

Predictive Value of Pre-Discharge Cardiac and Pulmonary Ultrasound in Older Adults Hospitalized for Acute Heart Failure

Valor pronóstico de la ecografía cardíaca y pulmonar previa al alta en adultos mayores hospitalizados por insuficiencia cardíaca aguda

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ABSTRACT

Background: Acute heart failure (AHF) remains a major clinical challenge due to its high morbidity and mortality. The use of cardiac and lung ultrasound has been increasingly recognized as valuable tools for the assessment of residual congestion.

Objective: The aim of this study was to assess the usefulness of cardiac and pulmonary congestion ultrasound parameters prior to discharge for identifying patients at risk of readmission and/or death within 180 days following the initial hospitalization.

Methods: This was a prospective study including consecutive patients over 65 years of age admitted with primary diagnosis of AHF. Patients with acute coronary syndromes, severe valvular disease requiring surgery, heart transplantation, and severe pulmonary disorders were excluded. Ultrasound characteristics at hospital discharge were assessed for their association with events during the 180-day follow-up period using univariate and multivariate Cox regression analyses. For B-lines, a ROC curve was generated, and the optimal cutoff point for predicting the primary endpoint was determined using the Youden index.

Results: A total of 200 patients were analyzed. Median age was 81 (interquartile range, IQR, 76–86) years, and 53% were men. During follow-up, 37.5% of patients experienced the composite endpoint of death or rehospitalization for AHF. The ultrasound variables significantly associated with the primary endpoint were the E/e' ratio (septal and lateral), the presence of dilated inferior vena cava (IVC), pulmonary artery systolic pressure (PASP), tricuspid annular plane systolic excursion (TAPSE), and the number of B-lines present at hospital discharge ($p < 0.001$). In a multivariate model adjusted for age, sex and ultrasound variables, B-lines at discharge remained significantly associated with the primary outcome. Patients with ≥ 7 B-lines had a significantly higher incidence of rehospitalization and death within the 180-day follow-up period ($p < 0.001$).

Conclusions: A comprehensive ultrasound-based assessment—including parameters such as septal and lateral E/e' ratio, PASP, TAPSE, IVC assessment, and B-lines—provides valuable prognostic information at discharge in patients hospitalized for AHF.

Key words: Heart failure - Ultrasound - Elderly health

RESUMEN

Introducción: La insuficiencia cardíaca aguda (ICA) continúa siendo un desafío clínico mayor debido a su elevada morbimortalidad. El uso de la ecografía cardíaca y pulmonar se ha consolidado como una herramienta valiosa para la evaluación de la congestión residual.

Objetivo: El objetivo de este estudio fue determinar la utilidad de parámetros ecográficos cardíacos y pulmonares de congestión previos al alta para identificar pacientes en riesgo de muerte y/o reinternación por ICA a los 180 días de la hospitalización índice.

Material y métodos: Estudio prospectivo en el que se incluyeron en forma consecutiva pacientes mayores de 65 años internados con diagnóstico principal de ICA. Se excluyeron pacientes con síndrome coronario agudo, valvulopatías graves con indicación quirúrgica, trasplante cardíaco y trastornos pulmonares graves. Se analizaron las características ecográficas al egreso hospitalario y su asociación con eventos durante el seguimiento a 180 días en un análisis de Cox univariado y multivariado. En el caso de las líneas B, se elaboró una curva ROC y se calculó el punto de corte con mejor discriminación para el punto final utilizando el índice de Youden.

Resultados: Se incluyeron 200 pacientes. La mediana de edad fue de 81 años (rango intercuartílico, RIC, 76-86), y el 53% eran hombres. El 37,5% de los pacientes presentó el punto final primario combinado (muerte y/o rehospitalización por ICA durante el seguimiento). Las variables ecográficas que se asociaron significativamente con el punto final fueron la relación E/e' (septal y lateral), la presencia de vena cava inferior (VCI) dilatada, la presión sistólica pulmonar, la excursión sistólica del plano del anillo tricuspídeo (TAPSE) y la cantidad de líneas B al egreso hospitalario ($p < 0,001$). En un modelo multivariado ajustado por sexo, edad y variables ecográficas, las líneas B al egreso mantuvieron su asociación estadísticamente significativa con el punto final primario. Se observó

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que el grupo que presentó ≥ 7 líneas B tuvo mayor incidencia de reinternaciones y muerte durante los 180 días posteriores ($p < 0,001$). **Conclusiones:** Un abordaje ecográfico integral que incluya parámetros como la relación E/e' (septal y lateral), la presión sistólica pulmonar, el TAPSE, la evaluación de la VCI y líneas B aporta información útil previo al egreso de pacientes internados por ICA.

Palabras clave: Insuficiencia cardíaca - Ultrasonografía - Salud de la tercera edad

INTRODUCTION

Acute heart failure (AHF) is associated with high rates of morbidity and mortality and exerts a growing negative impact on public health systems worldwide. (1–3). In this context, AHF is the leading cause of unplanned hospitalizations in patients over 65 years of age, (4) with a threefold increase in hospitalization rates over the past decades due to various factors such as population aging, improved survival following acute myocardial infarction, and delays in the timely diagnosis and treatment of this condition. (5)

Furthermore, patients discharged from a health-care facility following an episode of AHF frequently have high rehospitalization rates, leading to poorer prognosis. (6) Therefore, the early identification of patients at high risk of readmission prior to hospital discharge is essential, especially in the elderly population with multiple comorbidities.

