# Effect of Barthel Index on the Risk of Thirty-Day Mortality in Patients With Acute Heart Failure Attending the Emergency Department: A Cohort Study of Nine Thousand Ninety-Eight Patients From the Epidemiology of Acute Heart Failure in Emergency Departments Registry

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**Study objective:** We assess the value of the Barthel Index (BI) in predicting 30-day mortality risk among patients with acute heart failure who are attending the emergency department (ED).

**Methods:** We selected 9,098 acute heart failure patients from the Acute Heart Failure in Emergency Departments registry who had BI score available both at baseline and the ED visit. Patients' data were collected from 41 Spanish hospitals during four 1- to 2-month periods between 2009 and 2016. Unadjusted and adjusted logistic regression models were used to assess the association between 30-day mortality and BI score. *c* Statistics were used to estimate their prognostic value.

**Results:** The mean baseline BI score was 79.4 (SD 24.6) and the mean ED BI score was 65.3 (SD 29.1). Acute functional decline ($\geq$5-point decrease between baseline BI and ED BI score) was observed in 5,771 patients (53.4%). Within 30 days of the ED visit, 905 patients (9.9%) died. There was a steep inverse gradient in 30-day mortality risk for baseline BI and ED BI score. For instance, compared with BI score=100, a BI score of 50 to 55 doubled the mortality risk both at baseline and the ED visit. At the ED visit, a BI score of 0 to 5 carried a 5-fold increase in risk after adjustment for other risk predictors. In comparison with baseline BI score, ED BI score consistently provided greater discrimination. Neither baseline BI score nor the change in BI score from baseline to the ED visit added further prognostic value to the ED BI score.

**Conclusion:** Functional status assessed by the BI score at the ED visit is a strong predictor of 30-day mortality in acute heart failure patients, with higher predictive value than baseline BI score and acute functional decline. Routine recording of BI score at the ED visit may help in decisionmaking and health care planning. [Ann Emerg Med. 2019;73:589-598.]

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## INTRODUCTION

### Background

Acute heart failure is a highly prevalent condition, representing one of the most frequent diagnoses in the emergency department (ED).[1] Acute heart failure is a pivotal moment in the course of the disease, characterized by a poor short-term prognosis, in which 30-day mortality approaches 10% and there is a high risk of developing functional impairment.[2] The role of the emergency physician is crucial for the initial evaluation, immediate treatment, and disposition decisionmaking.

### Importance

The assessment of functional status through the Barthel Index (BI) has gained interest in recent years as a relevant prognostic indicator in acute heart failure patients attending the ED.[3] Baseline functional status has been described as a short- and midterm prognostic factor in

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**Editor's Capsule Summary**

*What is already known on this topic*

The Barthel Index is a measure of functional status in heart failure patients that can be used for long-term prognosis. It is a component of the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure.

*What question this study addressed*

Whether the Barthel Index score at emergency department (ED) presentation or the change in score from baseline to ED presentation is associated with short-term prognosis.

*What this study adds to our knowledge*

In this retrospective database study of 9,098 patients, the Barthel Index score in the ED was strongly associated with 30-day mortality. The change from reported baseline score did not add value.

*How this is relevant to clinical practice*

More studies are needed to determine whether this index has a useful role in patient care.

acute heart failure patients.[4-6] Its inclusion in relevant risk scores has been demonstrated to provide additional prognostic value and improve the discriminative ability to classify patients according to their short-term mortality risk.[7,8] To date, the assessment of functional status within the first hours of ED arrival or the deterioration in functional status has received little consideration and has not been studied as a potential risk prognostic factor.[9-11] The Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure risk score has recently emerged as a new tool to readily predict 30-day mortality from the ED visit in acute heart failure patients and includes BI score measured at the ED visit as a novel risk factor among 12 other items related to age, comorbidity, and clinical and analytic data.[12] BI score at the ED visit was the risk factor with highest predictive value in the risk model.[12] Its value at the ED visit may mirror the baseline functional status and the additional influence of an acute heart failure episode. Therefore, the identification of acute functional decline, evaluated by the change between baseline and ED BI scores, may have an additional prognostic value and become the clinical basis on which to make the disposition decision.[9]

### Goals of This Investigation

The aim of this study was to examine the prognostic value of functional status measured by the BI to assess whether BI score at the ED visit better predicts 30-day mortality in comparison with baseline BI score, and whether acute functional decline (difference between baseline and ED visit BI scores) can further improve the prognostic value among patients with acute heart failure attended in the ED.

