.1	25	69.4	
Overweight (25 -29.9)	0	00	0	00	
>Obese (>30)	0	00	0	00	

P value reached from chi square test

Table 4. Blood pressure values between case and control (n=72)

Blood pressure	Case (n=36)		Control (n=36)		P value
	No	%	No	%	
Normotensive	12	33.3	36	100	
Stage 1 HTN	1	2.8	0	00	0.001
Stage 2 HTN	23	63.9	0	00	

P value reached from chi square test

Table 5. Hematological & biochemical features of different stages of CKD (n=36)

Parameters	Stage 3 Mean±SD	Stage 4 Mean±SD	Stage 5 Mean±SD	P value
Hb% (g/dl)	11.00±2.12	9.20±1.43	7.34±1.22	0.001
Serum K+ (mmol/L)	4.50±0.42	4.40±0.27	5.35±0.922	0.074
Serum calcium (mmol/L)	2.10±0.28	2.12±0.22	2.00±0.23	0.554
Serum phosphate (mmol/L)	2.10±0.0	2.12±0.18	2.44±0.40	0.07
Serum PTH (pg/ml)	275.50±62.93	611.00±369.80	845.26±546.59	0.027

P value reached from anova test

Table 6. Echocardiographic measurement of different cardiovascular parameter between case and control (n=72)

Parameter	Case (n=36)	Control (n=36)	t value	P value
	Mean±SD	Mean±SD		
LVEDD (mm)	38.34±8.80	34.52±6.56	2.082	0.041
LVESD (mm)	26.64±3.46	20.75±4.84	3.594	0.001
IVS (mm)	11.34±2.08	7.27±1.81	4.502	0.001
LVPWT (mm)	10.36±3.69	7.46±1.61	2.287	0.025
EF (%)	54.68±14.32	70.36±7.69	5.047	0.001
FS (%)	29.88±9.93	38.30±7.58	3.079	0.003
E/A ratio	1.15±0.58	1.45±0.25	2.807	0.007

P value reached from student 't' test

LVEDD : Left Ventricular End Diastolic Diameter, LVESD: Left Ventricular End Systolic Diameter
IVS: Interventricular Septal Thickness
LVPWT: Left Ventricular Posterior Wall Thickness, EF: Ejection Fraction, FS: Fractional Shortening, E: Peak early diastole velocity, A: Peak atrial filling velocity

Table 7. Echocardiographic parameters in different stage of CKD (n=36)

	Stage 3 Mean±SD	Stage 4 Mean±SD	Stage 5 Mean±SD	P value
Left ventricular structure				
LVEDD (mm)	29.50±4.94	34.56±7.14	39.43±8.88	0.204
LVESD (mm)	17.50±3.53	23.13±5.35	27.71±8.73	0.182
IVS (mm)	9.00±1.41	9.42±2.32	10.56±2.07	0.390
LVPWT (mm)	9.50±0.70	9.92±2.07	11.41±1.72	0.866
Systolic function				
FS	41.50±0.70	31.75±3.50	31.26±10.54	0.116
EF	74.00±1.41	63.00±5.88	54.68±14.62	0.381
Diastolic function				
E/A ratio	1.05±0.21	1.17±0.09	1.53±0.61	0.316

P value reached from anova test

Table 8. Comparison of Echocardiographic findings between case and control (n=72)

Outcome	Case (n=36)		Control (n=36)	
	No	%	No	%
Left ventricular systolic dysfunction	16	44.4	0	00
Mild pulmonary hypertension	11	30.6	0	00
Left Atrial Dilatation	10	27.8	0	00
Minimum pericardial effusion	3	8.3	0	00
Mitral Regurgitation	4	11.1	0	00
Concentric LVH	2	5.6	0	00
Hypertrophied cardiomyopathy	2	5.6	0	00
Trivial Mitral Regurgitation	2	5.6	2	5.61
Patent foramen ovale (PFO)	3	8.3	0	00