Volume overload and congestion are present in 95% of patients with acute AHF. (7) Despite treatment with diuretics, a significant proportion of these patients are discharged with residual congestion, which has been associated with an increased risk of mortality and readmission for heart failure. (8) However, the assessment of residual congestion in the pre-discharge phase remains a significant clinical challenge, as conventional methods, such as physical examination and chest X-ray, exhibit considerable interobserver variability and low sensitivity. (9)

In this regard, objective assessment of the patient's volume status is essential for optimizing both treatment and follow-up after hospital discharge. Several studies have demonstrated the value of echocardiography and pulmonary ultrasound in revealing anatomical and physiological abnormalities in patients with AHF, and when correctly applied, they can improve patient assessment, management, and outcomes during follow-up. (10–12) However, there is limited information regarding their application in the elderly population of our setting.

Therefore, the objective of this study was to evaluate the prognostic utility of these methods in a cohort of elderly patients with “pure” heart failure—without secondary causes—in order to identify those at higher risk of readmission and/or death following discharge for AHF.

METHODS

Study design and population

A prospective, consecutive cohort study was conducted including patients over 65 years of age hospitalized for AHF between December 2022 and December 2024, in a health-care organization comprising a university hospital and out-

patient centers. Patients with de novo AHF or decompensated chronic heart failure admitted to the Cardiac Intensive Care Unit were included in the study.

Patients with acute coronary syndrome, severe valvular heart disease requiring surgery, a history of heart transplantation, Takotsubo syndrome, acute myocarditis, and congenital heart disease were excluded. These exclusions were established due to differences in the pathophysiology and therapeutic management of the aforementioned conditions. Similarly, pulmonary diseases that could limit obtaining an adequate ultrasound window, such as pulmonary fibrosis, advanced chronic obstructive pulmonary disease (GOLD C/D), acute respiratory distress syndrome, or acute parenchymal infectious processes were excluded.

Follow-up was conducted for six months following hospital discharge. Data sources included the institutional electronic medical records and administrative databases.

Methods and image analysis

Transthoracic echocardiography and lung ultrasound (LUS) studies were performed at hospital admission (within the first 12 hours) and prior to discharge (within the preceding 24 hours).

For echocardiography, measurements were performed following standardized protocols recommended by international guidelines. (13,14) In the case of LUS, the simplified 4-zone protocol described by Platz et al. was used for B-line quantification. (12) All images were acquired, analyzed, and interpreted by trained ultrasound staff.

Endpoint

The endpoint was a composite of mortality or readmission for AHF within 180 days of the index hospitalization. Outcome assessment was performed by an investigator blinded to the results of the transthoracic echocardiogram and LUS.

Mortality: all-cause mortality within 180 days following the index hospitalization.

Hospitalization for AHF: first readmission due to AHF, characterized by a hospital stay of more than 6 hours in the Cardiac Intensive Care Unit or the Emergency Department, caused by a worsening of signs and/or symptoms of heart failure requiring intravenous diuretic therapy.

Statistical analysis

Consecutive sampling was used, including all eligible patients. Sample size calculation was performed to estimate the accuracy of the area under the ROC curve (AUC). Considering an expected AUC of 0.8 and a margin of error (difference between the true and estimated AUC) of 0.08 with a 95% confidence level, the estimated number of patients required was 200.

Continuous variables were described using mean and standard deviation (SD) or median and interquartile range (IQR), depending on the distribution. Categorical variables were expressed as absolute and relative frequencies.

Bivariate associations were evaluated using Student's t-test or the Wilcoxon test for continuous variables, and the chi-square test or Fisher's exact test for categorical vari-

ables, as appropriate. Correlation was assessed using Spearman's correlation coefficient. A ROC curve analysis was performed to evaluate the ability of the B-line count to separate patients who presented with the composite endpoint. The optimal cutoff point to simultaneously maximize sensitivity and specificity was selected using the Youden index. Multivariate Cox proportional hazards models were used to estimate prognostic factors for the outcome. The hazard ratio (HR) and its 95% confidence interval were reported. The assumption of proportional hazards and the goodness of fit were evaluated.

Values of $p < 0.05$ were considered statistically significant, using two-tailed tests. Statistical analysis was performed using STATA software version 13.1 (StataCorp LP, College Station, TX).

Ethical considerations

The study was conducted in accordance with current regulations for research involving human subjects, following the Declaration of Helsinki (15) and the Personal Data Protection Act 25326. (16) The protocol was approved by an institutional ethics committee.

RESULTS

Baseline characteristics

The study included a total of 200 patients. Baseline characteristics are presented in Table 1. Median age was 81 years (IQR 76–86), and 53% were men. The most prevalent comorbidities were hypertension (85%), dyslipidemia (58%), history of heart failure (51%), chronic kidney disease (43%), and atrial fibrillation (44%). Additionally, 28% of patients had diabetes mellitus at the time of inclusion.

Characteristics of hospital stay

Pulmonary and/or systemic congestion was the most frequent clinical presentation, observed in 77% of cases, followed by acute pulmonary edema (21%) and low cardiac output syndrome (2%). On physical examination at admission, the predominant findings were pulmonary crackles (89%) and lower limb edema (72%). Median serum N-terminal pro-B-type natriuretic peptide (NT-proBNP) level at admission was 6515 pg/mL (IQR 3077–14 202).

