The Symptoms-based Algorithm for Early Detection of Systolic Heart Failure

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Abstract: Heart failure is one of the global health problem priorities and is largely caused by late recognition of the symptoms. Early detection is paramount to diagnosing heart failure; thus, a simplified algorithm is required. The objective is to examine the accuracy of a symptoms-based algorithm for early detection of systolic heart failure. We developed a symptom-based algorithm, compared to typical echocardiography examination. The algorithm model in this study consisted of four symptoms with the highest association to systolic heart failure. To evaluate outcomes in a larger population, we performed the derivation phase to assess the sensitivity and specificity of this algorithm. The derivation phase was tested on 477 heart failure patients. All symptoms in the algorithm—dyspnoea on exertion (DOE), paroxysmal nocturnal dyspnoea (PND), orthopnoea and leg oedema—occur significantly more often among patients with systolic heart failure, compared to those with diastolic heart failure ($p < 0.05$). The algorithm obtained an area under the curve and gave a sensitivity of 83.9% and a specificity of 81.1%. The symptom-based algorithm provides good outcomes for early detection of systolic heart failure and are feasible to be developed into a self-assessment application for heart failure patients with reduced ejection fraction.

1 BACKGROUND

Heart failure is one of the global health problem priorities because of the high morbidity and mortality among sufferers (Ponikowski et al., 2014; Tripoliti et al., 2017; Ponikowski et al., 2016). Currently, at least 26 million people in the world are living with heart failure. In Indonesia, based on data from Riset Kesehatan Dasar (Riskesdas, 2018), the prevalence of heart failure is 0.3%. This number will continue to grow, along with the increasing prevalence of heart failure risk factors, such as diabetes and hypertension. Heart failure also contributes to increasing the burden of national healthcare costs every year.

Although it has such a large impact on the health burden in society, awareness of heart failure is poor. Thus, numerous premature deaths occur, even though most types of heart failure are preventable and a healthy lifestyle can further reduce risk. The incidence of premature deaths could be prevented if people have an understanding of how to recognize symptoms and seek immediate medical attention, even after heart failure has developed (Ponikowski et al., 2014; Conrad et al., 2018; Devroey and Van Casteren, 2011).

There is little development in improving the progression of heart failure severity, which is largely due to non-effective approaches for early detection of heart failure in testing interventions. Lifestyle and pharmacologic interventions may be effectively developed by analysing the early detection of heart failure (Devroey and Van Casteren, 2011; Roberts et al., 2015). Unfortunately, heart failure is a clinically complex and heterogeneous disease that is challenging to detect in routine care due to the diversity of alternative explanations for symptoms. A simple algorithm is required to help the general population be able to early detect heart failure based

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on symptoms by using smartphone applications (Van Riet et al., 2016).

2 METHOD

The data for this study were collected from the Saiful Anwar Hospital Heart Failure Registry between 2016 and 2019. All patients hospitalized with the diagnosis of heart failure were eligible for this study. We included a patient with documented heart failure who had an echocardiography examination performed during hospitalization. All study participants were given informed consent.

This study used a data survey of patients, including history, physical examination, 12-lead ECG and chest X-ray at the time of the initial patient examination. Patients received an echocardiography examination. The quantitative two-dimensional (Biplane or Simpson) method was to assess the left ventricular ejection fraction (LVEF) of the patients in the study. Patients with LVEF ≤40% were categorized as systolic dysfunction, while those who had LVEF >40% were classified as diastolic dysfunction, and preserved EF further was grouped as diastolic heart failure group. The investigators were blinded to the echocardiography results, and they reviewed all medical records pertaining to the patient after completion of the clinical evaluation described above.

To determine the symptoms with the highest association to the diagnosis of systolic heart failure, we performed a backward stepwise logistic regression, with the diagnosis of heart failure based on LVEF data as a dependent variable. The symptoms with the highest association that were found to be significant were dyspnoea on exertion (DOE), paroxysmal nocturnal dyspnoea (PND), orthopnoea and leg oedema. We built and validated an algorithm model on our prior study from the basis of these four symptoms with the highest association to systolic heart failure. To evaluate outcomes in a larger population, we performed the derivation phase to assess the sensitivity and specificity of this algorithm.

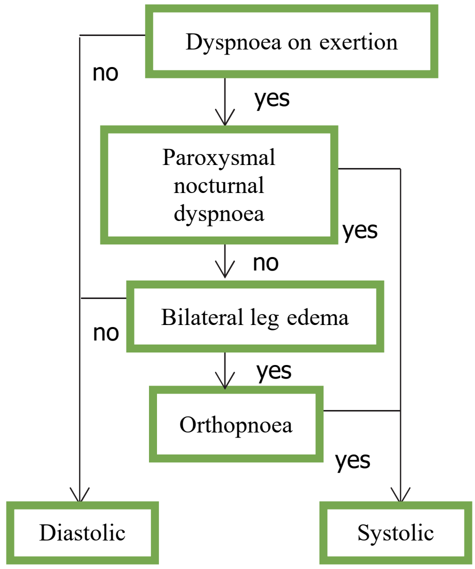

Figure 1: Symptom-based algorithm for systolic heart failure.

