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# The Prevalence, Types, and Risk Factors of Chronic Heart Failure (CHF) in End-Stage Kidney Disease Patients with Symptomatic CHF

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## ABSTRACT

**OBJECTIVE:** The objective of this study was to investigate the prevalence, types, and risk factors of chronic heart failure in Thai patients with end-stage kidney disease (ESKD).

**METHODS:** In this retrospective study, the authors examined patients with clinical heart failure in ESKD at Pranangklao Hospital between January 2021 and May 2022.

**RESULTS:** The study enrolled a total of 128 patients, with an average age of 58.82 ± 14.44 years, of which 56.30% were male. The average body surface area was 883.48 ± 398.41 $m^2$. The majority of patients received hemodialysis (65.60%). Hypertension and dyslipidemia were the most common comorbidities, and folic acid and statins were the most commonly prescribed medications. There were no statistically significant differences in left ventricular ejection fraction between patients receiving hemodialysis versus peritoneal dialysis. The study found that among the 3 different heart failure groups by left ventricular ejection fraction (LVEF) (LVEF ≤ 40%, 41-49%, ≥ 50%), the LVEF was 10 (7.81%), 7 (5.46%), and 111 (86.73%), respectively. Similarly, the diastolic function grades (grade I, II, III) were 62 (55.86%), 46 (41.44%), and 3 (2.70%), respectively. Patients with coronary artery disease had a significantly lower left ventricular ejection fraction.

**CONCLUSION:** Diastolic dysfunction and grade I diastolic dysfunction are common in Thai patients with ESKD.

**KEYWORDS:** chronic kidney disease, end-stage kidney disease, heart failure

## INTRODUCTION

Presently, chronic kidney disease (CKD) is a common cause of suffering and death because the risk factors, such as obesity and diabetes mellitus, have increased in the general population. The number of people affected by CKD has also been rising, with an estimated 843.6 million people affected globally in 2017. Although end-stage kidney disease patients' mortality has decreased, end-stage kidney disease (ESKD) has become the leading cause of death globally[1]. It is of significant importance[2].

A very frequent complication is cardiovascular disease (CVD), which is the primary factor in death for ESKD patients receiving hemodialyzed (HD) treatment. When compared to the general population, this population has a 20-fold higher rate of CVD-related mortality, and CVD is present in the majority of patients with maintenance HD, which is both non-traditional and most likely brought on by ventricular hypertrophy. Risk factors include chronic volume overload, anemia, inflammation, oxidative stress, chronic kidney disease, mineral bone disorder,

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and other 'uraemic milieu' components. Knowing more about how these various CVD-related factors interact would be beneficial, for both prevention and treatment, and a crucial step in the right direction. We concentrated on non-conventional CVD risk factors in HD patients in this review[3-4].

Kidney transplantation is the most effective treatment for end-stage kidney disease, leading to a marked improvement in survival and quality of life compared to maintenance dialysis. Furthermore, the risk of CVD is decreased in patients with ESKD following a kidney transplant[5]. Patients with ESKD often experience fatigue, which may be caused by ESKD or heart failure. The European Society of Cardiology uses the New York Heart Association (NYHA)[6] classification system as the basis for diagnosing heart failure and related complications[6]. This classification categorizes patients based on the severity of symptoms, including exertional dyspnea and other symptoms that occur during normal activities or at rest. It also subdivides the types of heart failure in order to aid in the appropriate treatment[7].

Echocardiography[8], a diagnostic tool that uses high-frequency sound waves, is a primary method for assessing structural and functional abnormalities of the heart. Therefore, evaluating the parameters from echocardiography in end-stage kidney disease patients can aid in risk stratification and the prognostication of cardiovascular and vascular diseases in this population.

According to a population-based study conducted at Ain Shams Hospital in Egypt[9], the prevalence of grade I diastolic dysfunction in patients with end-stage kidney disease was 46. The purpose of this study was to investigate the prevalence, types, and risk factors of CHF in patients with ESKD.