Among the echocardiographic variables measured at admission, several parameters are noteworthy. Mean left ventricular ejection fraction (LVEF) was $45\% \pm 14\%$ (Simpson method). Regarding diastolic dysfunction parameters, mean septal and lateral E/e' ratios were 19 ± 7 and 16 ± 6 , respectively; monophasic filling was observed in 48% of patients, and mean left atrial volume index was 58 ± 18 mL/m². A dilated inferior vena cava (IVC) (>20 mm) with inspiratory collapse <50% was observed in 67% of patients. In addition, mean TAPSE recorded was 19 ± 3.7 mm and mean pulmonary artery systolic pressure (PASP) was 47 ± 15 mmHg. In the case of significant valvular heart disease (moderate grade or greater), mitral regurgitation was the most common finding (39%), followed by tricuspid regurgitation (32%). At discharge, some echocardiographic variables showed no significant changes (LVEF, TAPSE, and left atrial index volume).

Table 1. Baseline characteristics

Characteristic	n=200
Age – years (median, IQR)	81 [76–86]
Male sex — n (%)	106 (53)
Hypertension — n (%)	170 (85)
Dyslipidemia — n (%)	116 (58)
Diabetes mellitus — n (%)	56 (28)
Coronary heart disease — n (%)	65 (32.5)
Prior functional class (NYHA) — n (%)	
I	102 (51)
II	89 (44.5)
III	6 (3)
IV	3 (1.5)
Chronic kidney disease — n (%)	86 (43)
History of heart failure — n (%)	103 (51.5)
Atrial fibrillation — n (%)	89 (44.5)
Medication — n (%)	
ACEI/ARB	88 (44)
Beta-blockers	138 (69)
MRA	30 (15)
Sacubitril/valsartan	6 (3)
SGLT2i	41 (20.5)
Furosemide	83 (41.5)
NT-proBNP — pg/mL (median, IQR)	6515 [3077–14202]
LVEF — % (mean \pm SD)	44 \pm 14

ARB 2: angiotensin II receptor blockers; ACEI: angiotensin-converting enzyme inhibitors; IQR: interquartile range; LVEF: left ventricular ejection fraction; MRA: mineralocorticoid receptor antagonists; NT-proBNP: N-terminal pro-B-type natriuretic peptide; SGLT2i: sodium-glucose cotransporter 2 inhibitors.

In contrast, septal and lateral E/e' ratios decreased to 14 ± 6 and 11 ± 5 , respectively, PASP decreased to 40 ± 14 mmHg, and the percentage of patients with dilated IVC without significant inspiratory collapse decreased to 8%. However, 29% of cases presented with a dilated IVC and significant inspiratory collapse at discharge.

On LUS, the median number of B-lines at admission was 13 (IQR 11–18), and it decreased to 4 (IQR 2–8) at discharge ($p < 0.001$), with a difference between admission and discharge of 9 (IQR 7–11).

Finally, median length of hospital stay was 5 days (IQR 3–7).

Post-discharge follow-up and variables associated with the incidence of the endpoint at 180 days

Median follow-up was 5.3 (IQR 2.9–5.9) months. The endpoint occurred in 75 patients (37.5%), comprising 25 deaths and 50 rehospitalizations for AHF.

A significant correlation ($p < 0.001$) was observed between the number of B-lines at discharge and established prognostic variables such as NT-pro-BNP at

admission ($r = 0.22$) and at discharge ($r = 0.46$). Significant, albeit weaker, correlations were also found with LVEF ($r = 0.13$) and left atrial volume ($r = 0.19$). No significant associations were identified between the number of B-lines and sex, age, or chronic kidney disease.

In the univariate analysis, the echocardiographic variables obtained at hospital discharge that were associated with the endpoint were the septal (HR 1.04; 95% CI 1.03–1.11) and lateral (HR 1.12; 95% CI 1.07–1.17) E/e' ratio, IVC dilation (HR 6.1; 95% CI 3.6–10.35), PASP (HR 1.03; 95% CI 1.02–1.05), and TAPSE (HR 0.87; 95% CI 0.81–0.95).

In contrast, LVEF (HR 0.99; 95% CI 0.97–1.01) and left atrial index volume (HR 1.00; 95% CI 0.99–1.01) showed no association with the outcome.

The number of B-lines at discharge was significantly associated with the endpoint in the univariate analysis (HR 1.28; 95% CI 1.19–1.37). Association with the endpoint was also found for the absence of significant weight loss (HR 1.18; 95% CI 1.10–1.27), the presence of crackles (HR 2.46; 95% CI 1.55–3.94), and the persistence of lower limb edema (HR 3.65; 95% CI 2.31–5.76) at discharge.

In the multivariate analysis, the number of B-lines was the only variable included that showed a significant association with the endpoint (HR 1.42; 95% CI 1.23–1.64). Table 2 shows the model results, including the ultrasound variables measured at discharge, and the cumulative incidence of readmissions or death at 180 days.

Finally, ROC analysis revealed an AUC of 0.77 (95% CI 0.73–0.81) of B-lines at discharge for endpoint discrimination (Figure 1). The optimal cutoff point was ≥ 7 B-lines, with a sensitivity of 61% and specificity of 86%, a positive predictive value of 73%, and a negative predictive value of 79%. The cumulative incidence of events among the groups with the highest and lowest number of B-lines according to this cutoff point is presented in Figure 2 ($p < 0.001$, Log-rank test).

