Original Article

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Assessment of Left Ventricular Hypertrophy and Dysfunction in Patients of Chronic Kidney Disease

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Abstract

Background: India experiencing an alarming increasing the burden of non-communicable diseases, like the prevalence of obesity and diabetes mellitus. Prevalence of CKD is also rising parallel but about this disease studied done infrequently, so the data on incidence of CKD is sparse. Cardiovascular disease can causing 50% fatality in these patients irrespective of biological age. According to international registries death in dialysis population that are occurring due to cardiac disease occurring up to 40%. Cardiovascular related morbidity and mortality that are associated with LVH is highly analytical for future progression that occurring in CKD patients.**Subjects and Methods:** This study was done in the Department of Medicine of TMMC & RC, TMU, MORADABAD, U.P. it was a Cross-sectional Observational Study.100 cases will be taken from OPD and IPD setting in TMMC & RC, TMU, Moradabad, U.P.Diagnosed cases of CKD patients aged >18 years of both sexes admitted in IPD or visiting to OPD in Teerthanker Mahaveer medical College & Hospital, Moradabad. Those who were give valid consent.Cases below 18years of age, pregnant women. All cases of acute renal failure. All known primary case of IHD, CHF, RHD, Cardiomyopathies and any other cardiac disorders.**Results:**Majority (54.0%) of sample were in the age group of 54 and above years, most (64.0%) of them were males.It revealed that, the mean body weight of the sample was 55.0±8.42 Kg, the mean Systolic Blood Pressure (mmHg) of the sample was 144.56±19.88 mmHg. Mean Diastolic Blood Pressure (mmHg) of the sample was 91.02±9.23 mmHg.ECG revealed that, around 65% of the sample had LVH.2-D ECHO-LVH/LV Function reveled that, around 36% AND 33% of the sample have Mild concentric LVH and Moderate LV systolic dysfunction and LVH respectively.Majority (71.0%) of the sample have reduced ejection fraction.**Conclusion:**Left ventricular hypertrophy and dysfunction is a veryimportant preventive feature of CKD associated cardiomyopathy.There is increased chance of left ventricular hypertrophy in CKD patients.With respect to category of chronic kidney disease, the LVH prevalence is progressively increases with increasing severity of CKD (chronic kidney disease).Blood pressure control is very important step to forestall the development of CKD and other related damage of end organs.

Keywords: Left Ventricular Hypertrophy, CKD.

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Introduction

India experiencing an alarming increasing the burden of non-communicable diseases, like the prevalence of obesity and diabetes mellitus. Prevalence of CKD is also rising parallel but about this disease studied done infrequently, so the data on incidence of CKD is sparse.[1]

CKD confers increased risk for CHF, disease of coronary arteries or fatality in these individuals by the mostly cardiovascular reasons.[2] In CKD patient's diastolic dysfunction of left ventricle occurring very often and related with the failure of heart (HF) with high fatality.[3] Another studies shows that severity of CKD is causing impaired LV filling pressure along with impaired diastolic & systolic function of heart in mostly predialysis patients and it is most autonomous predictor and could be answerable in these patients.[4] Even in primary stages of kidney dysfunction LV diastolic dysfunction is seen. Either diastolic or systolic dysfunction can causing clinically CHF.[5] Systolic dysfunction of left ventricle is related with the severe coronary artery disease & it is play a factor for further progression of disease.[6]

Cardiovascular disease can causing 50% fatality in these patients irrespective of biological age.[7,8] According to international registries death in dialysis population that are occurring due to cardiac disease occurring up to 40%.[9] Patients with ESRD who starting on haemodialysis prevalence of these disease is very high in these patients, that suggesting that it might be occurring in CKD patients in large percentage since very initial stages.[10,11] In, annual report year 1997 by 'US Renal Data System (USRDS)' revealed that in patients with chronic renal failure fatality occurring in 48% of cases by cardiac causes.[8]

LVH is an independent factor for fatality in patients who are on dialysis.[12,13] Its occurrence is very high in ESRD patients who are on hemodialysis.[14]

Cardiac Left ventricular dilatation and hypertrophy is defined as (LVMi) in female>100 g/m& in male >131 g/m. LVH was detected in nearly 75% of patients at start of dialysis.[15]

The incidence of LVH in common population is 15–21% but it influences 50.0%–70.0% of patients during the intermediate stages of CKD and up to 90.0% of the patients with ESRD.[14,16,17,18]

According to the 'kidney disease improving global outcomes (KDIGO) CKD classification' cardio vascular related risk becoming very high particularly in stage 3b-4 class of renal disease and in those patients who are on renal replacement therapy.[19]

Aim

- To study LVH and dysfunction in patient of CKD.

