

Pathological Findings in Chest Radiographs of Chronic Kidney Disease Patients Undergoing Hemodialysis

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Abstract

Chronic kidney disease is a condition in which there is destruction of the kidneys along with structural or functional abnormalities, with or without decreased glomerular filtration rate for more than 3 months. The common treatment for this condition is hemodialysis, however, it may cause complications, specifically cardiovascular and non-cardiovascular system dysfunctions that can be observed through thorax imaging. This study aims to observe pathologic thorax imaging findings on chronic kidney disease patients undergoing hemodialysis at RSUP Dr. Mohammad Hoesin Palembang. This study is a descriptive study using a cross-sectional design. The data is gathered from medical records from the Medical Records & Radiology Department of RSUP Dr. Mohammad Hoesin Palembang that have passed the inclusion and exclusion criteria. The data is processed using the SPSS application version 25. The results of this study indicate that, based on risk factors, patients are generally in the 55–64 age range (41%), female (60%), and with a normal BMI/normal weight (52%). Based on the patients' comorbid diseases, patients mostly have hypertension (59%), followed by diabetes mellitus (46%). Analysis of the chest radiographs indicate that (70%) of patients have cardiomegaly; (22%) of patients have grade 1, (15%) have grade 2, (7%) have grade 3 aortic arch calcification; (49%) have pulmonary edema; (31%) have unilateral pleural effusion, and (14%) have bilateral pleural effusion. The majority of chronic kidney disease patients undergoing hemodialysis at RSUP Dr. Mohammad Hoesin Palembang are in the 55–64 age range, female, and with normal BMI. The most common comorbid conditions are hypertension and diabetes mellitus. Analysis of the chest radiographs indicate that the majority of patients have cardiomegaly; grade 1, 2, and 3 aortic arch calcification; pulmonary edema; unilateral and bilateral pleural effusion.

Keywords: Chronic Kidney Disease, Hemodialysis, Pathologic, Thorax Imaging

1. Introduction

Chronic kidney disease (CKD) is a condition in which there is destruction, dysfunction, or structural abnormality of the kidneys with or without decreased glomerular filtration rate (GFR) for more than or equal to 3 months.¹ In 2015, the National Kidney Foundation (NKF) estimated that 10% of the world population suffers from chronic kidney disease (CKD),² and that millions of people die each year due to inadequate treatment. Based on data by Kemenkes RI in 2018, the prevalence of kidney failure in Indonesia is around 2‰, or 499,800 people and still a health problem around the world due to annually increasing prevalence.³

Chronic kidney disease is initially asymptomatic or void of any symptoms, however increased serum creatinine and urea concentration has already begun. Symptoms

start to become apparent at stage 3 and 4 or at a GFR lower than 30%.⁴ Due to the asymptomatic nature of CKD, a large number of patients seek treatment after complications had already occurred. Chronic kidney disease that is not treated early may eventually lead to terminal kidney failure.

The most common treatment for chronic kidney disease is hemodialysis intended to reduce symptoms resulting from decreased kidney function with the hope of increasing the patient's lifespan and quality of life.⁵ Although it has been proven to improve the prognosis, prolonged hemodialysis may cause complications. Complications from hemodialysis include dysfunction of the cardiovascular system and of the non-cardiovascular system, or respiration. All organs of the thorax are potential targets of the side effects of uremia, and radiological

findings from the thoracic complications are complex.^{6,7}

Patients undergoing hemodialysis suffer from structural and functional abnormalities of the cardiovascular system due to the non-physiologic loss of fluids that cause hemodynamical imbalance and initiation of systemic inflammation.⁸ Cardiovascular events are the most common cause of death among patients that routinely undergo hemodialysis.⁹ One of the risk factors of cardiovascular disease in patients that routinely undergo hemodialysis is vascular calcification in the aortic arch. In relation to vascular calcification, uremia causes dysregulation of calcium-phosphate levels.¹⁰ Cardiomegaly commonly occurs in patients with uremia and further increased the progression of cardiovascular disease in chronic hemodialysis patients.¹¹

Non-vascular complications reported in chronic kidney disease patients undergoing hemodialysis include pleural effusion and pulmonary edema.¹² Pleural effusion in hemodialysis patients may be caused by heart failure, excess fluid volume, infection, malignant tumors, and underlying diseases.¹³ In uremic patients undergoing dialysis, pulmonary edema is the most common complication. It is generally caused by excess fluid volume and left ventricular failure due to systemic hypertension, uremic cardiomyopathy, and coronary artery disease.¹⁴