DISCUSSION

In light of current published data, this is the first study to evaluate the prognostic value of echocardiography combined with a simplified LUS method in an elderly population with “pure” AHF. We suggest naming it this way because we excluded secondary causes of HF—such as acute myocardial infarction or severe valvular heart disease requiring surgery—that could alter therapeutic management and prognosis. This characteristic constitutes the main difference compared with other cohorts in which this restriction was not applied in patient selection. (12, 17–19) It should be noted that our research group had previously conducted a validation study of LUS in a study with a smaller number of patients and the same selection criteria. (20)

One of the main findings of our study was that one-third of patients hospitalized for AHF experienced the composite endpoint of rehospitalization or death within 180 days of the index admission. This high incidence is consistent with reports by other authors, (21) confirming the poor prognosis of AHF and underscores the need to identify patients with residual congestion prior to hospital discharge.

Compared with other AHF registries, such as the ADHERE, (22) and OPTIMIZE-HF (23) studies and various Argentine registries, (24) our cohort had a 10-year older median age. Although age distribution was similar to that of an Italian cohort, our population showed a higher prevalence of female patients, kidney failure, and prior history of heart failure. (25)

As previously mentioned, although there is evidence that patients with residual pulmonary congestion prior to hospital discharge are at higher risk of adverse events related to heart failure, there is no universally accepted definition of residual congestion assessed by echocardiography and pulmonary ultrasound that has prognostic value in older adults.

In our study, echocardiographic variables—septal and lateral E/e' ratios, TAPSE, IVC assessment, and

Table 2. Echocardiographic variables measured at discharge associated with the cumulative incidence of readmissions or death at 180 days

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	p	HR (95% CI)	p
Male sex	0.82 (0.52–1.29)	0.945	1.59 (0.83–3.06)	0.166
Age	1 (0.98–1.02)	0.805	0.99 (0.97–1.01)	0.765
B-lines	1.28 (1.19–1.37)	<0.001	1.42 (1.23–1.64)	<0.001
Septal E/e' ratio	1.07 (1.03–1.11)	<0.001	1 (0.92–1.02)	0.264
Lateral E/e' ratio	1.12 (1.07–1.17)	<0.001	-	-
Dilated inferior vena cava	6.1 (3.6–10.3)	<0.001	2 (0.91–4.53)	0.080
TAPSE	0.88 (0.81–0.95)	0.002	-	-
LVEF	0.99 (0.97–1.01)	0.316	0.99 (0.96–1.01)	0.474
PASP	1.03 (1.02–1.05)	<0.001	1.01 (0.99–1.03)	0.254

LVEF: left ventricular ejection fraction; PASP: pulmonary artery systolic pressure; TAPSE: tricuspid annular plane systolic excursion.

Fig. 1. ROC analysis revealed an area under the curve (AUC) of 0.77 (95% CI 0.73–0.81) for B-lines at discharge to discriminate the endpoint. The optimal cutoff point was ≥ 7 B-lines, with 61% sensitivity and 86% specificity.

