Echocardiography Parameter-Left Ventricle Dimensions Profile on Congestive Heart Failure with or Without Hypertension and Old Myocardial Infarction

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Abstract. Heart failure (HF) is a global pandemic that affects at least 26 million people worldwide and its prevalence continues to increase. Heart failure (HF) is a clinical syndrome caused by structural and functional defects in the myocardium resulting in impaired ventricular filling or blood ejection. Echocardiography is an essential investigation in patients with suspected heart failure. We gained information from an echocardiogram is whether the left ventricular function is normal or reduced. Methods: This research is descriptive-analytic with a cross-sectional study approach, taking 57 samples with 11 patients with Congestive Heart Failure (CHF) only, 28 people with CHF with Hypertension (HHD), 18 people with CHF with Old Myocardial Infarction (OMI). Results: The subjects in this study were 34 males (mean age 59.74 ± 8.543 years) and 23 females (mean age 63.78 ± 12,486 years). From all patients in this study, almost patients were diagnosis with CHF-OMI (N = 28). Male patients tended to be diagnose with CHF only (N = 10) and CHF-OMI (N = 22) than female patients diagnosis with CHF-HHD (N = 9). The distribution of samples by age, older age (>55 years) tended CHF more frequently (N = 40) consist of 13 samples on CHF only, and 22 samples on CHF-OMI. However, patients with CHF - HHD were dominated by a younger age (<55 years) obtained 6 samples. The data analysis revealed that the average EF value of CHF-HHD (58.18 ± 18.021) was higher than CHF-OMI (38.43 ± 18.743), while the average value of left ventricular internal diameter end-diastole/sistole (LVIDd/LVIDs) was both higher in samples with CHF-OMI. (59.96 ± 14.044/49.11 ± 16.249) compared to samples with CHF-HHD (48.55 ± 7.673/33.45 ± 10.624). Conclusions: EF values in CHF patients with HHD were higher than CHF with OMI and LVIDd/LVIDs values were higher in CHF with OMI than in CHF with HHD.

Keywords: Echocardiography · Congestive Heart Failure · Hypertension · Old Myocardial Infarction

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1 Introduction

Heart failure (HF) is a global pandemic affecting at least 26 million people worldwide and is increasing in prevalence. HF health expenditures are considerable and will increase dramatically with an ageing population [1].

According to data from the World Health Organization (2019) [2] as many as 17.9 million people died due to cardiovascular disorders. More than 75% of cardiovascular sufferers are in low- to middle-income countries, and 85% are due to heart attacks and strokes. The prevalence of heart disease in the United States in 2012 was 136 per 100,000 people, in European countries, such as Italy there were 106 per 100,000 people, France as many as 86 per 100,000 and in Asia as much as 300 per 100,000 people, Japan 82 per 100,000. Other data found around 4.7 million people suffer from heart failure in America (1.5–2% of the total population), with an incidence rate of 550,000 cases per year [3]. Data from the Basic Health Research [4] of the Indonesian Ministry of Health in 2018, the prevalence of heart failure in Indonesia based on a doctor's diagnosis was estimated at 1.5%. Most of them are in the province of North Kalimantan, which is 2.2%, while the fewest sufferers are in the province of NTT, which is 0.3%. As for the province in Central Java, based on a doctor's diagnosis, the prevalence of heart failure was around 1.56% [4]. The most common causes of death previously occupied by infectious diseases have now shifted to cardiovascular and degenerative diseases and are estimated to be the cause of death 5 times more than infectious diseases in 2013 Ministry of Health of the Republic of Indonesia / Ministry of Health of the Republic of Indonesia [4].