Table 9. Percentage of Left Ventricular Dysfunction in Study Cases

Echocardiographic finding in cases	No. of cases	Percentage
Left ventricular systolic dysfunction :		
Fractional shortening (< 25%)	10	27.7%
Ejection fraction (< 59%)	16	44.4%
Left ventricular diastolic dysfunction:		
E/A ratio (<0.75 or >1.8)	7	19.4%
Left ventricular hypertrophy:		
IVS (>12mm)	3	8.3%
LVPWd (>12mm)	3	8.3%

Table 7 shows there was no statistically significant difference in left ventricular structure, systolic and diastolic function between stage 3, stage 4 and stage 5.

Table 8 shows that 44.4% case had left ventricular systolic dysfunction, 30.6% had mild pulmonary hypertension, 27.8% had left atrial dilatation, 8.3% minimum pericardial effusion, 5.6% had concentric LVH and 5.6% had hypertrophied cardiomyopathy as their ultimate outcome on echocardiography.

This Table 9 shows FS (<25%) present in 27.7%, EF(<59%) in 44.4% cases both of which indicates Left Ventricular Systolic Dysfunction. Altered E/A ratio present in 19.4% patients which indicates Left Ventricular Diastolic Dysfunction. IVS (>12mm) and LVPWd (>12mm) both present in 8.3% cases respectively which indicate Left Ventricular Hypertrophy.

4. DISCUSSION

This cross-sectional study was carried out with an aim to determine the common echocardiographic findings and cardiovascular risk factors assessment in different stages of CKD in children in a tertiary care hospital in Bangladesh as well as their socio demographic parameters. A total of 36 children age ranged from 2-16 year with chronic kidney disease receiving treatment from the Department of Pediatric Nephrology, Dhaka Shishu Hospital and equal number to age and sex matched control were included in this study. The present study findings were discussed and compared with previously published relevant studies.

The present study shows the average age was 9.09±3.01 years (mean±SD) in case group and average age was 7.85±3.69 years (mean±SD) in control group similar to Hafiz I.N. et al. [35] where average age 9.88±3.92 years in case vs 10.72±2.88 years in control. The findings of the study are in well agreement with the findings of the other research works (Al-Doori et al.) [36].

In this study, 22 patients (61.1%) in the case group were male and 14 case (38.9%) were female and ratio was 1.5**:**1. However, this consistent results obtained in other studies, like Harambat et al. [37] where the higher prevalence of CKD in males. Another study Al-Doori et al. found 19 patients (47.5%) in the cases group were male and 21 cases (52.5%) were female which was not similar.

In the present study we found that a statistically significant decrease in Z-score for (Weight, Height and Body Mass Index) in the CKD patients group than control. Our study was in agreement with Hafiz I.N. et al. who found that there were growth deficit in anthropometric parameters in dialysis children compared to healthy control.

In terms of blood pressure, 66.7% of patients in the cases group were hypertensive (P = 0.001), though other studies show a similar prevalence. Mukesh L. et al. [38] found 37.1% cases were hypertensive which was contrary with our results. Many factors contribute to the raised incidence of hypertension in CKD patients. They include sodium retention, increased activity of the renin-angiotensin-aldosterone system, an exaggerated activity of the sympathetic nervous system, secondary hyperparathyroidism, deficient nitric oxide and endothelium-mediated vasodilation. Kale et al. [39] had found that hypertension was identified as important risk factor for all three Left ventricular disorder (Left ventricular hypertrophy, diastolic & systolic dysfunction). Systolic, diastolic and mean BP was separately and significantly associated with LV disease. There was no significant difference of hypertension among CKD stages in this study.

In the present study, the CKD Patients were anemic with significant decrease in hemoglobin level. Anemia found in 35 patients (97.2%) in the case group than control (P=0.001), in agreement with our results Mukesh L. et al. who found that CKD patients (patients vs controls) presented with anemia with significant low Hb (9.1 gm/dL vs 12.04 gm/dL) with P value <0.001. In this study there was statistically significant difference in hemoglobin level among different stages of CKD (P = .001). CKD stage 5 children had significantly lower hemoglobin level.