## METHODS

This was a retrospective, analytical, single-center study. The study protocol was approved by the Institutional Review Board, issued No. PE6528, which complies with the Declaration of Helsinki and CIOMS Guidelines and International Conference on Harmonization in Good Clinical Practice (ICH-GCP).

We queried the Pranangklao database between January 1, 2021 and May 31, 2022 in order to identify adults who underwent echocardiography; we identified ESKD and CHFe. We used the International Classification of Diseases, 10$^{th}$ Revision (ICD-10) Procedural Classification System codes beginning with N186 to identify ESKD. We used ICD-10-Clinical Modification (ICD-10-CM) codes, beginning with I50, to identify CHF.

ESKD is defined as patients with kidney failure who have undergone renal replacement therapy (RRT). Heart failure is defined as patients with a syndrome that consists of the symptoms of HF, such as shortness of breath or dyspnea[6]. There are 3 classifications for heart failure, according to LVEF: HF with reduced EF (HFrEF) LVEF ≤ 40%, HF with mildly reduced EF (HFmrEF) LVEF 41%–49%, and HF with preserved EF (HFpEF) LVEF ≥ 50%.

To select patients for the study, the following inclusion criteria were applied: patients with ESKD, aged 18 years or older and had undergone echocardiography examination due to clinical heart failure. However, patients with incomplete data or who were lost to follow-up, as well as those with arrhythmia heart rhythms, were excluded from the study.

Sample size was calculated based on the study of Ahmed A Elkaialy[9] using the following equation: $n = Z^2_{1-}\alpha/_2\, p(1-p) / d^2$. While n was the sample size, p was 0.78, d was 0.078, $\alpha = 0.05$, Z (0.975) was 1.96, and thus the number of patients required was 109.

## RESULTS

From January 1, 2021 to May 31, 2022, there were a total of 128 patients diagnosed with ESKD, presenting with symptoms of HF and undergoing echocardiography heart examination.

From Table 1, the baseline characteristic of ESKD patients: the average age was 58.82 ± 14.44 years, and 56.30% were male. The average body surface area was 1.61 ± 0.18 $m^2$; 65.60% of the patients underwent hemodialysis, and the average hematocrit concentration was 31.57 ± 4.80. The majority of patients had comorbidities such as hypertension, hyperlipidemia, and diabetes mellitus. Those with a history of coronary artery disease and significant stenosis or occlusion of the coronary arteries demonstrated a significant increase in heart failure exacerbation. Most patients received folic acid, statins, and non-dihydropyridine CCB, in that order.