Heart failure is a clinical syndrome caused by structural and functional defects in the myocardium resulting in impairment of ventricular filling or the ejection of blood. The most common cause for HF is reduced left ventricular myocardial function; however, dysfunction of the pericardium, myocardium, endocardium, heart valves, or great vessels alone or in combination is also associated with HF. Some of the major pathogenic mechanisms leading to HF are increased hemodynamic overload, ventricular remodeling, ischemia-related dysfunction [5]. Left ventricular ejection fraction (LVEF) is generally viewed as a clinically useful phenotypic marker indicative of underlying pathophysiological mechanisms and sensitivity to therapy. Currently, heart failure patients are most often categorized as having heart failure with reduced (HFrEF; LVEF $< 40\%$), mid-range (HFmrEF; LVEF 40–49%), or preserved ejection fraction (HFpEF; LVEF 50%). The most common causes of systolic dysfunction (HFrEF) are idiopathic dilated cardiomyopathy (DCM), coronary heart disease (ischemic), hypertension, and valvular disease. Hypertension, obesity, coronary artery disease, diabetes mellitus, atrial fibrillation, and hyperlipidemia are highly prevalent in HFpEF patients. Hypertension by far is the most important cause of HFpEF. In addition, conditions like hypertrophic obstructive cardiomyopathy, and restrictive cardiomyopathy are associated with significant diastolic dysfunction, leading to HFpEF [6].

Most long standing hypertension ultimately leads to heart failure unless this sequence of events is otherwise interrupted by other outcomes and, as a consequence, patients with HF very commonly have a history of hypertension. In the Framingham Heart Study cohort in a total population of 5,143 subjects, hypertension antedated the development of HF in 91% of all newly diagnosed HF patients during up to 20 years of follow-up (mean 14.1 years). Adjusting for age and HF risk factors, the hazard for developing HF in hypertensive compared with normotensive subjects in the Framingham Heart Study data was about 2-fold in men and 3-fold in women. Multivariable analyses revealed that hypertension had a high population-attributable risk for HF, accounting for 39% of cases in men and 59% in women [7].

Heart failure developing after myocardial infarction (MI) hospitalization is a consequence of cardiomyocyte death and scar formation, which triggers chronic neurohumoral activation (renin–angiotensin–aldosterone and sympathetic nervous system upregulation) and ventricular remodeling. Left ventricular (LV) remodeling is more pronounced in men, patients with larger infarct size, and late or unsuccessful reperfusion of epicardial or microvascular bed. Ventricular remodeling changes ventricular geometry and leads to wall thinning, ischaemic mitral regurgitation, and further cardiomyocyte loss. Heart failure development after hospital discharge is very prevalent. It is diagnosed in approximately 13% of patients at 30 days and 20–30% at 1 year after discharge for MI. The incidence of HF after MI discharge is highest in the first months, and then it drops and remains stable at a rate of 1.3–2.2% per year afterward [8].

This paper describes Echocardiography Parameter-Left Ventricle Dimensions Profile on Congestive Heart Failure with or without Hypertension and Old Myocardial Infarction, especially patients at PKU Muhammadiyah Surakarta Hospital so that it can be used to distinguish CHF profiles and determine further assessment and appropriate treatment planning.

2 Method

This research is descriptive-analytic with a cross-sectional study approach. The population of this study was all patients with heart failure at PKU Muhammadiyah Hospital Surakarta in January–August 2019 with 105 patients. The sample size in this study was 57 people. The sampling technique was purposive sampling technique. The inclusion criteria of this study were medical records of patients with congestive heart failure with or without OMI and HHD accompanied by echocardiographic examination results. The exclusion criteria were data from echocardiographic examination results which were incomplete. The equipment used is a GE Logiq P7 echocardiography. The data collected included patient identity, gender, date of birth, and results of echocardiography examination. The entire process of data processing and analysis uses the SPSS application. This research has been approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Muhammadiyah Surakarta with the number C3752/C.1/KEPK-FKUMS/IX/2021.

3 Result and Discussion

3.1 Distribution of Samples

The subjects in this study were 57 samples (Table 1.), including 34 males (mean age 59.74 ± 8.543 years) and 23 females (mean age 63.78 ± 12,486 years). From all patients in this study, almost all patients were diagnosed with CHF-OMI (N = 28). Male patients tended to be diagnosed with CHF only (N = 10) and CHF-OMI (N = 22) than female patients diagnosed with CHF-HHD (N = 9).