Thorax imaging findings in chronic kidney disease patients undergoing hemodialysis are complex. The initial imaging technique used to analyze symptoms is the use of thorax imaging as it is simple, cost efficient, easily available, and non-invasive. The analyses performed include analysis of abnormalities of the parenchyma (lung), the pleura, the vascular system, and the heart, that are related to hemodialysis. This study aims to observe the pathologic thorax imaging findings in chronic kidney disease patients undergoing hemodialysis at RSUP Dr. Mohammad Hoesin Palembang.

2. Methods

This study is a descriptive study using a cross-sectional design. The data is gathered from medical records from the Medical Records & Radiology Department of RSUP Dr. Mohammad Hoesin Palembang from July to December of 2020. The sample for this study is medical records of patients diagnosed with chronic kidney disease undergoing hemodialysis at RSUP Dr. Mohammad Hoesin Palembang in 2019 that meet the inclusion and exclusion criteria.

The data that was collected is secondary data using a consecutive sampling technique. The data from chronic kidney disease patients undergoing hemodialysis was taken from the medical records, and the size of the heart, aortic arch, lung parenchyma, and pleura from the thorax imaging findings were analyzed at the radiology department by a radiologist. The data that was obtained was processed and presented using the IBM SPSS Statistics 25.0 software.

3. Results

Collection of the data was performed by observation and recording of medical records from the Medical Records & Radiology Department of RSUP Dr. Mohammad Hoesin Palembang from the 8th of October 2020 – the 4th of November 2020. This study obtained 100 samples that meet the inclusion and exclusion criteria.

3.1 Frequency Distribution of Chronic Kidney Disease Patients Undergoing Hemodialysis by Risk Factors

Results show that the largest number of patients undergoing hemodialysis (41 subjects) are in the age group of 55–64 years (41%), followed by the age group of 45–54 years (24 subjects, 24%), whereas the smallest number patients undergoing hemodialysis (3 subjects) are in the age group of 25–34 years (3%).

Table 1 shows that the largest proportion of chronic kidney disease patients are female subjects (60 subjects, 60%), whereas male

subjects make up 40% of subjects (40 subjects). Body mass index (BMI) results were classified into 4 categories, underweight (15–19.9), normal weight (20–24.9), overweight (25–29.9), and obese (≥ 30). The largest proportion of body mass index as

measured by the attending physician are in the normal weight category (52 subjects, 52%), 29% are in the underweight category (29 subjects), 13% are in the overweight category (13 subjects), and 6% are in the obese category (6 subjects).

Table 1. Frequency Distribution of Patients by Risk Factors

	Category	Frequency	Percentage (%)
Age (years)	18–24	5	5%
	25–34	3	3%
	35–44	11	11%
	45–54	24	24%
	55–64	41	41%
	≥ 65	16	16%
Sex	Male	40	40%
	Female	60	60%
BMI	Underweight	29	29%
	Normal weight	52	52%
	Overweight	13	13%
	Obese	6	6%

Table 2. Frequency Distribution of Patients by Comorbid Diseases

	Category	Frequency	Percentage (%)
Hypertension	Hypertensive	59	59%
	Non-hypertensive	41	41%
Diabetes mellitus	DM	46	46%
	Non-DM	54	54%
Congestive heart failure	CHF	7	7%
	Non-CHF	93	93%
Pneumonia	Pneumonia	10	10%
	Non-pneumonia	90	90%
Tuberculosis	TB	6	6%
	Non-TB	94	94%
Malignant tumors	Malignant	13	13%
	Non-malignant	87	87%

3.2 Frequency Distribution of Chronic Kidney Disease Patients Undergoing Hemodialysis by Comorbid Diseases

Table 2 shows 59 subjects suffer from hypertension (59%), and 41 subjects do not suffer from hypertension (41%). 46 subjects suffer from diabetes mellitus (DM) (46%), and 54 subjects do not suffer from DM (54%). 7 subjects suffer from congestive heart failure (CHF) (7%), and 93 subjects do not suffer from CHF (93%). 10 subjects suffer from

pneumonia (10%), and 90 subjects do not suffer from pneumonia (10%). 6 subjects suffer from tuberculosis (TB) (6%), and 94 subjects do not suffer from TB (94%). 13 subjects suffer from malignant tumors (13%), and 87 subjects do not suffer from malignant tumors (87%).