**Table 1** The baseline characteristic of end-stage kidney disease patients (n = 128)

| Demographic data | Total (n = 128) | Left ventricular systolic dysfunction function | | | |
|---|---|---|---|---|---|
| | | HFrEF (n = 10) LVEF < 40 | HFmrEF (n = 7) LVEF 40 - 50 | HFpEF (n = 111) LVEF > 50 | P-value |
| Age (years) | 58.82 ± 14.44 | 60.6 ± 7.17 | 48 ± 14.25 | 59.34 ± 14.75 | 0.121 |
| Male gender (%) | 72 (56.30) | 3 (30) | 2 (28.60) | 67 (60.40) | 0.057 |
| Body surface area ($m^2$) | 1.61 ± 0.18 | 1.59 ± 0.11 | 1.70 ± 0.28 | 1.61 ± 0.18 | 0.384 |
| Peritoneal dialysis (%) | 44 (34.40) | 5 (50) | 1 (14.30) | 38 (34.20) | 0.311 |
| Hemodialysis (%) | 84 (65.60) | 5 (50) | 6 (85.70) | 73 (65.80) | 0.311 |
| Hematocrit | 31.57 ± 4.80 | 31.20 ± 4.48 | 31.29 ± 4.54 | 31.62 ± 4.87 | 0.954 |
| Medical history | | | | | |
| Hypertension (%) | 125 (97.70) | 10 (100) | 7 (100) | 108 (97.30) | 0.79 |
| Diabetes mellitus (%) | 84 (65.60) | 7 (70) | 5 (71.40) | 72 (64.90) | 0.897 |
| Dyslipidemia (%) | 120 (93.80) | 9 (90) | 6 (85.70) | 105 (94.60) | 0.564 |
| Coronary artery disease (%) | 35 (27.30) | 7 (70) | 4 (57.10) | 24 (21.60) | 0.001 |
| Percutaneous coronary intervention (%) | 16 (12.50) | 4 (40) | 2 (28.60) | 10 (9) | 0.007 |
| Coronary artery bypass graft (%) | 6 (4.70) | 0 (0) | 1 (14.30) | 5 (4.50) | 0.378 |
| Previous stroke (%) | 3 (2.30) | 0 (0) | 0 (0) | 3 (2.70) | 0.79 |
| Medication | | | | | |
| Aspirin (%) | 65 (50.80) | 5 (50) | 4 (57.10) | 56 (50.50) | 0.941 |
| Clopidogrel (%) | 28 (21.90) | 2 (20) | 3 (42.90) | 23 (20.70) | 0.385 |
| Beta blocker (%) | 70 (54.70) | 5 (50) | 5 (71.40) | 60 (54.10) | 0.638 |
| Non-dihydropyridine calcium channel blocker (%) | 87 (68) | 4 (40) | 6 (85.70) | 77 (69.40) | 0.095 |
| Angiotensin-converting enzyme inhibitors/Angiotensin II receptor blockers (%) | 53 (41.40) | 2 (20) | 3 (42.90) | 48 (43.20) | 0.359 |
| Statins (%) | 102 (79.70) | 8 (80) | 7 (100) | 87 (78.40) | 0.386 |
| Furosemide (%) | 82 (64.10) | 8 (80) | 5 (71.40) | 69 (62.20) | 0.486 |
| Isosorbide dinitrate (%) | 43 (33.60) | 1 (10) | 2 (28.60) | 40 (36) | 0.238 |
| Sodium bicarbonate (%) | 58 (45.30) | 2 (20) | 2 (28.60) | 54 (48.60) | 0.144 |
| Calcium carbonate (%) | 78 (60.90) | 6 (60) | 6 (85.70) | 66 (59.50) | 0.385 |
| Ferrous fumarate (%) | 75 (58.60) | 5 (50) | 4 (57.10) | 66 (59.50) | 0.842 |
| Folic acid (%) | 109 (85.20) | 6 (60) | 6 (85.70) | 97 (87.40) | 0.066 |
| Erythropoietin (%) | 51 (39.80) | 3 (30) | 2 (28.60) | 46 (41.40) | 0.64 |

Abbreviations: HFmrEF, heart failure mildly reduce ejection fraction; HFpEF, heart failure preserve ejection fraction; HFrEF, heart failure reduce ejection fraction; LVEF, left ventricular ejection fraction; $m^2$, meter$^2$; min, minute; mL, milliliter

From Table 2, which shows the characteristics of ESKD patients with echocardiographic findings, it was found that there were significant differences among the 3 groups divided by LVEF ≤ 40%, 41-49%, and ≥ 50%, in terms of the left ventricular internal dimension in diastole (LVIDd), which was 5.91 ± 0.78 cm, 5.24 ± 0.44 cm, and 4.57 ± 0.64 cm, respectively. The left ventricular mass index (LVmassIndex) also differed significantly among the 3 groups, with averages of 173.07 ± 30.68, 187.09 ± 49.25, and 137.1 ± 44.22, respectively. The left ventricular ejection fraction (LVEF by bi-plan) also varied significantly among the 3 groups, with averages of 30.47 ± 5.6, 45.81 ± 3.52, and 64.17 ± 7.19, respectively. Finally, the mean pulmonary arterial pressure (meanPAP), as measured by Abbas, also differed significantly among the 3 groups, with averages of 42.55 ± 14.35 mmHg, 37.1 ± 12.77 mmHg, and 24.22 ± 8.92 mmHg, respectively.