Based on (Table 2.) the distribution of samples by age, older age (>55 years old) tended CHF more frequently (N = 40) consist of 13 samples on CHF only, and 22 samples on CHF-OMI. However, patients with CHF - HHD were dominated by a younger age (<55 years old) obtained 6 samples.

3.2 The Differences in Echocardiography Parameters-Left Ventricle Dimensions

We analyzed (Table 3.) echocardiography parameter-left ventricle dimensions between CHF - OMI and CHF - HHD, most of the pairs were significant (Sig. < 0.05) from the mean of EF, LVIDd, and LVIDs. The data analysis revealed that the average EF value of CHF-HHD (58.18 ± 18.021) was higher than CHF-OMI (38.43 ± 18.743), while the average value of LVIDd/LVIDs was both higher in samples with CHF-OMI (59.96 ± 14.044/49.11 ± 16.249) compared to samples with CHF-HHD (48.55 ± 7.673/33.45 ± 10.624).

Table 1. Distribution Of Samples

Parameter	Male	Female	Total
Age (Mean)	59.74 ± 8.543	63.78 ± 12.486	61.37 ± 10.405
All CHF	34 (59.65%)	23 (40.35%)	57
CHF Only	10 (55.56%)	8 (44.44%)	18
CHF-OMI	22 (78.57%)	6 (21.43)	28
CHF-HHD	2 (18.18%)	9 (81.82)	11

Table 2. Distribution Of Samples By Age

		Diagnose			Total
		CHF only	***CHF HHD***	***CHF OMI***	
Age (years old)	>55	13	5	22	40
	<55	5	6	6	17
Total		18	11	28	57

Table 3. The Differences In Echocardiography Parameters-Left Ventricle Dimensions

Echocardiography Parameter	CHF - OMI (N: 28)	CHF – HHD (N: 11)	Total	Sig.
Ejection Fraction (EF)	38.43 ± 18.743	58.18 ± 18.021	44.37 ± 19.158	0.009
Left Ventricle Internal Dimension diastole (LVIDd)	59.96 ± 14.044	48.55 ± 7.673	56.16 ± 12.733	0.029
Left Ventricle Internal Dimension systole (LVIDs)	49.11 ± 16.249	33.45 ± 10.624	44.04 ± 15.237	0.09

4 Discussion

4.1 Distribution of Samples

From the 57 samples, 34 were male with an average age of 59 years, while 23 were female with an average age of 63 years. Here it can be seen that CHF patients at PKU Muhammadiyah Surakarta Hospital with or without HHD and OMI were more in the male sample and younger than the female sample. This is in line with Christiansen et al., [9] who stated that sex-stratified models showed similar trends, but men had a higher incidence rate than women overall, except in the age category of >74 years. The same thing is shown in a study from Magnussen et al., [10] where across 4 European community cohorts, women had a lower risk for incident HF than men in middle-aged to older individuals, whereas women exceeded men in HF risk in the oldest age groups [10]. This is because, by gender, a person's susceptibility to heart failure is influenced by the role of the female hormone, namely estrogen, which protects women from various cardiovascular diseases. The hormone estrogen increases the ratio of high-density lipoprotein (HDL) which is a protective factor in preventing the process of atherosclerosis. Therefore, men are susceptible to heart failure at the age of 50 years, while women at the age of 65 years or after menopause [11].

There were 10 males who experienced CHF only, 2 people with CHF-HHD, and 22 people with CHF-OMI, here it can be seen from 34 patients diagnosed with CHF, the most samples had CHF-OMI. While the female sex who experienced CHF only was 8 people, CHF-HHD 9 people, and CHF-OMI 6 people, here it can be seen from 23 female patients diagnosed with CHF, the most samples experienced CHF-HHD. Then for the total patients with CHF only from all samples of 18 people, CHF-HHD was 11 people, and the most CHF-OMI was 28 people.

