ความสัมพันธ์ระหว่างอัตราการกรองของไตต่อดัชนีมวลกล้ามเนื้อหัวใจห้องล่างซ้ายในผู้ป่วยไตเรื้อรัง

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Correlation between Glomerular Infiltration Rate and Left Ventricular Mass Index in Chronic Kidney Disease Patients

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Abstract

Background: Chronic kidney disease induced increases in left ventricular mass index were found to correlate with glomerular filtration rate. The relationship and risk factors of cardiac structure and glomerular filtration rate have not been studied in Thai patients. Objectives: This study was to investigate the correlation between glomerular filtration rate (GFR) and left ventricular mass index in chronic kidney disease (CKD) Thai patients. Methods: This cross-sectional study was conducted at Pranangklao Hospital between January 2016 and December 2021. A total of 248 CKD patients were included in the study. The mean age of the patients was 64.18±14.57 years, and 37.1% of the patients were male. The mean glomerular infiltration rate (GFR) was 57.63±34.22 ml/min/1.73m^2, and the mean LVMI was 113.31±41 g/m^2. The majority of the patients had hypertension and dyslipidemia and were being treated with statins and beta blockers. Results: Left ventricular mass index (LVMI) was negatively correlated with hematocrit ($r = -0.147$, $p = .02$) and GFR ($r = -0.283$, $p < .001$) and positively correlated with hypertension ($r = 0.228$, $p < .001$), diabetes mellitus ($r = 0.173$, $p = .006$), dyslipidemia ($r = 0.24$, $p < .001$), coronary artery disease ($r = 0.216$, $p = .001$), LVMI ($r = 0.947$, $p < .001$), relative wall thickness ($r = 0.205$, $p = .001$), left atrial volume index ($r = 0.557$, $p < .001$), right atrial pressure ($r = 0.161$, $p = .011$), tricuspid regurgitation velocity ($r = 0.214$, $p = .001$), right ventricular systolic pressure ($r = 0.306$, $p < .001$), and mean pulmonary artery pressure ($r = 0.344$, $p < .001$). Conclusion: This study found a significant correlation between GFR and LVMI in Thai CKD patients ($r = -0.283$). The results suggest that as GFR declines, LVMI increases, which may lead to adverse cardiovascular outcomes.

Keywords: Chronic kidney disease, Left ventricular mass index.

บทคัดย่อ

ภูมิหลัง: ดัชนีมวลหัวใจห้องล่างซ้ายที่เพิ่มขึ้นจากโรคไตเรื้อรังพบว่ามีความสัมพันธ์กับอัตราการกรองของไต ความสัมพันธ์และปัจจัยเสี่ยงของโครงสร้างหัวใจกับอัตราการกรองไตยังไม่มีการศึกษาในผู้ป่วยไทย **วัตถุประสงค์:** เพื่อศึกษาความสัมพันธ์ระหว่างอัตราการกรองของไตต่อดัชนีมวลกล้ามเนื้อหัวใจห้องล่างซ้ายในผู้ป่วยไตเรื้อรัง **วิธีการ:** ผู้นิพนธ์ได้ศึกษาข้อมูลช่วงเวลาหนึ่งที่โรงพยาบาลพระนั่งเกล้า ระหว่างเดือนมกราคม พ.ศ. 2561 ถึง เดือนธันวาคม พ.ศ. 2563 ในผู้ป่วยไตเรื้อรัง **ผล:** มีผู้ป่วยเข้าร่วมทั้งหมด 248 ราย อายุเฉลี่ยของผู้ป่วยคือ 64.18±14.57 ปี (ชาย 37.1%) อัตราการกรองของไต เฉลี่ยคือ 57.63±34.22 มล./นาที/1.73 ตร.ม. และดัชนีมวลกล้ามเนื้อหัวใจห้องล่างซ้ายเฉลี่ยเท่ากับ 113.31±41 ก./ตร.ม. ผู้ป่วยส่วนใหญ่มีความดันโลหิตสูงและไขมันในเลือดผิดปกติ ผู้ป่วยส่วนใหญ่ได้รับ statin, beta blocker. ดัชนี left ventricular mass (LVmass) เป็นความสัมพันธ์ที่เกี่ยวข้องกับ hematocrit -0.147 (.02), GFR -0.283 (< .001), HT 0.228 (< .001), DM 0.173 (.006), DLP 0.24 (< .001), CAD 0.216 (.001), Clopidogrel 0.187 (.003), ACEI/ARB 0.144 (.023), statin 0.141 (.027), PPI 0.138 (.03), LVmass 0.947(< .001), RWT 0.205 (.001), ดัชนีปริมาตร LA 0.557 (< .001), RAP 0.161 (.011), TR Vmax 0.214 (.001), RVSP 0.306 (< .001), meanPAP 0.344 (< .001), PAEDP 0.335 (< .001). การศึกษาปัจจุบันของเราในผู้ป่วยไทยที่เพิ่มเข้ามาแสดงให้เห็นความสัมพันธ์อย่างมีนัยสำคัญระหว่างอัตราการแทรกซึมของไตและดัชนีมวลกระเป๋าหน้าท้องด้านซ้ายด้วย r = 0.283 **สรุป:** การกรองไตที่ลดลงสัมพันธ์กับดัชนีมวลกล้ามเนื้อหัวใจห้องล่างซ้ายที่เพิ่มขึ้นในผู้ป่วยไตเรื้อรัง