**Table 2** Characteristics of end-stage kidney disease patients based on echocardiography findings (n = 128)

| Demographic data | Total (n = 128) | Left ventricular systolic dysfunction function | | | |
|---|---|---|---|---|---|
| | | HFrEF (n = 10) LVEF < 40 | HFmrEF (n = 7) LVEF 40 - 50 | HFpEF (n = 111) LVEF > 50 | P-value |
| LVIDd (cm) | 4.71 ± 0.74 | 5.91 ± 0.78 | 5.24 ± 0.44 | 4.57 ± 0.64 | < 0.001 |
| LVIDs (cm) | 3.16 ± 0.85 | 5.13 ± 0.65 | 3.90 ± 0.62 | 2.94 ± 0.58 | < 0.001 |
| LVEF by Teicholz method (%) | 60.48 ± 14.79 | 27.61 ± 7.16 | 48.21 ± 15.22 | 64.22 ± 10.66 | < 0.001 |
| Relative wall thickness | 1.07 ± 5.97 | 0.41 ± 0.10 | 0.57 ± 0.07 | 1.16 ± 6.41 | 0.908 |
| LV mass index (g/m$^2$) | 142.64 ± 45.64 | 173.07 ± 30.68 | 187.09 ± 49.25 | 137.1 ± 44.22 | 0.001 |
| LVEF by Bi-plane method (%) | 60.53 ± 11.93 | 30.47 ± 5.60 | 45.81 ± 3.52 | 64.17 ± 7.19 | < 0.001 |
| LA volume index (mL/m$^2$) | 44.69 ± 15.24 | 61.06 ± 13.06 | 47.90 ± 8.87 | 43.01 ± 14.90 | 0.001 |
| TAPSE (cm) | 2.30 ± 0.46 | 1.77 ± 0.58 | 2.21 ± 0.13 | 2.35 ± 0.44 | < 0.001 |
| Right atrium pressure (mmHg) | 6.28 ± 3.95 | 10.30 ± 4.32 | 9 ± 2.65 | 5.75 ± 3.73 | < 0.001 |
| TR Vmax (m/s) | 2.95 ± 1.21 | 4.40 ± 3.75 | 3.31 ± 0.82 | 2.79 ± 0.53 | < 0.001 |
| RVSP (mmHg) | 39.68 ± 16.17 | 47.53 ± 21.31 | 55.21 ± 21.99 | 38 ± 14.65 | 0.006 |
| meanPAP (mmHg) | 26.36 ± 11.05 | 42.55 ± 14.35 | 37.1 ± 12.77 | 24.22 ± 8.92 | < 0.001 |
| PAEDP (mmHg) | 15.46 ± 19.46 | 22.86 ± 8.66 | 21.46 ± 5.91 | 14.41 ± 20.52 | 0.299 |
| Med E (cm/s) | 94.84 ± 32.04 | 106.99 ± 31.94 | 120.89 ± 40.08 | 92.11 ± 30.82 | 0.031 |
| Med A (c/s) | 102.87 ± 30.18 | 86.72 ± 38.83 | 85.90 ± 49.96 | 105.40 ± 27.27 | 0.052 |
| E/A | 1.01 ± 0.53 | 1.41 ± 0.58 | 1.85 ± 1.20 | 0.92 ± 0.39 | < 0.001 |
| MV dec time (ms) | 227.82 ± 70.48 | 180.10 ± 47.35 | 192.57 ± 76.33 | 234.34 ± 70.03 | 0.025 |
| Med E' (cm/s) | 7.58 ± 28.23 | 4.07 ± 1.78 | 4.99 ± 1.50 | 8.06 ± 30.30 | 0.886 |
| Med A' (cm/s) | 8.06 ± 2.64 | 5.13 ± 2.28 | 7.65 ± 3.40 | 8.35 ± 2.47 | 0.001 |
| Med E'/A' | 0.73 ± 0.58 | 0.87 ± 0.39 | 0.78 ± 0.44 | 0.71 ± 0.61 | 0.688 |
| Med E/e' | 20.15 ± 9.44 | 29.36 ± 10.98 | 26.13 ± 10.96 | 18.94 ± 8.66 | 0.00 |
| Lat E' | 7.58 ± 3.53 | 5.55 ± 1.25 | 7.96 ± 2.49 | 7.74 ± 3.67 | 0.163 |
| Lat A' | 10.33 ± 3.36 | 6.49 ± 2.39 | 10.52 ± 2.84 | 10.66 ± 3.27 | 0.001 |
| Lat E'/A' | 0.90 ± 1.34 | 0.97 ± 0.43 | 0.81 ± 0.32 | 0.90 ± 1.44 | 0.973 |
| E/avg E' | 12.03 ± 5.01 | 17.29 ± 4.99 | 16.09 ± 6.82 | 11.3 ± 4.51 | < 0.001 |