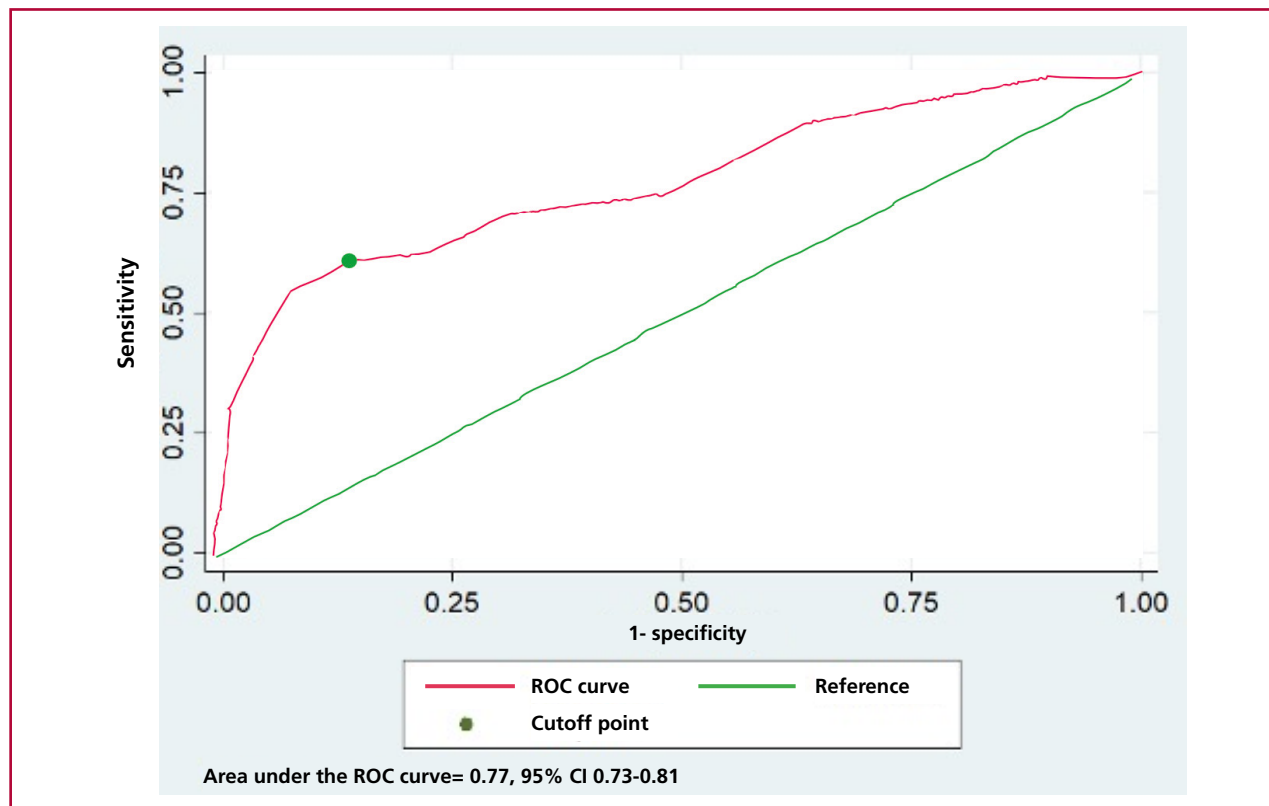
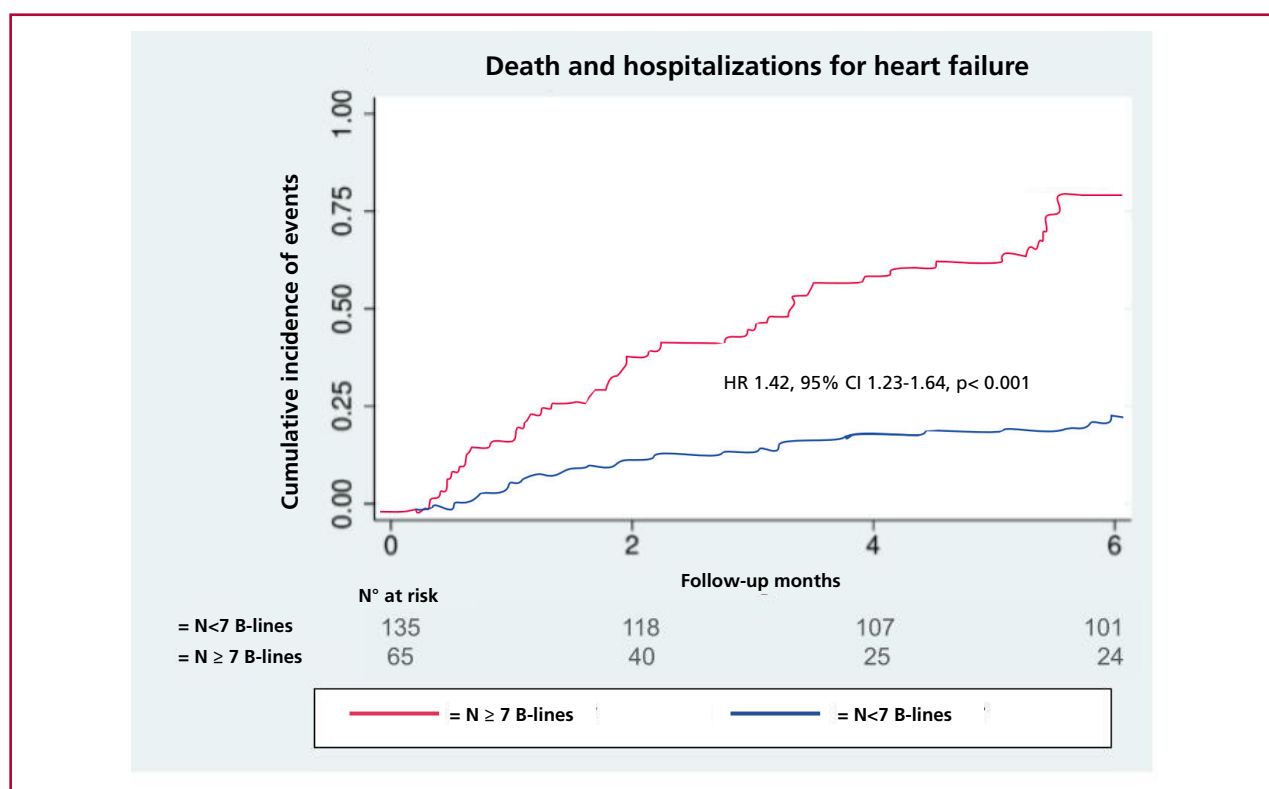


Fig. 2. Cumulative incidence of events among groups with the higher and lower number of B-lines according to the cutoff point of 7 B-lines



PASP—and the presence of B-lines on pulmonary ultrasound at hospital discharge were observed as predictors of the endpoint.

The E/e' ratio is a widely used parameter for assessing diastolic function. Its prognostic value has been extensively evaluated in other conditions such as acute myocardial infarction (26), hypertension (27), or atrial fibrillation. (28) In the field of heart failure, we can highlight studies that obtained conclusive results regarding the prognostic use of this variable, although they were conducted in a population with heart failure with reduced ejection fraction (HFrEF). (29) On the other hand, in patients with preserved ejection fraction (HFpEF), the study by Blanco et al., conducted at our institution in 2020, is worth noting. Following an analysis of diastolic dysfunction parameters in AHF, these authors concluded that an E/e' ratio greater than 14 measured at hospital discharge was significantly associated with the composite endpoint of all-cause mortality and readmissions for AHF (HR 4.63, 95% CI 2.71–18.2; $p < 0.001$). (30) Finally, Santas et al. conducted an analysis in a group of patients with AHF that included both HFrEF and HFpEF and demonstrated an independent association between elevated E/e' values and all-cause mortality. (19) Regarding the similarities between our study and the latter, we note that our population also included both HFrEF and HFpEF. The main difference lies in the patients' age: the mean age in the cited study was 72 years, whereas our median age exceeds it by 10 years, showing a substantially older population.

