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B-Lines Value on Lung Ultrasound and EVEREST Score Pre-Discharge as A Predictor of Rehospitalization and Total Mortality Post Hospitalization Due to Acute Heart Failure

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ABSTRACT

Background: The high rate of rehospitalization in the vulnerable phase after treatment for acute heart failure (AHF) is caused by persistent hemodynamic congestion, even though the patient has experienced clinical improvement before being discharged. The B-lines value on Lung Ultrasound is a hemodynamic parameter that has the potential to determine the post-treatment prognosis of patients with AHF, while the EVEREST score is a marker of congestion which consists of several parameters used to assess congestion clinically. ***Methods:*** Patients treated for AHF with varying ejection fraction (EF) were included in this prospective cohort study. Data on demographics, comorbidities, pre-discharge therapy and pre-discharge echocardiographic parameters were collected. The pre-discharge B-lines value and EVEREST score were calculated a maximum of 24 hours before the patient was discharged. The outcomes studied were rehospitalization and total mortality within 60 days. ***Results:*** A total of 66 samples with various EF were included until the end of the study (15 HFpEF, 8 HFmrEF, and 43 HFrEF, mean age 57.14 ± 14.68 years). During the 60-day follow-up period, 19 samples (28.9%) experienced rehospitalization and total mortality. Both the B-lines value (AUC 0.716; 95%CI 0.581-0.851; p<0.006) and the EVEREST score (AUC 0.675; 95%CI 0.542-0.807%; p<0.027) served as predictors of rehospitalization and total mortality. The regression model showed that the pre-discharge B-lines score was ≥9 (adjusted HR 4.865; 95%CI 1.749-13.534; p=0.002) and the pre-discharge EVEREST score ≥2 (adjusted HR 3.694; 95%CI 1.211-11.262; p=0.022) played an independent role as a predictor of rehospitalization and total mortality, regardless of BMI, diabetes mellitus, renal impairment or TAPSE. ***Conclusion:*** The pre-discharge B-line value and EVEREST score can be applied to stratify the risk of rehospitalization and total mortality after treatment for patients with AHF.

Keywords: acute heart failure; B-lines; EVEREST score; lung ultrasound; rehospitalization; total mortality.

INTRODUCTION

Heart failure is still a major health problem in the world, including in developing countries such as Indonesia. Based on Riskesdas data in 2018, more than one million or 1.5% of the Indonesian population suffer from heart disease and one-fifth of them are patients with heart failure. InaHF 2018 national register data shows that as many as 17% of heart failure patients in Indonesia will experienced hospitalizations. In addition, it is stated that 30% of heart failure patients experience rehospitalization within 60-90 days after discharge [1]. The most common cause of heart failure is heart disease itself and one study showed that 54% of heart failure cases were related to inadequate diuretic administration and 20% to poor patient adherence to treatment [2]. Acute heart failure (AHF) is defined as the process of worsening signs and symptoms of heart failure that occurs gradually or suddenly and leads to unplanned office visits, emergency department visits or even causes a patient to be hospitalized [1]. One study also mentioned that at least 40% of patients with AHF are discharged with residual congestion. Residual congestion at discharge is associated with rehospitalization and mortality within 6 months of discharge, regardless of the underlying pathology.

Although current guidelines emphasize the importance of treating congestion aggressively, they do not specify which congestion targets should be optimized at the time of AHF hospitalization or in the outpatient setting [3].

Given the devastating impact of recurrent episode of rehospitalization, optimization of heart failure management during inpatient and outpatient care should be done to prevent rehospitalization of patients with AHF. But it is often a difficult goal to achieve. Understanding factors that worsen the prognosis is necessary to identify predictors of rehospitalization in congestive heart failure patients. Identification of these predictors will serve as benchmarks to provide more aggressive management as well as guidelines for more rigorous monitoring and evaluation, so it will not only reduce the rehospitalization rates but also improve survival rates which lead to a better quality of life. Patients with heart failure often experience congestion that may require immediate hospitalization. Most patients with acute heart failure are discharged with persistent congestion, which is associated with higher rehospitalization and mortality [4]. Conceptually, volume overload has been divided into clinical congestion and hemodynamic congestion. Clinical congestion manifests as signs and symptoms of volume overload (e.g. dyspnea, orthopnea, JVD), whereas hemodynamic congestion has been defined as increased cardiac filling pressure with or without clinical congestion.

Increased intracardiac filling pressure often silently precedes and the appearance of congestive symptoms clinically takes place within days or weeks in patients with AHF. The main pathophysiology of pulmonary congestion is increased left ventricular filling pressure, which can be detected by the number of B-lines with lung ultrasonography and eRAP assessed using measurements of the IVC diameter and its collapsibility. In general, ultrasonography can be used in clinical practice to improve sensitivity in detecting congestion. Until now, the Prof. Ngoerah Hospital Clinical Practice Guidelines on acute heart failure and the clinical pathway of the Indonesian Association of Cardiovascular Specialists have not recommended routine lung ultrasound examination or as one of the discharge criteria. The European Society of Cardiology guidelines on heart failure also only recommend the use of pre and post lung ultrasound as adjunctive therapy to confirm the presence of acute heart failure, but whether one parameter of lung ultrasound can be used as a benchmark for the discharge criteria is not listed in the guidelines [5].

Pulmonary congestion is one of the most important signs in heart failure. Previous methods such as clinical examination and chest x-ray are relatively insensitive to detect it. The presence of residual congestion should be assessed before discharge, but congestion can be difficult to assess especially if signs of extrapulmonary congestion are mild.

Lung ultrasound (LUS) may be considered in the assessment of lung congestion. Recently there has been a tremendous development in the use of lung ultrasound to detect lung congestion in heart failure both in research and in clinical practice. LUS has been proposed as a useful tool in the assessment of patients with acute and chronic heart failure. This technique allows detection of pulmonary congestion in patients with acute dyspnea with higher accuracy than chest auscultation or chest x-ray. LUS imaging of B-lines may improve the evaluation of congestion. B-lines are defined as laser-like vertical hyperechoic reverberation artifacts that arise from the pleural line, extend to the bottom of the screen without fading and move synchronously with lung sliding. Significant B-lines are defined as the presence of three or more B-lines in the longitudinal plane between two ribs and two or more positive regions in each lung. In case of persistent lung congestion, treatment including increased diuretic dose should be optimized to keep the patient free of congestion [4,6].

Lung ultrasound is currently an emerging non-invasive marker for detecting pulmonary edema, where LUS can be measured anytime, anywhere, almost by anyone, even with portable instruments. Initially the recommended protocol for evaluating B-lines was performed by scanning 28 regions in the anterior chest. The number of B-lines in each protocol region was usually summed up to produce a quantitative score of B-lines. The original and comprehensive 28 protocol region scan takes about 3 minutes and was felt to be too complicated and time-consuming for routine use in echocardiography, but similar information can be obtained with less than 28 protocol regions, such as 8 or even 6 protocol regions. Although several software algorithms have been developed and validated to make this diagnosis completely independent of the operator, the current conventional eyeballing analysis is easy to learn. With a short training of a few hours, acquisition time of a few minutes, analysis time of a few seconds and with low variability even among inexperienced observers. The sensitivity and specificity of lung ultrasound for detecting congestion through B-lines are 94% and 92% respectively [4–6].

Picano et al hypothesized a lung water cascade that occurs in heart failure patients. The cascade is sequenced in a clear time sequence as follows: early phase, preceded by increased pulmonary capillary wedge pressure. Intermediate phase, direct imaging signs of pulmonary edema (easily detected on lung ultrasound as B-lines). Late phase, final clinical signs and symptoms such as dyspnea and pulmonary rales. Completion of the cascade (from hemodynamic signs to pulmonary to clinical congestion) can occur within minutes, hours or even weeks. Reversal of the cascade can be achieved by timely therapy of pulmonary congestion, such as diuretics or dialysis. Any therapeutic intervention is said to be more likely to be successful in the early steps of the cascade and at the imaging stage of asymptomatic pulmonary congestion than in the end of the cascade [7].