คำสำคัญ: โรคไตเรื้อรัง, ดัชนีมวลกล้ามเนื้อหัวใจห้องล่างซ้าย

Introduction

Chronic kidney disease (CKD) is a prevalent condition among patients with heart failure (HF) and is associated with increased mortality rates.[1] Reduced glomerular filtration rate (GFR) increases the risk of cardiovascular disease and incidence of heart failure.[2] Patients with eGFR < 60 mL/min/1.73 m^2 have increased rates of cardiovascular mortality and hospitalization from heart failure.[3] Additionally, patients with stage 2 CKD have double the mortality from cardiovascular disease and triple the mortality from cardiovascular disease compared to patients with normal renal function.[4]

Echocardiography is a diagnostic tool that can detect cardiovascular disease in patients with CKD at earlier stages than other tests, such as cardiac CT scan or cardiac MRI. It can identify structural and functional abnormalities in the heart associated with CKD, such as high left ventricular muscle mass, which is more commonly found in CKD patients than a high body mass index (BMI).[5] It has been found that left ventricular mass index relative to BMI is very high in more than a third of people with CKD.[6] This finding is further supported by the presence of cardiovascular disease commonly found in CKD patients, as evidenced by electrocardiogram and laboratory results.[7]

A comparative prevalence study of clinical features among hypertensive patients found that congestive heart failure with and without features of abnormal left ventricular relaxation is common in chronic renal patients.[8] Furthermore, this relationship is associated with GFR, cardiac structure, cardiac function, and prognosis after myocardial infarction.[9] There is literature on the relationship between decreased GFR and ventricular structure and function in patients with high blood pressure.[10] However, there are no studies in Thai patients with CKD.

The aim of this study was to determine the relationship between GFR and left ventricular mass index in Thai patients with CKD. This study can potentially provide valuable information for the early detection and management of cardiovascular disease in CKD patients in Thailand. This retrospective study was conducted at Pranangklao Hospital from January 1st, 2018 to December 31st, 2021, and included patients aged >18 years who underwent echocardiography.

Material and methods

Study design and population

A cross sectional study was conducted at Pranangklao Hospital. Chronic kidney patients (>18 years old) from outpatient clinic and inpatient who underwent echocardiography during period from 1 January 2018 to 31 December 2021.

