IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 13, Issue 1 Ver. IV (Jan. 2014), PP 69-73
www.iosrjournals.org

Echocardiographic Assessment of Left Ventricular Systolic Dysfunction in Chronic Kidney Disease Patients of a Rural Tertiary Medical Care Centre in West Bengal

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Abstract:
Objective: *To evaluate the prevalence of LV systolic dysfunction in patients with CKD (Hemodialysis naive patients) & assess the severity of dysfunction in respect to stages of CKD.* ***Methodology:*** *This is a cross sectional study conducted at the Medicine Department, B.S. Medical College, West Bengal during the period of one year from 1st May 2012 to 30th April 2013. 50 patients of both sexes and ages above 18 years and below 65 years presenting with chronic kidney disease who did not underwent dialysis, were included in the study. A proforma was designed to collect data containing basic information, history & physical examination and the relevant hematological, biochemical and radiological investigations like Electrocardiography and Echocardiography (2D & M mode). Based on the eGFR value (by Cockroft-Gault equation), Patients were divided in two categories - mild/moderate Chronic Kidney Disease [those with eGFR >30ml/min/1.73m^2 = CKD stages 1-3] (N = 27) and severe Chronic Kidney Disease [those with eGFR <30ml/min/1.73m^2 =CKD stages 4 - 5] (N = 23). And echocardiographic LV systolic parameters were analysed and compared between the two groups.* ***Result:*** *15% of mild/moderate CKD patients showed low EF & 48% of severe CKD had evidence of low EF. 22% patients with mild/moderate CKD, and 26% with severe CKD had impaired fractional shortening. LVH was 58% among total study population, & it was 33% and 87% among two groups. Among all LVH, 31% was concentric and 69% was eccentric type.* ***Conclusion****: Chronic Kidney Disease patients has higher prevalence of left ventricular hypertrophy (LVH) and higher prevalence of systolic dysfunction, which was more pronounced in CKD stage 4-5.*
Keywords: *Chronic kidney disease, Left ventricular systolic dysfunction*

I. Introduction

Chronic kidney disease (CKD) is increasingly being recognized as a global public health problem.[1] In India, prevalence of CKD is very high, as per data available by various studies, approximate prevalence is around 800/million population.[2,3,4] SEEK (Screening and Early Evaluation of Kidney Diseases)[5] data reported a 17.2% prevalence of CKD using estimated-GFR formula.

Cardiovascular disease remains the leading cause of morbidity and mortality in patients at every stages of CKD.[6] Many of the clinical consequences of cardiac disease results from Cardiomyopathy or Ischemic Heart Disease.[7] Cardiomyopathy may present as enlarged dilated Left Ventricle (LV) with or without systolic dysfunction or as diastolic dysfunction.[7] Anomalies of LV structure and function (systolic and or diastolic dysfunction, left ventricular hypertrophy) are very frequent among CKD patients and show a negative impact on cardiovascular prognosis.[8,9,10]

Heart and kidney are inextricably linked in terms of hemodynamic and regulatory functions. Communication between these two organs occurs at multiple levels including the sympathetic nervous system, the renin-angiotensin aldosterone system (RAAS), antidiuretic hormone, endothelin, and the natriuretic peptides. Cardiac disease is the major cause of death in dialysis population accounting for 40% of deaths in international registries. In 1997, National Kidney Foundation (NKF) convened a Task Force, which considered coronary artery disease (CAD) and left ventricular hypertrophy (LVH) as the two target conditions in their recommendations for decreasing the cardiovascular mortality in end-stage renal disease (ESRD) patients.

LVH is associated with both diastolic and systolic dysfunction of the left ventricle. LVH is also associated with LV systolic dysfunction, expressed by reduced mid wall systolic fractional shortening, as previously reported in hypertensive patients with cardiac hypertrophy and also in patients with ESRD in whom it is a powerful predictor of worse CV outcome. Taken together, these findings suggest that a mild reduction in renal perfusion induced by slightly impaired LV systolic function, associated with pathological, highly pulsatile perfusion in the kidney microvasculature might be the mechanisms through which a progressive reduction of renal function takes place in patients with pre-existing renal damage.

There is scanty information on the prevalence and natural history of LVH & left ventricular dysfunction in patients with milder degrees of chronic renal failure from India. This present study would be helpful in reviewing the prevalence and severity of LV systolic dysfunction in patients with varying degrees of CKD on conservative management in Eastern Indian Rural population of Bankura, Purulia and Midnapur Districts of West Bengal.