Abbreviations: cm, centimeter; g, gram; LA volume index, left atrial volume index; LV mass index, left ventricular mass index; LVEF, left ventricular ejection fraction; LVIDd, left ventricular internal diameter diastolic; LVIDs, left ventricular internal diameter systolic; m$^2$, meter$^2$; meanPAP, mean pulmonary artery pressure; min, minute; mL, milliliter; mmHg, millimeter of mercury; ms, milliseconds; MV dec time, mitral valve deceleration time; PAEDP, pulmonary artery ends diastolic pressure; RVSP, right ventricular systolic pressure; s, second; TAPSE, tricuspid annular plane systolic excursion; TR Vmax, tricuspid regurgitation velocity maximum

From Table 3, the characteristics of chronic decompensated heart failure patients with diastolic dysfunction grade III who had a history of bypass surgery were found to have an average age of 59.34 ± 14.75 years, with 56.3% being male. The average body surface area was 1.61 ± 0.18 $m^2$, and the average glomerular filtration rate was 7.01 ± 2.99 mL/min/1.73$m^2$; 65.6% of the patients underwent hemodialysis, and the average hematocrit was 31.62 ± 4.87%. Most patients had comorbidities such as hypertension, hyperlipidemia, and diabetes, in that order. The history of bypass surgery was significantly associated with grade III diastolic dysfunction. The majority of patients received folic acid, statins, and non-dihydropyridine CCB, in that order.

**Table 3** Characteristics of end-stage kidney disease patients in diastolic dysfunction group based on baseline characteristic findings (n = 111)