On the other hand, to compare our results from the IVC analysis, it is relevant to highlight the PRO-FUND-IC Registry. (31) This study evaluated the prognostic impact of LUS and IVC in a cohort of elderly patients with AHF, a population comparable to ours. The authors demonstrated that IVC collapsibility $< 50\%$ or a diameter > 2.25 cm was associated with increased short-term mortality, with greater predictive power than B-line quantification. A relevant methodological difference was the timing of the assessment: in the aforementioned registry, it was performed within the first 72 hours of hospitalization, whereas in our cohort, the measurements analyzed were taken at the time of hospital discharge.

The association between TAPSE, PASP, and the endpoint reflects the leading role of the right ventricle in this patient group. (32) It is known that right ventricular (RV) dysfunction is present in 4–50% of patients with heart failure and is a variable indicating poorer prognosis. (33–35) Several studies have reached similar conclusions when analyzing each of these parameters separately. (17, 36)

Regarding LUS, previous studies have identified several cutoff values for B-lines with prognostic significance, depending on the protocol used and the clinical context (12,31) Imanishi et al. investigated the correlation between the number of B-lines on LUS and pulmonary capillary pressure (PCP) and found that

a count of ≥ 6 B-lines was strongly correlated with elevated PCP values and associated with a higher risk of cardiac death and rehospitalization for AHF. (37) Similarly, we found that the identification of ≥ 7 B-lines at discharge was associated with an increased risk of death or rehospitalization during follow-up. Furthermore, the adoption of a simplified LUS protocol, such as the one used in this study, is beneficial in the hospital setting due to its shorter execution time and lower risk of data omission. This is particularly relevant in count-based quantification methods, in which the total number of B-lines in all evaluated areas is added. Additionally, although AHF can present with different clinical phenotypes, most patients exhibit some degree of pulmonary congestion, (38) which supports the usefulness of pulmonary ultrasound in assessing the state of decongestion. In this regard, all patients in our cohort presented with B-lines at admission. Finally, it is worth noting that we decided to prioritize the assessment at discharge in our analysis, rather than relying on measurements taken at admission and the admission-to-discharge variation. This choice was based on its greater feasibility in routine clinical practice, as it requires a single measurement.

Our findings highlight the prognostic value of echocardiography combined with pre-discharge LUS in patients hospitalized for AHF. Both methods represent a potential therapeutic target for decongestion, showing that different variables analyzed by both methods exhibit dynamic changes during hospitalization, with rapid positive changes in patients who respond to diuretic therapy and other interventions. Serial LUS, for its part, has proven to be an effective modality for guiding the titration of diuretic therapy, facilitating early resolution of congestion, and potentially contributing to a shorter length of hospital stay. (39) Further research is needed to evaluate the impact of both methods as therapeutic guides during hospitalization for AHF in order to achieve optimal decongestion, which could result in a lower incidence of adverse events during follow-up.

This study has several limitations that should be acknowledged. First, it was conducted at a single high-complexity center, which may limit the generalization of the findings to other healthcare settings or to populations with different clinical characteristics and access to care. Second, the multivariate model was developed to assess prognostic factors; therefore, we cannot establish causality. Third, although ultrasound is widely regarded as a highly useful noninvasive tool, it is operator-dependent, even when standardized protocols are used. Fourth, the exclusion of NT-pro-BNP in the multivariate model should be emphasized. This decision was based on two considerations: the limited number of events available to include additional variables in the model and, even more importantly, the priority of developing a clinical model that is feasible to apply in less complex centers at lower costs.

Future studies should validate these findings in

multicenter cohorts and explore interventions based on them to improve clinical outcomes during follow-up.

CONCLUSION

A comprehensive ultrasound approach that includes parameters such as the E/e' ratio (septal and lateral), PASP, TAPSE, IVC assessment and B-lines provides useful information prior to discharge of older adults hospitalized for AHF.

The main findings of our study were: a) one-third of patients hospitalized for AHF presented the composite endpoint of rehospitalization or death within 180 days of the index admission. b) several echocardiographic variables (septal and lateral E/e' ratios, TAPSE, IVC assessment, and PASP) and the presence of B-lines on the pulmonary ultrasound at hospital discharge were associated with the primary endpoint. c) The optimal cutoff point for B-lines at discharge to predict the endpoint was ≥ 7 .

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web).