Heart failure caused by myocardial infarction is more common in men, while hypertension and diabetes are more common in women. Women have a stiffness of the left ventricular wall and higher ejection fraction than men. This higher female heart stiffness may be based on increased fibrosis in old age. In younger women, estrogen reduces collagen production in female cardiac fibroblasts but stimulates it in males. Lipid and energy metabolism is better maintained in females than in male stressed hearts. Pulse pressure is a key determinant of outcome in HF women but not in men [12]. Eisenberg et al., 2018 [13] also said that on presentation, older women with HF are more likely to have

heart failure with preserved ejection fraction (HFpEF) and background of hypertension [13].

From 57 samples, categorized into age >55 years old and <55 years old, then the results obtained for age >55 years old who experienced CHF were 40 people with details of CHF only 13 people, CHF-HHD 5 people, and the most CHF-OMI were 22 people, while at the age of <55 years old, 17 people experienced CHF, with details of CHF only 5 and CHF-HHD and CHF-OMI each 6 people. This is in line with research by A.J.S. Coats et al., [14] that comorbidities and mortality in HF both increase with age. The typical pathophysiology of HF changes as we look at older patient populations. Younger HF patients typically have antecedent ischemic heart disease or idiopathic or genetic-dilated cardiomyopathies. Elderly patients, in contrast, typically have a history of hypertension and multiple other comorbidities. In the younger patient, a dilated ventricle with significant remodeling and reduced ejection fraction is more common (HFrEF), whereas in the elderly the more common picture is a small hypertrophied ventricle with preserved ejection fraction (HFpEF).

4.2 The Differences Echocardiography Parameter-Left Ventricle Dimensions

Echocardiography is a noninvasive modality that is often used to assess the left ventricular ejection fraction. Left ventricular systolic function is a prognostic factor for heart disease and plays an important role in determining therapy. Ejection fraction is a measurement, expressed as a percentage, of the amount of blood pumped by the left ventricle with each contraction. Decreased LVEF is a sign of failure of remission of cardiac function and is accompanied by the appearance of clinical symptoms in the patient. In patients with HFpEF, the myocardium of the left ventricle generally responds by increasing the radial thickness of the muscle, accompanied by an increase in extracellular collagen deposits. This results in an increase in left ventricular wall thickness and overall muscle mass which is referred to as concentric left ventricular hypertrophy (LVH). However, in some cases, absolute LV mass did not increase significantly but instead increased wall thickness. This is known as concentric remodeling. This distinction is important because concentric LVH is associated with a much poorer prognosis than concentric remodeling. A combined analysis of large-scale epidemiological studies and clinical studies showed that nearly 35% of patients with HFpEF had concentric LVH, whereas 30% of patients showed concentric remodeling. In 7–9% of patients, there may be eccentric LVH, which is characterized by an increase in LV mass without a proportional increase in LV wall thickness. Normal LV geometry was found in the remaining 30% of patients. Patients with HFrEF found long cardiac myocytes without an increase in LV mass. Myocyte necrosis and extracellular collagen degradation were observed due to increased activity of matrix metalloproteinases and other similar enzymes. The result is eccentric LV remodeling with an increase in the size of the LV cavity without an increase in LV wall mass, or LV wall thinning may occur. In addition, an enlarged LV tends to have a spherical (more rounded) shape, which allows it to accommodate a larger volume for the same length of the myocardium. However, increasing LV sphericity becomes a maladaptive process because it increases wall pressure, causes further LV remodeling, and is associated with poor clinical outcomes [15].