## MATERIALS AND METHODS

### Study Design and Setting

This was a secondary analysis of the Acute Heart Failure in Emergency Departments registry, which is a prospective observational multicenter cohort study that collects data on patients attending 41 Spanish EDs who receive a final diagnosis of acute heart failure. Hospitals participate in the Acute Heart Failure in Emergency Departments registry voluntarily and are a composition of tertiary and nontertiary hospitals from all areas of the regions, therefore representing a broad spectrum of Spanish EDs across the country. The information is collected for 1 to 2 months every 2 to 3 years.

### Selection of Participants

We used data from patients recruited in May 2009 (Acute Heart Failure in Emergency Departments–2), November to December 2011 (Acute Heart Failure in Emergency Departments–3), January to February 2014 (Acute Heart Failure in Emergency Departments–4), and January to February 2016 (Acute Heart Failure in Emergency Departments–5), thus providing a combination of 4 cohorts representing 12,843 episodes of acute heart failure. Details of the design and conduct of the Acute Heart Failure in Emergency Departments registry are published elsewhere.[12,13] Briefly, patient inclusion is performed by attending emergency physicians using the Framingham clinical diagnostic criteria.[14] All identified cases were also confirmed by the principal investigator of each center before inclusion in the database to ensure that all patients fulfilled the clinical diagnostic criteria of acute heart failure. The diagnosis was confirmed by natriuretic peptide determinations or echocardiography following the European Society of Cardiology criteria[15] for 92% of patients. Patients having a main diagnosis of ST-segment elevation myocardial infarction while developing acute heart failure were excluded from the registry, which happened in approximately 3% of acute heart failure cases. We included only patients with available BI scores at both baseline and the ED visit.

### Data Collection and Processing

For every patient, data on demographics, clinical history, presentation, and treatments were collected on specific case record forms. Routine interventions, treatments, and disposition (hospital admission or discharge) were entirely based on the decisionmaking of the attending emergency physician. Further details can be found in Appendix E1 (available online at http://www.annemergmed.com).

Functional status was assessed by the BI, an ordinal scale measuring a subject's ability to perform independently 10 basic activities of daily living related to self-care, continence, and mobility.[16] The 10 performance items addressed by the BI are presence or absence of fecal and urinary incontinence, and presence or absence of help needed with grooming, toilet use, feeding, transfers (ie, from chair to bed), walking, dressing, climbing stairs, and bathing. The final score ranges from 0 (completely dependent patient) to 100 (totally independent patient) in 5-point intervals. In our study, BI scores were obtained through the validated Spanish version of the questionnaire.[17] The investigators at each center collected baseline (1 month before the index acute heart failure episode) and ED visit (index acute heart failure episode) BI scores through interviews with patients or with relatives or caregivers for those unable to provide this information during the ED stay.

To explore the prognostic value provided by the BI, patients were grouped by functional categories using 3 different classifications: (1) by 10-point scoring intervals, with the top category of 100 points as the reference; (2) by clinically meaningful categories based on our previous publication,[8] thus stratifying patients by total disability (BI score 0 to 35), severe disability (BI score 40 to 55), moderate disability (BI score 60 to 85), and slight to no disability (BI score 90 to 100); and (3) by categories of the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure (cutoffs are 0 to 20, 25 to 45, 50 to 70, and 75 to 100).[12] Functional decline was assessed by determining the difference between baseline BI and ED BI scores within each level of the ED BI.

### Outcome Measures

All-cause 30-day mortality was recorded during hospitalization and subsequent follow-up through telephone contact and evaluation of medical records between 31 and 90 days after the index ED visit. A blinded investigator from each center assessed events at follow-up for all patients admitted at the relevant hospital.