B-lines are also observed in stable heart failure in both inpatients and outpatients. Platz et al reported that 85% of outpatient heart failure patients with asymptomatic pulmonary congestion were detected by B-lines with no rales on lung auscultation. In a population of stable inpatients and outpatients with chronic heart failure, Picano et al reported that 41% had B-lines at rest and 71% during exercise-stress echocardiography. Ohman et al measured B-lines, natriuretic peptides and dyspnea serially after pulmonary congestion therapy with diuretics. Patients who showed an early decrease in E/e' also showed a more pronounced decrease in B-lines, suggesting that LUS may provide a suitable marker to study pulmonary congestion as well as the phase of pulmonary decongestion that follows the administration of therapy. In addition, the B-lines value evaluated by lung ultrasound is one of the non-invasive examinations that can be performed in almost every hospital, can be performed in emergency and outpatient conditions, and is covered by government health insurance programs. If this hypothesis is proven, then evaluation of B-line values on pre-discharge lung ultrasound can be a supporting examination that can be performed routinely and is useful as a guideline in the therapy and monitoring of patients with heart failure [6].

Physical examination can only detect moderate to high levels of congestion. Although many clinical signs and symptoms of congestion have been characterized in various guidelines, no single element of the clinical history or physical examination can accurately detect the underlying hemodynamic changes that lead to congestion. Dyspnea, orthopnea, systemic edema, jugular venous pressure and third heart sound are important clinical findings to identify AHF. To date, there are no guidelines suggesting relying on only 1 single finding or parameter to identify acute heart failure, in this context residual congestion. Research suggests that if the congestion is mild, it may be difficult to assess, hence the need for a score that combines multiple clinical parameters to show higher accuracy than physical examination alone in assessing congestion. Clinical scores combining multiple clinical indicators have been shown to assess the degree of congestion more accurately than any standalone indicator. There are many prognostic scores for clinical congestion assessment, such as the Lucas score, Rohde score, Gheorgiade score and EVEREST score. However, of the studies most relevant to this study and evidence-based is the EVEREST score which is assessed at pre-discharge [3].

The EVEREST score was developed by Ambrosy et al in 2013 by performing a post hoc analysis on the placebo group of the EVEREST trial (Efficacy of Vasopressin Antagonism in Heart Failure Outcome Study with Tolvaptan) which examined changes in congestion within the hospitalization time frame and was associated with a markedly increased risk of death from heart failure in patients with overt clinical congestion. The role of each of these congestion scores in routine clinical practice remains to be investigated. The EVEREST score is based on several examinations such as dyspnea, orthopnea, jugular vein distension, ronchi, edema with predischarge assessed with a score range of 0-18. The interpretation is that a discharge score ≥ 1 is associated with a 10% absolute increase in the likelihood of rehospitalization within 6 months and a discharge score ≥ 3 is associated with a 10% absolute increase in the likelihood of all-cause death within 6 months [3]. Traditionally, the disappearance or reduction of dyspnea has been the primary endpoint for short-term efficacy in clinical trials in heart failure.

This study examined the volume overload sign of congestion clinically through EVEREST score and congestion hemodynamically through B-lines value on pre-discharge lung ultrasound to look at residual congestion in patients who have been treated according to current heart failure guidelines. Although many clinical scores, imaging tools and laboratory tests are available to assist clinicians in ascertaining and quantifying congestion, not all of them are readily available and easy to use at the patient management stage. In recent years, multidisciplinary management in the community has become increasingly important to prevent heart failure hospitalization.

METHOD

This study was conducted with a prospective cohort design. This study is a collaborative study to see the relationship B-lines value on lung ultrasound and pre-discharge EVEREST score on rehospitalization due to heart failure and total mortality in 60 days post-hospitalization in patients with AHF located at Prof. dr. I G. N. G. Ngoerah hospital, Denpasar, Bali. Examination of B-lines values through lung ultrasound using echocardiography equipment and EVEREST score was conducted through interviews and physical examinations that carried out simultaneously in the echocardiography room. The target population in this study were all patients with AHF who underwent hospitalization.

Inclusion criteria: 1) Patients with AHF who are ≥18 years old and willing to participate by signing the consent form after explanation; 2) Patients with de novo or recurrent AHF; 3) Patients with HFpEF, HFmrEF or HFrEF. Exclusion criteria: 1) Patients with AHF and pulmonary fibrosis confirmed through medical records; 2) Patients with AHF and moderate-severe pleural effusion (> 1/2 lower lung lobe based on chest x-ray); 3) Patients with AHF and pneumothorax confirmed through medical records; 4) Patients with AHF and lung cancer confirmed by medical records; 5) Patients with AHF and acute respiratory distress syndrome confirmed by medical records and diagnosed by Berlin criteria; 6) Patients with AHF and pregnancy; 7) Patients with AHF and malignancy

Pre-discharge B-lines Examination Procedure

All study samples underwent transthoracic echocardiography examination using a GE Vivid IQ echocardiography machine at the echocardiography room of Prof. Dr. I G. N. G. Ngoerah hospital.

The examination was performed by one echocardiography fellow who had been specially trained to evaluate B-lines and had been blinded to other study data. B-lines on lung ultrasound is one part of the transthoracic echocardiography examination. The results of the examination were then reviewed by two echocardiography consultant. Echocardiography examination is performed a maximum of 24 hours before the patient is discharged by following the standard guidelines.

B-lines analysis was performed through examination of 8 zones on the lung according to the previously listed points, using a phased-array probe with a depth of 15 cm and recording for 6-7 seconds on each zone of the video clip. The patient was examined in a semi-sitting position. The lung ultrasound examination through the echocardiography device is performed carefully to visualize all lung zones well, preventing the occurrence of inadequate visual images. B-lines measurements will be calculated based on each zone and then summed up for all zones. All echocardiographic examination data were measured and stored directly on the echocardiography machine without the use of additional software. The number of B-lines was assessed by two blind and independent observers. The data obtained was then entered into the point of care echocardiography examination form (attached).

EVEREST Score Examination Procedure

The EVEREST score was assessed using a questionnaire. The parameters obtained in the form of interviews were dyspnea, fatigue, orthopnea and the parameters obtained through physical examination were jugular vein distension, ronchi and leg edema. Each parameter was rated on a standardized 4-point scale ranging from 0 to 3. The EVEREST congestion score was calculated by summing these parameters and recording them on the questionnaire.

The parameters of dyspnea, fatigue and orthopnea were assessed purely based on the patient's answers to the questions given, no one researcher or health team was allowed to interfere with the patient's answers. For the assessment of jugular vein distension (JVD) using a ruler, rales using a stethoscope on both lung fields and leg edema using finger pressure and a time meter, for grade 0 (no edema and no indentation that persists after releasing finger pressure), grade 1 (mild pitting edema with a slight indentation that disappears within 10 seconds), grade 2 (moderate pitting edema that disappears after 10-15 seconds) and grade 3, severe pitting (edema that lasts more than 15 seconds, after the release of finger pressure), the examination was carried out by two observers and the final results were averaged. The data obtained was then entered into the EVEREST score examination form (attached).

All data collected in each group were then analyzed with the SPSS program. Data analysis performed included descriptive analysis, chi-square independent sample t-test, mann whitney U test, B-lines reliability test and EVEREST score blinded by two observers and then bland-altman limits of agreement test, then the values were averaged, Receiver Operating Characteristic (ROC) curve analysis and survival analysis performed with Kaplan-Meier Curve and Cox Regression test.