Objectives

- Identify the LVH and LV dysfunction with ECG/ECHO and correlate with stages of CKD.
- Identify and correlate correctable causes of LVH.

Subjects and Methods

This study was done in the Department of Medicine, Teerthanker Mahaveer Medical College and Research Centre, (Moradabad) for one year period.

Study Setting: This study was done in the Department of Medicine of TMMC & RC, TMU, MORADABAD, U.P.

Study Design: Cross-sectional Observational Study

Study Period: One year after approval from ethical committee.

Sampling Method: Purposive Sampling

Sample Size: 100 cases will be taken from OPD and IPD setting in TMMC & RC, TMU, Moradabad, U.P.

Selection of Subject: Patients were selected on the basis of Inclusion & Exclusion criteria.

Inclusion Criteria:

a) Diagnosed cases of CKD patients aged >18 years of both sexes admitted in IPD or visiting to OPD in Teerthanker Mahaveer medical College & Hospital, Moradabad.
b) Those who were give valid consent.

Exclusion Criteria:

a) Cases below 18years of age.
b) Pregnant women.
c) All cases of acute renal failure.
d) All known primary case of IHD, CHF, RHD, Cardiomyopathies and any other cardiac disorders.

Test Performed

All subjects, relevant detailed history was obtained along with salient clinical findings according to the pre-designed proforma and laboratory reports of the patients was collected and analysed.

a. The patient was undergone following Investigations:
   - Complete Blood Count
   - Random blood sugar
   - Kidney Function Test
   - Spot urinary protein creatinine ratio/24-hour urinary protein
   - ECG

b. The patients than were subjected to resting 2-D transthoracic echocardiography and were be evaluated for
   - Left atrium/Left ventricular dimension.
   - Left ventricular hypertrophy.
   - Left ventricular function.
   - Ejection fraction.
   - Pulmonary artery hypertension.

Results

The data presented in [Table 1] revealed that, majority (54.0%) of sample were in the age group of 54 and above years, most (64.0%) of them were males.

43.0% sample having no formal education, around 96% of them were married.

Regarding their personal history, majority (58.0%) of them were vegetarians, around 41.0% were smokers and about 72% of them were non- alcoholics.

Regarding past medical history, majority of them have hypertension, 48% of them are diabetic and only 3% of them had history of Tuberculosis.

Table 1: Frequency and Percentage Distribution of sample Characteristics (N=100)

Sample Characteristics			*f*	%
Age in years		< 53 Years	46	46.0
		53 and Above Years	54	54.0
Gender		Male	64	64.0
		Female	36	36.0
Education		No formal Education	43	43.0
		Middle school	2	2.0
		High school	37	37.0
		Intermediate	7	7.0
		Graduate	11	11.0
Marital status		Married	96	96.0
		Unmarried	04	4.0
Religion		Hindu	65	65.0
		Muslim	35	35.0
Personal History	Dietary Pattern	Vegetarian	58	58.0
		Mixed	42	42.0
	Smoking	Smokers	41	41.0
		Non-smokers	59	59.0
	Alcoholism	Alcoholic	28	28.0
		Non-Alcoholic	72	72.0
Past Medical History	Hypertension	Yes	76	76.0
		No	24	24.0
	Diabetes	Yes	48	48.0
		No	52	52.0
	Tuberculosis	Yes	3	3.0
		No	97	97.0

Table 2: General Examination of the sample (N=100)

Parameters	Mean±SD
Mean body weight	55.0±8.42
SBP (mmHg)	144.56±19.88
DBP (mmHg)	91.02±9.23
Heart Rate (per minute)	86.89±6.42
Pulse Rate (per minute)	16.06±1.75
Temperature (0F)	97.46±0.91

The data presented in [Table 2] represents the mean and standard deviation of general examination parameters of sample.

It revealed that, the mean body weight of the sample was 55.0±8.42 Kg, the mean Systolic Blood Pressure (mmHg) of the sample was 144.56±19.88 mmHg.
Mean Diastolic Blood Pressure (mmHg) of the sample was 91.02±9.23 mmHg.

