Left ventricular mass and cardiothoracic index in patients with chronic renal disease on hemodialysis

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ABSTRACT

Introduction: Left ventricular hypertrophy (LVH) is an independent predictor of cardiovascular risk in patients with chronic renal disease (CRD) on hemodialysis (HD). **Objective:** To show the usefulness of chest radiography in the diagnosis of LVH in CRD patients on HD. **Methods:** Cross-sectional study including 100 patients (58 men and 42 women), mean age 46.2 ± 14.0 years, with CRD of all causes, for at least six months on HD. Were obtained echocardiogram and chest x-rays of patients, always up to one hour after the end of HD sessions. **Results:** LVH was detected in 83 patients (83%), of whom 56 (67.4%) had the concentric pattern and 27 (32.6%) with eccentric pattern of LVH. Cardiomegaly - defined by cardiothoracic index (CTI) > 0.5 - was present in 61 patients (61%). The following were the sensitivity, specificity and accuracy, respectively, for the variable ICT: 66.2%, 70.5% and 68.0%. The Pearson correlation between ICT and index of left ventricular mass (LVMI) was 0.552 ($p < 0.05$) and positive likelihood ratio of 2.2. **Conclusion:** Chest radiography is a safe and useful as a diagnostic tool of LVH in CKD patients on HD.

Keywords: chest radiography; chronic renal disease; hemodialysis; left ventricular hypertrophy.

INTRODUCTION

Left ventricular hypertrophy (LVH) is an important hypertension-independent cardiovascular risk factor, one of its main causes.[1,2]

LVH can be detected by electrocardiogram (ECG), chest radiography, echocardiogram and magnetic resonance imaging. However, in clinical practice, ECG and echocardiography are the most widely used, not only for reasons of availability, but mainly by the prognostic association that clearly predicts increased cardiovascular risk when LVH is found.[3]

The aim of this study is to show the usefulness of chest radiography in the diagnosis of LVH in patients with chronic kidney disease (CKD) on hemodialysis, or stage 5 CKD, i.e., those with glomerular filtration rates of less than 15 ml/min/1.73 m^2 with a need for renal replacement therapy),[4] correlating the cardiothoracic index (CTI) with the left ventricular mass index (LVMI) obtained by the transthoracic echocardiography - here used as the gold standard for comparison.

METHODS

From June 2006 to February 2007 we assessed 133 patients with stage 5 CKD, of any etiology (see Table 1), clinically stable at an HD program for at least six months at the Agro - Sugar and Ethanol Industry of Alagoas Hospital Foundation. The Ethics Committee on Human Research of the State University of Health Sciences of Alagoas approved the study protocol and all patients signed an informed consent in accordance with the principles of the Declaration of Helsinki. The following were the exclusion criteria for the study: history of acute or chronic coronary syndrome (regardless

of weather), valve disease, cardiomyopathy of any origin detected by transthoracic echocardiography, pericardial effusion, pacemaker, right or left branch block, ventricular pre-excitation syndromes, and any other than sinus rhythm. Anyway, any factor that could potentially distort left ventricular geometry and thus interfere with echocardiographic and radiographic analysis. Of the 133 patients screened, 33 were excluded. Among the 100 selected patients, all were interviewed and submitted to casual blood pressure measurement, chest radiography and transthoracic echocardiography were always carried out within one hour after the end of the HD sessions.

Table 1 CDK etiology in the sample considered

CKD etiology	N = 100
Hypertensive nephrosclerosis (%)	40
Chronic glomerulonephritis (%)	33
Diabetic nephropathy (%)	11
Alport's syndrome(%)	5
Polycystic kidney disease (%)	4
Lupus nephritis (%)	3
Hydronephrosis (%)	2
Schistosomotic glomerulonephritis (%)	1
Kidney tuberculosis (%)	1

CKD: Chronic kidney disease.