We identified chronic kidney disease and echocardiography. We used the International Classification of Diseases, 10th Revision (ICD-10) Procedural Classification System codes beginning with N181 to identify chronic kidney disease stage 1, N182 to identify chronic kidney disease stage 2, N183 to identify chronic kidney disease stage 3, N184 to identify chronic kidney disease stage 4, N185 to identify chronic kidney disease stage 5, N186 to identify end stage renal disease, N189 to identify chronic kidney disease, unspecified.

Data collection

The collected data include patient characteristics, previous medical illness, echocardiography data. Patients who had a history of metallic prosthetic valve replacement surgery or arrhythmia were excluded. The sample size of 248 was estimated using the infinite population means calculation technique, based on previous data by Reid et al., where the standard deviation and error approximated 17 and 3, respectively (ref). Type I and II errors were set at 0.05 and 0.2, respectively.

The study protocol was approved by the Institutional Review Board (IRB), with an issued No. PE6529, and was conducted in compliance with the Declaration of Helsinki, the Council for International Organizations of Medical Sciences (CIOMS) Guidelines, and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP).

Statistical analysis

Descriptive statistics, including frequency and percentage, were used to summarize categorical variables. Continuous variables were reported as means and standard deviation (SD). The distribution of variables was assessed using the Kolmogorov-Smirnov test. ANOVA test was used to compare normally distributed continuous variables among three groups, and the Chi-square test was used for categorical data. A p-value less than .05 was considered statistically significant. Pearson's correlation was used to determine the correlation between TTR and eGFR. IBM SPSS version 26 (SPSS, Inc., Chicago, IL, USA) was used to perform all statistical analyses.

Results

A total of 248 patients were diagnosed with chronic kidney disease at Pranangklao Hospital from 1 January 2018 to 31 December 2021, as recorded in the echocardiographic database.

Table 1 Baseline characteristics of the patients.