II. Materials & Methods

This is a cross sectional study conducted at the Medicine Department, B.S. Medical College, West Bengal with the objective to evaluate the prevalence of LV systolic dysfunction in patients with CKD (Hemodialysis naive) & assess the severity of dysfunction in respect to stages of CKD. 50 patients of both sexes and ages above 18 years and below 65 years presenting with chronic kidney disease in the OPD or admitted in the medicine ward were included in the study. A proforma was designed to enter all the collected data containing the basic information about the patient, history & physical examination and the relevant investigations. A detailed history & physical examination were carried out on a questionnaire. Risk factor were also stratified based on diabetes, hypertensive and anaemic status. Based on the eGFR value (by Cockroft-Gault equation), Patients were divided in two categories - mild/moderate Chronic Kidney Disease [those with eGFR >30ml/min/1.73m^2 = CKD stages 1-3] (N = 27) and severe Chronic Kidney Disease [those with eGFR <30ml/min/1.73m^2 =CKD stages 4 - 5] (N = 23). All patients underwent two dimensional M mode & doppler echocardiography performed on Siemens acuson CV70, in left lateral decubitus position using 3.5 MHz transducer by consultant cardiologist at BSMCH , experienced in echocardiography. The left ventricular ejection fraction (EF) and fractional shortening (FS) were taken as measures of LV systolic function. EF = (LVEDD^2 ─ LVESD^2) ÷ LVEDD^2 x 100%. The mean EF in normal population is taken as 59.2 ± 6%. [11, 12, 13] EF was considered decreased if it was < 50%. And FS = (LVIDd ─ LVIDs) ÷ LVIDd x 100%. Normal reference value in adults for FS is 35 ± 8 %. [14] FS of ≤ 25% was taken as index of systolic dysfunction. Left ventricular Mass was calculated by the following cube formula after measuring left ventricular posterior wall thickness at end-diastole (PWd) & interventricular septal wall thickness at end-diastole: LVM = 0.8 x [1.04 x (LVEDD + PWd + IVSd)^3 – LVEDD^3] + 0.6 Normal reference value of LVMI for female as 43-95, and for male 49-115 was taken for evaluation of study population. Calculation was done using the online calculator (Cardio math) of Canadian Society of Echocardiography. And thereafter echocardiographic LV systolic parameters were analysed and compared between the two groups. Data is analyzed at the end of study using standard statistical methods (Microsoft mathematics & medcalc software).

III. Result & Analysis

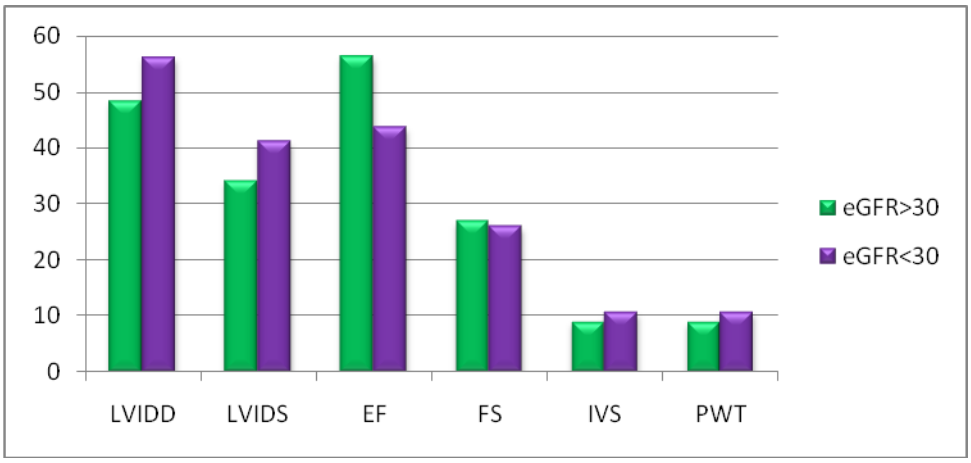
In the present study, study participants which were divided into the two groups & compared between 1) group with mild/moderate Chronic Kidney Disease [those with eGFR >30ml/min/1.73m^2 = CKD stages 1-3] (N = 27) and 2) group severe Chronic Kidney Disease [those with eGFR <30ml/min/1.73m^2 =CKD stages 4 - 5] (N = 23).

Table 1 - Echocardiographic parameters in the study participants:

	Mild/moderate CKD (mean ± SD)	Severe CKD (mean ± SD)	p value*
LVIDd (mm)	48.37 ± 4.72	56.17 ± 5.57	<0.0001
LVIDs (mm)	34.17 ± 3.98	41.09 ± 4.48	<0.0001
EF %	56.39 ± 7.57	43.71 ± 9.24	<0.0001
FS %	28.15 ± 4.4	25.94 ± 5.32	0.1140
IVSd (mm)	8.95 ± 0.88	10.6 ± 1	<0.0001
PWd (mm)	8.91 ± 1.03	10.69 ± 1.26	<0.0001

LVIDd - left ventricular internal diameter at end diastole, LVIDs - left ventricular internal diameter at end systole, IVSd - interventricular septal thickness at end diastole, PWD - posterior wall thickness at end diastole, EF - ejection fraction, FS - fractional shortening. * Significance level of p value was 0.05

Table 1 showed, the mean left ventricular internal diameter in diastole (LVIDd) and systole (LVIDs) were lower in patients with mild/moderate CKD. The mean interventricular septal thickness in diastole (IVSd) and systole (IVSs) and posterior wall thickness in diastole (PWd) were higher in patients with CKD, especially in those with severe degree of renal failure.



