Acute Heart Failure Registry: Risk Assessment Model in Decompensated Heart Failure

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Abstract

Background: Heart failure (HF) is a highly prevalent syndrome. Although the long-term prognostic factors have been identified in chronic HF, this information is scarcer with respect to patients with acute HF. Despite available data in the literature on long-term prognostic factors in chronic HF, data on acute HF patients are more scarce.

Objectives: To develop a predictor of unfavorable prognostic events in patients hospitalized for acute HF syndromes, and to characterize a group at higher risk regarding their clinical characteristics, treatment and outcomes.

Methods: cohort study of 600 patients admitted for acute HF, defined according to the European Society of Cardiology criteria. Primary endpoint for score derivation was defined as all-cause mortality and/or rehospitalization for HF at 12 months. For score validation, the following endpoints were used: all-cause mortality and/or readmission for HF at 6, 12 and 24 months. The exclusion criteria were: high output HF; patients with acute myocardial infarction, acute myocarditis, infectious endocarditis, pulmonary infection, pulmonary artery hypertension and severe mitral stenosis.

Results: 505 patients were included, and prognostic predicting factors at 12 months were identified. One or two points were assigned according to the odds ratio (OR) obtained (p < 0.05). After the total score value was determined, a 4-point cut-off was determined for each ROC curve at 12 months. Two groups were formed according to the number of points, group A < 4 points, and group B = 4 points. Group B was composed of older patients, with higher number of comorbidities and predictors of the combined endpoint at 6, 12 and 24 months, as linearly represented in the survival curves (Log rank).

Conclusions: This risk score enabled the identification of a group with worse prognosis at 12 months. (Arq Bras Cardiol. 2016;107(6):557-567)

Keywords: Heart Failure/complications; Prognosis; Acute Coronary Syndrome; Biomarkers; Echocardiography,Doppler.

Introduction

Heart failure (HF) is a syndrome with high prevalence (1-3% of the population, 5-10% among individuals aged 65-79 years, and 10-20% in older than 80 years), which has been increasing in the last decade due to population ageing and higher survival of subjects suffering from certain diseases, such as ischemic heart disease and arterial hypertension.1

HF is characterized by a defective cardiac feeling and/or impairment of blood ejection according to metabolic needs, resulting in a classic constellation of signs and symptoms of pulmonary or systemic congestion.2,3

HF is the first cause of early rehospitalizations (in the first 30 days) in elderly individuals. A high rate of readmission for acute HF is observed in the first month after hospital discharge.4 Despite the significant increase in hospitalizations due to acute decompensated HF, models of risk stratification in patients hospitalized for acute HF have not been well established.5 For this reason, clinical, analytical (including biomarkers) and echocardiographic tools for risk stratification may be useful in the medical decision making.6 Among the biomarkers, natriuretic peptides, which are correlated with left ventricular telediastolic pressure (LVTP), usually increased in the HF, are strong prognostic predictors of rehospitalizations and/or death.7

LVTP can also be predicted by echocardiography. The assessment of the relationship between mitral ring velocity and transmitral flow velocity curves by tissue Doppler echocardiography provides better estimates of LVTP as compared with other echocardiographic methods.8

There are other classical biomarkers with prognostic value in HF. Natremia is inversely correlated with plasma renin activity and is a strong predictor of cardiovascular mortality.9 Serum urea and creatinine levels are also predictors of a worse prognostic in HF.10 Kidney injury in HF generally represents a combination of previous kidney
injury, aggravation of renal perfusion, venous congestion and effect of therapy, namely angiotensin-converting-
enzyme inhibitor (ACE inhibitor)/ angiotensin II receptor
blockers (ARBs), diuretics and mineralocorticoid receptor
antagonists (MRAs).  

The benefits of the therapy with ACE inhibitors are
noticed since the beginning of the therapy that continue
in long-term, with greater reduction in the risk of death
or rehospitalization for HF in patients with reduced left
ventricular ejection fraction (LVEF).  

Therefore, despite available data in the literature on
long-term prognostic factors in chronic HF, data on (acute
or chronic) decompensated HF patients are more scarce.  

The aim of this analysis was to develop an AHFR (acute
heart failure registry) score, predictor of unfavorable prognostic
events in hospitalized patients with acute HF syndromes.

Methods

Study design
We designed an observational, retrospective cohort study.