	Total (n = 248)	eGFR <30 (n = 60)	eGFR 30-59 (n = 63)	eGFR 60-89 (n = 65)	eGFR >=90 (n = 60)	*p*-value
Age (years)	64.18 ± 14.57	62.73 ± 13.68	75.97 ± 12.26	66.75 ± 9.91	50.47 ± 9.41	<.001*
Male	92 (37.1%)	22 (36.7%)	24 (38.1%)	24 (38.1%)	22 (36.7%)	.998
Height (cm)	159.54 ± 8.27	159.8 ± 8.78	158.11 ± 8.28	159.23 ± 7.21	161.12 ± 8.71	.240
Weight (kg)	64.53 ± 14.37	58.42 ± 10.5	62.95 ± 12.98	67.55 ± 15.78	69.03 ± 15.33	<.001*
Body surface area (m^2)	1.66 ± 0.19	1.59 ± 0.16	1.63 ± 0.19	1.7 ± 0.19	1.73 ± 0.2	<.001*
Hematocrit (%)	35.97 ± 5.72	31.94 ± 4.97	36.12 ± 5.39	37.36 ± 4.45	38.35 ± 5.96	<.001*
Glomerular infiltration rate ($ml/min/1.73m^2$)	57.63 ± 34.22	10.53 ± 3.3	45.35 ± 8.73	72.02 ± 8.58	102.02 ± 9.17	<.001*
Medical history						
Hypertension	200 (80.6%)	56 (93.3%)	57 (90.5%)	54 (83.1%)	33 (55%)	<.001*
Diabetes mellitus	119 (48%)	44 (73.3%)	33 (52.4%)	26 (40%)	16 (26.7%)	<.001*
Dyslipidemia	183 (73.8%)	54 (90%)	56 (88.9%)	47 (72.3%)	26 (43.3%)	<.001*
Coronary artery disease	61 (24.6%)	22 (36.7%)	15 (23.8%)	16 (24.6%)	8 (13.3%)	.032*
Previous stroke	18 (7.3%)	5 (8.3%)	4 (6.3%)	5 (7.7%)	4 (6.7%)	.973
Medical history						
Aspirin	88 (35.5%)	31 (51.7%)	20 (31.7%)	21 (32.3%)	16 (26.7%)	.023*
Clopidogrel	51 (20.6%)	17 (28.3%)	14 (22.2%)	14 (21.5%)	6 (10%)	.091
Betablocker	112 (45.2%)	32 (53.3%)	33 (52.4%)	29 (44.6%)	18 (30%)	.036*
ACEI/ARB	108 (43.5%)	21 (35%)	32 (50.8%)	33 (50.8%)	22 (36.7%)	.129
Statin	154 (62.1%)	42 (70%)	49 (77.8%)	35 (53.8%)	28 (46.7%)	.001*
Fenofibrate	7 (2.8%)	1 (1.7%)	1 (1.6%)	3 (4.6%)	2 (3.3%)	.691
Proton pump inhibitor	85 (34.3%)	28 (46.7%)	22 (34.9%)	21 (32.3%)	14 (23.3%)	.060
Echocardiography parameter						
Left ventricular mass (g)	188.84 ± 72.46	213.02 ± 68.52	186.8 ± 71.91	174.43 ± 60.6	182.41 ± 83.66	.020
Left ventricular mass index (g/m^2)	113.31 ± 41	133.78 ± 42.49	113.44 ± 39.48	102.47 ± 31.3	104.46 ± 43.56	<.001*
Relative wall thickness	0.48 ± 0.14	0.54 ± 0.15	0.47 ± 0.14	0.46 ± 0.13	0.43 ± 0.11	<.001*
Left atrial volume index (ml/m^2)	39.67 ± 15	43.55 ± 14.64	40.23 ± 15.25	38.2 ± 14.91	36.79 ± 14.7	.073
Right atrial pressure (mmHg)	6 ± 3.7	6.32 ± 3.96	6.17 ± 3.56	5.02 ± 2.96	6.55 ± 4.25	.095
TR Vmax (meter/second)	2.73 ± 0.94	2.98 ± 1.71	2.77 ± 0.53	2.63 ± 0.37	2.55 ± 0.43	.058
RVSP (mmHg)	35.96 ± 14.0	38.5 ± 16.73	38.73 ± 16.46	33.29 ± 9.32	33.31 ± 11.75	.031
meanPAP (mmHg)	22.61 ± 9.62	26.19 ± 11.37	23.43 ± 9.06	19.81 ± 7.08	21.02 ± 9.47	.001*
PAEDP (mmHg)	12.05 ± 5.8	13.85 ± 6.42	12.57 ± 5.66	10.27 ± 4.21	11.5 ± 6.25	.005

cm: centimeter, Kg: kilogram, m^2: $meter^2$,ml: milliliter, min: minute, ACEI: Angiotensin-Converting enzyme inhibitors, ARB: Angiotensin II Receptor Blockers, mmHg: millimeter of mercury, g: gram, s: second, ms: milliseconds, TR Vmax: Tricuspid regurgitation velocity maximum, RVSP: Right ventricular systolic pressure, meanPAP: Mean pulmonary artery pressure, PAEDP: Pulmonary artery ends diastolic pressure,

Baseline characteristics: Table 1 displays the baseline characteristics of the patients. The mean age was 64.18 ± 14.57 years, and males accounted for 37.1% of the patients. The mean glomerular infiltration rate was 57.63 ± 34.22 $ml/min/1.73m^2$. Patients with the lowest level of glomerular infiltration rate, when compared to those with a rate > 90 ml/min per $1.73m^2$, were more likely to have hypertension, diabetes mellitus, dyslipidemia, coronary artery disease, and were taking aspirin, beta blockers, and statins. On average, these patients had higher left ventricular mass, left ventricular mass index, relative wall thickness, left ventricular ejection fraction (measured by bi-plane method), right ventricular systolic pressure, mean pulmonary artery pressure, and pulmonary artery end-diastolic pressure.