RESULT

This study was conducted over 4 months and involved a total of 66 samples at the end of the study. In this study, 44 samples were male (66.7%) and 22 samples were female (33.3%). The samples involved in this study had a mean age of 57.14±14.68 years. In terms of body mass index, the majority of the samples belonged to the obese (39.4%) and normal (28.8%) categories. Most of the samples were admitted for first-time or de novo acute events (66.7%) and some were worsening of previously diagnosed heart failure (33.3%). Based on heart failure phenotype, 65.2% of the sample belonged to heart failure with reduced ejection fraction, while heart failure with preserved ejection fraction and mid-ranged ejection fraction accounted for 12.1% and 22.7%, respectively. Descriptive analysis of several classic comorbidities of AHF showed that hypertension was the most common comorbid disease found in patients with AHF (54.5%), followed by smoking (45.5%), CHD (39.4%) and diabetes mellitus (28.8%). During the 60-day follow-up period, a total of 19 samples (31.8%) experienced rehospitalization and total mortality. A total of 18 samples (27.3%) experienced rehospitalization due to worsening heart failure. Of all the samples who experienced rehospitalization, 6 samples (9.1%) died during treatment due to worsening of heart failure. One patient was found to have died at home unexpectedly without a clear extracardiac cause so that it could be categorized as probable sudden cardiac death.

TABLE 1: Basic Characteristics of the Research Sample.

Basic Characteristics	Total (N=66)
Male, n (%)	44 (66,7)
Female, n (%)	22 (33,3)
Age, years, mean ± SB	57,14±14,68
BMI, kg/m^2, mean ± SB	24,64±4,26
Underweight (BMI <18.9 kg/m2), n (%)	3 (4,5)
Normal (BMI ≥18.9-22.9 kg/m2), n (%)	19 (28,8)
Overweight (BMI ≥23-24.9 kg/m2), n (%)	18 (27,3)
Obesity (BMI ≥25 kg/m2), n (%)	26 (39,4)

Basic Characteristics	Total (N=66)
Heart failure	
De novo heart failure, n (%)	44 (66,7)
ADHF, n (%)	22 (33,3)
Heart failure phenotype	
HFpEF (LVEF ≥50%), n (%)	15 (22,7)
HFmrEF (LVEF 41-49%), n (%)	8 (12,1)
HFrEF (LVEF ≤40%), n (%)	43 (65,2)
Comorbidities	
Hypertension, n (%)	36(54,5)
Smoking, n (%)	30 (45,5)
Diabetes mellitus, n (%)	19 (28,8)
Renal impairment, n (%)	3 (4,5)
CHD, n (%)	26 (39,4)
Outputs	19 (28,9)
Rehospitalization, n (%)	18 (27,3)
Rehospitalized and alive until the end of follow-up, n (%)	12 (18,2)
Rehospitalization and death during follow-up, n (%)	6 (9,1)
Died at home, n (%)	1 (1,5)
Duration of follow-up, days	60

The pre-discharge B-lines value was evaluated through lung ultrasound examination using echocardiography equipment by taking the total number of B-lines in 8 zones in the lung field for 6-7 seconds per zone. Reliability analysis in this study was performed to assess the consistency of the measurement results of the average B-lines value calculated by two competent observers at different times. Reliability analysis was performed using the Bland Altman test to determine the limit of agreement of the B-lines value measured by the two observers and expressed in the form of a Bland Altman curve.

The inter-observer variability of the B-lines values calculated by the two observers is shown in Figure 1. Based on the curve, there is a high level of agreement from observers 1 and 2 with a small mean difference, which is not statistically significant and there are no data deviations that exceed the 95% upper and lower limits of the Bland Altman diagram. The results of the reliability analysis showed that the mean difference between the B-lines of the two observers was 0.015% (p=0.7839).

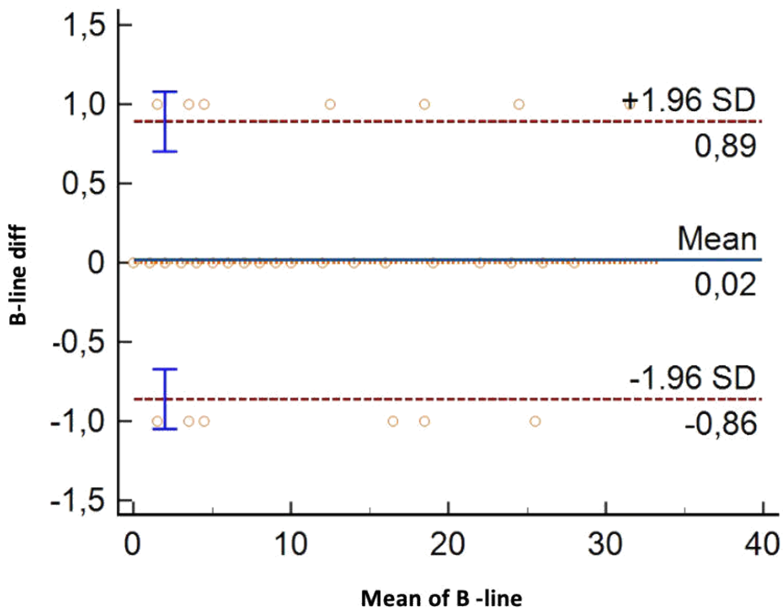

FIGURE 1: Bland Altman diagram of inter-observer variability of pre-discharge B-lines value measurements showing high agreement between observers 1 and 2.

The pre-discharge EVEREST score was evaluated through history taking and physical examination using the provided forms. Reliability analysis in this study was conducted to assess the consistency of the measurement results of the average EVEREST score calculated by two competent observers at different times. Reliability analysis was performed using the Bland Altman test to determine the limit of agreement of the EVEREST score examined by the two observers and expressed in the form of a Bland Altman curve.

The inter-observer variability of the EVEREST score calculated by the two observers is shown in Figure 2. Based on the curve, it can be seen that the high level of agreement of observers 1 and 2 with a small mean difference, is not statistically significant and there is no deviation of data that passes the 95% upper and lower limits of the Bland Altman diagram. The results of the reliability analysis showed that the mean difference between the EVEREST scores of the two observers was 0.015% (p=0.5677).

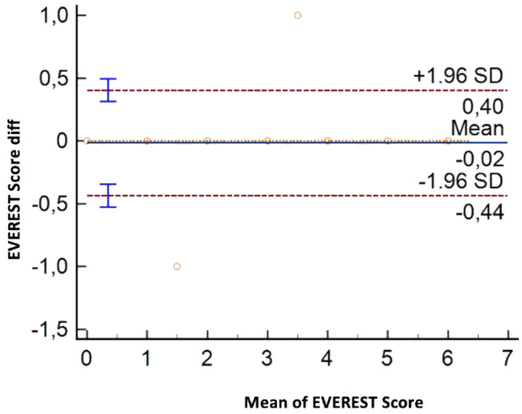

FIGURE 2: Bland Altman diagram of inter-observer variability for pre-discharge EVEREST score measurement showing high agreement between observers 1 and 2.

Cut-off points for pre-discharge B-lines and EVEREST scores as predictors of rehospitalization and total mortality were determined using ROC curve analysis. Based on this analysis, the best cut-off point for pre-discharge B-lines score as a predictor of rehospitalization and total mortality was ≥9 with an area under the curve (AUC) value of 0.716 (95%CI 0.581-0.851; p<0.006), sensitivity of 73.7% and specificity of 72.3%. Through the same analysis method, the best cut-off point for pre-discharge EVEREST score to predict rehospitalization and total mortality within 60 days was ≥2 with an area under the curve (AUC) value of 0.675 (95%CI 0.542-0.807%; p<0.027), sensitivity of 51.1% and specificity of 78.9% (Figure 3 A and B). Furthermore, samples with pre-discharge B-lines score ≥9 and/or pre-discharge EVEREST score ≥2 were categorized as risk factors, while samples with pre-discharge B-lines score <9 and/or pre-discharge EVEREST score <2 were categorized as comparators.