Study population
The total population consisted of 600 patients hospitalized
for acute HF in a cardiology service of a non-tertiary hospital
from 2009 to 2011. All patients signed the informed consent
form, according to the protocol.

Inclusion criterion was diagnosis of acute HF, defined
according to the European Society of Cardiology criteria.  

Exclusion criteria were high-output HF, high suspicion for acute
coronary syndrome as the etiology of HF at hospital admission
(including patients requiring urgent reperfusion therapy), acute
myocarditis, infectious endocarditis, pulmonary infection,
 pulmonic arterial hypertension, and severe mitral stenosis.
Patients admitted and discharged in the emergency service
were also excluded.

Variables and definitions
Variables of anthropometry, clinical presentations, comorbidities, precipitating factors, echocardiographic
measurements, intra-hospital treatment and medications
prescribed at discharge were included.

Data collection and electrocardiography were conducted at
patient’s admission in the emergency service.

Anemia and chronic kidney disease (CKD) were defined
according to the National Kidney Foundation as hemoglobin
≤ 12 g/dL for men and postmenopausal women, and estimated
glomerular filtration rate (eGFR) calculated by the Modification
of Diet in Renal Disease (MDRD) equation lower than 60 mL/
min/1.73 m² prior to hospital admission.

Hypertensive crisis was defined as a relatively abrupt and
symptomatic rise in systolic arterial pressure ≥ 180 mmHg and/
or diastolic arterial pressure ≥ 110 mmHg.

Non-hypertensive acute pulmonary edema (APE) was defined
as a gradual or sudden onset of dyspnea, tachypnea, hypoxemia
and/or radiologic changes compatible to pulmonary edema, and
not precipitated by severe hypertension.

Arrhythmia was defined as sustained ventricular tachycardia,
atrila fibrillation (AF) or flutter with rapid response or any
other supraventricular tachycardia. HF with preserved LVEF
measured approximately 72 hours after hospital admission for
decompensated HF, was defined as the presence of HF signs
and symptoms and LVEF higher than 50% and/or atrial dilation,
mitral inflow E/A ratio < 1 or > 2, E/e’ ratio > 15.  

HF caused by valve heart disease included moderate or severe valve disease.
Multifactorial HF referred to multiple anomalies; it is not possible
to identify the main one.

Endpoints
Clinical follow-up of patients were performed up to 24
months (median time [interquartile range]. The primary
endpoint for score derivation was defined as all-cause mortality
and/or rehospitalization for HF at 12 months. For score
validation, the following endpoints were used: (i) all-cause mortality and/or (ii) rehospitalization for HF at 6, 12 and 24
months of clinical follow-up.

Echocardiographic study
Transthoracic echocardiography was conducted during
hospitalization (mean of 3.2 ± 2.8 days of hospital admission)
with a GE Vivid 7® echo machine. LVEF was determined by the
biplane Simpson’s method. The echocardiographic parameters
‘estimated pulmonary artery systolic pressure’ (PASP) and ‘E/e’
ratio’ were also evaluated in the study.

Statistical analysis
Continuous variables were reported as mean and standard
deviation, and percentage of patients in the intervals obtained
with the cutoff points. Categorical variables were described as
absolute and relative frequencies (%).

The Student’s t-test was used for continuous variables (that had
previously passed the Kolmogorov-Smirnov normality test) and
the chi-square test for comparisons between categorical variables.

Logistic regression analysis and Cox regression were
performed when appropriate (95% confidence interval). A
significance level of p<0.05 was adopted.

Of the 600 patients included, 95 were lost to clinical
follow-up. In the population of 505 patients, six independent,
predicting variables of the event (death/rehospitalization for HF)
were identified using the endpoint in 242 patients. Then, 337
patients were classified according to the risk score as Group A
(lower risk) or Group B (higher risk) (Figure 1).

It is important to assess this prognostic score regarding its
discrimination and calibration. Discrimination was estimated by
the area under the curve (AUC), and calibration was estimated by
the Hosmer-Lemeshow test.

All analyses were performed by the Statistical Package for
The Social Sciences (SPSS) software, version 18.0.

Results

Characterization of the study population
Clinical characteristics of the patients from whom the
score was obtained are shown in table 1. Clinical, analytical
and echocardiographic markers that were independent predictors of the primary endpoint (death for any cause or rehospitalization at 12 months of clinical follow-up) were determined by Cox regression analysis. These markers corresponded to the variables included in the score (Table 2).