| Demographic data | Total (n = 111) | Left ventricular diastolic dysfunction | | | |
|---|---|---|---|---|---|
| | | Grade I (n = 62) | Grade II (n = 46) | Grade III (n = 3) | P-value |
| Age (years) | 59.34 ± 14.75 | 60.65 ± 14.72 | 58.04 ± 13.64 | 52.33 ± 31.66 | 0.472 |
| Male gender (%) | 67 (56.3) | 32 (51.60) | 33 (71.70) | 2 (66.70) | 0.104 |
| Body surface area ($m^2$) | 1.61 ± 0.18 | 1.63 ± 0.17 | 1.59 ± 0.18 | 1.43 ± 0.23 | 0.141 |
| Peritoneal dialysis (%) | 38 (34.4) | 25 (40.30) | 12 (26.10) | 1 (33.30) | 0.305 |
| Hemodialysis (%) | 73 (65.6) | 37 (59.7) | 34 (73.90) | 2 (66.70) | 0.305 |
| Glomerular infiltration rate (mL/min/1.73$m^2$) | 7.01 ± 2.99 | 7.06 ± 3 | 7.04 ± 3.05 | 5.33 ± 2.08 | 0.620 |
| Hematocrit | 31.62 ± 4.87 | 31.59 ± 5.17 | 31.63 ± 4.45 | 32.13 ± 6.62 | 0.982 |
| Medical history | | | | | |
| Hypertension (%) | 108 (97.70) | 59 (95.2) | 46 (100) | 3 (100) | 0.296 |
| Diabetes mellitus (%) | 72 (65.60) | 38 (61.30) | 33 (71.70) | 1 (33.30) | 0.271 |
| Dyslipidemia (%) | 105 (93.80) | 57 (91.90) | 45 (97.80) | 3 (100) | 0.374 |
| Coronary artery disease (%) | 24 (27.30) | 12 (19.40) | 11 (23.90) | 1 (33.30) | 0.751 |
| Percutaneous coronary intervention (%) | 10 (12.50) | 4 (6.50) | 6 (13) | 0 (0) | 0.426 |
| Coronary artery bypass graft (%) | 5 (4.70) | 2 (3.20) | 2 (4.30) | 1 (33.30) | 0.049 |
| Previous stroke (%) | 3 (2.30) | 2 (3.20) | 1 (2.20) | 0 (0) | 0.906 |
| Medication | | | | | |
| Aspirin (%) | 56 (50.80) | 29 (46.80) | 24 (52.20) | 3 (100) | 0.189 |
| Clopidogrel (%) | 23 (21.90) | 12 (19.40) | 11 (23.90) | 0 (0) | 0.566 |
| Beta blocker (%) | 60 (54.70) | 29 (46.80) | 28 (60.90) | 3 (100) | 0.094 |
| Non-dihydropyridine calcium channel blocker (%) | 77 (68) | 39 (62.90) | 37 (80.40) | 1 (33.30) | 0.058 |
| Angiotensin-Converting enzyme inhibitors/Angiotensin II Receptor Blockers (%) | 48 (41.40) | 24 (38.70) | 23 (50) | 1 (33.30) | 0.474 |
| Statins (%) | 87 (79.70) | 48 (77.40) | 37 (80.40) | 2 (66.70) | 0.822 |
| Lasix (%) | 69 (64.10) | 38 (61.30) | 29 (63) | 2 (66.70) | 0.97 |
| Isosorbide dinitrate (%) | 40 (33.60) | 18 (29) | 21 (45.70) | 1 (33.30) | 0.205 |
| Sodamint (%) | 54 (45.30) | 30 (48.40) | 22 (47.80) | 2 (66.70) | 0.817 |
| Calcium carbonate (%) | 66 (60.90) | 37 (59.70) | 29 (63) | 0 (0) | 0.098 |
| Ferrous sulfate (%) | 66 (58.60) | 39 (62.90) | 25 (54.30) | 2 (66.70) | 0.648 |
| Folic acid (%) | 97 (85.20) | 54 (87.10) | 40 (87) | 3 (100) | 0.8 |
| Espogen (%) | 46 (39.80) | 29 (46.80) | 16 (34.80) | 1 (33.30) | 0.439 |

Abbreviations: $m^2$, $meter^2$; min, minute; mL, milliliter

Table 4 shows the characteristics of ESKD patients according to their echocardiographic findings. There were significant differences among the 3 groups in LVmass index, LA volume index, TAPSE, RAP, TR Vmax, RVSP, meanPAP, Med E, Med A, E/A, MV dec time, Med E/e', Lat A', and E/avg E'.

## DISCUSSION

This study investigated the prevalence, types, and risk factors of CHF in ESKD patients with the symptoms of heart failure at Phranangklao Hospital. The study population included patients who underwent peritoneal dialysis or hemodialysis. The duration of their kidney disease was unknown.