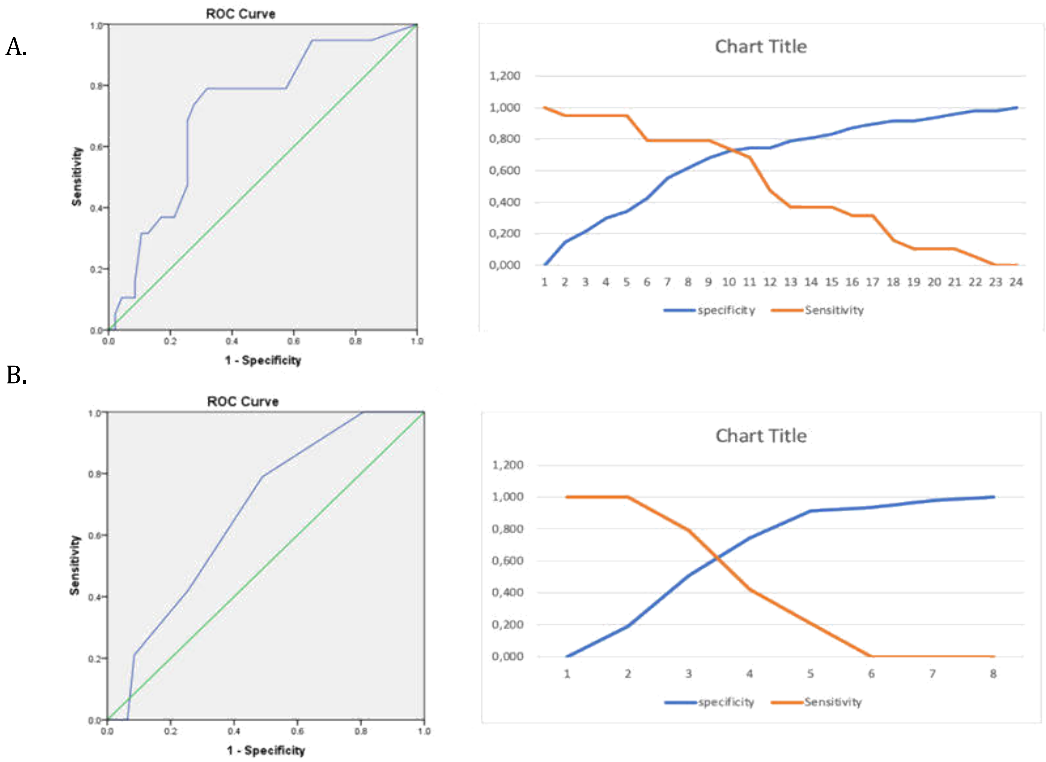

FIGURE 3: ROC curve and line diagram of sensitivity and specificity (A) values B-lines and (B) pre-discharge EVEREST scores as predictors of rehospitalization and total mortality within 60 days.

Through Kolmogorov-Smirnov normality test, the variables of age, BMI, gender, pre-discharge hemodynamic parameters (pulse) and pre-discharge echocardiographic parameters (LAVi, LVEF, TAPSE and B-lines value) were found to be normally distributed with homogeneous variance (p>0.05). Other parameters such as eRAP and EVEREST score were not normally distributed, so non-parametric tests were conducted for these variables.

Table 2 presents the bivariate analysis of baseline characteristics, comorbidities, pre-discharge hemodynamic conditions, pre-discharge heart failure therapy, as well as echocardiographic parameters at the time of discharge based on the pre-discharge cut-off B-lines values and EVEREST scores determined based on the previous ROC curves. Through bivariate analysis, it was found that patients with B-lines values ≥9 and EVEREST scores ≥2 had lower mean body mass index, LVEF and TAPSE, and higher LAVi compared with the group without risk factors. However, only the higher LAVi was significantly significant. Samples with higher B-lines scores had higher median EVEREST scores (2 versus 1, p=0.07). Similarly, samples with high EVEREST scores had higher mean B-lines scores (10.53 versus 6.96, p=0.07), but both were not significant.

TABLE 2: Sample characteristics based on pre-discharge B-lines and EVEREST scores.

Variables	B-lines Value		P-value	EVEREST Score		P-value
	<9 (N=39)	≥9 (N=27)		<2 (N=28)	≥2 (N=38)	
Age, years, mean ± SB	56,33±13,81	57,69±15,41	0,709	55,89±15,79	58,05±13,9	0,559
BMI, kg/m2, mean ± SB	25,44±4,63	23,48±3,41	0,052	25,2±5,42	24,18±3,15	0,318
Gender						
Male, n (%)	24(54,5)	20(45,5)	0,426	16(36,4)	28(63,6)	0,137
Female, n (%)	15(68,2)	7(31,8)		12(54,5)	10(45,5)	
Heart failure						
ADHF, n (%)	12(54,5)	10(45,5)	0,607	8(36,4)	14(63,6)	0,600
De novo heart failure, n (%)	27(61,4)	17(38,6)		20(45,5)	24(54,5)	
Cardiogenic shock						
Yes, n (%)	8(61,5)	5(38,5)	1,000	5(38,5)	8(61,5)	1,000
No, n (%)	31(58,5)	22(41,5)		23(43,4)	30(56,6)	
Comorbid						
Hypertension						
Yes, n (%)	24(66,7)	12(33,3)	0,213	18(50)	18(50)	0,215
No, n (%)	15(50)	15(50)		10(33,3)	20(66,7)	
Diabetes mellitus						
Yes, n (%)	9(47,4)	10(52,6)	0,273	10(52,6)	9(47,4)	0,410
No, n (%)	30(63,8)	17(36,2)		18(38,3)	29(61,7)	
Coronary Heart Disease						
Yes, n (%)	14(53,8)	12(46,2)	0,610	8(30,8)	18(69,2)	0,137
No, n (%)	25(62,5)	15(37,5)		20(50)	20(50)	
Smoking						
Yes, n (%)	16(53,3)	14(46,7)	0,455	11(36,7)	19(63,3)	0,458
No, n (%)	23(63,9)	13(36,1)		17(47,2)	19(52,8)	
Kidney Disorders						
Yes, n (%)	2(66,7)	1(33,3)	1,000	1(33,3)	2(66,7)	1,000
No, n (%)	37(58,7)	26(41,3)		27(42,9)	36(57,1)	
Stroke						
Yes, n (%)	2(66,7)	1(33,3)	1,000	1(33,3)	2(66,7)	1,000
No, n (%)	37(58,7)	26(41,3)		27(42,9)	36(57,1)	
Pre-discharge Clinical Parameters						
EVEREST Score (IQR)	1(2)	2(2)	0,07	-	-	-
Pre-discharge Hemodynamic Parameters						
Pulse, beats per minute, mean ± SB	78,95±12,94	80,26±13,05	0,689	79,89±9,55	79,18±15,03	0,828
TDS, mmHg, mean ± SB	122,64±17,74	108,93±19,06	0,004*	121,68 ±18,39	113,61±19,6	0,095
TDD, mmHg, mean ± SB	74,74±10,6	67,74±12,52	0,17	75,39±13,35	69,29±10,01	0,38