REFERENCES

- Felker GM, Adams KF Jr, Konstam MA, O'Connor CM, Gheorghide M. The problem of decompensated heart failure: nomenclature, classification, and risk stratification. *Am Heart J* 2003;145(2 Suppl):S18-25. <https://doi.org/10.1067/mhj.2003.150>
- Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Executive Summary: Heart Disease and Stroke Statistics—2016 Update. *Circulation*. 2016;133:447-54. <https://doi.org/10.1161/CIR.0000000000000366>
- Gheorghide M, Pang PS. Acute heart failure syndromes. *J Am Coll Cardiol* 2009;53:557-73. <https://doi.org/10.1016/j.jacc.2008.10.041>
- Arrigo M, Jessup M, Mullens W, Reza N, Shah AM, Sliwa K, et al. Acute heart failure. *Nature Reviews Disease Primers* 2020;6:1-15. <https://doi.org/10.1038/s41572-020-0151-7>
- Ahmed A, Allman RM, Fonarow GC, Love TE, Zannad F, Dell'italia LJ, et al. Incident heart failure hospitalization and subsequent mortality in chronic heart failure: a propensity-matched study. *J Card Fail* 2008;14:211-8. <https://doi.org/10.1016/j.cardfail.2007.12.001>
- Solomon SD, Dobson J, Pocock S, Skali H, McMurray JJV, Granger CB, et al. Influence of nonfatal hospitalization for heart failure on subsequent mortality in patients with chronic heart failure. *Circulation* 2007;116:1482-7. <https://doi.org/10.1161/CIRCULATIONAHA.107.696906>
- Pandhi P, Ter Maaten JM, Emmens JE, Struck J, Bergmann A, Cleland JG, et al. Clinical value of pre-discharge bio-adrenomedullin as a marker of residual congestion and high risk of heart failure hospital readmission. *Eur J Heart Fail* 2020;22:683-91. <https://doi.org/10.1002/ejhf.1693>
- Rubio-Gracia J, Demissei BG, Ter Maaten JM, Cleland JG, O'Connor CM, Metra M, et al. Prevalence, predictors, and clinical outcome of residual congestion in acute decompensated heart failure. *Int J Cardiol* 2018;258:185-91. <https://doi.org/10.1016/j.ijcard.2018.01.067>
- Wang CS, FitzGerald JM, Schulzer M, Mak E, Ayas NT. Does this dyspneic patient in the emergency department have congestive heart failure? *JAMA* 2005;294:1944-56. <https://doi.org/10.1001/jama.294.15.1944>
- Fitzsimons S, Doughty RN. Role of transthoracic echocardiogram in acute heart failure. *Rev Cardiovasc Med* 2021;22:741-54. <https://doi.org/10.31083/j.rcm2203081>
- Ilieșiu AM, Hodorogea AS, Balahura AM, Bădilă E. Non-Invasive Assessment of Congestion by Cardiovascular and Pulmonary Ultrasound and Biomarkers in Heart Failure. *Diagnostics (Basel)* 2022;12. <https://doi.org/10.3390/diagnostics12040962>
- Platz E, Campbell RT, Claggett B, Lewis EF, Groarke JD, Docherty KF, et al. Lung Ultrasound in Acute Heart Failure: Prevalence of Pulmonary Congestion and Short- and Long-Term Outcomes. *JACC Heart Fail* 2019;7:849-58. <https://doi.org/10.1016/j.jchf.2019.07.008>
- Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2016;17:412. <https://doi.org/10.1093/ehjci/jew041>
- Nagueh SF, Sanborn DY, Oh JK, Anderson B, Billick K, Derrumieux G, et al. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography. *J Am Soc Echocardiogr* 2025;38:537-69. <https://doi.org/10.1016/j.echo.2025.03.011>
- World Medical Association. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA* 2013;310:2191-4. <https://doi.org/10.1001/jama.2013.281053>
- <https://servicios.infoleg.gob.ar/infolegInternet/anexos/60000-64999/64790/norma.htm>
- Merlos P, Núñez J, Sanchis J, Miñana G, Palau P, Bodí V, et al. Echocardiographic estimation of pulmonary arterial systolic pressure in acute heart failure. Prognostic implications. *Eur J Intern Med* 2013;24:562-7. <https://doi.org/10.1016/j.ejim.2013.04.009>
- Bok Y, Kim JY, Park JH. Prognostic Role of Right Ventricular-Pulmonary Artery Coupling Assessed by TAPSE/PASP Ratio in Patients With Acute Heart Failure. *J Cardiovasc Imaging* 2023;31:200-6. <https://doi.org/10.4250/jcvi.2023.0055>
- Santas E, García-Blas S, Miñana G, Sanchis J, Bodí V, Escribano D, et al. Prognostic implications of the tissue Doppler imaging-derived e/ea ratio in patients with acute heart failure. *Echocardiography* 2015;32:213-20. <https://doi.org/10.1111/echo.12617>
- Iroulart JM, Garagoli F, Bergier MG, Decotto S, Villar GF, Belziti C, et al. Utility of lung ultrasound to identify patients at risk of rehospitalization for acute decompensated heart failure. *Curr Probl Cardiol* 2025;50:103002. <https://doi.org/10.1016/j.cpcardiol.2025.103002>
- Ambrosy AP, Pang PS, Khan S, Konstam MA, Fonarow GC, Traver B, et al. Clinical course and predictive value of congestion during hospitalization in patients admitted for worsening signs and symptoms of heart failure with reduced ejection fraction: findings from the EVEREST trial. *Eur Heart J* 2013;34:835-43. <https://doi.org/10.1093/eurheartj/ehs444>
- Adams KF Jr, Fonarow GC, Emerman CL, LeJemtel TH, Costanzo MR, Abraham WT, et al. Characteristics and outcomes of patients hospitalized for heart failure in the United States: rationale, design, and preliminary observations from the first 100,000 cases in the Acute Decompensated Heart Failure National Registry (ADHERE). *Am Heart J* 2005;149:209-16. <https://doi.org/10.1016/j.ahj.2004.08.005>
- Abraham WT, Fonarow GC, Albert NM, Stough WG, Gheorghide M, Greenberg BH, et al. Predictors of in-hospital mortality in patients hospitalized for heart failure: insights from the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF). *J Am Coll Cardiol* 2008;52:347-56. <https://doi.org/10.1016/j.jacc.2008.04.028>
- Perna ER, Barbagelata A, Grinfeld L, García Ben M, Címbaro Canella JP, Bayol PA, et al. Overview of acute decompensated heart failure in Argentina: lessons learned from 5 registries during the last decade. *Am Heart J* 2006;151:84-91. <https://doi.org/10.1016/j.ahj.2005.03.010>
- Maggioni AP, Orso F, Calabria S, Rossi E, Cinconze E, Baldasseroni S, et al. The real-world evidence of heart failure: findings from 41,413 patients in the ARNO database. *Eur J Heart Fail* 2016;18:402-10. <https://doi.org/10.1002/ejhf.471>
- Iwahashi N, Gohbara M, Kirigaya J, Abe T, Horii M, Takahashi H, et al. Prognostic Significance of a Combination of QRS Score and E/e' Obtained 2 Weeks After the Onset of ST-Elevation Myocardial Infarction. *Circ J* 2020;84:1965-73. <https://doi.org/10.1253/circj.CJ-20-0486>
- Wang M, Yip GW, Wang AY, Zhang Y, Ho PY, Tse MK, et al. Tissue Doppler imaging provides incremental prognostic value in patients with systemic hypertension and left ventricular hypertrophy. *J Hypertens* 2005;23:183-91. <https://doi.org/10.1097/00004872->