### Primary Data Analysis

Categoric variables are expressed as frequency and percentage, and continuous variables as mean and SD or, if not normally distributed, as median and interquartile range. Time-to-first-event curves for 30-day mortality were obtained for BI subgroups with the Kaplan-Meier method and compared with the log-rank test. The association between BI score and 30-day mortality was assessed with both unadjusted and adjusted logistic regression, with estimates of odds ratios and their 95% confidence intervals for 30-day mortality. In the latter, estimations were adjusted for the 12 risk predictors included in the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure risk score. This risk score is a tool developed and validated to predict 30-day all-cause mortality in patients presenting with acute heart failure in the ED.[12] It is formed by the following variables: BI score at ED visit, age, systolic blood pressure, New York Heart Association class IV, potassium level, NT-proBNP, troponin level, low output symptoms, respiratory rate, oxygen saturation, acute coronary syndrome, creatinine level, and hypertrophy on ECG. Further details for the development and previous validation of the risk score have been published elsewhere,[12] and the online calculator can be found at http://meessi-ahf.risk.score-calculator-ica-semes.portalsemes.org. The BI was introduced into each model by use of the relevant categorization system under evaluation. A multiple imputation technique using chained equations[18] was used to produce 50 imputed data sets replacing the missing values in the 12 variables included in the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure risk score (age, systolic blood pressure, New York Heart Association class IV, potassium level, NT-proBNP, troponin level, low output symptoms, respiratory rate, oxygen saturation, episode associated with acute coronary syndrome, creatinine level, and hypertrophy on ECG). Data in regard to BI score, cohort, and the outcome were also used in the multiple imputation procedure. These imputed data were used to estimate the adjusted odds ratios.

To compare the ability to predict 30-day mortality between models containing a single variable (baseline versus ED visit BI score, and BI using clinically meaningful groups versus BI categories in the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure risk score either at baseline or the ED visit), we assessed the change in *c* statistic and used the DeLong method for hypothesis testing. Acute functional decline was evaluated by fitting a model with both baseline and ED BI score, and simultaneously fitting the BI score at the ED visit and the change in BI score from baseline to the ED visit (both as categoric variables). The change in model coefficients was evaluated to assess the contribution of baseline BI score and functional decline to predict 30-day mortality when added to the ED visit BI score.

The 2-tailed significance level was set at $P<.05$. Stata (version 15.1; StataCorp, College Station, TX) and GraphPad Prism (version 6.00; GraphPad Software, La Jolla, CA) were used to create some of the graphs.

The Acute Heart Failure in Emergency Departments study complies with the Declaration of Helsinki and was approved by the ethical committees of all participating centers. All patients gave informed consent to participate in the study.

## RESULTS

### Characteristics of Study Subjects

A total of 9,098 patients were included in this analysis, thus excluding 3,745 subjects (29.2%) because of the lack of complete BI measurement (2,023 lacked BI score at the ED visit, 136 lacked baseline BI score, and 1,550 lacked both BI scores) or follow-up (36 patients). Comparisons between Acute Heart Failure in Emergency Departments registry patients included in and excluded from this analysis are reported in Table E1 (available online at http://www.annemergmed.com). Mean age, female sex percentage, and 30-day mortality did not differ substantially and there were no other clinically relevant differences between groups.

The patients included in our cohort had a mean age of 80.2 years (SD 10.2 years), and 56% were women. In regard to medical history, 84% of patients had systemic hypertension, 42% had diabetes mellitus, 29% had ischemic heart disease, 51% had atrial fibrillation, and 62% had previous heart failure. Sixty-seven percent of patients were receiving long-term diuretic treatment, 43% were receiving $\beta$-blockers, and 56% were receiving either angiotensin-converting-enzyme inhibitors or angiotensin II receptor *blockers*. Further data in regard to baseline and acute clinical status, ECG, laboratory results, and ED management are shown in Table 1.