**AHFR score: derivation**

One or two points (p.) were given according to the odds ratio (OR) obtained (p<0.05); 1 point for OR<1.5 and 2 points for OR>1.5. The maximum total score was 9 points (Table 2). After calculation of total score, a 4-point cut-off was determined for each ROC curve at 12 months (Figure 2). Two groups were formed based on the number of points, group A (n=195) < 4 points versus group B (n=142) ≥ 4 points.

**AHFR score: validation**

Clinical, analytical, echocardiographic parameters as well as event rate (death for any cause and/or rehospitalization for HF) at 6, 12 and 24 months were compared between the two groups.

Therefore, the area under the ROC curve for the endpoint (mortality and/or rehospitalization at 12 months) was 0.74, with an intermediate discrimination score. The score was predictor of the event (p<0.001), with 65% accuracy.

In Table 3, comparisons of the two groups according to the AHFR score are found. Group B was composed of older patients, with lower body mass index and higher prevalence of kidney disease. Other risk factors for anemia observed in the study group included female gender and CKD. In addition, group B had lower eGFR than group A (p<0.001).

With respect to electrocardiographic changes, AF rhythm was predominant in group A, whereas other non-sinus rhythm was predominant in group B (p<0.01). No statistically significant differences in intraventricular conduction (QRS) duration were detected between the groups.

The identification of the precipitating factor is crucial for patient's stabilization. In our study, the most frequent precipitating factor was multifactorial (including low compliance to diet and therapy) in both groups.

The most frequent HF etiology was ischemic heart disease (40.1%).

In group B, we found a high proportion of older patients non-adherent to the therapy and posology proposed.

In group B, nearly 40% of patients had LVEF higher than 50%. Other echocardiographic parameters are described in Table 3.

Medication started during hospitalization was considered of higher relevance and prognostic impact. At hospital discharge, approximately 52% of patients in group B were receiving ACE inhibitors and 46% spironolactone, and 20% of them had LVEF lower than 30%. Medications received by the patients at discharge are described in Table 3.

Mean hospital stay duration was 8.6 ± 7 days, with a mean of 10 (±7.7) days in group B.

**AHFR score as predictor of events during clinical follow-up**

Rehospitalization rates at 6, 12 and 24 months are shown in Table 4.
Nearly one-fourth of patients in group B were rehospitalized within 90 days after hospital discharge. Approximately 25% of patients in group A and 50% in group B reached the endpoint at 6 months after discharge (p<0.001). However, in both groups, the rehospitalization rate for decompensated HF and/or all-cause mortality was higher at three months after discharge, as indicated in the Kaplan Meier curves (Figures 3A, B and C).
Discussion

In this retrospective study, a new risk score for medium-term events was constructed in patients hospitalized for acute HF syndrome. The inclusion of four variables previously identified in risk models and the identification of two new variables – E/e’ ratio and lack of ACE inhibitor/ARBs (for those intolerant to ACE inhibitors) prescription at discharge – enabled the identification of a high-risk group, with score higher than 4 (group B). This group was mostly constituted of older patients, who exhibited higher number of comorbidities, higher hemodynamic instability at admission, higher left ventricular dysfunction and worse prognosis in short, medium and long term.

The identification and clinical characterization of a higher risk group for events facilitates an earlier multidisciplinary approach, and promotes the correct identification of decompensating factors, higher therapy compliance, and reduced hospital stay, hospital morbimortality and readmission that consume most of the resources involved in this syndrome.\(^5\)

Four of the variables included in the score developed in this study are also present in many models. Nevertheless, our study is original in including an echocardiographic variable (E/e’ ratio) determined during hospitalization and another variable determined on the day of discharge (lack of ACE inhibitor/ARBs prescription). As in previous models, this score enabled the identification of a higher risk, older group, with higher number of comorbidities, named cardiorenal syndrome.

The risk models used in acute HF have several particularities. First, patients are assessed at admission or at the emergency service, which generally prioritizes the assessment of a very short-term risk (during hospitalization) or a medium-term risk.