Table 3: Laboratory investigation of the sample (N=100)

Investigation		Mean±SD
Blood Investigation	Hemoglobin (gm %)	9.19±2.35
	Total leucocyte count	12857.64±5190.13
Kidney Function Test	Urea (mg/dl)	129.74±66.09
	Serum creatinine (mg/dl)	5.77±4.35
	Serum sodium (mmol/L)	138.04±5.35
	Serum potassium (mmol/L)	4.69±0.87

The data presented in [Table 3] represents the mean and standard deviation of Laboratory investigation of the sample including blood investigation and kidney function test.
It reveled that the mean Hemoglobin (gm%) of the sample was 9.19±2.35 gm%,
The mean urea (mg/dl) value of the sample was 129.74±66.09 mg/dl.
The mean Serum creatinine (mg/dl) value of the sample was 5.77±4.35 mg/dl.
The mean Serum sodium (mmol/L) value of the sample was 138.04±5.35 mmol/L
The mean Serum potassium (mmol/L) value of the sample was 4.69±0.87 mmol/L.

Table 4: Frequency and Percentage Distribution of sample based on other investigations. (N=100)

Sample Characteristics		*f*	%
Category of Anemia	Severe anemia	19	19.0
	Moderate anemia	24	24.0
	Mild anemia	47	47.0
	Normal	10	10.0
24hr.urinary protein/spot urinary protein creatinine ratio	A1	0	0
	A2	29	29.0
	A3	71	71.0
ECG-LVH	LVH	65	65.0
	No LVH	35	35.0
Chest X-ray	Within normal limit	44	44.0
	Cardiomegaly	50	50.0
	B/L basal infiltration	2	2.0
	B/L mild pleural effusion	1	1.0
	B/L Pleural effusion	1	1.0
	B/L infiltrate, cardiomegaly	2	2.0
2-D ECHO-LVH/LV Function	Concentric LVH	5	5.0
	Mild concentric LVH	36	36.0
	Moderate LV systolic dysfunction and LVH	33	33.0
	Severe LV systolic dysfunction and LVH	7	7.0
	Global hypokinesia	11	11.0
	Dilated LV/LA	1	1.0
	Normal echo	7	7.0
Ejection Fraction	Preserved	29	29.0
	Reduced Ejection Fraction	71	71.0
On Maintenance Hemodialysis	Yes	41	41.0
	No	59	59.0

The data presented in [Table 4] reveled that, majority (47.0%) of the sample had mild anemia, 19% of the sample had severe anemia.
71.0% of the sample had A3 Category of 24hr.urinary protein/spot urinary protein creatinine ratio.
ECG revealed that, around 65% of the sample had LVH.
Chest X-ray revealed that, 50.5% of the sample has Cardiomegaly.
2-D ECHO-LVH/LV Function reveled that, around 36% AND 33% of the sample have Mild concentric LVH and Moderate LV systolic dysfunction and LVH respectively.
Majority (71.0%) of the sample have reduced ejection fraction.
41% of patients were on Maintenance Hemodialysis.
The data presented in [Table 5] represents the stages of CKD based on GFR ml/min and it revealed that
7% of the sample were in the stage 2 CKD.
14% of the sample were in stage 3 CKD.
17% of the sample were in the stage 4 CKD.
(62%) of them were in stage 5 CKD.

Table 5: Frequency and Percentage Distribution of sample based on stages of CKD. (N=100)

CKD Stages	GFR Range	Frequency (%)
Stage 1	Signs of mild kidney disease with normal or better GFR; GFR>90%	0 (0.0)
Stage 2	Mild kidney disease with reduced GFR, GFR60-89%	7 (7.0)
Stage 3	Moderate chronic renal insufficiency; GFR 30-59%	14 (14.0)
Stage 4	Severe chronic renal insufficiency; GFR 15-29%	17 (17.0)
Stage 5	End stage renal disease; GFR <15%)	62 (62.0)

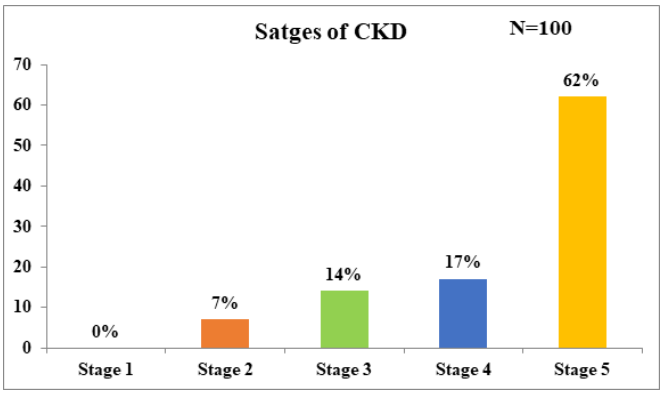

Figure 1: Bar graph showing percentage distribution of sample based on stages of CKD.