### Main Results

The median baseline BI score was 90 (interquartile range 65 to 100), with 4,834 subjects (53.1%) being classified as slightly dependent to not dependent, 2,614 (28.7%) as moderately dependent, 917 (10.1%) as severely dependent, and 733 (8.1%) as completely dependent. In contrast, the median BI score at ED visit was 70 (interquartile range 45 to 90), with 2,799 subjects (30.8%) being classified as slightly dependent to not dependent, 3,050 (33.5%) as moderately dependent, 1,506 (16.6%) as severely dependent, and 1,743 (19.2%) as completely dependent. Acute functional decline (at least a 5-point decrease in BI score from baseline to the ED visit) was observed in 5,771 patients (53.4%) (baseline and ED visit BI scores are cross-tabulated in Table E2, available online at http://www.annemergmed.com). Figure E1 (available online at http://www.annemergmed.com) depicts percentages of patients with different degrees of acute functional decline.

Nine hundred five patients (9.9%) died within 30 days of the ED visit. There was a steep gradient in 30-day mortality across the 10-point-interval categories in both baseline BI score and ED visit BI score (linear trend $P<.001$ for each case) (Figure 1). Crude and Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure risk-score-adjusted odds ratios for 10-point intervals are shown in Tables E3 and E4 (available online at http://www.annemergmed.com). Kaplan-Meier curves evaluating the association between several BI grouping categories and 30-day mortality are shown in Figure 2. Both baseline BI and ED BI scores offered good prognostic capacity, although the latter demonstrated greater discrimination irrespective of the BI score categorization (DeLong $P<.001$) (Table 2). In comparison with BI categories provided by Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure risk scores, the classification of BI score according to clinically meaningful categories demonstrated a higher ability to predict 30-day mortality at both measurement points (DeLong $P<.001$ and $P<.03$, respectively).

A logistic model simultaneously fitting baseline BI and ED BI scores as continuous predictors of 30-day mortality showed that the former did not add to prediction ($P=.65$) once the latter was taken into account. Also, a model simultaneously fitting BI score at the ED visit and change in BI score from baseline to the ED visit (both as categoric variables) showed that change in BI score did not contribute to prediction once the actual ED visit BI score was considered.

## LIMITATIONS

This study should be interpreted in the context of its limitations. BI score was evaluated by many physicians across participating hospitals. Although it has a good interobserver reproducibility, some degree of variability should be expected. Neither interobserver variability (agreement) nor intraobserver variability (test-retest reliability) was measured in our study; however, it had high interrater reliability (0.95) and test-retest reliability (0.89), as well as high correlations (0.74 to 0.80) with other measures of physical disability in another study.[3] We did not take into account repeated measures in our analysis. We did not record the BI items separately, so whether a low BI score reflects a particular impairment more likely associated with heart failure symptoms and treatments