Table 2 – Independent predictors of primary endpoint (mortality and/or rehospitalization for heart failure at 12 months of follow-up) by Cox multivariate regression analysis

| Variables                                      | HR    | Confidence Interval (95%) | p value | Score |
|------------------------------------------------|-------|---------------------------|---------|-------|
| Age ≥ 75 years                                  | 1.7   | 1.1-2.5                   | 0.01    | 2     |
| E/e’ ratio ≥ 15                                 | 1.6   | 1.1-2.3                   | 0.009   | 2     |
| BNP ≥ 400 pg/mL                                 | 1.37  | 1.0-1.9                   | 0.04    | 1     |
| Uremia ≥ 60 mg/dL                               | 1.15  | 1.0-1.5                   | 0.04    | 1     |
| Natremia < 135 mEq/L                            | 1.37  | 1.0-1.6                   | 0.03    | 1     |
| Without ACE inhibitor/ARBs* at discharge        | 1.9   | 1.2-2.9                   | 0.004   | 2     |

BNP: brain-type natriuretic peptide; ACE: angiotensin-converting-enzyme; ARBs: angiotensin II receptor blockers; (*) in case of intolerance to ACE inhibitors.
## Table 3 – Clinical characterization by risk groups

| Characteristics | Group A (n=195) | Group B (n=142) | p value* |
|-----------------|----------------|----------------|----------|
| Age (mean ± SD) | Mean 75.2±9.6 | 80.1±9.6 | < 0.001 |
|                 | Women 77.2±8.2 | 81.6±7.9 | 0.05    |
|                 | Men 73.3±10.2 | 78.5±11.0 | 0.002   |
| Female (%)      | 49.2 (n=195) | 52.1 (n=142) | 0.6      |
| Mean BMI (Kg/m² ± SD) | 28.2±4.9 | 26.2±5.2 | 0.01    |
| Mean RICA score ± SD | 2.4±1.4 | 5.8±1.3 | <0.001 |
| Risk/etiologic factors and associated comorbidities (%) | | | |
| DM | 36.5 | 32.4 | 0.25 |
| Arterial hypertension | 72.8 | 57.0 | 0.003 |
| Dyslipidemia | 30.8 | 21.1 | 0.048 |
| Known CHD | 36.9 | 38.7 | 0.7 |
| Previous AMI | 13.4 | 17.4 | 0.6 |
| Previous CTS | 4.6 | 10.6 | 0.03 |
| Stroke | 9.7 | 7 | 0.38 |
| AF | 50 | 42.3 | 0.03 |
| CKD | 21.0 | 42.3 | <0.001 |
| Anemia | 37.4 | 57.7 | <0.001 |
| Clinical presentation of HF (%) | | | |
| Decompensated HF | 67.7 | 72.5 | |
| APE (nh) | 13.3 | 11.3 | |
| APE (h) | 16.9 | 7.7 | 0.01 |
| Cardiogenic shock | 0.5 | 2.8 | |
| Right HF | 1.5 | 5.6 | |
| Precipitating factors (%) | | | |
| Ischemia/ type 2 ACS | 11.8 | 14.1 | |
| Cardiac arrhythmias | 22.1 | 16.9 | |
| Hypertensive crisis | 15.9 | 7.0 | 0.03 |
| Multifactorial (renal dysfunction, anemia, infection, poor compliance to therapy, diet and others) | 50.3 | 62.0 | |
| HF subtypes (%) | | | |
| HF with decreased LVEF | 47.7 | 59.6 | |
| HF with preserved LVEF | 52.3 | 40.4 | |
| Hypertensive heart diseases (including those associated with AF and DM) | 33.3 | 28.9 | |
| HF etiology (%) | | | |
| Ischemic CM | 25.6 | 40.1 | 0.02 |
| Non-ischemic DCM | 21.0 | 15.5 | |
| Valve disease | 11.8 | 8.5 | |
| Cor pulmonale | 3.6 | 6.3 | |
| Multifactorial | 4.6 | 0.7 | |
| Parameters at admission | | | |
| AP (mean ± SD) | SAP (mmHg) 146.2±30.5 | 130.9±29.5 | < 0.001 |
|                 | DAP (mmHg) 83.7±19.9 | 75.4±16.0 | <0.001 |
| Laboratory | | | |
| eGFR (mL/min) mean± SD | 51.0±21.8 | 37.7±17 | < 0.001 |
| eGFR MDRD < 60 mL/min/1.73m² (%) | 21 | 42.3 | <0.001 |
For this reason, the variables of these models may be similar but are slightly different as compared with those of chronic HF scores, in emphasizing easy, rapidly accessible clinical, demographic and analytical factors.

