



Analysis of How Emergency Physicians' Decisions to Hospitalize or Discharge Patients With Acute Heart Failure Match the Clinical Risk Categories of the MEESSI-AHF Scale

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Study objective: The Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure (MEESSI-AHF) is a validated clinical decision tool that characterizes risk of mortality in emergency department (ED) acute heart failure patients. The objective of this study is to compare the distribution of risk categories between hospitalized and discharged ED patients with acute heart failure.

Methods: We included consecutive acute heart failure patients from 34 Spanish EDs. Patients were retrospectively classified according to MEESSI-AHF risk categories. We calculated the odds of hospitalization (versus direct discharge from the ED) across MEESSI-AHF risk categories. Next, we assessed the following 30-day postdischarge outcomes: ED revisit, hospitalization, death, and their combination. We used Cox hazards models to determine the adjusted association between ED disposition decision and the outcomes among patients who were stratified into low- and increased-risk categories.

Results: We included 7,930 patients (80.5 years [SD 10.1 years]; women 54.7%; hospitalized 75.3%). Compared with that for low-risk MEESSI-AHF patients, odds ratios for hospitalization of patients in intermediate-, high-, and very-high-risk categories were 1.83 (95% confidence interval [CI] 1.64 to 2.05), 3.05 (95% CI 2.48 to 3.76), and 3.98 (95% CI 3.13 to 5.05), respectively. However, almost half (47.6%) of all discharged patients were categorized as being at increased risk by MEESSI-AHF, and 19.0% of all the increased-risk patients were discharged from the ED. Among the low-risk MEESSI-AHF patients, the 30-day postdischarge mortality did not differ by ED disposition (hazard ratio [HR] for discharged patients with respect to hospitalized ones 0.65; 95% CI 0.70 to 1.11), nor did it differ in the increased-risk group (HR 0.88; 95% CI 0.63 to 1.23). The discharged low-risk MEESSI-AHF patients had higher risks of 30-day ED revisit and hospitalization (HR 1.86, 95% CI 1.57 to 2.20; and HR 1.92, 95% CI 1.54 to 2.40, respectively) compared with the admitted patients, as did the discharged patients in the increased-risk group (HR 1.62, 95% CI 1.39 to 1.89; and HR 1.40, 95% CI 1.16 to 1.68, respectively), with similar results for the combined endpoint.

Conclusion: The disposition decisions made in current clinical practice for ED acute heart failure patients calibrate with MEESSI-AHF risk categories, but nearly half of the patients currently discharged from the ED fall into increased-risk MEESSI-AHF categories. [Ann Emerg Med. 2019;74:204-215.]

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INTRODUCTION

Background

The emergency department (ED) plays a central role in the management of acute heart failure because approximately 90% of patients with this condition attend an ED to relieve their symptoms.¹ In the ED, acute heart failure

patients are usually treated with diuretic intensification, oxygen supplementation, and, if needed, vasodilators and morphine.² Once these treatments have been administered and their effects evaluated, a decision is needed about whether the patient should be hospitalized or can be discharged with adequate treatment and subsequent follow-up. Some risk scores to help in this decisionmaking have recently been developed,³⁻⁶ although currently none are

*All members are listed in the Appendix.

Editor's Capsule Summary

What is already known on this topic

Risk-prediction tools for emergency department (ED) heart failure are not currently used in clinical practice.

What question this study addressed

How well does current emergency physician practice agree with the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure (MEESSI-AHF) heart failure risk-prediction tool?

What this study adds to our knowledge

In this observational study of 7,930 patients from 34 Spanish EDs, physician admission decisions correlated well with increasing MEESI-predicted risk. However, 19% of increased-risk patients were discharged home. Regardless of predicted risk, discharged patients were at higher risk for repeated ED visits and readmission.

How this is relevant to clinical practice

Current emergency physician heart failure practice includes discharge of some high-risk patients. Future studies are needed to determine whether decision tools can improve heart failure discharge decisions and the outcomes associated with them.

widely used in the ED. Therefore, the decision to discharge patients directly from the ED without hospitalization, which currently takes place for approximately one quarter of acute heart failure patients,² is still empirically driven by the subjective assessment of emergency physicians. Some authors have highlighted that patients with acute heart failure who are discharged from the ED have worse outcomes than those discharged after hospitalization⁷⁻¹²; in this setting, risk stratification could probably improve the outcomes of acute heart failure patients by better (objective) selection of those who need to be hospitalized.

We recently derived the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure (MEESSI-AHF) scale to risk stratify acute heart failure patients in EDs.⁶ This risk score demonstrates that the individual 30-day risk of mortality in acute heart failure patients admitted to the ED can be reliably estimated with 13 readily available items. This tool (available at <http://meessi-ahf.risk.score-calculator-ica-semes.portalsemes.org>) achieved a strong risk discrimination in derivation and validation cohorts (c statistic 0.836/0.828)

with an adequate goodness-of-fit model. A posterior validation in a new Spanish cohort of acute heart failure patients obtained similar results, and the discriminative capacity was very similar (c statistic 0.832) in hospitals that had not participated in the development of the score.¹³ Recently, a validation in a Swiss cohort also confirmed its high discriminative capacity (c statistic 0.80).¹⁴ The MEESSI-AHF scale stratifies patients into 4 clinical categories, corresponding to low-, intermediate-, high-, and very-high-risk groups.

Importance

Before implementation of the MEESSI-AHF scale into clinical practice, it is important to know how emergency physician disposition decisions compare with the MEESSI-AHF risk score. Ideally, most admitted patients should be classified to one of the "increased-risk" categories (ie, intermediate-, high-, or very-high-risk groups), whereas most discharged patients should be classified as low risk. In addition, because the recommendation of MEESSI-AHF is to admit patients with increased risk, it is also important to evaluate whether the hospitalization of these patients is associated with better outcomes than if they were discharged home. In a select sample of low-risk patients who were discharged home from the ED, we found that 30-day mortality and 7-day ED revisit rates fell into the standards recommended by experts^{15,16}; however, to our knowledge no comparison has been made between the outcomes obtained in discharged versus hospitalized low-risk patients, nor has the potential beneficial effect of hospitalization for patients at increased risk of developing adverse outcomes been assessed.