**Table 1.** Clinical features of the study population.

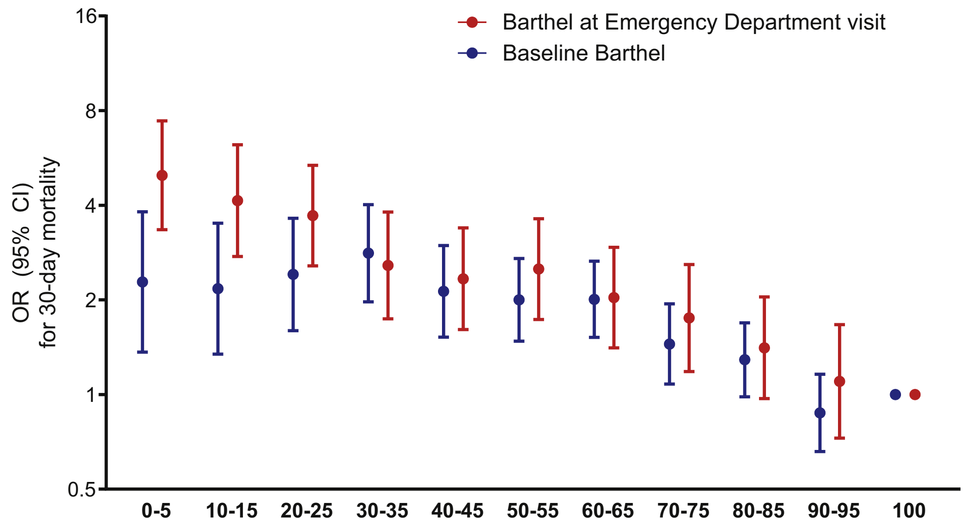
| Variables | No. (%) | Missing Values (%) |
|---|---|---|
| **Functional status, BI (points)** | | |
| At baseline, median (IQR) | 90 (65–100) | 0 |
| At ED visit, median (IQR)* | 70 (45–90) | 0 |
| **Sociodemographic data** | | |
| Age, mean (SD), y* | 80.2 (10.2) | 13 (0.1) |
| Female sex | 5,053 (55.7) | 24 (0.3) |
| Nursing home resident | 621 (8.8) | 2,029 (22.3) |
| **Comorbidities** | | |
| Hypertension | 7,663 (84.3) | 10 (0.1) |
| Diabetes mellitus | 3,853 (42.4) | 11 (0.1) |
| Ischemic heart disease | 2,605 (28.7) | 12 (0.1) |
| Chronic kidney disease (creatinine >2 mg/dL) | 2,481 (27.3) | 8 (0.1) |
| Cerebrovascular disease | 1,225 (13.5) | 11 (0.1) |
| Atrial fibrillation | 4,632 (51.0) | 11 (0.1) |
| Heart valve disease | 2,490 (27.4) | 9 (0.1) |
| Peripheral artery disease | 833 (9.2) | 10 (0.1) |
| Chronic obstructive pulmonary disease | 2,287 (25.2) | 18 (0.2) |
| Dementia | 1,096 (13.7) | 1,124 (12.4) |
| Cancer | 1,149 (14.4) | 1,123 (12.3) |
| Previous heart failure* | 5,586 (62.4) | 140 (1.5) |
| **Long-term treatments at home** | | |
| Diuretic | 5,865 (66.7) | 304 (3.3) |
| β-Blocker | 3,733 (42.5) | 308 (3.4) |
| Angiotensin-converting enzyme inhibitor or angiotensin-receptor blocker | 5,067 (55.7) | 0 |
| Mineralocorticoid-receptor antagonist | 1,540 (17.5) | 303 (3.3) |
| Digoxin | 1,409 (16.0) | 313 (3.4) |
| **Clinical data at ED arrival** | | |
| Systolic blood pressure, mean (SD), mm Hg* | 141.4 (27.8) | 82 (0.9) |
| Pulse rate, mean (SD), beats/min* | 88.5 (23.8) | 116 (1.3) |
| Respiratory rate, mean (SD), breaths/min* | 22.5 (6.5) | 2,336 (25.7) |
| Air-room pulse oximetry, mean (SD), %* | 92.1 (6.7) | 213 (2.3) |
| New York Heart Association class IV* | 3,946 (43.4) | 200 (2.2) |
| Acute coronary syndrome triggering index episode* | 169 (1.9) | 0 |
| **Electrocardiogram** | | |
| Atrial fibrillation | 4,356 (49.6) | 314 (3.5) |
| Left ventricular hypertrophy* | 412 (4.7) | 312 (3.4) |
| Left bundle branch block | 915 (10.4) | 312 (3.4) |
| Pacemaker rhythm | 694 (8.9) | 1,336 (14.7) |

**Table 1.** Continued.

| Variables | No. (%) | Missing Values (%) |
|---|---|---|
| **Laboratory data** | | |
| Hemoglobin, mean (SD), g/dL | 11.9 (2.1) | 100 (1.1) |
| Glucose, mean (SD), mg/dL | 149.0 (87.9) | 1,241 (13.6) |
| Creatinine, mean (SD), mg/dL* | 1.4 (0.8) | 49 (1.0) |
| Sodium, mean (SD), mEq/L | 138.1 (5.1) | 175 (1.9) |
| Potassium, mean (SD), mEq/L* | 4.4 (0.7) | 551 (6.1) |
| NT-proBNP, median (IQR), pg/mL* | 3,929 (6,395) | 4,785 (52.6) |
| Elevated troponin* | 2,656 (52.6) | 4,049 (44.5) |
| **Treatment and management at the ED** | | |
| Oxygen | 6,638 (73.8) | 100 (1.1) |
| Noninvasive ventilation | 650 (7.2) | 100 (1.1) |
| Mechanical ventilation | 250 (2.8) | 99 (1.1) |
| Morphine | 478 (6.0) | 1,164 (12.8) |
| Diuretic (IV) | 7,814 (85.9) | 116 (1.3) |
| Nitroglycerin (IV) | 1,478 (16.3) | 99 (1.1) |
| Inotropic or vasopressor treatment | 170 (1.9) | 107 (1.2) |
| Hospitalized | 6,921 (76.1) | 5 (0.1) |

*IQR*, Interquartile range; *IV*, intravenous.
*Variables included in the Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure (MEESSI) risk score. BI score has no missing values because only patients with BI score at both baseline and the ED visit were included in this analysis.