The aim of this study was to evaluate medium-term risk (12 months) by including a variable different from the majority of the models – the lack of ACE inhibitor/ARBs (if intolerant to ACE inhibitor) prescription at discharge. Although “in-hospital mortality” or “mortality at 90 days” endpoints seem to be more relevant in acute diseases, including acute HF, long-term follow-up cannot be neglected, and other variables such as evidence-based therapy that has a later impact on the prognosis should be included.

Several prognostic models in the context of acute HF are available in the literature. These models can be classified into three groups: five models were conducted with hospitalized patients, one included hospitalized patients included in clinical trials, and two models were conducted in an emergency service.

Table 5 describes the summary of the prognostic models in acute HF. Three markers included in the score created by us – age, natremia, and uremia – are common in most of

| Table 4 – Rate of rehospitalization for heart failure at 6, 12 and 24 months by risk groups |
|----------------------------------|---------|---------|----------------|----------------|
| Rehospitalization (%)           | Group A | Group B | OR (IC 95%)    | p value |
| 6 months                        | 21.5    | 30.5    | 1.6 (1.2-2.6)  | 0.04    |
| 12 months                       | 34.7    | 44.4    | 1.6 (1.2-2.5)  | 0.04    |
| 24 months                       | 48.2    | 58.7    | 1.5 (0.9-2.4)  | 0.06    |

ACE: angiotensin-converting-enzyme; ACS: acute coronary syndrome; AF: atrial fibrillation; AHFR: acute heart failure registry; AMI: acute myocardial infarction; APE (h): acute pulmonary edema (hypertensive); APE (nh): acute pulmonary edema (non-hypertensive); ARBs: angiotensin II receptor blockers; BB: beta-blockers; BMI: body mass index; CAD: coronary artery disease; CG: Cockcroft-Gault; CKD: chronic kidney disease; CM: cardiomyopathy; CTS: cardiothoracic surgery; DAP: diastolic arterial pressure; DCM: dilated cardiomyopathy; DM: diabetes mellitus; eGFR: estimated glomerular filtration rate; LVEF: left ventricular ejection fraction; HF: heart failure; MDRD: modification of diet in renal disease; PCR: protein chain reaction; PASP: pulmonary artery systolic pressure; ROW: red cell distribution width; SAP: systolic arterial pressure; SD: standard-deviation; (*) comparison between the risk groups (A e B).
the models. The prognosis of acute HF progressively worsens with age, for the effect of age per se and for its association with higher comorbidity and frailty.26 Renal failure is common among patients with acute HF. Some studies have reported that high levels of urea triplicate the risk for intra-hospital mortality and post-discharge mortality.10 With respect to hyponatremia, a multivariate analysis showed that a 3 mmol/L decrease in case of natremia lower than 140mmol/L increases the intra-hospital mortality by 19.5%.9

Despite higher availability and proved prognostic utility of natriuretic peptides, these compounds have not been included in most of the risk prediction models. Some studies suggest that an increment by 30% in normal NT-proBNP levels at admission increases by six times the risk of rehospitalization.27

The assessment of the relationship of mitral ring velocity with transmitral flow velocity curves (E/e’ ratio) by tissue Doppler was found to be an independent predictor of yearly mortality in patients hospitalized for acute HF.28

Although the benefits of an early start of ACE inhibitors in acute HF have not been demonstrated in the literature, their prescription is mandatory within the first 48h-72h after admission, with proven benefits in reducing mortality and rehospitalization rate, according to the European Society of Cardiology recommendations.3

Despite numerous studies showing that the lack of the prescription of beta-blockers at discharge is a mortality predicting factor, this was not observed in this study, probably due to a selection bias.