In this study, CKD patients had a left ventricular end diastolic diameter (LVEDD) (38.34 vs 34.52, P = 0.041), left ventricular end systolic diameter LVESD (26.64 vs 20.75, P = 0.001), interventricular septal thickness (IVS) (9.34 vs 7.27, P=0.001), left ventricular posterior wall thickness (LVPWT) (8.36 vs 7.46, P=0.025), ejection fraction (EF) (56.68 vs 70.36, P=0.001), fractional shortening (FS) (31.88 vs 38.30, P=0.003) and peak early diastole velocity/peak atrial filling velocity (E/A ratio) (1.45 vs 1.15, P= 0.007) in comparison to controls. These results are consistent with those obtained by Adiele et al., Malikenas et al. [40] and van Huis et al. [41]. Increased LVEDD, LVESD, IVS, LVPWT in comparison to control indicate LVH. In this study 16.6% case had definite Left Ventricular Hypertrophy.

In this study left ventricular systolic dysfunction (44.4%), mild pulmonary hypertension (30.6%), left atrial dilatation (27.8%), minimal pericardial effusion 8.3% was noted in this study to be the most common cardiac abnormality in children and tends to develop early in the disease and cuts across all the stages of CKD. Therefore, the findings of the study are in well agreement with the findings of the other research works (Adiele et al.).

In studies using different methodologies, the prevalence of the LV systolic dysfunction varied from 15% to 18% in patients undergoing dialysis (starting the treatment or undergoing regular chronic therapy, respectively), reaching 28% in individuals assessed at the moment of the renal transplant. In this study we found systolic dysfunction in 44.4% cases among them all had low ejection fraction (<59%) and 27.7% had low fractional shortening (<25%).

The analysis of LV diastolic parameters on the basis of E/A ratio was significantly altered in CKD patients as compared to controls, P value in our study is 0.007 in comparison to controls. Left ventricular diastolic dysfunction is an important cause of cardiac morbidity in end stage renal disease. We found 19.4% case had definitive left ventricular diastolic dysfunction. In concordance with our results Schoenmaker et al. [41] who found that diastolic dysfunction in 20-22% of children on regular hemodialysis but S.Agarwal et al. [42] had observed diastolic dysfunction in 60% and systolic dysfunction in 15% of patients and its findings were not consistent with our study.

The specific Left ventricular hypertrophy prevalence documented in this study is similar to the reports by Nashwa et al. [43] in similar group of patients in Australia and El-Husseini et al. [44] in post- transplant patients in Egypt. However, this Left ventricular hypertrophy prevalence rate similar compared to 16-31% reported in similar groups of patients by some authors from Cincinnati, United States of America and Canada. The relatively high prevalence rate of systolic dysfunction in this study could be attributed to factors such as poor standard of health services, low level of health awareness, drug abuse and use of herbal concoctions, poor

health seeking behavior and extreme poverty, all of which could be a contributor to the late presentation and late initiation of appropriate therapy seen amongst most of the patients with CKD in the sub region.

5. CONCLUSION

Left ventricular systolic dysfunction was the commonest echocardiographic findings in CKD children.