(ie, urinary continence) cannot be addressed. The BI score, both at baseline and at the ED visit, was self-reported by patients or by relatives or caregivers if patients were acutely ill. This could be accompanied by some degree of information bias either because of some recall bias or because combining self-reported and performance-based measures can provide more information than either method alone.[19] The cause of death (cardiovascular versus noncardiovascular) was not recorded. Patient selection from the Acute Heart Failure in Emergency Departments registry to be analyzed in this study may had have bias selection, although the analysis of selected versus unselected individuals did not find relevant differences on the main characteristics of the study population. Results were not analyzed while differences between clusters were taken into account (ie, hospitals) because of a large variation in patient enrollment between centers. Do-not-resuscitate orders or palliation status data were not available for our cohort, and their assessment might have had an effect on the associations between BI score and 30-day mortality. Caution should be exercised when measures of model performance improvement are interpreted because their interpretation does not always translate into clinically meaningful information.[20]




| | 0-5 | 10-15 | 20-25 | 30-35 | 40-45 | 50-55 | 60-65 | 70-75 | 80-85 | 90-95 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Barthel's index at Emergency Department visit (no. of subjects) | 328 | 325 | 557 | 533 | 737 | 769 | 965 | 828 | 1257 | 1120 | 1679 |
| Baseline Barthel's Index (no. of subjects) | 113 | 145 | 196 | 279 | 388 | 529 | 707 | 772 | 1135 | 1447 | 3387 |

**Figure 1.** Association between baseline and ED visit and BI scores, with 30-day mortality. Adjusted odds ratio (95% CI) for 30-day mortality risk by BI value was grouped with 10-point intervals and measured either at baseline or at the ED visit. Both models showed adequate calibration (for the Hosmer-Lemeshow test for the model using BI score at the ED revisit and baseline BI score, $P$=.81 and $P$=.67, respectively). Estimates for either baseline BI score or BI score at the ED visit were adjusted for the 12 risk predictors of the MEESSI risk score: age, systolic blood pressure, New York Heart Association class IV, potassium level, NT-proBNP, troponin level, low output symptoms, respiratory rate, oxygen saturation, acute coronary syndrome, creatinine level, and hypertrophy on ECG.

## DISCUSSION

BI score at the ED visit is a strong independent predictor for all-cause 30-day mortality in ED acute heart failure patients, regardless of the BI score categorization approach used. BI score at admission and acute functional decline, which is the difference between baseline and ED BI values, did not add extra predictive value to the use of BI score at the ED visit.

The BI was introduced to evaluate patients with stroke[16] but has been used in several chronic conditions to assess disability and to monitor changes in functional status over time.[10,21,22] It is not a time-consuming process, and it does not require specialized personnel or equipment. These features make the BI a suitable tool to be used in EDs for easily predicting prognosis with a simple method. To improve prognostic accuracy, this functional assessment, which measures the effect of the acute episode on the ability to perform activities of daily living, can be added to other prognostic factors provided by routine physical examination and medical history.[12]

The observation that ED BI score could have greater predictive value than baseline BI score represents a novel concept in the field, to our knowledge. To date, most investigations have focused on the assessment of baseline BI score and long-term outcomes.[5,8,23] Previous publications showed that severe baseline functional dependence (BI score ≤60) in older patients with acute heart failure was associated with an increase in 30-day mortality,[4,5] and the BI's inclusion in risk-stratification models was able to improve the prediction for short-term prognosis.[7,8] We have not only observed ED BI score to provide more predictive information in short-term prognosis but also found that it presents a dose-response relationship with 30-day mortality.