Goals of This Investigation

In this study, we explored how well emergency physician disposition decisions matched the MEESSI-AHF scale categories by investigating the MEESSI-AHF risk category distribution of patients hospitalized and discharged home after their initial management at the ED. In addition, we looked for differences in outcomes among patients classified into the low- versus increased-risk categories, depending on whether they were admitted to the hospital or sent home after ED care.

MATERIALS AND METHODS

Selection of Participants

We included all consecutive patients with a diagnosis of acute heart failure in the EDs of 34 Spanish hospitals (representing 10% of the 339 Spanish public hospitals) from February 1 to March 31, 2014 (Epidemiology of Acute Heart Failure in Emergency Department [EAHFE] registry, phase 4), and from January 1 to February 29, 2016 (EAHFE registry, phase 5). These cohorts of patients had

not been included in the previous derivation of the MEESSEI-AHF scale. Hospital participation in the study was by convenience because all EDs were participating in the EAHFE registry^{2,6,7} at the study. Details of patient inclusion have been reported previously.^{6,7,17} Briefly, patient enrollment is conducted by any attending emergency physician at the participating EDs who received specific study protocol instructions during a weekly ED meeting preceding patient recruitment. Attending physicians are responsible for acute treatment following the prevailing international guidelines, and patient management is wholly performed without any specific intervention in connection with patient inclusion into the EAHFE registry.

All cases are confirmed by the principal investigator of each center to ensure that the patients meet the diagnostic criteria of acute heart failure according to the Framingham clinical criteria.¹⁸ If possible, the diagnosis is also confirmed by measurement of plasma natriuretic peptide, echocardiography, or both during the ED or hospital stay, following the guidelines for acute heart failure.^{1,19} However, patients with clinical diagnostic criteria but without echocardiographic or natriuretic peptide confirmation are accepted in the registry to obtain a cohort as close as possible to what is observed in routine emergency medicine practice. The principal investigator of each center is responsible for deciding the final diagnosis of the cases. All principal investigators are provided with a common dictionary of terms to ensure standard definitions at all centers (Table E1, available online at <http://www.annemergmed.com>). The only exclusion criterion to the EAHFE registry is a primary diagnosis of ST-segment elevation myocardial infarction with the concurrent development of acute heart failure (which occurred in 3% of the acute heart failure cases). The decision about the final patient placement after ED care was made by the attending physicians according to their own experience and local protocols, and risk stratification was not estimated by using any objective scale for any patient included in the present study.

Study Design

In this prospective cohort study, we retrospectively estimated the MEESSEI-AHF risk score of each patient by using the complete model (13 variables), assigning each patient to 1 of the 4 MEESSEI-AHF risk categories: low risk (this includes the bottom 2 quintiles of the original derivation study of the MEESSEI-AHF scale), intermediate risk (includes the third and fourth quintiles), high risk (ninth decile), and very high risk (10th decile). The latter 3 categories were

collectively termed “increased risk.” Next, we divided the sample into 2 groups: patients admitted to the hospital after ED care versus those discharged directly from the ED.

We recorded 45 variables (including the 13 needed to calculate the MEESSEI-AHF score): 2 on epidemiology, 12 on comorbidity, 6 on long-term treatments received at home, 8 on clinical status at ED arrival, 4 on ECG, 7 on laboratory data, and 6 on treatment and management at the ED. The definition of each variable is presented in Table E1, available online at <http://www.annemergmed.com>. The data collection process and protocols were the same as those used in the previous EAHFE registries.^{2,6,7} Because this was an observational study, no intervention was tested; hence, our data reflect the usual patient management provided by the attending physicians. During patient recruitment, the MEESSEI-AHF risk score was not yet available, and all decisions on patient management were carried out without knowledge of the patient risk category.

Outcome Measures

We determined the disposition status for each risk category. For the purposes of the present study, we also defined 4 postdischarge outcomes, with follow-up starting at discharge, either from the ED or from hospitalization. These outcomes were limited to patients discharged alive after the index episode (ie, in-hospital deaths were not considered) and consisted of the following: 30-day all-cause mortality; 30-day ED revisit (with or without subsequent hospitalization) because of persistence or reappearance of acute heart failure signs and symptoms; 30-day hospitalization because of persistence or reappearance of acute heart failure signs and symptoms; and 30-day combined endpoint (made up of the latter 3 outcomes, whichever came first). The outcomes were assessed by telephone call and review of primary care and hospital medical records.

Primary Data Analysis

Continuous data are presented as mean and SD or median and interquartile range, whereas categorical data are presented as frequencies and percentages. A multiple imputation technique using chained equations was used to produce 50 imputed data sets that replaced the missing values in the 13 variables included in the MEESSEI-AHF risk score. Using the imputed data, we calculated the individual MEESSEI-AHF risk score for each patient, adding his or her relevant coefficient for each risk factor to the intercept value. Patients were then assigned to 4 clinical risk categories (low/intermediate/high/very high) with the original thresholds obtained in the MEESSEI-AHF risk score stratification.⁶

They were also further categorized as low and increased risk; the latter was defined as intermediate, high, or very high.

We used logistic regression to evaluate the association between the clinical decision to hospitalize or discharge the patient from the ED (the dependent variable of interest) and the MEESSEI-AHF clinical risk category (4-level variable using low risk as the reference). Survival curves were separately performed for patients at low and increased risk for each postdischarge outcome, using the Kaplan-Meier method, and the log-rank test was used to compare curves of discharged and hospitalized patients. Univariate Cox proportional hazards modeling was used to examine the association between patient disposition and the postdischarge outcomes in patients in the low- and increased-risk groups. To adjust for potential differences in the severity of the acute heart failure episode between the hospitalized and discharged patients included in the same risk category, we included the MEESSEI-AHF score in each risk cohort.

Sensitivity Analyses

We performed 2 sensitivity analyses. The first estimated all the associations, using only patients with enough data to calculate the MEESSEI-AHF score (ie, without multiple imputation). In the second sensitivity analysis, we selected patients with a comparable MEESSEI-AHF score within each of the categories and compared outcomes for

discharged and hospitalized patients, following the same strategy as that used by Lee et al.⁹ Briefly, we compared outcome rates in patients with predicted probabilities of 30-day death estimated by the MEESSEI-AHF scale within the same range, defined empirically by the 75th percentile of risk for discharged patients and the 25th percentile for admitted patients. Thus, we compared the overlapping region of patients with a comparable MEESSEI-AHF risk score included within the higher risk of discharged patients and the lower risk of admitted patients. The 2-tailed significance level was set at $P < .05$ or when the 95% CI of odds ratio or hazard ratio (HR) excluded the value 1. Stata (version 15.1; StataCorp, College Station, TX) was used to perform both of the analyses and produce graphs.