ETHICAL APPROVAL AND CONSENT

Certificate from the ethical review committee of Dhaka Shishu Hospital, Dhaka was obtained for the study. Written informed consent was taken from the legal guardian of the patient.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. US Renal Data System (USRDS). 2010 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States. Bethesda, Md: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2010.
2. Kopple JD. National kidney foundation K/DOQI clinical practice guidelines for nutrition in chronic renal failure. Am J Kidney Dis. 2001;37(1 Suppl 2):S66-70.
3. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Am J Kidney Dis. 2002;39(2 Suppl 1):S1-266.
4. Wilson AC, Mitsnefes MM. Cardiovascular disease in CKD in children: update on risk factors, risk assessment, and management. Am J Kidney Dis. 2009;54:345-360.
5. Chavers BM, Li S, Collins AJ, Herzog CA. Cardiovascular disease in pediatric chronic dialysis patients. Kidney lnt. 2002;62:648-653.
6. Ardissino G, Dacco V, Testa S Epidemiology of chronic renal failure in children: data from the ItalKid project. Pediatrics. 2003;111(4 Pt 1):382-7.
7. Seikaly MG, Ho PL, Emmett L. Chronic renal insufficiency in children: the 2001 Annual Report of the NAPRTCS. Pediatr Nephrol. 2003;18(8):796-804.
8. Voroneanu L, Covic A. Arrhythmias in hemodialysis patients. J Nephrol. 2009;22(6):716—25.
9. Groothoff JW, Gruppen MP, Offringa M, Hutten J, Lilien MR. Mortality and causes of death of end-stage renal disease in children: a Dutch cohort study. Kidney Int. 2002;61: 621-629.
10. Benjamin EBS, Frishberg FY. A comprehensive study of cardiovascular risk factors, cardiac function and vascular disease in children with chronic renal failure. Nephrology Dialysis Transplantation. 2010;25(Issue 3):785–793.
11. El-Gamasy MA, Mawlana WH. Risk factors and prevalence of cardiac diseases in Egyptian pediatric patients with end-stage renal disease on regular hemodialysis. Saudi J Kidney Dis Transpl. 2019;30:53-61.
12. Mitsnefes MM. Cardiovascular disease in children with chronic kidney disease. J Am Soc Nephrol. 2012;23(4):578–585.
13. Hüting J. Mitral valve calcification as an index of left ventricular dysfunction in patients with end-stage renal disease on peritoneal dialysis. Chest. 1994;105:383-388.
14. Buckalew VM Jr, Berg RL, Wang SR. Prevalence of hypertension in 1,795 subjects with chronic renal disease: the modification of diet in renal disease study baseline cohort. Modification of Diet in Renal Disease Study Group. Am J Kidney Dis. 1996;28(6): 811–21.
15. Neumann J, Ligtenberg G, Klein, II. Sympathetic hyperactivity in chronic kidney disease: pathogenesis, clinical relevance, and treatment. Kidney Int. 2004; 65(5): 1568–76.
16. Passauer J, Pistrosch F, Bussemaker E. Reduced agonist-induced endothelium-dependent vasodilation in uremia is attributable to an impairment of vascular nitric oxide. J Am Soc Nephrol. 2005;16(4):959–65.
17. Raine AE, Bedford L, Simpson AW, et al.: Hyperparathyroidism, platelet intracellular free calcium and hypertension in chronic renal failure. Kidney Int. 1993;43(3):700–5.