Table 6: Data comparing of severity of CKD with presence of LVH based on ECG.(N=100)

Stages of CKD	LVH		No LVH	
	f	%	*f*	%
Stage 1	0	0.0	0	0.0
Stage 2	1	1.0	6	6.0
Stage 3	3	3.0	11	11.0
Stage 4	7	7.0	10	10.0
Stage 5	54	54.0	8	8.0

The data presented in table 6 revealed that, 1% of stage 2 CKD cases had LVH and 6% of stage 2 CKD cases were not having LVH, 3% of stage 3 CKD cases had LVH and 11% of stage 3 CKD cases were not having LVH, 7% of stage 4 CKD cases had LVH and 10% of stage 4 CKD cases were not having LVH and around 54% of stage 5 CKD cases had

LVH and 8 % of stage 5 CKD cases were not having LVH

Table 7: Data comparing of severity of CKD with condition of ejection fraction (N=100)

Stages of CKD	Ejection Fraction			
	Preserved (n=29)		Reduced Ejection Fraction (n=71)	
	f	%	*f*	%
Stage 1	0	0.0	0	0.0
Stage 2	4	17.1	3	64.3
Stage 3	5	35.7	9	11.0
Stage 4	6	35.3	11	64.7
Stage 5	14	22.6	48	77.4

The data presented in [Table 7] revealed that
17.1% of stage 2 CKD cases had preserved ejection fraction and 64.3% of stage 2 CKD cases were having reduced ejection function.
35.7% of stage 3 CKD cases had preserved ejection fraction and 64.7% of stage 3 CKD cases were having reduced ejection function
35.3% of stage 4 CKD cases had preserved ejection fraction and 64.7% of stage 4 CKD cases were having reduced ejection function
22.6% of stage 5 CKD cases had preserved ejection fraction and 77.4 % of stage 5 CKD cases were having reduced ejection function.

Table 8: Data comparing of severity of CKD with 2-D ECHO-LVH/LV function (N=100)

Stages of CKD	2-D ECHO-LVH/LV function	*f*	%
Stage 2	Mild concentric LVH ,gr.1 LVDD	6	85.7
	Normal echo	1	14.3
Stage 3	Mild concentric LVH ,gr.1 LVDD	9	64.3
	Moderate LV systolic dysfunction gr.1 LVDD	2	14.3
	Normal echo	3	21.4
Stage 4	Mild concentric LVH ,gr.1 LVDD	11	64.7
	Moderate LV systolic dysfunction gr.1 LVDD	3	17.6
	Global hypokinesia	2	11.8
	Normal echo	1	5.9
Stage 5	Concentric LVH gr.1 LVDD	5	8.1
	Mild concentric LVH ,gr1 LVDD	10	16.1
	Moderate LV systolic dysfunction gr.1 LVDD	28	45.2
	Severe LV systolic dysfunction, dilated LA/LV	7	11.3
	Global hypokinesia	8	14.5
	Dilated LA/LV	1	1.6
	Normal echo	2	3.2

2-D ECHO-LVH/LV function revealed around 6% of stage 2 CKD cases had Mild concentric LVH, gr.1 LVDD, among stage 3 CKD cases around 64.3% of the cases had Mild concentric LVH, gr.1 LVDD and 14% of them had Moderate LV systolic dysfunction gr.1 LVDD, among stage 4 CKD cases around 11.2% of the cases had Global hypokinesia and among stage 5 CKD cases around 8.1% of the cases had Concentric LVH gr.1 LVDD, 11.3% of cases had Severe LV systolic dysfunction, dilated LA/LV and , 1.6% of them had Dilated LA/LV.

Discussion

Samples distribution characteristics

In our study, most of the (54.0%) of patients were in the age group of 54 and above years, most (64.0%) of them were males, about 43.0% sample having no formal education, around 96% of them were married. Regarding their personal history, majority (58.0%) of them were vegetarians, around 41.0% were smokers and about 72% of them were non-alcoholics. Regarding past medical history, majority of them have hypertension, 48% of them are diabetic and only 3% of them had history of Tuberculosis.
The study conducted by Kartheek et al,[20] in 2019 had finding similar to our study. The results revealed that, majority (68.0%) of sample were males, around 42% of the sample had hypertension and around 20% of them were diabetic. A research done by Chillo&Mujuni, et al,[21] in year 2018 majority of the sample belonged to the age group of 48 and above, around 54.5% of the samples were males and around 98.4% of the samples were hypertensive and about 22.8% of them were diabetics.