The estimated risk at hospital admission may help to decide whether or not a patient is candidate for intensive therapy. However, several studies have shown that risk scores estimated on the day of discharge (including biomarkers and therapy prescribed at discharge) have better prognostic value as compared with those determined at admission.29 Risk predicting tools are crucial to determine the prognosis in HF. Although these risk models can precisely determine short-term prognosis of acute HF, they should be extensively tested in elderly patients or those with multiple comorbidities.29 Besides, prospective, randomized studies are needed to establish the impact of long term risk stratification on acute HF patients.29

Figure 3 – Kaplan Meier curves showing the rate of combined endpoint (mortality and/or rehospitalization) of group A (score < 4) and group B (score > 4) at 6 (A), 12 (B) and 24 months (C) of clinical follow-up.
### Table 5 – Prognostic models in acute heart failure*

| Author | Year of publication | Deriving cut-off (n) | Validation cut-off (n) | Variables (n) | Result/AUC |
|--------|---------------------|----------------------|------------------------|---------------|------------|
| ADHERE\textsuperscript{1} Fonarow | 2005 | International Multicentric (33,046) | Multicentric (32,229) | Age, Clinical Laboratory (4) | IHM / 0.75 |
| AHFI\textsuperscript{16} Auble | 2005 (derivation) 2008 (validation) | National Multicentric (33,533) | Randomized sample (8,384) | Demographic Clinical Laboratory Non-invasive diagnostic tests (21) | IHM / 0.59 |
| GWTG-HF\textsuperscript{20} Peterson | 2010 | International Multicentric Community (27,850) | Multicentric Community (11,933) | Demographic Clinical Laboratory Comorbidities 7 | IHM / 0.75 |
| EFFECT\textsuperscript{21} Lee | 2003 | National Multicentric (2,624) | Multicentric Community (1,407) | Demographic Clinical Laboratory Comorbidities (10) | Mortality in 30 days /0.79 Mortality at one year /0.76 |
| OPTIMIZE-HF\textsuperscript{22} O’Connor | 2008 | International Multicentric Registry (4,402) | OPTIME CHF (949) y ESCAPE (433) | Demographic Clinical Laboratory Comorbidities (13) | Mortality in 60-90 days/0.72 |
| OPTIMIZE-HF\textsuperscript{23} Abraham | 2008 | International Multicentric Registry (37,548) | Internal Bootstrapping ADHERE trial (181,830) | Demographic Clinical Laboratory Systolic dysfunction (7) | IHM / 0.74 |
| OPTIME CHF\textsuperscript{23} Felker | 2004 | International Multicentric (949) | Internal Bootstrapping | Demographic Clinical Laboratory (5) | Mortality in 60 days/0.77 |
| Ottawa\textsuperscript{24} Stiell | 2013 | National Multicentric Community (507) | Internal Bootstrapping | Clinical laboratory (10) | Mortality in 30 days or non-fatal event in 14 days /BNP 0.77, no BNP 0.75 |
| EHRMG\textsuperscript{25} Lee | 2012 | National Multicentric Community (7,433) | Multicentric Community (5,158) | Clinical Laboratory Comorbidities (10) | Mortality in 7 days/0.8 |

AUC: area under the curve; ADHERE: Acute Decompensated Heart Failure National Registry; AHFI: Acute Heart Failure Index; EFFECT: Enhanced Feedback for Effective Cardiac Treatment; EHRMG: Emergency Heart Failure Mortality Risk; GWTG-HF: Get With the Guidelines-Heart Failure; OPTIMIZE-HF: Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure; OPTIME-CHF: Outcomes of a Prospective Trial of Intravenous Milrinone for Exacerbations of Chronic Heart Failure; Ottawa: Ottawa Heart Failure Risk Model; (\textsuperscript{*})Adapted from Ferrero P. et al. Int J Cardiol. 2015;188:1-920.

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**Limitations**

Some limitations inherent in the construction of this score should be considered in the interpretation of the results. The fact that this is a retrospective study opens up the possibility of selection bias. An external validation of the model is needed, preferentially in another center. The diagnosis of acute HF was based only on the European Society of Cardiology criteria and the date of onset of symptoms was not determined. For this reason, it is not possible to differentiate de novo acute HF from acutely worsened chronic HF. In addition, analysis of treatment and prognosis should be adjusted because of the heterogeneity of the sample. Another limitation refers to the fact that we did not include patients discharged home from the emergency department. Also, there was a large number of missing variables when the completion of data was optional, which affected the results. The echocardiography was performed some days post-admission, rather than on the day of admission, which may influence the measurements used in the score construction.