3 RESULTS

This study was the derivation phase of our prior study. We tested the algorithm on 477 heart failure patients derived from the Saiful Anwar Hospital Heart Failure Registry between 2016 and 2019. In this study, 284 patients were male and there was no significant difference in mean age between the two groups. The average age of the systolic heart failure group was 56.05 years (SD = 11.8), and 56.59 years (SD = 13.2, P = 0.02) was the average age of those with diastolic heart failure (table 1).

Traditional risk factors associated with systolic HF analysed in this study include diabetes mellitus type II, a history of coronary artery disease (CAD), impaired renal function and the presence of atrial fibrillation. Statistically, the frequency of the four risk factors analysed in the two study groups was not significantly different ($p > 0.05$). In this study, patients with type II DM and atrial fibrillation were more prevalent in the systolic heart failure population, whereas CAD and kidney function disorders were more prevalent in patients with diastolic heart failure.

Algorithms that have been created based on tests in the previous validation phase include four symptoms: dyspnoea on exertion (DOE), paroxysmal nocturnal dyspnoea (PND), orthopnoea and leg oedema. This algorithm was then tested in the study population in the derivation phase, and it appears that patients with systolic heart failure had experienced all four symptoms more often than others with systolic heart failure, compared to those with diastolic heart failure ($p < 0.05$).

Table 1: Patient characteristics according to HF classification (n = 477).

Demographic and clinical features	HF classification		P value
	Systolic HF	Diastolic HF	
Men/ women	131/61	153/132	0.02
Age (years)	56.05(±11.8)	56.59(±13.2)	0.65
DM (%)	33.5	30.5	0.36
Known CAD (%)	27.7	33.1	0.21
Renal dysfunction (%)	1	3.2	0.12
AFib (%)	18.3	16.4	0.64
Symptoms (%)			
DOE	93.8	47	0,00
PND	88	8.1	0,00
Orthopnea	68.2	46	0,00
Leg edema	43.8	26	0,00

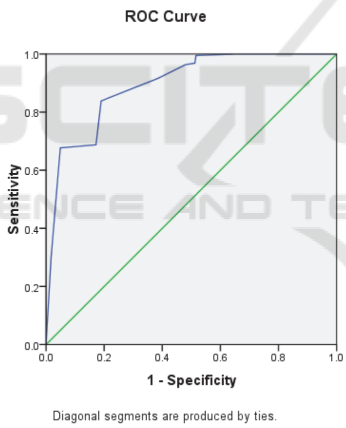

Figure 2: ROC of the derivation phase.

As the final result from the receiver operating curve analysis obtained area under the curve (AUC) 0.895 (95% CI, 0.867-0.922) the value obtained is better than the results of the previous validation phase. This algorithm provides a sensitivity of 83.9% and a specificity of 81.1%.

4 DISCUSSION

Heart failure is one of the main cardiovascular diseases in the world and has also become a major concern in developing countries. The outreach of the health system and the lack of awareness in the population of cardiovascular risk factors results in treatment delays, which ultimately increases mortality. As shown in Devroey and Van Casteren's study (2011), heart failure is one of the problems in primary health care that requires careful history-taking and physical examination.

Unfortunately, the symptoms of heart failure are very diverse, so additional modalities are needed for diagnosis. The algorithm to diagnose heart failure according to ESC guidelines in a non-acute setting is based on the previous clinical history of the patient, the presenting symptoms, physical examination and resting ECG. If all elements are normal, heart failure is impossibly found in the patients. Plasma Natriuretic Peptides should be measured when one element is detected as being abnormal. This measurement provides the opportunity for doctors to detect those patients who need an echocardiography.

Clinical symptoms, such as dyspnoea on exertion (DOE), paroxysmal nocturnal dyspnoea (PND), orthopnoea and leg oedema, are arranged in an algorithm, giving AUC 0.895 (95% CI, 0.867-0.922). This is consistent with Devroey and Van Casteren's study that DOE and leg oedema are heart failure predictors with good sensitivity and specificity. The combination of peripheral oedema, breathlessness on exercise and pulmonary rales had good specificity to detect heart failure, but low sensitivity.

This study attempted to create a simpler approach with the symptom-based diagnostic tool so that patients are able to do an accurately self-assessment and then quickly seek medical advice. This symptom-based algorithm was developed in an effort to facilitate the common population in recognizing heart failure symptoms that they may have experienced before.

With high sensitivity and specificity, this algorithm is expected to be able to reduce the diagnostic delay that has happened thus far. We expect that the heart failure morbidity and mortality rate could be reduced in the future. This algorithm is also expected to be used as a simple tool to help medical practitioners in the early detection of systolic heart failure. For further research, this algorithm model can be tested in the general population, especially for primary healthcare patients, as a first-line screening tool before using more advanced diagnostic modalities.

5 CONCLUSIONS

The symptom-based algorithm provides good outcomes for early detection of systolic heart failure.

With the massive development of smartphone-based technology, this algorithm is feasible to be developed into a self-assessment application for heart failure patients with reduced ejection fraction.

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