The present study followed the Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and patients gave informed consent to participate and to be contacted for follow-up. The protocol was approved by the Ethical Committee at the Hospital Universitario Central de Asturias (Oviedo, Spain).

RESULTS

A total of 7,946 patients were admitted to the ED because of an acute heart failure index episode, and 30-day mortality data were available for 7,930 (Figure 1). The mean age was 80.5 years (SD 10.1 years), and 54.7% were

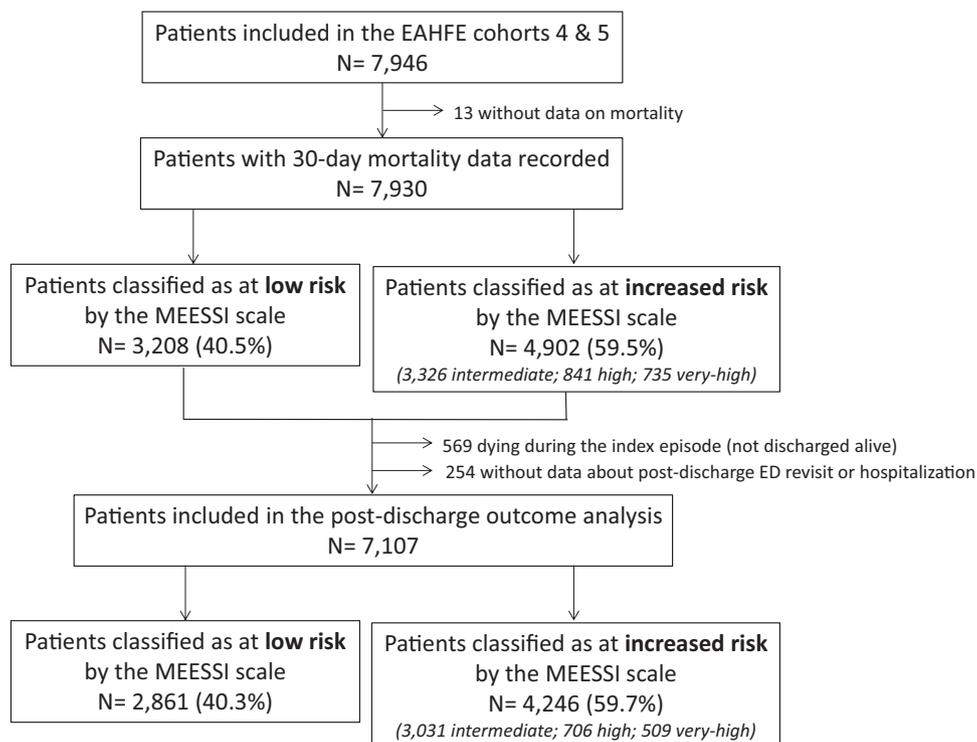


Figure 1. Triage flow chart for patient inclusion.

Table 1. Characteristics of the 7,930 ED acute heart failure patients in the study.

Characteristics	No. (%)	Missing Values (%)
Epidemiologic data		
Age, mean (SD), y*	80.5 (10.1)	5 (0.1)
Female sex	4,316 (54.7)	45 (0.6)
Comorbidities		
Hypertension	6,655 (84.1)	15 (0.2)
Diabetes mellitus	3,340 (42.2)	13 (0.2)
Ischemic heart disease	2,251 (28.4)	14 (0.2)
Chronic kidney disease (creatinine >2 mg/dL)	2,160 (27.3)	14 (0.2)
Cerebrovascular disease	1,020 (12.9)	15 (0.2)
Atrial fibrillation	3,934 (49.6)	13 (0.2)
Heart valve disease	2,084 (26.3)	15 (0.2)
Peripheral artery disease	766 (9.7)	17 (0.2)
Chronic obstructive pulmonary disease	1,859 (23.5)	15 (0.2)
Dementia	1,060 (13.4)	16 (0.2)
Cancer	1,162 (14.7)	19 (0.2)
Previous episodes of acute heart failure	4,479 (56.7)	35 (0.4)
Long-term treatments at home		
Diuretic (any)	4,998 (63.0)	320 (4.0)
β-Blocker	3,486 (45.9)	327 (4.1)
Angiotensin-converting enzyme inhibitor or angiotensin-receptor blocker	4,319 (54.5)	0
Mineralocorticoid-receptor antagonist	1,318 (17.3)	323 (4.1)
Ivabradine	103 (2.2)	3,164 (39.9) [†]
Digoxin	1,033 (13.6)	330 (4.2)
Clinical status at ED arrival		
Systolic blood pressure, mean (SD), mm Hg*	140.7 (27.2)	112 (1.4)
Pulse rate, mean (SD), beats/min	87.5 (23.3)	173 (2.2)
Respiratory rate, mean (SD), breaths/min*	22.3 (6.7)	2,598 (32.8)
Air-room pulse oximetry, mean (SD), %*	92.4 (6.6)	266 (3.4)
NYHA functional class >II, No. (%)*	6,769 (88.5)	284 (3.6)
Functional status assessed by Barthel index, mean (SD), points*	66.1 (29.4)	2,134 (26.9)
Low output signs and symptoms*	1,351 (17.1)	17 (0.2)
Acute coronary syndrome triggering index episode*	129 (1.6)	0
ECG		
Atrial fibrillation	3,945 (52.0)	337 (4.3)
Left ventricular hypertrophy*	269 (3.5)	338 (4.3)
Left bundle branch block	717 (9.5)	339 (4.3)
Pacemaker rhythm	657 (8.7)	338 (4.3)
Laboratory data		
Hemoglobin, mean (SD), g/L	112.0 (21.2)	78 (1.0)
Glucose, mean (SD), mg/dL	149.0 (90.8)	144 (1.8)
Creatinine, mean (SD), mg/dL*	1.4 (0.9)	99 (1.2)
Sodium, mean (SD), mEq/L	138.3 (5.1)	205 (2.6)
Potassium, mean (SD), mEq/L*	4.4 (0.7)	532 (6.7)
NT-proBNP, median (IQR), pg/mL*	3,721 (6,197)	4,320 (54.5)
Elevated troponin*	2,668 (61.9)	3,621 (45.7)

Table 1. Continued.