Variables	B-lines Value		P-value	EVEREST Score		P-value
	<9 (N=39)	≥9 (N=27)		<2 (N=28)	≥2 (N=38)	
Pre-discharge Heart Failure Therapy						
ACEi/ARB/ARNI, n (%)						
Yes, n (%)	37(58,7)	26(41,3)	1,000	27(42,9)	36(57,1)	1,000
No, n (%)	2(66,7)	1(33,3)		1(33,3)	2(66,7)	
Beta blockers, n (%)						
Yes, n (%)	39(60,9)	25(39,1)	0,164	27(42,2)	37(57,8)	1,000
No, n (%)	0(0)	2(100)		1(50)	1(50)	
MRA, n (%)						
Yes, n (%)	26(55,3)	21(44,7)	0,757	20(42,6)	27(57,4)	1,000
No, n (%)	13(68,4)	6(31,6)		8(42,1)	11(57,9)	
Digitalis, n (%)						
Yes, n (%)	2(50)	2(50)	1,000	2(50)	2(50)	1,000
No, n (%)	37(59,7)	25(40,3)		26(41,9)	36(58,1)	
Diuretics, n (%)						
Yes, n (%)	35(57,4)	26(42,6)	0,641	26(42,6)	35(57,4)	1,000
No, n (%)	4(80)	1(20)		2(40)	3(60)	
Echocardiographic Parameters						
LAVi, ml/m2, mean±SB	31.62±12,73	47.59±11,91	<0,001*	36,3±13,4	42,2±14,3	0,008*
LVEF, %, mean±SB	41,23±15,76	34,99±15,31	0,114	43,57±14,57	35,07±15,8	0,029*
TAPSE, cm, mean±SB	2,02±0,28	1,72±0,46	0,002*	1,93±0,49	1,87±0,30	0,511
Diastolic parameters						
Average E/e', mean±SB	15,06±6,92	20,14±8,62	0,010*	15,87±7,73	18,07±8,18	0,274
ePCWP, mmHg, mean±SB	20,63±8,53	26,78±10,95	0,011*	21,53±9,47	24,2±10,35	0,281
Hemodynamic parameters						
eRAP, mmHg, median (IQR)						
3, n(%)	14(87,5)	2(12,5)		7(43,8)	9(56,3)	
8, n(%)	23(59)	16(41)	<0,0001*	17(43,6)	22(56,4)	0,942
15, n(%)	2(18,2)	9(81,8)		4(36,4)	7(63,6)	
CI, l/min/m2, mean±SB	2,4(0,97)	2,1(0,92)	<0.100	2,30±0,59	2,35±1,17	0,839
B-lines values, mean±SB	-	-	-	6,96±7,98	10,53±7,8	0,07

Normally distributed numerical data are presented as mean ± standard deviation (SB), while non-normally distributed data are presented as median (interquartile range). Numerical data were analyzed using the independent Student t-test. Categorical data were displayed in frequency (n) and percentage (%), and analyzed using the Chi-square test.

*: There is a statistical difference between the two groups ($p<0.05$).

The bivariate analysis shown in Table 3 shows the differences in characteristics between the groups that experienced rehospitalization and total mortality and those that did not. The results of bivariate analysis showed that the rehospitalization and total mortality group had significantly higher B-lines and pre-discharge EVEREST scores than the non-hospitalization group. In addition, the group that experienced rehospitalization and total mortality had significantly lower TAPSE than the group that did not. There were no significant differences in heart failure treatment regimens between the two groups.

TABLE 3: Characteristics of the study sample based on rehospitalization and total mortality within 60 days.

Variables	Rehospitalization and Total Mortality		P-value
	Yes (N=19)	No (N=47)	
Age, years, mean±SB	58,21±14,2	56,7±14,98	0,709
BMI, kg/m2, mean±SB	23,02±3,03	25,2±4,53	0,050
Gender			
Male, n (%)	15(34,1)	29(65,9)	0,252
Female, n (%)	4(78,9)	18(81,8)	
Heart failure			
ADHF, n (%)	10(22,7)	34(77,3)	0,154
De novo heart failure, n (%)	9(40,9)	13(59,1)	
Cardiogenic shock			
Yes, n (%)	5(38,5)	8(61,5)	0,496
No, n (%)	14(26,4)	39(73,6)	
Comorbid			
Hypertension			
Yes, n (%)	11(30,6)	25(69,4)	0,790
No, n (%)	8(26,7)	22(73,3)	
Smoking, n (%)			
Yes, n (%)	9(30)	21(70)	1,000
No, n (%)	10(27,8)	26(72,2)	
Diabetes mellitus, n (%)			
Yes, n (%)	8(42,1)	11(57,9)	0,145
No, n (%)	11(23,4)	36(76,6)	
Coronary heart disease, n (%)			
Yes, n (%)	8(30,8)	18(69,2)	0,788
No, n (%)	11(27,5)	29(72,5)	
Renal Impairment, n (%)			
Yes, n(%)	2(66,7)	1(33,3)	0,197
No, n(%)	17(27)	46(73)	
Stroke, n(%)			
Yes, n(%)	0(0)	3(100)	0,551
No, n(%)	19(30,2)	44(69,8)	
Pre-discharge Clinical Parameters			
EVEREST score, median (IQR)	2(1)	1(2)	0,023*
Pre-discharge Hemodynamic Parameters			
Pulse, beats per minute, mean±SB	77,37±18,47	80,34±9,96	0,401
TDS, mmHg, mean±SB	111,37±21.81	119,32±18,05	0,132
TDD, mmHg, mean±SB	70,26±9,35	73,94±11,98	0,253
Pre-dischar Heart Failure Therapy			
ACEi/ARB/ARNI, n (%)			
Yes, n (%)	18(28,6)	45(71,4)	0,154
No, n (%)	1(33,3)	2(66,7)	
Beta blockers, n (%)			
Yes, n (%)	18(28,1)	46(71,9)	0,496
No, n (%)	1(50)	1(50)	
MRA, n (%)			
Yes, n (%)	13(27,7)	34(72,3)	0,770
No, n (%)	6(31,6)	13(68,4)	
Digitalis, n (%)			
Yes, n (%)	1(25)	3(75)	1,000
No, n (%)	18(29)	44(71)	

Variables	Rehospitalization and Total Mortality		P-value
	Yes (N=19)	No (N=47)	
Pre-dischar Heart Failure Therapy			
Diuretics, n(%)			
Yes, n (%)	17(27,9)	44(71,2)	0,621
No, n (%)	2(40)	3(60)	
Echocardiographic Parameters			
LA Parameters			
LAVi, ml/m2, mean±SB	41,9±15,07	36,63±14,34	0,187
LV and RV parameters			
LVEF, %, mean±SB	38,1±15,4	38,9±16,07	0,851
EF≥ 50%, n(%)	4(26.7)	11(73.3)	
EF 41-49%, n(%)	1(12.5)	7(87.5)	0.505
EF ≤ 40%, n(%)	14(32.6)	29(67.4)	
TAPSE, cm, mean±SB	1,71±0,25	1,97±0,42	0,016*
Diastolic parameters			
Average E/e', mean±SB	17,85±9,6	16,85±7,36	0,650
ePCWP, mmHg, mean±SB	23,97±12,1	22,7±9,1	0,632
Hemodynamic parameters			
eRAP, mmHg			
3, n(%)	4(25)	12(75)	
8, n(%)	12(30,8)	27(69,2)	0,930
15, n(%)	3(27,3)	8(72,7)	
CI, l/min/m2, mean±SB	2,18±1,01	2,39±0,94	0,411
B-lines Value	12,74±7,75	7,51±7,77	0,016*

Normally distributed numerical data are presented as mean±SB, while non-normally distributed data are presented as median (IQR). Numerical data were analyzed using the independent Student t-test. Categorical data were displayed in frequency (n) and percentage (%), and analyzed using the Chi-square test.

*: There was a statistical difference between the two groups ($p<0.05$) and was included in the multivariate analysis ($p<0.05$).