The study found that patients with ESKD and the symptoms of HF were classified based on the function of their left ventricle. Most patients (86.73%) had heart failure with preserved ejection fraction, which is consistent with previous research[9]. In addition, risk factors for

**Table 4** Characteristics of end-stage kidney disease patients in diastolic dysfunction group based on echocardiography findings (n = 111)

| Demographic data | Total (n = 111) | Left ventricular diastolic dysfunction | | | |
|---|---|---|---|---|---|
| | | Grade I (n = 62) | Grade II (n = 46) | Grade III (n = 3) | P-value |
| LVIDd (cm) | 4.57 ± 0.64 | 4.47 ± 0.61 | 4.69 ± 0.68 | 4.57 ± 0.40 | 0.217 |
| LVIDs (cm) | 2.94 ± 0.58 | 2.87 ± 0.58 | 3 ± 0.58 | 3.37 ± 0.61 | 0.209 |
| LVEF by Teicholz method (%) | 64.22 ± 10.66 | 64.13 ± 12.17 | 65.13 ± 7.78 | 52.17 ± 11.64 | 0.124 |
| Relative wall thickness | 1.16 ± 6.41 | 1.63 ± 8.58 | 0.56 ± 0.15 | 0.52 ± 0.13 | 0.688 |
| LVmass index (g/m$^2$) | 137.1 ± 44.22 | 121.98 ± 28.66 | 156.29 ± 53.63 | 155.3 ± 41.30 | < 0.001 |
| LVEF Bi-plane method (%) | 64.17 ± 7.19 | 63.34 ± 6.95 | 65.56 ± 6.98 | 60 ± 13.46 | 0.169 |
| LA volume index (mL/m$^2$) | 43.01 ± 14.90 | 36.49 ± 13.60 | 50.46 ± 10.94 | 63.6 ± 25.50 | < 0.001 |
| TAPSE (cm) | 2.35 ± 0.44 | 2.27 ± 0.38 | 2.47 ± 0.49 | 2.03 ± 0.15 | 0.024 |
| Right atrium pressure (mmHg) | 5.75 ± 3.73 | 4.95 ± 3.19 | 6.63 ± 4.04 | 8.67 ± 6.03 | 0.025 |
| TR Vmax (m/s) | 2.79 ± 0.53 | 2.47 ± 0.28 | 3.18 ± 0.48 | 3.52 ± 0.39 | < 0.001 |
| RVSP (mmHg) | 38 ± 14.65 | 29.65 ± 7.23 | 47.90 ± 15.02 | 58.67 ± 8.74 | < 0.001 |
| meanPAP (mmHg) | 24.22 ± 8.92 | 20.21 ± 7.13 | 29.47 ± 8.42 | 26.53 ± 9.3 | < 0.001 |
| PAEDP (mmHg) | 14.41 ± 20.52 | 14.06 ± 27.16 | 14.9 ± 5.29 | 14.27 ± 4.21 | 0.978 |
| Med E (cm/s) | 92.11 ± 30.82 | 75.08 ± 19.72 | 112.14 ± 28.26 | 136.67 ± 35.02 | < 0.001 |
| Med A (cm/s) | 105.40 ± 27.27 | 101.8 ± 26.55 | 113.64 ± 24.32 | 53.47 ± 9.38 | < 0.001 |
| E/A | 0.92 ± 0.39 | 0.76 ± 0.20 | 1.02 ± 0.31 | 2.57 ± 0.21 | < 0.001 |
| MV dec time (ms) | 234.34 ± 70.03 | 250.23 ± 81.56 | 216.17 ± 43.11 | 184.67 ± 77.05 | 0.019 |
| Med E' (cm/s) | 8.06 ± 30.30 | 5.27 ± 1.48 | 11.95 ± 4.05 | 5.92 ± 2.15 | 0.527 |
| Med A' (cm/s) | 8.35 ± 2.47 | 9.27 ± 2.25 | 7.34 ± 2.15 | 4.83 ± 2.96 | < 0.001 |
| Med E'/A' | 0.71 ± 0.61 | 0.6 ± 0.22 | 0.84 ± 0.88 | 1.03 ± 0.59 | 0.091 |
| Med E/e' | 18.94 ± 8.66 | 15.29 ± 6.06 | 23.59 ± 9.47 | 23.2 ± 6.88 | < 0.001 |
| Lat E' | 7.74 ± 3.67 | 7.96 ± 2.89 | 7.36 ± 4.53 | 9.07 ± 4.10 | 0.575 |
| Lat A' | 10.66 ± 3.27 | 11.41 ± 3.23 | 9.90 ± 3.040 | 7 ± 3.36 | 0.008 |
| Lat E'/A' | 0.90 ± 1.44 | 1.03 ± 1.89 | 0.73 ± 0.37 | 0.93 ± 0.42 | 0.555 |
| E/avg E' | 11.30 ± 4.51 | 8.75 ± 2.50 | 14.63 ± 4.47 | 12.80 ± 4.22 | < 0.001 |