General examination and laboratory findings

In our study, mean body weight of sample were 55.0±8.42 Kg, the mean S.B.P (mmHg)of the sample was 144.56±19.88 mmHg, the mean D.B.P (mmHg)of the sample was 91.02±9.23 mmHg.
In the present study, the mean Haemoglobin (gms%) of the sample was 9.19±2.35gms%, the mean urea (mg/dl) value of the sample was 129.74±66.09 mg/dl, the mean S. creatinine (mg/dl) value of sample was 5.77±4.35 mg/dl, the mean Serum sodium (m mol/L) value of the sample was 138.04±5.35m mol/L and the mean Serum potassium (m mol/L) value of the sample was 4.69±0.87m mol/L.
The study conducted by Kartheek et al,[20] in 2019 had mean body weight of 58.09±8.03 Kg, the mean S.B.P (mmHg) of the sample was 148.16±18.22 mmHg, the mean D.B.P (mmHg)of the sample was 93.26±10.68 mmHg. The mean Haemoglobin (gms%) of the sample was 7.41±1.60 gms%, the mean Serum creatinine (mg/dl) value of the sample was 6.86±1.69 mg/dl, the mean Serum sodium (m mol/L) value of the sample was 133.54±18.26 m mol/L and the mean Serum potassium (m mol/L) value of the sample was 4.57±0.87m mol/L.
In the study conducted by Vankayala et al,[22] in 2019 the mean SBP (mmHg) of the sample was 153.72±21.97 mmHg, the mean DBP (mmHg)of the sample was 93.12±7.83 mmHg. the mean Hemoglobin (gms%) of the sample was 8.52±0.78 gms%, the mean urea (mg/dl) value of the sample was 88.22.74±22.90 mg/dl, the mean S. creatinine (mg/dl) measurement of the sample was 6.82±2.12 mg/dl. This research done by Laddha, et al,[23] in year 2014 revealed that the mean Haemoglobin (gms%) was 7.78±1.84 gms%, the mean Serum creatinine (mg/dl) value was 10.35±5.56 mg/dl and the mean blood urea (mg/dl) value of the sample was 151.7.±51.37 mg/dl.

Distribution of sample based on stages of CKD

In our current study 7% of the patients of CKD was in stage

2 that is G.F.R is 60-89% ml/min, and 14% of the CKD patients was in stage 3 that is (G.F.R is 30-59% ML/Min/1.73 M^2), and other 17% CKD patients was in the stage 4 that is (GFR is 15-29% Ml/Min/1.73 M^2) and all others 62% CKD patients was in stage 5 that is GFR is<15% Ml/Min/1.73 M^2.

This research conducted by Reddy et al,[24] in 2018 carried out among 100 CKD cases supported the findings of our current study. The results revealed that, 9% of the cases were in stage II (GFR60-89% ml/min/1.73 m^2), 17% of cases were in stage III (GFR 30-59% ml/min/1.73 m^2), 32% of the cases were in the stage IV (GFR 15-29% Ml/Min/1.73 M^2) and majority (42%) of them were in the stage V of CKD (<16% Ml/Min/1.73 M^2). I.M. conducted a research in 2018,[25] based on GFR rate. Around 22% of cases were included in group 1 included GFR 89-45Ml/Min/1.73 M^2, 68 % of cases were included in group 2 included GFR 44-15Ml/Min/1.73 M^2 and about 10% of the sample were included in group 3 GFR < 15ml/min/1.73 m^2.

Comparison of severity of CKD with LVH status on ECG

In our study, 1% of stage 2 CKD cases had LVH and 6% of stage 2 CKD cases were not having LVH, In stage 3 of CKD 3% of cases had LVH & 11% of CKD stage 3 cases were not having LVH, 7% of stage 4 CKD cases had LVH and 10 % of stage 4 CKD cases were not having LVH and around 54% of stage 5 CKD cases had LVH and 8 % of stage 5 CKD cases were not having LVH.