**Conclusions**

In this study, we constructed a new risk score of medium-term events in patients hospitalized for acute HF syndrome. The inclusion of four variables previously identified in risk models, in addition to the identification of two additional variables: E/e’ ratio and lack of ACE inhibitor/ARBs prescription on the day of discharge enabled the identification of group at high risk for all-cause mortality at 12 months after discharge. This group (group B), with score higher than 4, was mostly constituted of older patients, who exhibited higher number of comorbidities, higher hemodynamic instability at admission, higher left ventricular dysfunction and worse prognosis in short, medium and long term. This group may benefit from a closer monitoring and early start of evidence-based therapy.

**Author contributions**

Conception and design of the research: Bohlen APD, Rodrigues B; Acquisition of data: Bohlen APD, Rodrigues B, Marmelo B, Moreira D, Gama P, Santos O; Analysis and interpretation of the data and Statistical analysis: Bohlen APD, Nunes S; Writing of the manuscript: Bohlen APD, Rodrigues B, Baptista R; Critical revision of the manuscript for intellectual content: Baptista R, Nunes L, Santos O, Cabral C.

**Potential Conflict of Interest**

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References
1. Anguita Sanchez M, Crespo Leiro MG, de Teresa Galvan E, Jiménez Navarro M, Alonso-Pulpon L, Muñiz García J. PRICE Study Investigators. Prevalence of heart failure in the Spanish general population aged over 45 years. The PRICE Study. Rev Esp Cardiol. 2008;61(10):1041-9.

2. Jessup M, Buzena S. Heart failure. N Engl J Med. 2003;348(20):2007-18.

3. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JG, Coats A, et al; Authors/Task Force Members. 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(27):2129-200.

4. Dharmarajan K, Hsieh AF, Lin Z, Bueno H, Ross JS, Horwitz LI, et al. Diagnoses and timing of 30-day readmissions after hospitalization for heart failure. acute myocardial infarction, or pneumonia. JAMA. 2013;309(4):355-63.

5. Abraham WT, Fonarow GC, Albert NM, Stough WG, Gheorghiade M, Greenberg BH, et al; OPTIMIZE-HF Investigators and Coordinators. 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.). Am Coll Cardiol. 2008;52(S):347-56.

6. Fonarow GC, Adams KF Jr, Abraham WT, Yancy CW, Boscardin WJ; ADHERE Scientific Advisory Committee, Study Group, and Investigators. Risk stratification for in-hospital mortality in acutely decompensated heart failure: classification and regression equation. JAMA. 2005;293(5):572-80.

7. Maisel A, Mueller C, Adams K Jr, Anker SD, Acramonte N, Cleland JG, et al. State of the art: using natriuretic peptide levels in clinical practice. Eur Heart J. 2008;29(10):B24-39.

8. Ommen SR, Nishimura RA, Appleton CP, Miller FA, Ommen SR, Nishimura RA, Appleton CP, Miller FA, et al. Clinical utility of Doppler echocardiography and tissue Doppler imaging in the estimation of left ventricular filling pressures: a comparative simultaneous Doppler-catheterization study. Circulation. 2000;102(13):1768-94.

9. Gheorghiade M, Abraham WT, Albert NM, Gattis Stough W, Greenberg BH, O'Connor CM, et al; OPTIMIZE-HF Investigators and Coordinators. Relationship between admission serum sodium concentration and clinical outcomes in patients hospitalized for heart failure: an analysis from the OPTIMIZE-HF registry. Eur Heart J. 2007;28(9):980-9.

10. Singh G, Peterson EL, Wells K, Williams LK, Lanfear DE. Comparison of renal predictors for in-hospital and postdischarge mortality after hospitalization for heart failure. J Cardiovasc Med [Hagerstown]. 2012;13(4):246-53.

11. Flather MD, Yusuf S, Kober L, Pfeiffer M, Hall A, Murray G, et al. Long-term ACE-inhibitor therapy in patients with heart failure or left-ventricular dysfunction: a systematic overview of data from individual patients. ACE-Inhibitor Myocardial Infarction Collaborative Lancet. 2000;355(9195):1575-81.

12. Felker GM, Adams KF Jr, Konstam MA, O'Connor CM, Gheorghiade M. The problem of decompensated heart failure: nomenclature, classification, and risk stratification. Am Heart J. 2003;145(2 Suppl):S18-25.