The relationship between B-lines scores and pre-discharge EVEREST scores as predictors of rehospitalization outcomes and short-term total mortality was performed using survival analysis. Survival analysis was first performed by checking the proportional hazard (PH) assumption using Kaplan-Meier curves for the independent variables (B-lines score and pre-discharge EVEREST score) and dependent variables (rehospitalization and total mortality) (Figure 4). Based on survival analysis, samples with pre-discharge B-lines score ≥9 had a significantly lower 60-day survival rate than samples with lower pre-discharge B-lines score (48.1% versus 87.2%; $p<0.001$). Similarly, the pre-discharge EVEREST score, where a higher EVEREST score at pre-discharge of ≥2 was associated with a lower survival rate than samples with a lower EVEREST score (60.5% versus 85.7%; $p<0.028$).

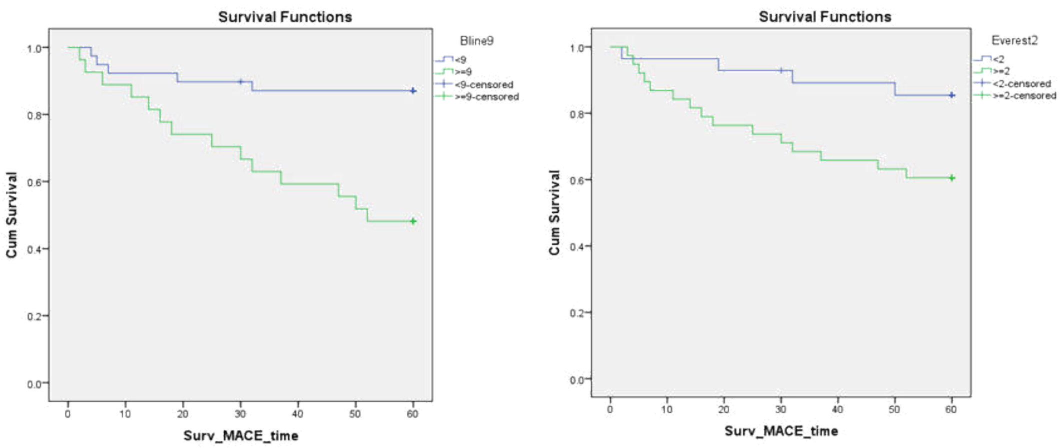

FIGURE 4: Kaplan-Meier survival curves based on (A) pre-discharge B-lines scores (cut-off points <9 and ≥9) and (B) pre-discharge EVEREST scores (cut-off points <2 and ≥2) on rehospitalization and total mortality.

The Kaplan-Meier curves in Figure 4 show that both the pre-discharge B-lines and EVEREST scores met the PH assumption, so the analysis was performed using independent Cox regression (Table 4). Through independent Cox regression analysis, it was found that samples with high pre-discharge B-lines scores had a 4.865 times higher risk of rehospitalization and total mortality within 60 days (unadjusted HR 4.865; 95% CI 1.749-13.534; p=0.002). In addition, a high pre-discharge EVEREST score was also associated with a 3.225 times increased risk of rehospitalization and total mortality within 60 days (unadjusted HR 3.225; 95% CI 1.069-9.726; p=0.038).

TABLE 4: Results of independent Cox regression analysis of B-lines and pre-discharge EVEREST scores on rehospitalization and total mortality.

Variables	Unadjusted HR	95%CI		P-value
		Lower limit	Upper limit	
Pre-discharge B-lines value ≥9	4,865	1,749	13,534	0,002*
Pre-discharge EVEREST score ≥2	3,225	1,069	9,726	0,038*

To identify independently associated risk factors as predictors of rehospitalization and total mortality in patients with AHF, all variables that did not have a multicollinearity relationship and had a p value <0.25 in the bivariate test (Table 3), namely B-lines score, EVEREST score, TAPSE, BMI (obese or not obese), diabetes mellitus and renal impairment were included in the multivariate analysis. Multivariate analysis was performed using the Cox regression test with the backward method.

TABLE 5: Multivariate analysis results using the Cox regression test with backward method on B-lines values.

Variables	HR	95%CI		P-value
		Lower limit	Upper limit	
Step 1				
Pre-discharge B-lines value	3,842	1,340	11,016	0,012
Obesity	1,060	0,380	2,956	0,911
DM	3,255	0,954	11,104	0,059
Kidney Disorders	4,209	0,858	20,652	0,077
TAPSE	3,103	0,855	11,264	0,085
Step 5				
Pre-discharge B-lines value	4,865	1,749	13,534	0,002*

TABLE 6: Multivariate analysis results using the Cox regression test with backward method on EVEREST score.

Variables	HR	95%CI		P-value
		Lower limit	Upper limit	
Step 1				
Pre-discharge EVEREST score	3,538	1,340	11,016	0,012
Obesity	0,809	0,380	2,956	0,911
DM	2,709	0,954	11,104	0,059
Kidney Disorders	2,862	0,858	20,652	0,077
Step 3				
Pre-discharge EVEREST score	3,694	1,211	11,262	0,022*
DM	2,463	0,981	6,185	0,055

Through backward analysis, after adjustment for confounding factors (IMT/Obesity, DM, renal impairment and TAPSE), it was found that the B-lines score≥ 9 pre-discharge (adjusted HR 4.865; 95%CI 1.749-13.534; p=0.002) had a significant independent relationship as a predictor of rehospitalization and total mortality in patients with AHF.

For the EVEREST score after adjusting for confounding factors (BMI/Obesity, DM and renal impairment), the EVEREST score≥ 2 pre-discharge was found to have a significant independent relationship as a predictor of rehospitalization and total mortality in patients with AHF and no confounding variables were found in the final multivariate model.

TABLE 7: Combination of B-lines Values and Pre-discharge EVEREST scores as Predictors of Rehospitalization and Mortality in AHF Patients.

B-lines Value			Rehospitalization and total mortality		P-value
			There is	None	
High	EVEREST Score	High	12(63,2)	7(36,8)	0.026*
		Not high	2(25)	6(75)	
Not high	EVEREST Score	High	3(15,8)	16(84,2)	
		Not high	2(10)	18(90)	

To determine the combination of B-lines value and pre-discharge EVEREST score as a predictor of rehospitalization and total mortality, a crosstab analysis was conducted, which is a tabular analysis method that displays a cross tabulation of the observed data. The results of the combination of B-lines score and pre-discharge EVEREST score are shown in Table 7 with the result that there is an association between the combination of B-lines score and pre-discharge EVEREST score on the incidence of rehospitalization and total mortality (p=0.026).

DISCUSSION

The 2018 InaHF national register data shows that as many as 17% of heart failure patients in Indonesia will experience repeated hospitalizations. In addition, it is mentioned that 30% of heart failure patients experience rehospitalization within 60-90 days after discharge [1]. One study also mentioned that at least 40% of patients with AHF were discharged with residual congestion. Residual congestion at discharge is associated with rehospitalization and mortality within 6 months after discharge, regardless of the underlying pathology. Optimization of heart failure management during inpatient and outpatient care should be done to prevent rehospitalization of patients with AHF.

Management of AHF with the latest perspective presented by Benjamin Deniau et al. in 2023, said that until now there is no diagnostic algorithm that can be used universally for quantification of congestion and therapeutic success. In his presentation, there are several things that can be used in assessing congestion, namely through signs and clinical, biologically, namely by measuring natriuretic peptides, hematocrit, serum creatinine and through ultrasonography in the form of measuring B-lines and inferior vena cava.

Pulmonary congestion is one of the most important signs of heart failure, ideally patients with heart failure should be discharged without residual symptoms of pulmonary congestion, either subjectively (clinical) or objectively (hemodynamic examination). Conceptually, in conditions of volume overload, congestion can be assessed through clinical congestion and hemodynamic congestion. Clinical congestion manifests as signs and symptoms of volume overload (e.g. dyspnea, orthopnea, JVD), whereas hemodynamic congestion has been defined as an increase in cardiac filling pressure with or without clinical congestion. Increased left ventricular filling pressure, which can be detected by the number of B-lines with lung ultrasonography and eRAP assessed using measurements of the IVC diameter and its collapsibility.