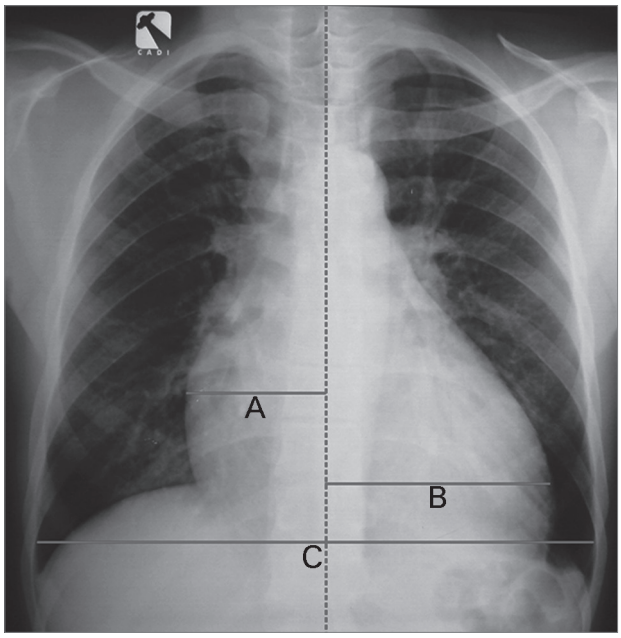
Chest X-rays

Chest X-rays were obtained from all patients in the orthostatic position, in a posteroanterior view (equipment Helliophos 4B®, Germany). We calculated the CTI, and values > 0.5 defined cardiomegaly. Furthermore, we assessed the presence or absence of signs of pulmonary congestion. The reproducibility status was assessed by reviewing 30 chest radiographs, taken at random to analyze the CTI variable. Figure 1 shows a chest X-ray, in which we see cardiomegaly and the points considered for the correct CTI calculation.

Transthoracic echocardiogram

The tests were carried out by two echocardiography experts certified by the Echocardiography Department of the Brazilian Society of Cardiology, strictly following the standards recommended by the Guidelines for Indications and Use of Echocardiography in Clinical Practice.[5] It is noteworthy that none of these two observers maintained any relationship with the chest X-ray

Figure 1. Chest X-ray from patient RAS, 28 years of age, male. Here are the points which must be properly utilized to calculate the CTI. CTI = A + B/C.



analysis. The patient was placed in the left lateral decubitus position and we used the Caris® echocardiograph (Esaote-Biomedica, Italy) model, equipped with a 2.5 MHz transducer, using the usual slices thorough the study to obtain the M-mode, two-dimensional mode and pulsed Doppler, simultaneously with continuous ECG recording. According to the recommendations from the American Society of Echocardiography/ European Association of Echocardiography,[6] the interventricular septum thickness (IVST) and that of the posterior wall of the left ventricle (LVPW) were obtained during diastole, and the LV mass, in grams, was calculated according to the following formula: LV mass = 0.8 x {1.04 $[(IVST + LVDD + LVPW)^3 - (LVEDD)^3]$} + 0.6 g,[6,7] where IVSD is the interventricular septum in diastole, LVDD is the LV end-diastolic diameter and LVPW is the posterior wall thickness in diastole. The LV mass was corrected for body surface area. The echocardiographic diagnosis of LVH was established when LVMI was > 88 g/m^2 for women and > 102 g/m^2 for men.[5] The left ventricular wall relative thickness (WRT) was also calculated by the formula: WRT = 2 x LVPW/LVDD, where LVPW is the posterior wall of the left ventricle during diastole and LVDD is the LV end-diastolic diameter. From the calculation of the WRT, it was possible to establish the two geometric patterns of LVH:

concentric, when RWT ≥ 0.42; and eccentric, when WRT < 0.42.[6] The LV systolic function was assessed by the percentage shortening of the cavity and the LV ejection fraction obtained by the Teicholz method.

Anthropometric measures

We checked weight and height, always up to one hour after the end of the dialysis sessions. The body surface area in m^2 was calculated according to the Mosteller equation (0.20247 x weight,$^{0.425}$ height$^{0.725}$). The body mass index was calculated by dividing the weight (kg) by height squared (m).

Hemodialysis

The patients underwent three weekly dialysis sessions, each lasting about four hours. The amount of fluid to be withdrawn was measured from estimating the "dry weight", taking into account clinical signs of hydration and blood pressure behavior during the treatment session. The dialysis machines used were the models 1550 Baxter and AltraTouch (Baxter, USA) with cellulose acetate dialyzer regulated by blood flow at 250-300 ml/min and 500 ml/min dialysate flow, reverse osmosis method.