3.3 Frequency Distribution of Chronic Kidney Disease Patients Undergoing Hemodialysis by Thorax Imaging Findings

Based on thorax imaging analyses, 70 subjects suffer from cardiomegaly (70%), whereas 30 subjects do not suffer from cardiomegaly (30%). Fifty-six of the 100 subjects do not suffer from aortic arch calcification (grade 0) (56%), 22 subjects suffer from grade I aortic arch calcification

(22%), 15 subjects suffer from grade II aortic arch calcification (15%), and 7 subjects suffer from grade III aortic arch calcification (7%). Fifty-one of the 100 subjects have not pulmonary edema (51%), whereas 49 subjects have pulmonary edema (49%). Fifty-five subjects do not suffer from pleural effusion (55%), 31 subjects suffer from unilateral pleural effusion (31%), and 14 subjects suffer from bilateral pleural effusion (14%).

Table 3. Frequency Distribution of Patients by Thorax Imaging Findings

	Category	Frequency	Percentage (%)
Cardiomegaly	CTR < 50% (no cardiomegaly)	30	30%
	CTR ≥ 50% (Cardiomegaly)	70	70%
Aortic Arch Calcification	Grade 0	56	56%
	Grade 1	22	22%
	Grade 2	15	15%
	Grade 3	7	7%
Pulmonary Edema	Pulmonary Edema (+)	49	49%
	Pulmonary Edema (-)	51	51%
Pleural Effusion	No Pleural Effusion	55	55%
	Unilateral Pleural Effusion	31	31%
	Bilateral Pleural Effusion	14	14%

4. Discussion

4.1 Cardiomegaly

Based on the results, 70% of chronic kidney disease patients undergoing hemodialysis have thorax imaging results that indicate cardiomegaly (70 subjects), whereas 30% do not have cardiomegaly (30 subjects). This resembles a 2016 study by Liou *et al* that found that a majority of CKD patients undergoing hemodialysis from a total of 622 people have thorax imaging results that indicate cardiomegaly (61.4%) whereas 38.6% do not.¹¹

Several diseases that accompany CKD such as DM, hypertension, anemia, malnutrition, chronic inflammation, and body fluid status contribute to cardiomegaly.¹¹ There are several mechanisms in which cardiomegaly increases risk of death or other cardiovascular diseases. Firstly, CTR is a sensitive marker of excess fluid volume. Excess fluid volume is a known factor in

worsening arteriosclerosis by a mechanism related to reactive oxygen species, such as incorrect activation of the RAAS and vascular endothelial dysfunction mediated by nitric oxide resulting from excess pressure. Second, cardiomegaly indicates reduced cardiac function caused by congestive heart failure.¹⁵

The size of the heart is affected by non-cardiac factors. Patients with chronic obstructive pulmonary disease (COPD) have an increased lung volume and a relatively decreased heart volume. Conversely, a large heart may be caused by a small thorax. Geriatric persons often have a decreased bone mineral density and costal deformities, that appear to be “bell-shaped” which may cause a larger CTR.¹⁶

4.2 Aortic Arch Calcification

Based on the results, 56% of chronic kidney disease patients undergoing hemodialysis have thorax imaging results that

do not indicate aortic arch calcification (56 subjects), 22% have grade 1 calcification (22 subjects), 15% have grade 2 calcification (15 subjects), and 7% have grade 3 calcification (7 subjects). This resembles a 2014 study by Lee *et al* that found that from 712 subjects, 43% of chronic kidney disease patients undergoing hemodialysis have thorax imaging results that do not indicate aortic arch calcification, 23% have grade 1 calcification, 16.3% have grade 2 calcification, and 17.7% have grade 3 calcification.¹⁷