Most of these publications used a single cutoff value (BI score ≤60) to determine the risk of adverse outcomes,[4-6] and only a few of them evaluated more than one cutoff value based on the broadly extended classification.[5,8,23] In the present study, we tested different category systems (10-points intervals, Multiple Estimation of Risk Based on the Emergency Department Spanish Score in Patients With Acute Heart Failure categories, and clinically meaningful group) in both baseline and ED BI scores. For BI grouping using clinically meaningful categories, we proposed novel cutoff points that differed from those published by Shah et al[23] for stroke patients because this novel classification is based on prognosis terms, not decisions about rehabilitation.

Our results suggest that acute functional impairment as a result of acute heart failure does not add prognostic value to the use of ED functional status alone. Some authors have suggested that, in the context of an acute condition, functional loss has some degree of prognostic value and the history of functional independence is a sign of greater

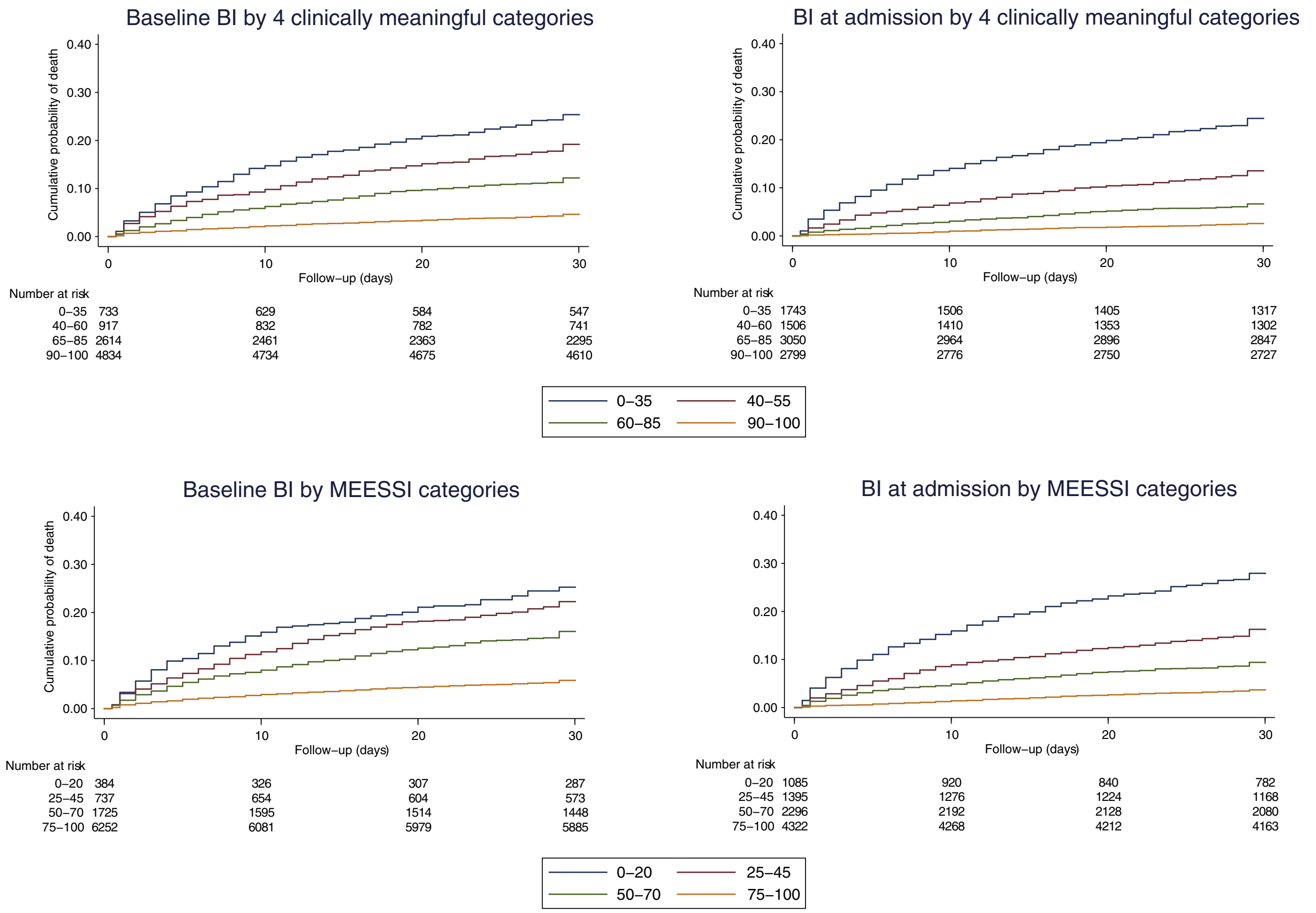



**Figure 2.** Kaplan-Meier curves evaluating the association between several BI grouping classifications and 30-day mortality.