18. Cullis JO: Diagnosis and management of anaemia of chronic disease: current status. Br J Haemato. 2011;154(3):289–300.
19. Krzesinski JM, Sumaili KE, Cohen E. How to tackle the avalanche of chronic kidney disease in sub-Saharan Africa: the situation in the Democratic Republic of Congo as an example. Nephrol Dial Transplant. 2007;22:332-335.
20. Agarwal SK, Dash SC, Irshad M, Raju S, Singh R, Pandey RM. Prevalence of chronic renal failure in adults in India. Nephrol Dial Transplant. 2005;20:1638-42.
21. Van der Heijden BJ, Van Dijk PC, Varrier-Jones K, Jager KJ, Brigs JD. Renal replacement therapy in children: data from 12 registries in Europe. Pediatr Nephrol. 2004;19:213-221.
22. Chavers BM, Li S, Collins AJ, Herzog CA. Cardiovascular disease in pediatric chronic dialysis patients. Kidney mt. 2002; 62:648-653.
23. Mitsnefes M, Ho PL, McEnery PT Hypertension and progression of chronic renal insufficiency in children: a report of the North American Pediatric Renal Transplant Cooperative Study (NAPRTCS). J Am Soc Nephrol. 2003;14:2618-2622.
24. Fivush BA, Jabs K, Neu AM Chronic renal insufficiency in children and adolescents: the 1996 annual report of NAPRTCS. North American Pediatric Renal Transplant Cooperative Study. Pediatr Nephrol. 1998;12:328-337.
25. Bruch C, Rothenburger M, Gotzmann M, Wichter T, Scheld HH, Breithardt G, et al. Chronic kidney disease in patients with chronic heart failure: impact on intracardiac conduction, diastolic function and prognosis. Int J Cardiol. 2007;118(3):375-80.
26. North American Pediatric Renal Transplant Cooperative Study (NAPRTCS) (2005) 2005 annual report. The EMMES Corporation, Rockville, MD.
27. Han P, Singla HK, Mantan M, Kanitkar M, Batra B, Bagga A. Chronic renal failure in children. Indian Pediatr. 2003;40:1035-1042.
28. Hamed RMA. The spectrum of chronic renal failure among Jordanian children. J Nephrol 2002;15:130-135.
29. Anochie I, Eke F. Chronic renal failure in children: a report from Port Harcourt, Nigeria (1985—2000). Pediatr Nephrol. 2003;18:692-695.
30. Bradley A, Warady, Vimal Chandha. Chronic kidney disease in children: the global perspective. Pediatr Nephrol. 2007;22:1999-2009.
31. Available:http://www. kidney.org/professionais/kdoqi/guidelines_ bp/guide_13.htm acc-essed 13 Dec-05.
32. Foley RN, Parfrey PS, Sarnak MJ. Epidemiology of cardiovascular disease in chronic renal disease. J Am Soc Nephrol. 1998;9:S16-S23.
33. Manjunath G, Ibrahim H. Level of kidney function as a risk factor for atherosclerotic cardiovascular outcomes in the community. J Am Coil Cardiol. 2003;41:47-55.
34. Yap HK, Liu ID, Tay WC. Paediatric nephrology: On-the-go children kidney center. 2012:24.
35. Iman N, Hafez et al. AL-Azhar Assiut Medical Journal. January 2015;13(1).
36. Al-Doori TF, El-Salam A, Al-Ethawi D, Hasan JS, Al-Kaaby BA. Towards cardiovascular risks in children with chronic kidney disease: a prospective cohort study. F1000 Research. 2018;7:1-15.
37. Harambat J, van Stralen KJ, Kim JJ. Epidemiology of chronic kidney disease in children. Pediatr Nephrol. 2012;27(3):363–73.
38. Mukesh L et al. Journal of the Association of Physicians of India. January 2016;62.
39. Kale SA et al. Left ventricular disorder in patients of end stage renal disease entering hemodialysis programme. Indian J Nephrol. 2001;11:12-16.
40. Malikenas A, Cerniauskiene V, Jakutovic M, Jankauskiene A. Left ventricular geometry in children with chronic renal failure. Medicina (Kaunas). 2005;41 Suppl 1:5-11.
41. Van Huis M, Schoenmaker NJ, Groothoff JW. Impaired longitudinaldeformation measured by speckle-tracking echocardiography in children with end-stage renal disease. Pediatr Nephrol. 2016;31(9):1499–508.
42. S agarwal, P Dangri, OP Kalra, S Rajpal. Echocardiographic assessment of cardiac dysfunction in patients of chronic renal failure. JIACM. 2003;4:296
43. Nashwa MS, Bahia HM, Fatina IF. Prevalence of viral infection among Egyptian children with end stage renal

disease. Aust J Basic Appl Sci. 2009;3:3479-3491.

44. El-Husseini AA, Sheashaa HA, Hassan NA, El-Demerdash FM, Sobh MA. Echocardiographic changes and risk factors for left ventricular hypertrophy in children and adolescents after renal transplantation. Pediatr Transplant. 2004;8:249-254.

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