Characteristics	No. (%)	Missing Values (%)
Treatment and management at ED		
Oxygen	5,476 (69.7)	73 (0.9)
Noninvasive ventilation	529 (6.7)	74 (0.9)
Morphine	489 (6.2)	71 (0.9)
Diuretic (IV)	6,516 (82.9)	74 (0.9)
Nitroglycerin (IV)	922 (11.7)	71 (0.9)
Inotropic or vasopressor treatment	110 (1.4)	77 (1.0)

IQR, Interquartile range.

*Variables included in the MEESSE-AHF risk score.

†Data for long-term treatment with ivabradine were collected by a single pilot center during the EAHFE-4 registry (2011) and for all centers during the EAHFE-5 registry (2014).

women (Table 1). Patients had a high burden of comorbidities, including cardiovascular diseases (hypertension 84.1%, acute heart failure 56.7%, atrial fibrillation 49.6%, and diabetes mellitus 42.2%). During the ED stay, 6.7% of patients required noninvasive ventilation and 1.4% inotropic or vasopressor drugs.

According to the MEESSE-AHF scale, patients were classified into the risk categories of low (3,028 patients; 38.2%), intermediate (3,326 patients; 41.9%), high (841 patients; 10.6%), and very high (735 patients; 9.3%). The 30-day all-cause mortality for the entire cohort was 10.1% (802 patients). The mortality observed in each MEESSE-AHF risk category was 139 patients (4.6%) in the low-risk category, 276 (8.3%) in the intermediate-risk category, 137 (16.3%) in the high-risk category, and 250 (34.0%) in the very-high-risk category. Hospitalization occurred for 5,971 patients (75.3%), whereas the remaining 1,959 patients (24.7%) were discharged home after ED management. The disposition distribution across risk categories is shown in Figure 2. Of the patients categorized as increased risk, 932 (19.0%) were discharged from the ED, and 47.6% of the discharged patients were categorized as increased risk by MEESSE-AHF. Among the latter discharged patients, the majority were categorized as intermediate risk (37.1%), whereas 6.2% and 4.3% were categorized as high and very high risk, respectively. The higher the risk category, the higher the probability of being hospitalized.

Follow-up data after discharge were available for 7,107 patients (Figure 1). In this cohort, the following outcomes were found: 30-day postdischarge mortality, 317 patients (4.5%); 30-day postdischarge ED revisit, 1,408 patients (19.8%); 30-day postdischarge hospitalization, 933 patients (13.1%); and 30-day postdischarge combined endpoint, 1,571 patients (22.1%). There were 4,246 patients categorized as increased risk (3,031 intermediate, 706 high, and 509 very high) and 2,861 as low risk. Figure 3 shows detailed curves for all the postdischarge outcomes for

patients at low and increased risk, along with comparison between discharged and admitted patients. After adjustment, the 30-day postdischarge mortality for increased-risk patients did not differ significantly in the 866 patients discharged from the ED compared with the 3,380 patients discharged after hospitalization (HR 0.88; 95% CI 0.63 to 1.23; $P=.45$), but the former had significantly increased rates of 30-day postdischarge ED revisit (HR 1.62; 95% CI 1.39 to 1.89; $P<.001$), hospitalization (HR 1.40; 95% CI 1.16 to 1.68; $P<.002$), and the combined endpoint (adjusted HR 1.48; 95% CI 1.28 to 1.71; $P<.001$). In addition, the analysis for the low-, intermediate-, high-, and very-high-risk categories showed similar results: no effect on mortality and increased risk for ED revisit, hospitalization, or the combined endpoint (Table 2). Likewise, the low-risk MEESSE-AHF patients discharged from the ED without hospitalization had higher risks of 30-day ED revisit (HR 1.86; 95% CI 1.57 to 2.20; $P<.001$), hospitalization (HR 1.92; 95% CI 1.54 to 2.40; $P<.001$), and combined endpoint (HR 1.69; 95% CI 1.43 to 1.99; $P<.001$), without a statistically significant change in mortality (HR 0.65; 95% CI 0.38 to 1.11; $P=.11$) (Table 2).

In a sensitivity analysis using only patients' complete data for calculating a MEESSE-AHF score, we observed results that were similar to the primary results (Table 2). Finally, very similar associations were also observed in the analysis with a comparable MEESSE-AHF score within each risk category (Figure E1, available online at <http://www.annemergmed.com>), although this second sensitivity analysis could be carried out only in the low- and intermediate-risk categories because of the small number of patients in the high- and very-high-risk categories who were discharged from the ED (Table 2).

LIMITATIONS

This study has several limitations. Because of the observational nature of the data, the study design cannot