13. McMurray JJ, Adamopoulos S, Anker SD, Auricchio A, Böhm M, Dickstein K, et al; ESC Committee for Practice Guidelines. ESC Guidelines for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. Eur Heart J. 2012;33(14):1787-847. Erratum in: Eur Heart J. 2013;34(2):158.

14. Zile MR, Brutsaert DL. New concepts in diastolic dysfunction and diastolic heart failure: Part I: diagnosis, prognosis, and measurements of diastolic function. Circulation. 2002;105(11):1387-93.

15. Tang YD, Katz SD. Anemia in chronic heart failure: prevalence, etiology, clinical correlates, and treatment options. Circulation. 2006;113(20):2454-61.

16. Diaz A, Cicchioni C, Esperatti M, Becerra A, Mainardi S, Farah A. Precipitating factors leading to decompensation of chronic heart failure in the elderly patient in South American community hospital. J Geriatr Cardiol. 2011;8(1):12-4.

17. Fonarow GC, Albert NM, Stough WG, Gheorghiade M, Greenberg BH, et al; OPTIMIZE-HF Investigators and Hospitals. Factors identified as precipitating hospital admissions for heart failure and clinical outcomes: findings from OPTIMIZE-HF. Arch Intern Med. 2008;168(6):847-54.

18. Ferrero P, Iacovoni A, D’Elia E, Vaduganathan M, Gavazzi A, Senni M. Prognostic scores in heart failure: critical appraisal and practical use. Int J Cardiol. 2015;188:1-9.

19. Auble TE, Hsieh M, Gardner W, Cooper GF, Stone RA, McGusland JB, et al. A prediction rule to identify low-risk patients with heart failure. Acad Emerg Med. 2005;12(6):514-21.

20. O’Connor CM, Abraham WT, Albert NM, Claire R, Gattis Stough W, Gheorghiade M, et al. Predictors of mortality after discharge in patients hospitalized with heart failure: an analysis from the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF). Am Heart J. 2008;156(4):662-73.

21. Peterson PN, Rumsfeld JS, Liang L, Albert NM, Hernandez AF, Peterson ED, et al; American Heart Association Get With the Guidelines-Heart Failure Program. A validated risk score for in-hospital mortality in patients with heart failure from the American Heart Association get with the guidelines program. Circ Cardiovasc Qual Outcomes. 2010;3(1):25-32.

22. Lee DS, Austin PC, Rouleau JL, Liu PP, Naimark D, Tu JV. Predicting mortality among patients hospitalized for heart failure: derivation and validation of a clinical model. JAMA. 2003;290(19):2581-7.

23. Felker GM, Leimberger JD, Calif RM, Cufie MS, Massie BM, Adams KF Jr, et al. Risk stratification after hospitalization for compensated heart failure. J Card Fail. 2004;10(6):460-6.

24. Stiell IG, Clement CM, Brison RJ, Rowe BH, Borgundvaag B, Aaron SD, 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(1):17-26.

25. Lee DS, Stitt A, Austin PC, Stukel TA, Schulz MJ, Chong A, et al. Prediction of heart failure mortality in emergency care: a cohort study. Ann Intern Med. 2012;156(11):767-75, W-261, W-262.

26. Gafniasson F, Torg-Pedersen C, Selbaek M, Burchardt H, Kober L, DIAMOND study group. Effect of age on short and long-term mortality in patients admitted to hospital with congestive heart failure. Eur Heart J. 2004;25(19):1711-7.

27. Januzzi JL, van Kimmenade R, Lainchbury J, Bayes-Genis A, Ordonez-Llanos J, Santalo-Bel M, et al; NT-proBNP testing for diagnosis and short-term prognosis in acute destabilized heart failure: an international pooled analysis of 1256 patients: the International Collaborative of NT-proBNP Study. Eur Heart J. 2006;27(3):330-7.

28. Santas E, Garcia-Blas S, Minana G, Sanchis J, Bodi V, Escrivo G, et al. Prognostic implications of tissue Doppler imaging-derived e/a ratio in acute heart failure patients. Echocardiography. 2015;32(2):213-20.

29. Cohen-Solal A, Larbi S, Ishihara S, Vergaro G, Baudet M, Logeat D, et al. Prognostic markers of acute decompensated heart failure: the emerging roles of cardiac biomarkers and prognostic scores. Arch Cardiovasc Dis. 2015;108(1):64-74.