200501000-00029

28. Okura H, Takada Y, Kubo T, Iwata K, Mizoguchi S, Taguchi H, et al. Tissue Doppler-derived index of left ventricular filling pressure, E/E', predicts survival of patients with non-valvular atrial fibrillation. *Heart* 2006;92:1248-52. <https://doi.org/10.1136/hrt.2005.082594>
29. Benfari G, Miller WL, Antoine C, Rossi A, Lin G, Oh JK, et al. Diastolic Determinants of Excess Mortality in Heart Failure With Reduced Ejection Fraction. *JACC Heart Fail* 2019;7:808-17. <https://doi.org/10.1016/j.jchf.2019.04.024>
30. Blanco R, Ambrosio G, Belziti C, Lucas L, Arias A, D'Antonio A, et al. Prognostic value of NT-proBNP, and echocardiographic indices of diastolic function, in hospitalized patients with acute heart failure and preserved left ventricular ejection fraction. *Int J Cardiol*. 2020;317:111-20. <https://doi.org/10.1016/j.ijcard.2020.04.044>
31. Pérez-Herrero S, Lorenzo-Villalba N, Urbano E, Sánchez-Sauce B, Aguilar-Rodríguez F, Bernabeu-Wittel M, et al. Prognostic Significance of Lung and Cava Vein Ultrasound in Elderly Patients Admitted for Acute Heart Failure: PROFUND-IC Registry Analysis. *J Clin Med*. 2022;11. <https://doi.org/10.3390/jcm11154591>
32. Decotto S, Fernandez Villar G, Rossi E, Iroulart JM, Bergier M, Del Castillo S, et al. Prognostic value of right ventricle-pulmonary artery uncoupling in elderly patients hospitalized for heart failure with preserved ejection fraction. *Curr Probl Cardiol*. 2025;50:103126. <https://doi.org/10.1016/j.cpcardiol.2025.103126>
33. Puwanant S, Priester TC, Mookadam F, Bruce CJ, Redfield MM, Chandrasekaran K. Right ventricular function in patients with heart failure with preserved and reduced ejection fraction. *Eur J Echocardiogr*. 2009;10:733-7. <https://doi.org/10.1093/ejehocardi/jep052>
34. Shah AM, Cikes M, Prasad N, Li G, Getchevski S, Claggett B, et al. Echocardiographic Features of Patients With Heart Failure and Preserved Left Ventricular Ejection Fraction. *J Am Coll Cardiol*. 2019;74:2858-73. <https://doi.org/10.1016/j.jacc.2019.09.063>
35. Berglund F, Piña P, Herrera CJ. Right ventricle in heart failure with preserved ejection fraction. *Heart*. 2020;106:1798-804. <https://doi.org/10.1136/heartjnl-2020-317342>
36. Kjaergaard J, Akkan D, Iversen KK, Køber L, Torp-Pedersen C, Hassager C. Right ventricular dysfunction as an independent predictor of short- and long-term mortality in patients with heart failure. *Eur J Heart Fail* 2007;9:610-6. <https://doi.org/10.1016/j.ejheart.2007.03.001>
37. Imanishi J, Maeda T, Ujiro S, Masuda M, Kusakabe Y, Takemoto M, et al. Association between B-lines on lung ultrasound, invasive hemodynamics, and prognosis in patients with acute heart failure. *Eur Heart J Acute Cardiovasc Care* 2023;12:115-23. <https://doi.org/10.1093/ehjacc/zuac158>
38. Adamson PB, Abraham WT, Aaron M, Aranda JM Jr, Bourge RC, Smith A, et al. CHAMPION trial rationale and design: the long-term safety and clinical efficacy of a wireless pulmonary artery pressure monitoring system. *J Card Fail* 2011;17:3-10. <https://doi.org/10.1016/j.cardfail.2010.08.002>
39. Gargani L, Girerd N, Platz E, Pellicori P, Stankovic I, Palazzuoli A, et al. Lung ultrasound in acute and chronic heart failure: a clinical consensus statement of the European Association of Cardiovascular Imaging (EACVI). *Eur Heart J Cardiovasc Imaging* 2023;24:1569-82. <https://doi.org/10.1093/ehjci/jead169>