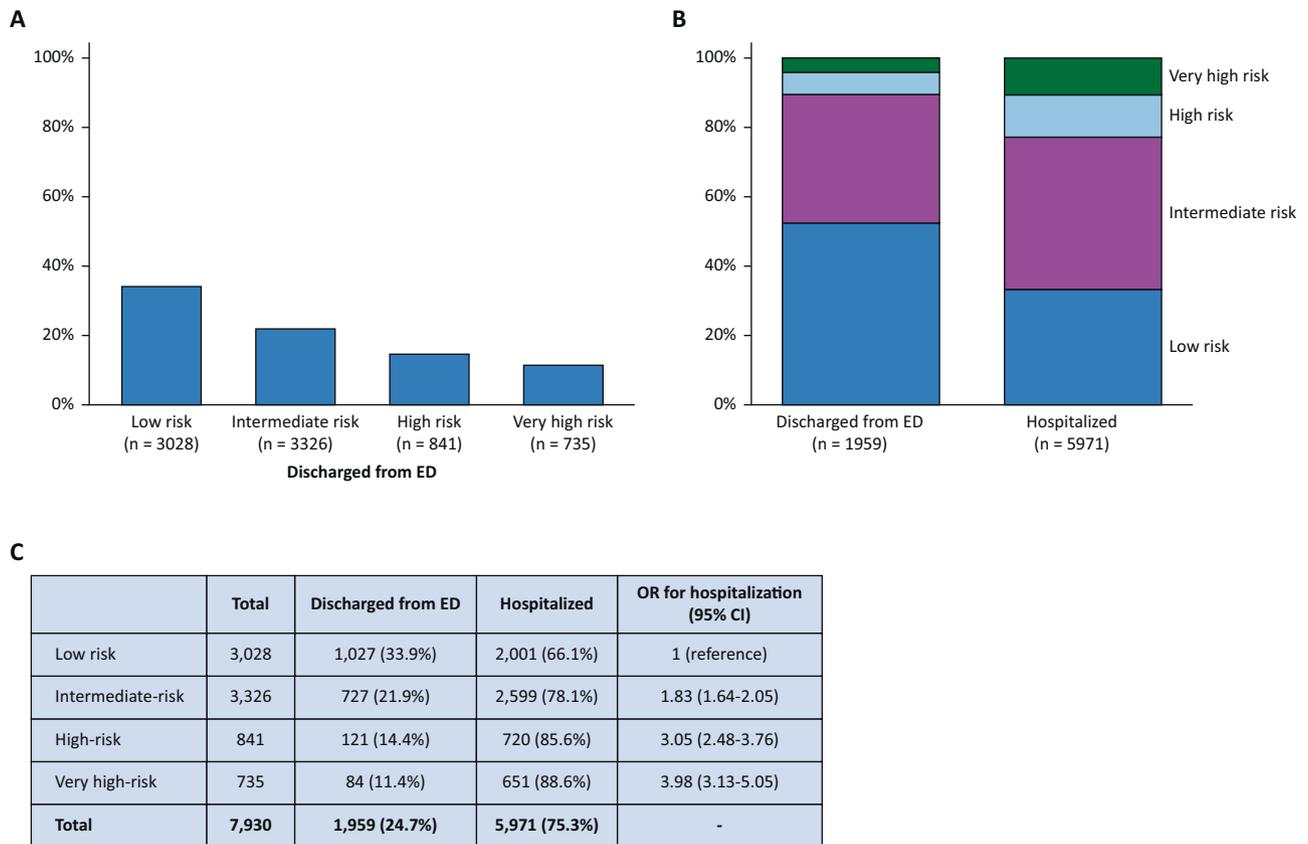


Figure 2. Stacked bar chart for category of risk and admission to the hospital at the index ED visit (A) and by admission to the hospital at the index ED visit and category of risk (B). C, Detailed patient distribution and unadjusted odds ratios for hospitalization according to the MEESSE-AHF risk category.

show causality, but rather only an association. Some residual confounding factors may still remain for some of our estimations, especially in regard to the effect of hospitalization on postdischarge outcomes. Indeed, although the current data seem to indicate that hospitalization prevented adverse postdischarge outcomes in any risk group, this could have been due to residual confounding factors in the hospitalized group, which would have had higher adverse outcome rates if they had not been stabilized by hospitalization. The diagnosis of acute heart failure was based on clinical criteria, and the final diagnosis of acute heart failure was not supported by natriuretic peptide or echocardiographic criteria in all the cases. This was an actual cohort, without intervention, and attending emergency physicians did not receive any specific instructions about patient management and placement. Therefore, the current practice could have differed from one center to another. There was no sample size calculation because of its exploratory nature, and a type II error cannot be ruled out in some of the estimations made, especially in the outcomes with fewer events.

Study patients were from a single country; thus, further studies in other countries are needed to confirm our findings in different settings. We did not record whether the reason leading to the final decision to discharge or hospitalize patients was based on clinical parameters or on patient or family wishes; therefore, we cannot interpret the increased adverse outcomes found in the patients discharged from the ED as physician errors. The MEESSE-AHF scale was derived and validated to predict 30-day mortality but not 30-day ED revisit or hospitalization; therefore, its performance to predict these outcomes is unknown. In fact, we found that this performance was poor (c statistics <0.60) in low-risk patients who were discharged home from the ED.¹⁵ Finally, we had to use multiple imputation methods because a considerable number of variables were missing, particularly for the variables in the MEESSE-AHF score.

DISCUSSION

Our study has 3 main findings. First, hospitalization versus discharge decisions made by emergency physicians correlate with MEESSE-AHF severity: hospitalization rates were higher in higher MEESSE-AHF risk categories. The