Chronic kidney disease patients have a higher prevalence of vascular calcification than the general population, at 23–37.5%.¹⁸ Risk factors include age, hypertension, diabetes, dyslipidemia, inflammation, malnutrition, and oxidative stress.¹⁹ The process of vascular calcification is multifactorial and is related to calcium and phosphorus metabolism, loss of osteopontin, increased number of vascular osteoblasts, and proliferation of chondrocyte-like cells. Inflammation and oxidative stress are also involved in vascular calcification. Inflammatory cytokines such as interleukin-6 and TNF increase differentiation of vascular smooth muscle cells and vascular calcification. Inflammation increases production of reactive oxygen species which stimulates vascular regeneration and the process of calcification. Vascular calcification is linked with structural and functional changes of the blood vessels that disturb the microcirculation of the kidneys which causes renal dysfunction. Vascular calcification may also induce thickening of fibroelastic tissue and reduction of elastic connective tissue. Aortic arch calcification causes increased cardiac load and arterial circumferential stress that causes ventricular hypertrophy. Structural and functional changes of the cardiovascular system not only increase cardiovascular morbidity and mortality, but also worsens renal function.²⁰

4.3 Pulmonary Edema

Based on the results, 49% of chronic kidney disease patients undergoing

hemodialysis have thorax imaging results that indicate pulmonary edema (49 subjects), whereas 51% do not (51 subjects). This resembles a 2016 study by Pradesya & Faesol that found that from 69 subjects, 47.8% of chronic kidney disease patients undergoing hemodialysis have thorax imaging results that indicate pulmonary edema, whereas 52.2% do not.²¹

Pulmonary edema is a common complication in chronic kidney disease patients.²² Pulmonary edema is present in congestive heart failure patients, patients with excessive body fluid due to irregular hemodialysis visits, inappropriate eating patterns, and inappropriate “dry weight”. Determination of fluid balance to prevent lack of or excessive fluid is very important for hemodialysis patients.²³ In uremic patients, pulmonary edema is caused by hemodynamic disturbances. Several factors are involved: pulmonary overhydration due to water retention and solutes, left ventricular failure due to systemic hypertension, uremic cardiomyopathy, coronary artery disease, anemia or polycythemia, hypoproteinemia, excessive arteriovenous fistules, and alveolocapillary membrane damage due to lesions and toxins.²⁴

Pulmonary edema in relation to CKD is linked with excessive extracellular fluid accumulation such as excessive fluid due to chronic kidney failure in renal artery stenosis (RAS) cases and may also be caused by increased pulmonary capillary permeability with decreased plasma oncotic pressure. A sign of pulmonary edema due to RAS is a substantially increased secretion of renin in the juxtaglomerular apparatus of ischemic kidneys.²⁵ Decreased oncotic pressure causes displacement of water from pulmonary capillaries into the interstitium and eventually into the alveoli.²²

4.4 Pleural Effusion

Based on the results, 31% of chronic kidney disease patients undergoing hemodialysis have thorax imaging results that

indicate unilateral pleural effusion (31 subjects), 14% indicate bilateral pleural effusion (14 subjects), and 55% do not indicate pleural effusion (55 subjects). This resembles a 2017 study by Moger *et al* that found that from 100 subjects, 42% of chronic kidney disease patients have thorax imaging results that indicate unilateral pleural effusion, 12% indicate bilateral pleural effusion, and 46% do not indicate pleural effusion.²²

A 2007 study by Bakirci *et al* mentions that from 257 long-term hemodialysis patients, 52 patients suffer from pleural effusion (20.2%). 26 out of the 52 patients suffer from unilateral pleural effusion (50%) and the rest suffer from bilateral pleural effusion (50%). This difference may be caused by the long-term effects of hemodialysis affecting progression of CKD, and several complications such as infection and heart failure may have already occurred.²⁴

Pleural effusion often occurs in chronic hemodialysis patients and is recurrent in nature, presenting with dyspnea, paroxysmal nocturnal dyspnea, and orthopnea.^{22,26} Pleural effusion can be caused by uremic pleuritis, overhydration, heart failure, bronchopulmonary bacterial infection or tuberculosis, hypoproteinemia, and hemothorax.²⁴ Uremic pleural effusion may occur unilaterally or bilaterally in various levels of severity.²⁵

5. Conclusion

In conclusion, thorax imaging findings were analyzed to determine the size of the heart, aortic arch, lung parenchyma, and pleura among patients diagnosed with chronic kidney disease undergoing hemodialysis at RSUP Dr. Mohammad Hoesin Palembang resulting in 70 subjects with cardiomegaly, 22 subjects with grade 1 aortic arch calcification, 15 subjects with grade 2 calcification, and 7 subjects with grade 3 calcification, 49 subjects with pulmonary edema, 31 subjects with unilateral pleural effusion, and 14 subjects with bilateral pleural effusion.

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