In this data (Table 3.), it was found that the mean EF between CHF-OMI patients (38.43 ± 18.743) compared to CHF-HHD (58.18 ± 18.021) was obtained. This is in line with the findings from a study of the ADHERE that showed that 77% of the patients with HFpEFs had elevated Blood Pressures [16]. Meanwhile, Reduced LVEF is associated with the risk of HF development in MI patients. A 5% decrease in LVEF determined by ventriculography performed during the MI hospitalization increases the risk of HF development after the hospital discharge by 12–18%. Similarly, a 5% decrease in LVEF evaluated by echocardiography 5–20 months after MI increases the risk of HF by 20% [8]. In addition, according to Laode Rinaldi [11], this decrease in LVEF is a reflection of a decrease in systolic function which is a further impact of a decrease in diastolic function. The high prevalence of heart failure with eccentric hypertrophy geometric pattern that experienced a decrease in systolic function was related to the geometric pattern of the left ventricle itself. The widened left ventricular space will make it difficult for the left ventricle to pump blood, resulting in a decrease in systolic function. While the decrease in systolic function in patients with concentric hypertrophy patterns is thought to be related to ischemic heart disease which causes the heart's pumping ability to decrease due to myocardial infarction.

LV size is standardly reported by measurement of the internal diameter in diastole (IDD) in patients undergoing echocardiography. It is quickly and easily obtained in the majority of patients and provides important diagnostic and prognostic information. In some conditions, such as valvular heart disease, the LV dimension is important for assessing severity and guiding the timing of surgical intervention [17].

Data on the mean value of LVIDd/LVIDs in this study also showed a significant difference between CHF-OMI patients (59.96 ± 14.044/49.11 ± 16.249) compared to CHF-HHD patients (48.55 ± 7.673/33.45 ± 10.624). These data are related to previous data (Table 1.) where the number of CHF-OMI patients was higher in male patients who tended to have HFrEF and CHF-HHD in female patients with a tendency to HFpEF, this was related to the mechanism in which patients with HFrEF found long cardiac myocytes without an increase in LV mass. Myocyte and extracellular necrosis were found due to increased activity of matrix metalloproteinases and other similar enzymes. The result is eccentric LV remodeling with an increase in the size of the LV cavity without an increase in LV wall mass, or LV wall thinning may occur. The widened left ventricular space will make it difficult for the left ventricle to pump blood, resulting in a decrease in systolic function. Meanwhile, a decrease in systolic function in patients with a concentric hypertrophy pattern is thought to be related to ischemic heart disease which causes the heart's pumping ability to decrease due to myocardial infarction [15]. The study of Laode, et al., [11] also obtained the same results where the average left ventricular end-systolic diameter (LVIDs) in the ejection fraction group > 45% (4.403 ± 0.126) was smaller than the ejection fraction group < 45% (6.136 ± 0.174). Likewise, left ventricular end-diastolic diameter (LVIDd), EF > 45% (2.859 ± 0.138) and EF < 45% (5.157 ± 0.183). Research by Gibson et al., [17] stated that male patients tended with a larger LV diameter (5.4 vs 4.6 cm) but lower ejection fraction (45% vs 60%). Increasing LV cavity size portends a worsening prognosis with adverse remodeling after myocardial infarction [17]. Patients with HFpEF are more likely to be older, with a two-fold predominance of females. This predominance of men in HFrEF might be the result of greater susceptibility to developing

MI. Additionally, men more easily develop eccentric left ventricular hypertrophy upon pressure-overload, while concentric hypertrophy is more common in females. Patients with HFpEF have a higher prevalence of non-cardiac comorbidities (i.e., hypertension, T2DM, stroke, anemia, pulmonary disease, liver disease, sleep apnoea, gout, and cancer) than HFrEF patients [18].

5 Conclusion

The number of male patients is more and younger than female patients. Male patients tend to have CHF-OMI while female patients tend to experience CHF-HHD. EF values in CHF patients with HHD were higher than CHF with OMI and LVIDd/LVIDs values were higher in CHF with OMI than CHF with HHD.

The limitation of this study is the small number of samples and only limited to hospital patients. PKU Muhammadiyah Surakarta and only assessed the EF, LVIDd, and LVIDs profiles between CHF-OMI and CHF-HHD patients.

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