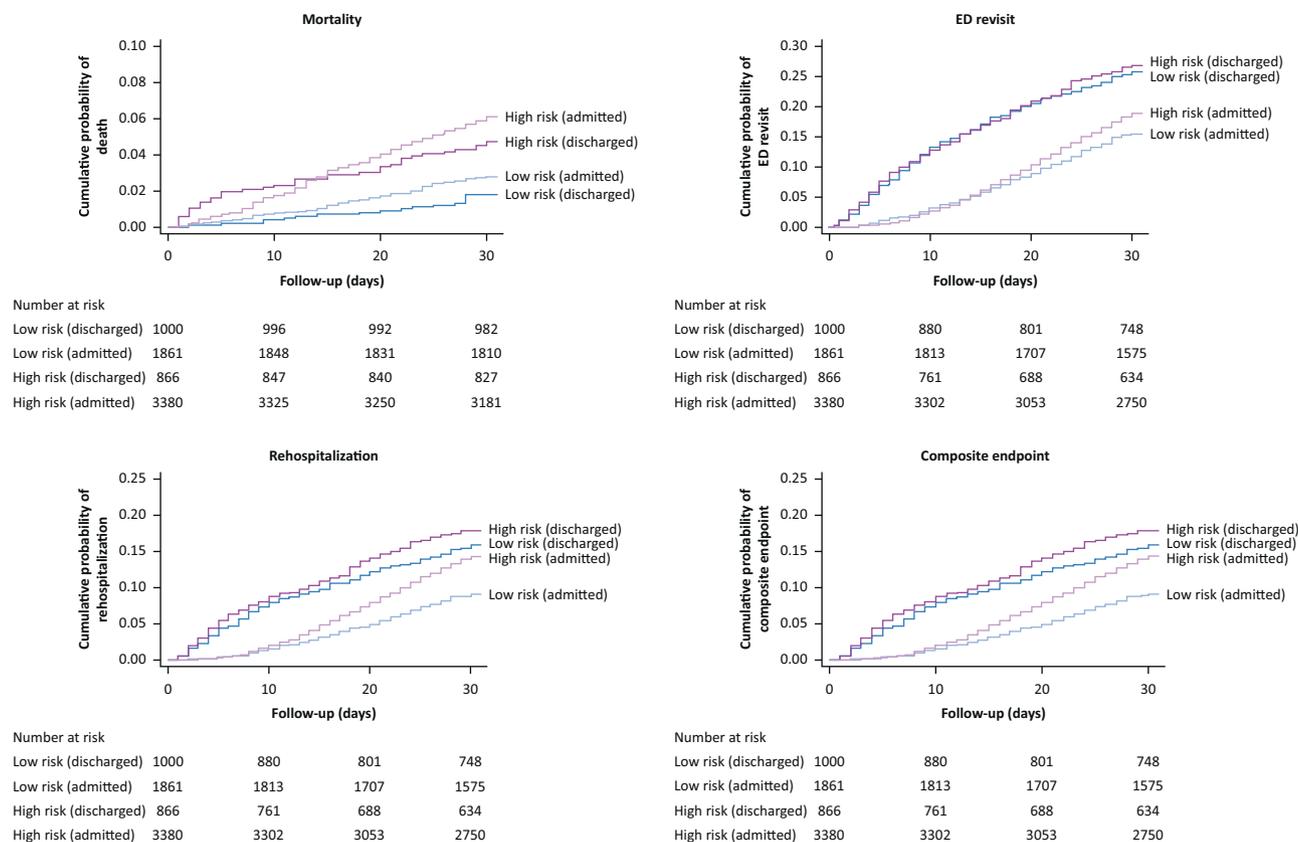


Figure 3. Survival curves by clinical risk categories determined by the MEESI-AHF scale for the four 30-day postdischarge outcomes evaluated in the present study. Blue represents patients at low risk and red at increased risk, whereas solid and dashed lines represent discharged and admitted patients, respectively. Outcomes for discharged and admitted patients are compared within each of these subgroups by log-rank test.

second finding is that among patients who were discharged home directly from the ED, approximately half were in categories of increased MEESI-AHF risk, with almost 11% of the discharged patients at high and very high risk (6.2% and 4.3%, respectively). Finally, we found that acute heart failure patients discharged from the ED were at increased risk of ED revisit or hospitalization after discharge because of persistence or reappearance of acute heart failure signs, irrespective of the MEESI-AHF risk category.

Patient disposition after complete ED management is one of the most important decisions to be made by emergency physicians. To make this decision, many medical and nonmedical circumstances have to be considered,^{20,21} and among these, evaluation of the risk of adverse events is one of the most important. There are well-proven and widely used risk scores for some conditions frequently observed in the ED, such as in pneumonia or acute coronary syndrome (ie, the Fine²² or Global Registry of Acute Coronary Events²³ scores, respectively). However, to date risk scores in patients with acute heart failure in the ED have not been widely used. Most of the scores developed in acute heart failure have been exclusively tested

in hospitalized patients (thereby ignoring the fact that, depending on the country, between 16% and 36% of patients are exclusively managed in the ED), tested by using biomarkers that are not currently available in the majority of EDs, or both.¹⁶ Only 5 scores have been developed in the ED,^{3-6,24} including MEESI-AHF.⁶ The present study shows that emergency physicians make hospitalization decisions that correlate with mortality risk predicted by the MEESI-AHF. Indeed, for patients in the highest-risk category, the odds ratio for hospital admission was nearly 4-fold that of patients in the low-risk category.

Our study also demonstrates that MEESI-AHF can provide data to support emergency physician disposition decisions because a substantial proportion of increased-risk patients were discharged home. However, although no increase in postdischarge mortality was observed, patients discharged from the ED were at increased risk of repeated ED revisits or rehospitalization. This could have been due to the fact that once patients with a decompensation of a chronic disease (such as heart failure) have improved and are discharged (from the ED or after hospitalization), a vulnerable phase lasting for several weeks exists in which such patients are

Table 2. Postdischarge HRs (95% CI) for the outcomes of patients directly discharged from the ED compared with hospitalized patients.*