Table 2 Pearson Correlation

	Variables	r	*p*-value
Left ventricular mass index (g/m^2)	**Age (years)**	-0.048	.450
	Male	0.248	<.001*
	Height (cm)	0.153	.016*
	Weight (kg)	0.033	.610
	Body surface area (m^2)	0.047	.462
	Hematocrit (%)	-0.147	.020*
	Glomerular infiltration rate (mL/min/1.73m^2)	-0.283	<.001*
	Medical history		
	Hypertension	0.228	<.001*
	Diabetes mellitus	0.173	.006*
	Dyslipidemia	0.24	<.001*
	Coronary artery disease	0.216	.001*
	Previous stroke	-0.06	.345
	Medical history		
	Aspirin	0.064	.317
	Clopidogrel	0.187	.003*
	Betablocker	0.109	.087
	ACEI/ARB	0.144	.023*
	Statin	0.141	.027*
	Fenofibrate	0.103	.106
	Proton pump inhibitor	0.138	.030*
	Echocardiography parameter		
	Left ventricular mass (g)	0.947	<.001*
	Relative wall thickness	0.205	.001*
	Left atrial volume index (milliliter/m^2)	0.557	<.001*
	Right atrial pressure (mmHg)	0.161	.011*
	TR Vmax (m/s)	0.214	.001*
	RVSP (mmHg)	0.306	<.001*
	meanPAP (mmHg)	0.344	<.001*
	PAEDP (mmHg)	0.335	<.001*

Cm: centimeter, Kg: kilogram, m^2: meter^2,ml: milliliter, min: minute, ACEI: Angiotensin-converting enzyme inhibitors, ARB: Angiotensin II receptor blockers, mmHg: millimeter of mercury, g: gram, s: second, ms: milliseconds, TR Vmax: Tricuspid regurgitation velocity maximum, RVSP: Right ventricular systolic pressure, meanPAP: Mean pulmonary artery pressure, PAEDP: Pulmonary artery ends diastolic pressure,

Table 2 shows the Pearson correlation analysis between left ventricular mass index and various factors. Hematocrit, glomerular infiltration rate, hypertension, diabetes mellitus, dyslipidemia, coronary artery disease, clopidogrel, angiotensin-converting enzyme inhibitors/ angiotensin II receptor blockers, statins, proton pump inhibitors, left ventricular mass, relative wall thickness, left atrial volume index, right atrial pressure, tricuspid regurgitation velocity, right ventricular systolic pressure, mean pulmonary artery pressure, and pulmonary artery end-diastolic pressure were all significantly correlated with left ventricular mass index.