Bar diagram showing means of systolic echo parameters among CKD groups

From table 1 we can see that, EF was significantly lower in CKD stage 4-5 than mild/moderate CKD (stage 1-3) {43.72 vs. 56.39}.

Table – 2: Left Ventricular Mass Index (LVMI) & sex-wise distribution:

	Mild/moderate CKD	Severe CKD	p value*
Whole group	102.63 ± 36.07	158.35 ± 35.87	<0.0001
Male	107.35 ± 37	155.47 ± 33.66	0.0025
Female	96.75 ± 28	155.11 ± 38.73	0.0002

* Significance level of p value was 0.05

As evident, ***Table 2*** showed LVMI was higher in patients of CKD in both the sexes also between mild/moderate and severe chronic renal failure groups, however it was more marked among males. Based on value of LVMI and sex of the individual, a patient was labelled as having LVH or not. It was seen that trend towards increased LVMI values with increasing severity of renal insufficiency and also between males and females, which had significant association.

Table – 3: LV systolic function indices (EF and FS) in study groups:

	Mild/moderate CKD	Severe CKD	p value*
No of patients with EF <50%	4 (15%)	11 (48 %)	0.0261
No of patients with FS <25%	3 (11%)	6 (26%)	0.3130

* Significance level of p value was 0.05

Table 3 showed indices of left ventricular (LV) systolic function in the two groups. LV ejection fraction showed a progressive decline with increase in severity of renal failure. Further analysis showed that whereas in patients with mild/moderate CKD only 15% patients showed low EF (<50%), 11/23 (48%) patients with severe CKD had evidence of low EF. detailed analysis revealed that 3/27 (22%) patients with mild/moderate CKD, and 6/23 (26%) with severe CKD had impaired fractional shortening (i.e., ≤ 25%).

Table – 4: No. of patients with concentric & eccentric LVH:

	Mild/moderate CKD	Severe CKD
LVH concentric type	3 (11%)	6 (26%)
LVH eccentric type	6 (22%)	14 (61%)

There was progressive increase in Incidence of LVH with increase in severity of renal failure. In present study, incidence of LVH was 58% (29 out of 50 patients) in CKD patients in which, mild/moderate chronic renal failure patients group and severe chronic renal failure had incidence of 33% and 87% respectively. From all patients of LVH, 31% hypertrophy was of concentric type and 69% was of eccentric type.

IV. Discussion

Premature cardiovascular disease is a significant cause of morbidity and mortality among patients with CKD.[15] which promote systolic as well as diastolic LV dysfunction which predisposes to symptomatic heart failure, which is a risk factor for premature death. Various diagnostic modalities, both invasive and noninvasive such as electrocardiography, echocardiography and radionuclide scans are utilized for diagnosing left ventricular hypertrophy and dysfunction. Cardiac assessment by echocardiography is non-invasive, inexpensive to perform

and generates detailed information about gross cardiac anatomy, objective quantification of LVM and the geometry of left ventricle hypertrophy (LVH), along with measures of function during systole. Prospective studies have shown the presence of LVH in most (70–80%) patients with end-stage renal disease which confers a poor prognosis.

In the present study, in the male and female, there is no significant difference in prevalence of LVH, which is comparable with a study of 141 pretransplant patients in which McGregor et al.[16] found prevalence of LVH in 64-70% of males and 63-65% of females, but the result is opposite to the study P Dangri et al.[17] suggesting that prevalence of LV hypertrophy was more in females. The results being same as the study-Deveroux et al.[18] Left ventricular hypertrophy is the single strongest independent predictor of adverse cardiovascular events.[19,20]

Study had found that LVMI showed a progressive rise with increase in severity of renal failure which is significant. This is in concordance with the study done by P Dangri et al.[18] Greaves and co-workers who also found a similar trend of LVMI in patients of CKD. Few studies done in predialysis population have shown LVMI to be significantly higher in CKD patients than the normal population.[21]

In the present study, the mean ejection fraction in patients with mild/moderate CKD and severe CKD groups showed a downward trend but neither of the CKD groups had mean LVEF < 50%. These findings conform to findings of P Dangri et al. [18] Raj et al. [22]

Among patients in the mild/moderate CKD group, only 4(15%) patient had LVEF < 50%, while 11(48%) patients in severe CKD group had LVEF < 50% which was significantly different from mild/moderate CKD population. This findings correlate with P Dangri et al. [18] Thus, these studies suggests that LVEF is well maintained in patients with CKD patients till late.