	Low Risk, N = 2,861	Increased Risk (Intermediate, High, and Very High Risk Grouped), N = 4,246	Intermediate Risk, N = 3,031	High Risk, N = 706	Very High Risk, N = 509
30-day mortality					
Events in discharged patients, No. (%)	18 (1.8)	41 (4.7)	28 (4.1)	6 (5.4)	7 (10.9)
Events in discharged patients, No. (%)	52 (2.8)	206 (6.1)	101 (4.3)	48 (8.1)	57 (12.8)
Unadjusted HR (95% CI) discharged vs hospitalized	0.64 (0.37–1.90)	0.78 (0.55–1.08)	0.94 (0.62–1.43)	0.66 (0.28–1.55)	0.85 (0.39–1.87)
Adjusted HR (by MEESSE score) (95% CI) with multiple imputation	0.65 (0.38–1.11)	0.88 (0.63–1.23)	0.99 (0.65–1.50)	0.66 (0.28–1.54)	0.82 (0.37–1.81)
Adjusted HR (by MEESSE score) (95% CI) [†] without multiple imputation	1.40 (0.70–2.81)	0.88 (0.54–1.44)	1.15 (0.66–2.00)	0.25 (0.03–1.82)	0.78 (0.19–3.27)
HR in patients with comparable MEESSE score (95% CI) [‡]	0.67 (0.25–1.82)	0.88 (0.50–1.57)	0.88 (0.50–1.57)	— [§]	—
30-day ED revisit (irrespective of hospitalization)					
Unadjusted HR (95% CI) discharged vs hospitalized	257 (25.7)	231 (26.7)	181 (26.2)	30 (27.0)	20 (31.3)
Events in discharged patients, No. (%)	287 (15.4)	633 (18.7)	416 (17.8)	121 (20.3)	96 (21.6)
Unadjusted HR (95% CI) discharged vs hospitalized	1.85 (1.56–2.18)	1.59 (1.37–1.85)	1.64 (1.38–1.96)	1.47 (0.98–2.19)	1.65 (1.02–2.68)
Adjusted HR (by MEESSE score) (95% CI) with multiple imputation	1.86 (1.57–2.20)	1.62 (1.39–1.89)	1.65 (1.39–1.97)	1.46 (0.98–2.18)	1.67 (1.02–2.70)
Adjusted HR (by MEESSE score) (95% CI) [†] without multiple imputation	1.75 (1.40–2.19)	1.99 (1.61–2.45)	2.01 (1.59–2.56)	1.64 (0.92–2.91)	2.74 (1.36–5.53)
HR in patients with comparable MEESSE score (95% CI) [‡]	2.13 (1.53–2.97)	1.51 (1.19–1.91)	1.51 (1.19–1.91)	—	—
30-day hospitalization					
Unadjusted HR (95% CI) discharged vs hospitalized	150 (15.0)	147 (18.0)	113 (16.4)	17 (15.3)	17 (26.6)
Events in discharged patients, No. (%)	163 (8.8)	473 (14.0)	304 (13.0)	92 (15.5)	77 (17.3)
Unadjusted HR (95% CI) discharged vs hospitalized	1.90 (1.52–2.37)	1.35 (1.12–1.63)	1.40 (1.13–1.74)	1.09 (0.65–1.84)	1.75 (1.04–2.95)
Adjusted HR (by MEESSE score) (95% CI) with multiple imputation	1.92 (1.54–2.40)	1.40 (1.16–1.68)	1.41 (1.13–1.75)	1.09 (0.65–1.83)	1.75 (1.03–2.97)
Adjusted HR (by MEESSE score) (95% CI) [†] without multiple imputation	1.90 (1.40–2.58)	1.89 (1.46–2.44)	1.89 (1.40–2.55)	1.42 (0.70–2.89)	3.27 (1.54–6.94)
HR in patients with comparable MEESSE score (95% CI) [‡]	2.12 (1.40–3.22)	1.35 (1.01–1.81)	1.35 (1.01–1.81)	—	—
30-day endpoint (ED revisit, hospitalization, death)					
Events in discharged patients, No. (%)	260 (26.0)	246 (28.4)	190 (27.5)	32 (28.8)	24 (37.5)
Events in discharged patients, No. (%)	317 (17.0)	748 (22.1)	467 (20.0)	145 (24.4)	136 (30.6)
Unadjusted HR (95% CI) discharged vs hospitalized	1.68 (1.42–1.98)	1.41 (1.22–1.63)	1.53 (1.29–1.81)	1.29 (0.88–1.90)	1.36 (0.88–2.09)
Adjusted HR (by MEESSE score) (95% CI) with multiple imputation	1.69 (1.43–1.99)	1.48 (1.28–1.71)	1.54 (1.30–1.83)	1.29 (0.88–1.89)	1.34 (0.87–2.07)
Adjusted HR (by MEESSE score) (95% CI) [†] without multiple imputation	1.70 (1.37–2.12)	1.79 (1.47–2.19)	1.83 (1.45–2.29)	1.43 (0.82–2.47)	2.35 (1.22–4.55)
HR in patients with comparable MEESSE score (95% CI) [‡]	1.90 (1.38–2.61)	1.39 (1.10–1.75)	1.39 (1.10–1.75)	—	—

*The reference group is hospitalized patients; hence, the risk is for patients discharged directly from the ED.

[†]Calculations using only the 3,956 patients (1,694 low risk, 1,602 intermediate risk, 392 high risk, and 268 very high risk) with actual data for calculation of MEESSE scores (patients requiring multiple imputation for MEESSE calculation were excluded).

[‡]Calculations using a limited sample of 791 patients at low risk and 1,574 at intermediate risk for whom MEESSE scores were in the overlap zone (Figure E1, available online at <http://www.annemergmed.com>).

[§]Indicates data not available.

at increased risk of the reappearance of signs and symptoms. This period could be permanently extended in patients with a severe chronic condition and advanced age. Several authors have proposed that, during this vulnerable period, hospital care instead of home-based care achieves better outcomes, and this would be especially true for frail patients for whom the early postdischarge phase constitutes a highly vulnerable period.²⁵⁻²⁸ We have observed that such improvement in outcomes accounted for a need for ED revisit or hospitalization, but not for mortality, the most important outcome. Additionally, because resources for in-hospital care will become increasingly limited, we believe that transitional hospital-to-home programs may soon have a broader role, especially among select higher-risk patients.^{5,29-31}

The higher rate of postdischarge ED revisits and hospitalizations for patients who were directly discharged home from the ED may contribute to the increased adverse outcomes previously reported in acute heart failure patients discharged directly from EDs.⁷⁻⁹ Hospitalization also prevented these same adverse outcomes in patients classified as being at low risk. However, 30-day mortality of low-risk patients was not reduced when they were managed with hospitalization. There are several potential explanations: it could be that hospitalization does not benefit low-risk MEESSI-AHF patients, it could be a result of hospitalization's acting as a confounding factor that cannot be completely eliminated by statistical adjustment (ie, the hospitalized patients were sicker but treatment they received in the hospital improved their outcomes to make them similar to the discharged patients), or it could be due to a lack of statistical power because only 18 and 52 deaths occurred in the discharged and hospitalized groups, respectively.

Disposition decisions may not be exclusively guided by the patient risk of adverse events. The MEESSI-AHF risk score was conceived for use together with clinical judgment and not as the only source of information to decide which patient is a candidate for hospitalization. Some acute heart failure patients with an increased risk of death may prefer to live their last days at home. Given our study findings, if the only real risk of going home were the higher probability of ED revisit or future hospitalization, then patient wishes should prevail in the decisionmaking process. This is especially relevant because if every patient identified as being at increased risk by the MEESSI-AHF scale were hospitalized, health care costs would increase enormously. Moreover, because 30-day revisits are monitored by the Centers for Medicare & Medicaid Services, our finding that patient hospitalization is associated with an improvement of this quality marker should be taken into account in the US context.