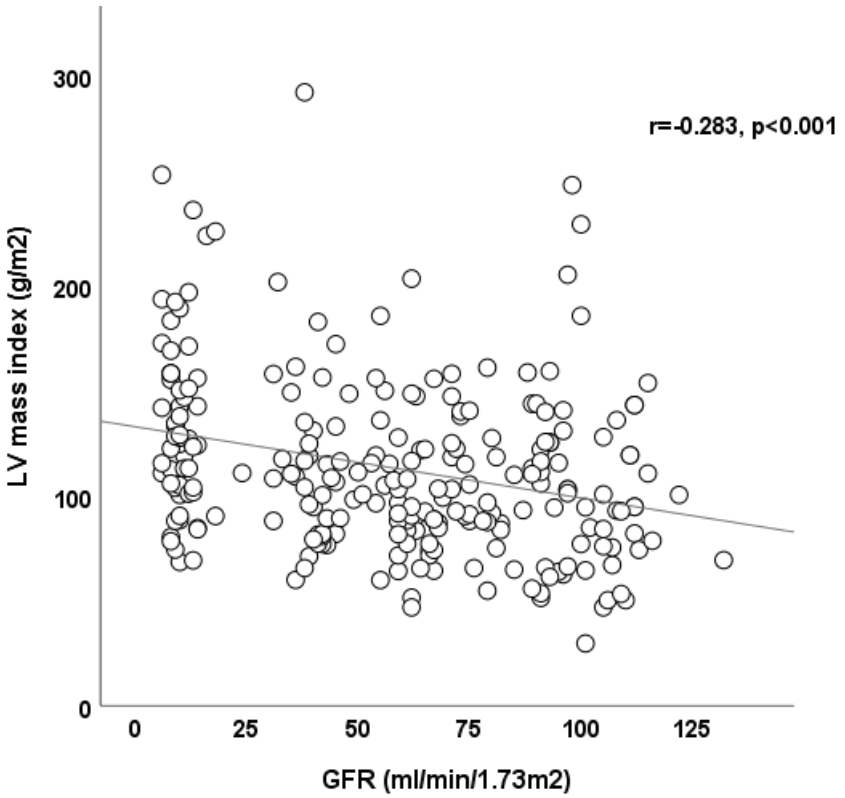

Figure 1 scatter plot LV mass index and GFR

Figure 1 demonstrates the negative correlation between glomerular infiltration rate and left ventricular mass index, with left ventricular mass index tending to increase as glomerular infiltration rate decreases (Pearson's correlation coefficient = 0.283, $p < .001$).

Discussion

The present study aimed to evaluate the echocardiographic characteristics of Thai patients with chronic kidney disease who were referred for echocardiography. Our findings demonstrated a higher prevalence of left ventricular abnormalities, including both structural and functional abnormalities, in patients with chronic kidney disease, even in those with stage I disease.[11] This is consistent with previous research that has shown a higher likelihood of left ventricular hypertrophy in patients with chronic kidney disease compared to the general population.[12-13]

CKD and CVD share common risk factors, such as high blood pressure. atherosclerosis and abnormalities endothelial. Previous studies have shown that the prevalence of LVH is higher in patients with CKD than in the general population. Moreover, a gradual increase in LVMI has been observed along with the progression of CKD.[14] The pathogenesis relies on the increase in LVMI in CKD patients to be of multifactorial origin. Vascular wall changes, such as increased hardening of the arteries and calcification Happens with increasing age Primary arterial stiffness contributes to increased peripheral resistance. worsening high blood pressure and increased pulse pressure This results in an increase in the LV mass. Additionally, protein in the urine is an indicator of inflammation. oxidative stress and endothelial dysfunction. The interaction of these factors can result in vascular injury and myocardial growth and fibrosis. which leads to kidney and heart involvement.[15]

Traditional cardiovascular risk factors such as hypertension, diabetes mellitus, dyslipidemia, and coronary artery disease may contribute to the increased cardiovascular risk observed in patients with chronic kidney disease. However,

additional risks such as metabolic disorders, inflammation, oxidation, and heart abnormalities may also be present. Several studies have highlighted the higher prevalence of left ventricular hypertrophy and subclinical cardiac abnormalities in CKD patients. Additionally, left ventricular hypertrophy has been found to be a significant predictor of mortality in end-stage renal disease, and left ventricular systolic function monitoring is recommended in asymptomatic dialysis patients due to its potential prognostic significance.[14, 16-21]

Our study also found a significant positive correlation between decreased glomerular filtration rate and increased left ventricular mass index, consistent with previous research.

However, some limitations of our study should be acknowledged, including the limited sample size, potential unaccounted factors, and the retrospective nature of the study. Our study is subject to bias due to lack of data (intraobserver and interobserver).

Therefore, further research is needed to confirm and expand upon our findings, and to examine the potential factors that contribute to left ventricular abnormalities in patients with chronic kidney disease.

Conclusion

Our study found a significant positive correlation between decreased glomerular filtration rate and increased left ventricular mass index in Thai patients with chronic kidney disease. These findings highlight the importance of monitoring cardiac function in patients with chronic kidney disease, particularly those with lower glomerular filtration rates. Further research is needed to confirm and expand upon our findings and to identify effective strategies for preventing or reversing left ventricular hypertrophy in patients with chronic kidney disease.

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