Statistical analysis

Continuous variables were expressed as mean and standard deviation. Categorical variables were expressed as a percentage. The association between LVMI and the other variables of interest was made by means of the Pearson correlation coefficient. For this study, we considered only relevant the Pearson coefficient ≥ 0.50. We used the ROC curve to study the CTI sensitivity and specificity, considering values above 50% as cutoff points. The Fisher exact test was used to compare CTI sensitivity, according to the geometric patterns of LVH, and we used the *Student t*-test to compare the LVMI of men and women. The CTI likelihood ratio was also calculated. The reproducibility test for the studied variable (CTI) was performed using the Lin agreement coefficient. To check for statistical significance in all comparisons, we used the 95% confidence intervals and a $p < 0.05$.

Results

Of the 100 patients who completed the study, 58 were men (58%) and 42 were women (42%), aged 46.2 ± 14.0 years (range 18-78 years) and HD duration 50.7 ± 46.5 months (ranging between six and 225 months, median value of 33.5 months). Table 2 summarizes patient demographics and clinical characteristics.

Table 2 Demographic data/clinical characteristics

Variable	N = 100
Age (years)	46.2 ± 14.0
Gender M/F	58/42
Skin color White/Black/Brown	42/35/23
Body surface (m^2)	1.6 ± 0.1
Body surface index (Kg/m^2)	22.7 ± 3.7
Time in hemodialysis (months)	50.7 ± 46.5
Systemic arterial hypertension (%)	90
Diabetes mellitus (%)	14
Smoking (%)	4
Systolic arterial pressure (mm Hg)	138.2 ± 21.1
Diastolic arterial pressure (mm Hg)	78.1 ± 8.2
Anti-hypertensive drugs	
- one	35
- two	24
- three	15
- four	1

M: Male; F: Female.

LVH prevalence by echocardiography was 83%, with 56 of these patients (67.4%) with the concentric type and 27 (32.6%) patients with the LVH eccentric pattern. The LVMI in the studied population was 154.9 ± 57.3 g/m^2. Separating by gender, the LVMI was 159.9 ± 57.0 g/m^2 in men and 148.0 ± 57.6 g/m^2 in women ($p = 0.306$). Table 3 shows the values of echocardiographic variables.

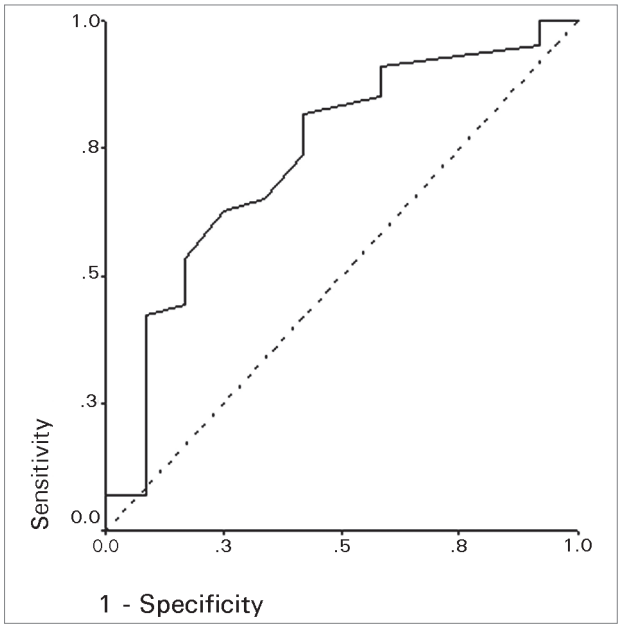
Table 3 Demographic findings

Variable	N = 100	Normal values[6]
LVDD (mm)	51.1 ± 6.8	39-53
IVS (mm)	51.1 ± 6.8	6.0-9.0
LVPW (mm)	11.7 ± 2.3	6.0-9.0
LV mass (g)	255.1 ± 98.8	67-162
LV mass index (g/m^2)	154.9 ± 57.3	43-95
EF (%)	66.7 ± 5.6	≥ 55

LVDD: Left ventricle diastolic diameter; IVS: Interventricular septum; LVPW: Left ventricle posterior wall; EF: Ejection fraction (of the left ventricle).

Regarding the radiological findings, the mean CTI score was 0.53 ± 0.07. Cardiomegaly, defined by CTI > 0.5, was present in 61 patients (61%) and signs of pulmonary congestion were found in 41 cases (41%). The following were the sensitivity, specificity and accuracy values for the CTI variable in the general population: 66.2% (0.555 to 0.755); 70.5% (0.468 to 0.867) and 68.0% (0.579 to 0.770), respectively. Now, the ROC curve for this continuous variable is shown in Figure 2. According to the Lin coefficient, levels of agreement for the intra - and inter CTI were 0.91 and 0.90 are considered excellent and good, respectively.