Current subjective disposition decisions made by emergency physicians for acute heart failure patients

correlate with the objective risk categories defined by the MEESSI-AHF scale; however, almost half of patients discharged from the ED were at increased risk. Patients in all risk categories had an increased risk of a postdischarge return event if they were discharged directly home from the ED, whereas mortality did not differ by disposition in any risk group. A cluster randomized trial is needed to confirm the potential benefit of risk stratification of acute heart failure patients in the ED.³²

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REFERENCES

- Weintraub NL, Collins SP, Pang PS, et al. American Heart Association Council on Clinical Cardiology and Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Acute heart failure syndromes: emergency department presentation, treatment, and disposition: current approaches and future aims: a scientific statement from the American Heart Association. *Circulation*. 2010;122:1975-1996.
- Llorens P, Escoda R, Miró O, et al. Characteristics and clinical course of patients with acute heart failure and the therapeutic measures applied in Spanish emergency departments: based on the EAHFE registry (Epidemiology of Acute Heart Failure in Emergency Departments). *Emergencias*. 2015;27:11-22.
- Stiell IG, Clement CM, Brison RJ, et al. A risk scoring system to identify emergency department patients with heart failure at high risk for serious adverse events. *Acad Emerg Med*. 2013;20:17-26.
- Lee DS, Stitt A, Austin PC, et al. Prediction of heart failure mortality in emergent care: a cohort study. *Ann Intern Med*. 2012;156:767-775.
- Collins SP, Jenkins CA, Harrell FE Jr, et al. Identification of emergency department patients with acute heart failure at low risk for 30-day adverse events: the STRATIFY decision tool. *JACC Heart Fail*. 2015;3:737-747.
- Miró O, Rosselló X, Gil V, et al. Predicting 30-day mortality for patients with acute heart failure who are in the emergency department: a cohort study. *Ann Intern Med*. 2017;167:698-705.
- Ò Miró, Gil V, Xipell C, et al. IMPROV-ED study: outcomes after discharge for an episode of acute-decompensated heart failure and comparison between patients discharged from the emergency department and hospital wards. *Clin Res Cardiol*. 2017;106:369-378.
- Brar S, McAlister FA, Youngson E, et al. Do outcomes for patients with heart failure vary by emergency department volume? *Circ Heart Fail*. 2013;6:1147-1154.
- Lee DS, Schull MJ, Alter DA, et al. Early deaths in patients with heart failure discharged from the emergency department: a population-based analysis. *Circ Heart Fail*. 2010;3:228-235.
- Calder L, Tierney S, Jiang Y, et al. Patient safety analysis of the ED care of patients with heart failure and COPD exacerbations: a multicenter prospective cohort study. *Am J Emerg Med*. 2014;32:29-35.
- Rame JE, Sheffield MA, Dries DL, et al. Outcomes after emergency department discharge with a primary diagnosis of heart failure. *Am Heart J*. 2001;142:714-719.
- Lee DS, Stukel TA, Austin PC, et al. Improved outcomes with early collaborative care of ambulatory heart failure patients discharged from the emergency department. *Circulation*. 2010;122:1806-1814.
- Miró Ò, Rosselló X, Gil V, et al. The usefulness of the MEESSI score for risk stratification of patients with acute heart failure at the emergency department. *Rev Esp Cardiol*. 2019;72(3):198-207; <https://doi.org/10.1016/j.rec.2018.05.002>.
- Wussler D, Kozhuharov N, Sabti Z, et al. External validation of the MEESSI acute heart failure risk score: a cohort study. *Ann Intern Med*. 2019; <https://doi.org/10.7326/M18-1967>.
- Miró O, Gil V, Rosselló X, et al. Patients with acute heart failure discharged from the emergency department and classified as low risk by the MEESSI score (Multiple Risk Estimate Based on the Spanish Emergency Department scale): prevalence of adverse events and predictability. *Emergencias*. 2019;31:5-14.
- Miró Ò, Levy PD, Möckel M, et al. Disposition of emergency department patients diagnosed with acute heart failure: an international emergency medicine perspective. *Eur J Emerg Med*. 2017;24:2-12.
- Miró O, Llorens P, Escalada X, et al. Analysis of the different factors of prehospital care for patients with acute heart failure in Spain. *Emergencias*. 2017;29:223-230.
- Ho KKL, Anderson KM, Kannel WB, et al. Survival after the onset of congestive heart failure in Framingham Heart Study subjects. *Circulation*. 1993;88:107-115.
- Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure: the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur Heart J*. 2016;37:2129-2200.
- Llorens P. Risk assessment in emergency department patients with acute heart failure: we need to reach beyond our clinical judgment. *Emergencias*. 2018;30:75-76.
- Formiga F, Chivite D. Acute heart failure: understanding the patient is essential. *Emergencias*. 2018;30:145-146.
- Fine MJ, Auble TE, Yealy DM, et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med*. 1997;336:243-250.
- Fox KA, Dabbous OH, Goldberg RJ, et al. Prediction of risk of death and myocardial infarction in the six months after presentation with acute coronary syndrome: prospective multinational observational study (GRACE). *BMJ*. 2006;333:1091.
- García-Gutiérrez S, Quintana López JM, Antón-Ladislao A, et al. External validity of a prognostic score for acute heart failure based on the Epidemiology of Acute Heart Failure in Emergency Departments registry: the EAHFE-3D scale. *Emergencias*. 2018;30:84-90.
- Rocha BM, Menezes Falcão L. Acute decompensated heart failure (ADHF): a comprehensive contemporary review on preventing early readmissions and postdischarge death. *Int J Cardiol*. 2016;223:1035-1044.
- Harjola P, Harjola VP. Can we do more for patients with acute heart failure before arrival at the hospital? *Emergencias*. 2017;29:221-222.
- Arrigo M, Nijst P, Rudiger A. Optimising heart failure therapies in the acute setting. *Card Fail Rev*. 2018;4:38-42.
- Greene SJ, Fonarow GC, Vaduganathan M, et al. The vulnerable phase after hospitalization for heart failure. *Nat Rev Cardiol*. 2015;12:220-229.
- Martín-Sánchez FJ, Rodríguez-Adrada E, Vidan MT, et al. Impact of frailty and disability on 30-day mortality in older patients with acute heart failure. *Am J Cardiol*. 2017;120:1151-1157.
- Martín-Sánchez FJ, Rodríguez-Adrada E, Vidan MT, et al. Impact of geriatric assessment variables on 30-day mortality among older patients with acute heart failure. *Emergencias*. 2018;30:149-155.
- Martín-Sánchez FJ, Rodríguez-Adrada E, Mueller C, et al. The effect of frailty on 30-day mortality risk in older patients with acute heart failure attended in the emergency department. *Acad Emerg Med*. 2017;24:298-307.
- Lee DS, Armstrong R, Mohamed S. Investigators of the COACH Trial. Patient engagement in a trial testing a new strategy of care for acute heart failure. *CMAJ*. 2018;190(Suppl):S34-S36.

APPENDIX

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