In the present study, there was no significant difference in the mean fractional shortening among the two groups, however, 11% in mild/moderate CKD group and 26% patients in severe CKD group had fractional shortening ≤ 25%. Raj et al. (1997)[22] and Greaves et al (1994) also did not find significant difference in the mean fractional shortening between the three groups. In a group of 218 ESRD patients on dialysis who never developed CHF, Harnett et al (1995) [23]. found a mean FS of 35 ± 6 with only 4% patients having evidence of systolic dysfunction. Colan et al. (1987)[24] in severe CKD group not on dialysis found mean fractional shortening to be 33.0 ± 9.1%. Thus, all these studies also show that fractional shortening as a function of left ventricular systolic function is well maintained in CKD patients.

In the present study, in patients with mild/moderate CKD, the ejection fraction was depressed only in 15% whereas FS was depressed in 11%. It is because when the ventricle is stressed by a hemodynamic overload, it first uses its compensatory mechanism to maintain normal mechanical performance and the ejection indices (e.g. ejection fraction) within normal limits. It is only when all the compensatory mechanisms in the form of operation of Frank Starling's mechanism, development of hypertrophy, and endogenous adrenergic stimulation have been maximally used; there is decline in ejection phase indices. Ventricular systolic functions have invariably been evaluated using ejection phase indices, viz., ejection fraction, but this is highly sensitive to left ventricular loading conditions (pre load and after load) which are usually abnormal in CKD patients. Normalization of loading conditions is invariably associated with restoration of normal ejection phase indices.[24] Similarly when FS is taken as index of systolic dysfunction, it is assumed that the ventricle must be contracting uniformly for them to reflect global function. FS assesses the status of basal chamber only; it may falsely be normal, depressed, or increased in segmentally depressed left ventricle.[25]

The number of patients with LVH and systolic dysfunction (ejection fraction < 50%) was 3 (11%) in mild/moderate CKD group and 11 (48%) in severe CKD group. In a study by Greaves et al (1994) [10] 13% of patients had LVH with systolic dysfunction in the dialysis patients. Thus, in the present study, systolic function was well preserved in patients with mild/moderate and severe CKD which was in concordance with the previous studies done by Harnett et al (1995), Colan et al (1987), and Raj et al (1997). In comparison to systolic function, diastolic function was deranged in more number of patients suggesting that diastolic dysfunction is first to appear in patients with chronic renal failure which was statistically significant.

In the present study, concentric LVH was found in 11.11% cases with mild/moderate CKD and 26% in severe CKD group, while eccentric hypertrophy was seen in only 22% of patients in mild/moderate CKD group and 61% in severe CKD group, suggesting that eccentric LVH was far more common than concentric LVH in CKD population. A study by Huting et al [26] had suggested eccentric hypertrophy to be a predominant form of LVH in CKD patients. On the other hand, a study by London et al [27] suggested that LV hypertrophy in ESRD combines features of concentric as well as eccentric hypertrophy. In a prospective study by Parfrey et al [28] on 432 patients of ESRD, 41% patients had concentric LVH while 28% had eccentric hypertrophy at the start of dialysis. Here, it was found that High prevalence of anaemia and hypertension in patients with CKD may also partly account for increased prevalence of LVH in patients with CKD.

To summarize, the present study concluded that patients with chronic renal failure had higher left ventricular mass index and higher prevalence of left ventricular hypertrophy (LVH), which was more

pronounced in patients with severe renal failure. The high prevalence of Left ventricular hypertrophy on echocardiography implies that these patients require detailed cardiovascular evaluation despite absence of symptoms, and also that timely efforts targeted at prevention and control of left ventricular hypertrophy should be implemented early during the course of renal insufficiency, such as effective control of hypertension, anaemia etc.

V. Conclusion

From our study we may conclude that patients with Chronic Kidney Disease had higher left ventricular mass index (LVMI) and higher prevalence of left ventricular hypertrophy (LVH) and higher prevalence of both systolic dysfunction, which was more pronounced in patients with severe renal failure. The high prevalence of Left ventricular hypertrophy, systolic dysfunction on echocardiography implies that these patients require detailed cardiovascular evaluation despite absence of symptoms, and also that timely efforts targeted at prevention and control of left ventricular hypertrophy should be implemented as early as possible such as effective & maintained control of hypertension, anaemia etc. which may reduce mortality & morbidity for these patients specially in these remote areas of West Bengal where both availability & affordability of renal replacement therapy is very much limited & much of the patient rely on drug treatment alone.

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