Study conducted by Vankayala et alin2019,[22] revealed that, 3% of CKD stage 3 cases had LVH & 38% of CKD stage 3 cases were not having LVH, 39% of stage 4 CKD cases had LVH and 43% of stage 4 CKD cases were not having LVH and around 59% of stage 5 CKD cases had LVH and 19 % of stage 5 CKD cases were not having LVH. A study was conducted by Amoako et al.[26] in 2017in 203 CKD cases. The study revealed that, 12.5% of stage 3 CKD cases had LVH and 15.7% of stage 3 CKD cases were not having LVH, 5.7% of stage 4 CKD cases had LVH and 6.0% of stage 4 CKD cases were not having LVH and around 81.8% of stage 5 CKD cases had LVH and 78.3 % of stage 5 CKD cases were not having LVH.

Comparison of severity of CKD with condition of ejection fraction

In the present study, 17.1% of stage 2 CKD cases had preserved ejection fraction and 64.3% of stage 2 CKD cases were having reduced ejection function, 35.7% of stage 3 CKD cases had preserved ejection fraction and 64.7% of stage 3 CKD cases were having reduced ejection function, 35.3% of stage 4 CKD cases had preserved ejection fraction and 64.7% of stage 4 CKD cases were having reduced ejection function and around 22.6% of stage 5 CKD cases had preserved ejection fraction and 77.4 % of stage 5 CKD cases were having reduced ejection function.

Smith et al,[27] in 2013 found that 54.7% of stage 1 CKD cases had preserved ejection fraction and 45.3% of stage 1 CKD cases were having reduced ejection function, 57.1% of stage 2 CKD cases had preserved ejection fraction and 42.9% of stage 2 CKD cases were having reduced ejection function, 60.1% of stage 3 CKD cases had preserved ejection fraction and 63.6% of stage 3 CKD cases were having reduced ejection function, 66.0% of stage 4 CKD cases had preserved ejection fraction and 34.0% of stage 4 CKD cases were having reduced ejection function and around 26.7% of stage 5 CKD cases had preserved ejection fraction and 74.3 % of stage 5 CKD cases were having reduced ejection function.

Comparison of severity of CKD with 2-D ECHO-LVH/LV function

In our study, around 6% of stage 2 CKD cases had Mild concentric LVH ,gr1 LVDD, among stage 3 CKD cases around 64.3% of the cases had Mild concentric LVH ,gr1 LVDD and 14% of them had Moderate LV systolic dysfunction gr.1 LVDD, among stage 4 CKD cases around 11.2% of the cases had Global hyperkinesias and among stage 5 CKD cases around 8.1% of the cases had Concentric LVH gr.1 LVDD, 11.3% of cases had Severe LV systolic dysfunction, dilated LA/LV and , 1.6% of them had Dilated LA/LV.

Reddy et al,[24] in 2017 carried out similar study among 50 CKD cases and Echocardiography was performed to rule out the cardiac dysfunction. The study finding reveals that, around 47% of the CKD cases had Concentric LVH, 22% of them had Dilated LA and 18% them had dilated LA and 27.5 of the CKD cases had systolic dysfunction. Kartheek et al,[20]showed that, 92% of CKD cases had LVH, 16% of the cases had Global hypokinesia and 4% of the cases had LV systolic dysfunction.

Conclusion

Left ventricular hypertrophy and dysfunction is a veryimportant preventive feature of CKD associated cardiomyopathy. It is defined as the final outcome of pathophysiological related singling pathways that play a vital role inmyocardial cell thickening and LV concentric remodelling. There is a increased chance of left ventricular hypertrophy in CKD patients.With respect to category of chronic kidney disease, the LVH prevalence is progressively increases with increasing severity of CKD (chronic kidney disease).Patients of CKD due to adverse effects causing increased thickness of left ventricle that further causing myocardial cell distortion and leading to systolic and diastolic function alterationthat occurring very often. Blood pressure control is very important step to forestall the development of CKD and other relateddamage of end organs.The lower the GFR, the more severe the LV diastolic dysfunction. The LV diastolic dysfunction is more, if there is association of increased hypertension and anemia. So, early identification & cure of above conditions can retard the cardiovascular mortality and morbidity. At early stage if identification have been donefor LVH & accordingly interventions should be done to avoid and/or regression of LVH should be encouraged.Echocardiography provides a simple, non-invasive technique that can identify even asymptomatic patients at a prior stage of CKD.Finally, the cure of the Left ventricle increased thickness is mainly prevented by blood pressure control and improvement in

anaemia, & optimization of renal additional therapy maximization.

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