This study will discuss the signs of volume overload in the form of clinical congestion through EVEREST score and hemodynamic congestion through B-lines values on pre-discharge lung ultrasound to look at residual congestion in patients who have been treated according to current heart failure guidelines as a risk factor for rehospitalization and overall mortality. Although many clinical scores, imaging tools and laboratory tests are available to assist clinicians in ascertaining and quantifying congestion, not all of them are readily available and easy to use at the patient management stage. The results of this study are expected to provide information regarding a simple and applicable non-invasive predictor method to predict the probability of rehospitalization and total mortality in patients with AHF undergoing hospitalization. In addition, the results of this study are expected to provide additional information that supports the "clinical judgment" of a cardiologist before deciding whether to discharge a patient after receiving adequate therapy for AHF.

The basic characteristics in this study indicate the dominance of male gender in cases of AHF with an average age of 57.14 years. This is in accordance with research conducted by Pastore et al., on the incidence of de novo and decompensated AHF. In their study, Pastore et al. reported that most patients with AHF were male (73%) (Pastore et al., 2022). The same results were reported in an epidemiologic study by Reyes et al., who reported male predominance in cases of AHF in Southeast Asia, such as the Philippines (57%), Singapore (64%), Vietnam (59%), and Indonesia (66%). The study also showed that the average age at admission due to a AHF episode in Indonesia was 57.8 years old [8].

In this study, the prevalence of comorbidities in AHF cases was not much different compared to the Acute Decompensated Heart Failure Registry (ADHERE) International - Asia Pacific and Latin America (APLA) study which examined the demographic characteristics of patients with AHF in five hospitals in Indonesia. Some of the comorbidities included hypertension (54.5% versus 54.8%) and diabetes mellitus (28.8% versus 31.2%).

However, the prevalence of smoking in this study was found to be much lower (45.5% versus 74%). This finding could be due to the low number of traditional and electric smokers in Bali Province compared to other provinces in Indonesia, even based on data from the Central Bureau of Statistics, Bali Province has the highest number of smokers aged≥ 15 years during 2020-2022 (BPS, 2022). In addition, the decline in the number of smokers can also be caused by smoking cessation activities after the COVID-19 pandemic due to decreased social activities outside the home reduced access to cigarettes, as well as motivation to quit smoking due to concerns about the increased risk of COVID-19 infection due to smoking that persists to this day (Almeda and Gómez, 2022). Based on the data obtained in this study, it can be compared with previous AHF research that in general the results obtained are not much different.

In the characteristics of the study sample based on rehospitalization and total mortality, ejection fraction was seen with an average of 38% in both groups with and without outcomes, with results that were not statistically significant. This result is different from previous studies which state that low ejection fraction is associated with high rehospitalization and mortality rates, for example by Silverman et al (2019), which states that patients with low ejection fraction increase the occurrence of rehospitalization and mortality [9]. One of the causes of the difference in results in this study is the distribution of the number of samples related to ejection fraction, where in this study about 65% of the samples were patients with reduced ejection fraction, besides that this study was not designed to examine the relationship of ejection fraction with rehospitalization and total mortality. So, in this study it cannot be concluded that ejection fraction is a risk factor for rehospitalization and total mortality. Other characteristics that differ from existing research are systolic and diastolic blood pressure. In this study, systolic and diastolic blood pressure were not statistically significant to the outcomes of rehospitalization and total mortality. Whereas in previous studies, for example by Stuijfzand et al (2017) stated that low systolic blood pressure is associated with higher rehospitalization and mortality rates and Amini (2021) stated that low diastolic blood pressure increases adverse events in patients with heart failure [10,11]. The assumption of differences in results in this study is partly due to the number of samples with hypertension which is dominant at 54% of the sample which is likely to cause the average blood pressure both systolic and diastolic to be higher.

Research on the potential of B-lines value as a predictor of rehospitalization and total mortality is still limited and until now there is no guideline regarding the cut-off value of B-lines before patients are discharged. The method of measuring the pre-discharge B-lines value in this study was taken through 8 lung zones, recorded for 6-7 seconds then the results were summed up as the total pre-discharge B-lines value. Based on ROC curve analysis, the pre-discharge B-lines cut-off value≥ 9 showed the best accuracy as a predictor of rehospitalization and total mortality within 60 days with an (AUC) value of 0.675 (95%CI 0.542-0.807%; p<0.027), sensitivity of 51.1% and specificity of 78.9%.

The cut-off value of B-lines as a predictor of rehospitalization and all-cause mortality in this study was lower than the studies by Rattarasarn et al (cut-off≥ 12) and Gargani et al (cut-off >15) [5]. In the study by Rattarasarn et al, in 57 patients who experienced rehospitalization and all-cause mortality, the cut-off value of B-lines≥ 12 (measured after the administration of decongestion therapy and determined based on the mean B-lines value) was independently associated with a composite event of rehospitalization due to worsening heart failure and all-cause mortality within 6 months (HR =1.96; 95% confidence interval=1.14-3.37) [5]. Another study by Gargani et al, in patients with AHF who were examined for B-lines values pre-discharge reported that B-lines values >15 were independently associated with the incidence of rehospitalization due to cardiovascular causes in 6 months (HR 11.74; 95 % confidence interval [CI] 1.30-106.16) [12].

The difference in cut-off values can be caused by several factors, especially the method of taking B-lines. Each study has a different measurement method, such as the study by Rattarasarn et al using 8 lung zones and Gargani et al using 28 lung zones [5,12]. Indeed, from existing literature such as the 2019 Lung Ultrasound consensus made by Platz et al, it is said that the use of 8 or 28 zones does not reduce the accuracy of the examination, this is also supported by Gheorghiade (2013) who compared the difference in the number of B-lines if using 8 zones with 28 zones with the results there was no significant difference[1,6] . Another thing is position, in the study of Gargani et al the patient was examined in a lying position while in Rattarasarn et al the patient was examined in a half-sitting position [5]. Based on research from Saraf Frasure et al (2015) said the number of B-lines was more in patients with a lying position when compared to a half-sitting position [13]. In addition, there are things that can affect the number of B-lines that are almost not explained in detail in each study, namely the duration of the clip on each ultrasound lung zone examination. According to Platz et al (2015), longer duration (6 - 7 seconds/video clip) provides better observation. Other things that are thought to affect the number of B-lines include the position or location of the focus when used and the use of harmonics, but there are no specific studies evaluating this [6]. Second, there are differences in exclusion criteria, for example, Gargani et al excluded patients with lung cancer while Rattarasarn et al did not. Nevertheless, these three studies prove that higher B-lines values are associated with a higher risk of rehospitalization and total mortality [5].

The second independent variable studied was the EVEREST score which in this study was examined by history taking and physical examination with a pre-made form guide.

In this study, the pre-discharge EVEREST score cut-off as a predictor of rehospitalization and total mortality within 60 days was≥ 2 which showed good accuracy with an AUC value of 0.675 (95%CI 0.542-0.807%; p<0.027), sensitivity 51.1% and specificity 78.9%. The findings of this cut-off point are similar to the results of a study from Amborsy et al (2013), where in their study AHF patients with an EVEREST score of≥ 1 were associated with an increased probability of rehospitalization by 10% in 6 months and an EVEREST score of≥ 3 was associated with an increased probability of total mortality by 10% in 6 months [3]. In addition, another study from Rattarasarn et al, an EVEREST score of≥ 1 was associated with an increase in the incidence of rehospitalization due to heart failure and total mortality by 2.08 times compared to an EVEREST score of 0 points. In line with the previously described studies, a higher EVEREST score is associated with a higher risk of rehospitalization and total mortality[5].