Abbreviations: cm, centimeter; g, gram; LA volume index, left atrial volume index; LV mass index, left ventricular mass index; LVEF, left ventricular ejection fraction; LVIDd, left ventricular internal diameter diastolic; LVIDs, left ventricular internal diameter systolic; m$^2$, meter$^2$; meanPAP, mean pulmonary artery pressure; min, minute; mL, milliliter; mmHg, millimeter of mercury; ms, milliseconds; MV dec time, mitral valve deceleration time; PAEDP, pulmonary artery ends diastolic pressure; RVSP, right ventricular systolic pressure; s, second; TAPSE, tricuspid annular plane systolic excursion; TR Vmax, tricuspid regurgitation velocity maximum

heart failure, such as abnormal cardiac contractility, were significantly associated with a history of coronary artery disease, which is consistent with previous research.

It was found that grade I diastolic dysfunction was the most common type of diastolic dysfunction, accounting for 55.86% of cases, which is consistent with research from other countries. Grade II diastolic dysfunction was found in 41.44% of cases, and grade III diastolic dysfunction in 2.70%. Prevention of diastolic dysfunction can reduce the severity and incidence of death from heart and vascular diseases in patients with renal failure[10]. With the data from this study, there is an opportunity to study the prevention and treatment of abnormal relaxation-type heart failure in the future.

The progression of CKD is characterized by uremic toxin accumulation. Uremic toxin retention gets worse over time without treatment because CKD is a progressive condition by nature. A growing body of evidence suggests that uremic toxins are to blame for CVD, which is the leading cause of death in the population with CKD[11].

All types of HF can be effectively treated to extend life and lower hospitalization rates. The recommendations state that the main factors contributing to the underuse of renin-angiotensin-aldosterone system inhibitors, particularly aldosterone receptor antagonist, in clinical practice are renal dysfunction and hyperkalemia. By encouraging the tolerance of small or moderate drops in eGFR, it will be possible to prevent needless dose reductions or discontinuations of HF medications, which will reduce cardiovascular mortality while concurrently slowing the rate of CKD progression over the long term[12].

Overall, this study provides valuable information on the prevalence and risk factors of CHF in ESKD patients. The findings can stimulate further research on the mechanisms and treatments of abnormal cardiac contractility in this population. The present study had some limitations. First, the study population was recruited from a single center and thus might be generalizable. Second, this study was a retrospective study with a small sample size and thus might be underpowered for the purpose of evaluating some risk factors. Therefore, a larger study is needed in the future.

## CONCLUSION

Diastolic dysfunction of the heart is common in patients with ESKD. There is a significant correlation between heart failure with preserved ejection fraction and a history of coronary artery disease and/or left ventricular hypertrophy. This highlights the importance of preventing and managing diastolic dysfunction in order to reduce the incidence of heart failure and its associated complications.

## CONFLICT OF INTEREST

The authors report no conflict of interest for this article.

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## DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this article. Future enquiries can be directed to the corresponding author.

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