Figure 2. ROC curve for variable CTI. Area under the curve = 0.734 (confidence interval = 0.577-0.891).



Proceeding to the Pearson correlation coefficient we found a coefficient of 0.552 between the CTI and the LVMI ($p < 0.05$, CI = 0.399 to 0.675).

As seen on Table 4, the calculation of the likelihood ratio demonstrates that the CTI has discriminatory power in the diagnosis of LVH in this population.

Table 4 CTI x LVH likelihood ratio

Criterion assessed	Positive LR (CI)	Negative LR (CI)
CTI	2.2 (1.21-5.63)	0.4 (0.31-0.78)

LR: Likelihood ratio; CI: Confidence interval; CTI: Cardiothoracic index

Discussion

It is assumed that the chest X-Ray is an admittedly limited method for LVH diagnosis. In the anteroposterior view it is possible to observe apex cordis and LV bulging, when there is LVH. However; hypertrophy alone does not alter the cardiac silhouette as to be detected on chest X-Ray. When the LV displays a more pronounced disorder, resulting in dilation, the chest radiography may grossly show this increase by the cardiothoracic index (CTI), which should be more than 0.5.[8,9]

Under normal conditions, the heart silhouette is located in the lower half of the chest, above the diaphragm, obliquely to the left, so that one third of the cardiac mass lies to the right of the midline and two thirds on the left. The sum of the distance between the cardiac contour over to the right side of the midline with the distance from the left side of this boundary line should not exceed half the distance of the side edges of the lungs (Figure 1).[8,9] This relationship is defined as CTI, which normal value is up to 0.5.[8]

In the present study the prevalence of cardiomegaly was 61 % and the statistical analysis showed a correlation between LVMI and CTI, perhaps a reflection of the severity of the study population.

However; in the general population, chest radiography has not been used for the purpose of diagnosing LVH, because it is surpassed by other highly available and low cost tools, such as the electrocardiogram.

In this study, we used the transthoracic echocardiography as the gold standard test for LVH detection. There is no doubt that this imaging study represents a major advance in the diagnosis of various cardiac pathologies, including LVH. However; its high cost and methodological limitations with regard to reproducibility, since it is very examiner-dependent, restricts its use in epidemiological studies, unlike what happens with chest radiography and electrocardiography.

It is important to stress that the two tests used in our study, the echocardiogram and the chest X-ray, were carried out up to an hour after the HD session, and there is an estimate that LVMI may

decrease 26 g/m^2 on average during the sessions, as a consequence of body fluids removal.[10]

The Framingham study, in a 30-year follow-up, showed clearly that the electrocardiogram pattern of LVH increased the hazard ratio for coronary events in 3.0 to 5.8 times; of stroke from 3.2 to 7.0 times and heart failure in up to 17.5 times. Particularly in relation to heart failure, the possibility of developing it was higher in the presence of an ECG compatible with LVH than even a cardiomegaly seen on a chest film.[11]

In this study, the chest film showed good performance in LVH diagnosis, with over 66% sensitivity, although its specificity was only 70.5%. When we divided the population effectively with the LVH within the known geometric patterns: concentric (worst prognosis) and eccentric, the CTI showed no statistically significant difference with respect to differentiating one pattern from the other, which can be explained by the small sample size.

Regarding the Pearson's correlation coefficient, the CTI showed strength, both when one considers the general population, as well as when separating by gender, emphasizing that correlation r was higher among women, although the mean LVMI was lower in this group (148.0 ± 57.6 g/m^2 x 159.9 ± 57.0 g/m^2; $p = 0.306$).

Also important is the likelihood ratio calculation, which shows discriminatory power in the CTI for LVH diagnosis in our sample.

Based on the data presented, it can be concluded that, although not among the diagnostic procedures of choice for the detection of LVH, the study showed that the chest radiography is safe, useful, and cannot be neglected as a diagnostic tool for LVH in patients with stage 5 kidney disease.

Limitations of the study

This is a sample made up of severely ill patients, whose clinical profile and the long time in dialysis already indicate a high LVH prevalence. Therefore, the results presented hereby may not be extrapolated to the general population.

Although ventricular mass was indexed to body surface, the echocardiography and chest radiography were performed within one hour after the end of the HD session, the weight reduction is not uniform for all patients and there can be variations according to the dialysis sessions.

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