In this study, the B-lines value showed potential as a predictor of the composite event between rehospitalization due to cardiovascular disease and total mortality. Patients with a pre-discharge B-lines value of≥ 9 had a 4.865 higher risk of rehospitalization and total mortality than patients with pre-discharge B-lines < 9 (unadjusted HR 4.865; 95% CI 1.749-13.534; p=0.002). To determine whether the pre-discharge B-lines values were independent predictors of rehospitalization and total mortality, multivariate analysis using Cox Regression was conducted. Variables included in the multivariate test were control variables that showed a p value <0.25 and variables that were theoretically important. In addition to the pre-discharge B-lines values, the variables BMI (obese and non-obese), diabetes mellitus, renal disease and TAPSE, having a p value <0.25 were included in the multivariate analysis. After controlling for confounding variables in the multivariate analysis, a high pre-discharge B-lines score was shown to be an independent predictor of rehospitalization and total mortality with an adjusted hazard ratio of 4.865 (95% CI 1.749-13.534; p=0.002). This means that a high pre-discharge B-lines value is an independent predictor of rehospitalization and total mortality with a 4-fold greater risk than a non-high pre-discharge B-lines value.

The usefulness of B-lines values as predictors of rehospitalization and all-cause mortality was demonstrated in a study by Rattarasarn et al. Rattarasan et al. recently conducted a B-lines value analysis, the study was the first prospective observational study in Thailand to predict rehospitalization from heart failure events and all-cause mortality within 6 months using B-lines values obtained at point-of-care lung ultrasound in the Thai population in 2020-2021. In this 126-patient study, patients with B-lines values ≥ 12 were significantly reported to have a 1.96 times higher HR (P=0.02) of rehospitalization and all-cause mortality compared with lower B-lines values [5].

Evaluation of B-lines scores has been shown to provide additional prognostic information in evaluating patients post-treatment for heart failure beyond the conventional clinical assessment. The role of B-lines score as a predictor of rehospitalization and all-cause mortality is related to its capacity to assess the presence of extra-vascular lung water (EVLW) bedside. The presence of EVLW directly demonstrates the persistence of signs of volume overload in the lung, which in this case is called hemodynamic assessment of congestion. Pulmonary congestion is one of the most important signs in heart failure. Previous methods such as clinical examination and chest x-ray are relatively insensitive to detect it. Based on a 2015 study by Platz et al, the sensitivity and specificity of lung ultrasound to detect congestion through B-lines were 94% and 92%, respectively, which is higher than that of physical examination in assessing lung congestion at only 60% and 78% for sensitivity and specificity, respectively. Thus, previous studies have shown that B-lines are better at evaluating residual congestion and have an effect on the incidence of rehospitalization and overall mortality [4–6]. Picano et al.'s study of the lung water cascade in heart failure patients suggests that the immediate imaging sign of lung congestion is B-lines which are easily detected by lung ultrasound. The clinical implication is that any therapeutic intervention is said to be more likely to be successful in the early steps of the cascade and in the asymptomatic imaging stage of lung congestion than in the phase near the end of the cascade or in the symptomatic phase [7].

In this study, the EVEREST score showed potential as a composite event predictor between rehospitalization due to cardiovascular disease and total mortality. Patients with a pre-discharge EVEREST score of≥ 2 had a 3.694 higher risk of rehospitalization and total mortality than patients with a pre-discharge EVEREST score <2 (unadjusted HR 3.225; 95% CI 1.096-9.726; p=0.038). To determine whether the pre-discharge EVEREST score≥ 2 was an independent predictor of rehospitalization and total mortality, multivariate analysis using Cox Regression was conducted. Variables included in the multivariate test were control variables that showed a p value <0.25 and variables that were theoretically important. In addition to the pre-discharge EVEREST score, the variables BMI (obese and non-obese), diabetes mellitus and renal disease and, having a p value <0.25 were included in the multivariate analysis. After controlling for confounding variables in the multivariate analysis, a high pre-discharge EVEREST score was shown to be an independent predictor of rehospitalization and total mortality with an adjusted hazard ratio of 3.694 (95% CI 1.211-11.262; p=0.022). This means that a high pre-discharge EVEREST score is an independent predictor of rehospitalization and total mortality with a 3-fold greater risk than a non-high pre-discharge EVEREST score.

EVEREST score as a predictor of rehospitalization and all-cause mortality was initially studied by Ambrosy et al in 2013 by conducting a post hoc analysis on the EVEREST trial (Efficacy of Vasopressin Antagonism in Heart Failure Outcome Study with Tolvaptan) which examined changes in congestion during hospitalization and was associated with an increased risk of death from heart failure. In the study, a pre-discharge EVEREST score ≥ 1 was associated with a 10% absolute increase in the likelihood of rehospitalization within 6 months and a discharge score ≥ 3 was associated with a 10% absolute increase in the likelihood of all-cause death within 6 months [3]. In this study by Ambrosy et al, it has been explained that signs and symptoms of congestion are associated with rehospitalization rates, so it is very important to achieve targets in hospital care, so these signs and symptoms of congestion can be a big determinant in making decisions before patients are discharged.

Another study by Ratarasarn et al. showed that a pre-discharge EVEREST score ≥1 increased the probability of rehospitalization due to worsening heart failure by 2.08 times compared to patients with a pre-discharge EVEREST score of 0 (HR 2.08; 95% confidence interval=1.02-4.05; p=0.12) within 6 months, but indeed in multivariate analysis this EVEREST score was not clinically significant [5]. The primary endpoint of patients with AHF based on the European Society of Cardiology guidelines is clinical, so according to the results of this study using the pre-discharge EVEREST score can be used as a predictor for rehospitalization and total mortality in patients with AHF. In the EVEREST score there are assessments such as tightness, orthopnea, fatigue, JVD, ronki and edema, which are dominated by subjective or clinical examinations.

There are many prognostic scores for clinical congestion assessment, such as the Lucas score, Rohde score, Gheorgiade score and EVEREST score. In brief, when compared between congestion assessment scores, it can be seen that the EVEREST score is a score that can be used pre-discharge with complete indicators, simple and easy to perform. So, from the results of this study the EVEREST score can significantly be a predictor of rehospitalization and total mortality in patients with AHF.

The combination of B-lines value and Pre-discharge EVEREST score as a Predictor of Rehospitalization and Mortality in AHF patients is known by crosstab analysis according to table 5.6. In this study, it was found that the incidence of rehospitalization and total mortality was highest in AHF patients with the presence of two high predictors, namely high B-lines value and high EVEREST score. Patients with non-high B-lines value and non-high EVEREST score, constituted the smallest percentage for the occurrence of rehospitalization and total mortality. This analysis showed that there was an association between the combination of pre-discharge B-lines score and EVEREST score on the incidence of rehospitalization and total mortality (p=0.026).

The findings in this study are based on studies conducted in one center only, making it difficult to generalize the results of this study to all heart failure patients. In addition, the follow-up period of 60 days is short, so research can be developed with a longer follow-up period so that medium and long-term prognosis can also be assessed in heart failure patients based on B-lines and EVEREST scores. Another weakness in this study is that other confounding residuals that can affect the incidence of rehospitalization or death from cardiovascular disease were not examined. Some of these residual confounding includes drug dosage during outpatient care, adherence to low salt and water diet recommendations, and sample involvement in the cardiovascular rehabilitation process during follow-up.

CONCLUSION

(1) High pre-discharge B-lines scores (≥9) were significantly independently associated as predictors of rehospitalization and total mortality within 60 days in patients with AHF who underwent hospitalization.

(2) A high pre-discharge EVEREST score (≥2) was significantly independently associated as a predictor of rehospitalization and total mortality within 60 days in patients with AHF who underwent hospitalization.

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DECLARATIONS

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