functional reserve.[21] However, we failed to demonstrate this additive prognostic value when acute functional impairment was added to ED BI score alone, which simplifies the prognosis assessment at the ED visit because the ED BI score provides enough information. Despite not having an effect on 30-day mortality prediction, the degree of functional impairment might be useful in clinical decisionmaking and in the design of individualized care plans.

A reduction in physical function is commonly observed in older patients admitted with decompensated chronic cardiopulmonary conditions.[24] The percentage of acute functional impairment (1 out of 2 patients) is similar to that of previous studies.[25] The effect of the acute episode on activities of daily living may be worsened by the presence of comorbidities, sarcopenia, cognitive impairment, mood disorders, malnutrition, polypharmacy, and immobilization as a result of hospitalization.[8,26] Similarly, a recent study showed that factors such as physical frailty in older patients with acute heart failure and with nonsevere dependency, delirium, risk of malnutrition, and a recent hospitalization could have a synergistic effect

**Table 2.** Model performance using several classifications of the BI either at baseline or the ED visit for predicting 30-day mortality.

| | Baseline BI *c* Statistic (95% CI) | ED Visit BI *c* Statistic (95% CI) |
|---|---|---|
| By 10-point intervals | 0.698 (0.680–0.716) | 0.743 (0.726–0.760) |
| By 4 clinically meaningful groups of 0–35, 40–60, 65–85, and 90–100 | 0.689 (0.671–0.706) | 0.731 (0.715–0.747) |
| By MEESSI risk score categories 0–20, 25–45, 50–70, and 75–100 | 0.666 (0.649–0.684) | 0.724 (0.707–0.740) |

*CI*, Confidence interval.
For all comparisons between baseline and the ED visit BI scores, $P<.001$.

on disability and affect short-term prognosis.[27] Therefore, awareness of noncardiovascular variables with predictive value may be particularly relevant for very old patients with acute heart failure, particularly those presenting with acute functional impairment.

Our findings have several important implications for clinical practice. Thirty-day mortality is high in acute heart failure, and simple tools to identify individual risk are needed in the ED setting to estimate prognosis and to assist emergency physicians in making disposition decisions.[26] In our study, BI score at the ED visit identified several groups of patients who were at risk of poor short-term outcomes. Although early recognition of acute functional impairment and baseline functional status did not add prognostic value to the BI score at the ED visit, these might help in designing a plan either focused on returning to previous functional status (mildly or moderately frail patient) or oriented to mainly manage symptoms (severely frail patient). These decisions should be determined in conjunction with the severity and cause of the acute episode, the presence of comorbid conditions, and the desires and expectations of the patient.[2] Future research should be focused on assessing whether BI score at the ED visit merely represents a prognostic marker without grounds for disease-modifying interventions or whether management strategies aimed at improving patient functional status may have an effect on 30-day mortality reduction. The additive prognostic value of this marker in addition to provider decisionmaking and health care planning is currently unclear.

In summary, functional status assessed by the BI score at the ED visit is a strong predictor for all-cause 30-day mortality in acute heart failure patients attending the ED. Baseline BI score and the change in BI score from baseline to the ED visit did not add prognostic value when ED BI score was taken into account. Therefore, to predict 30-day mortality systematic collection of functional status at the ED visit should be recommended for all patients with acute heart failure who are attending the ED.

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## REFERENCES


1. Miró Ò, Levy PD, Möckel M, et al. Disposition of emergency department patients diagnosed with acute heart failure. *Eur J Emerg Med*. 2017;24:2-12.
2. Miró Ò, Peacock FW, McMurray JJ, et al. European Society of Cardiology–Acute Cardiovascular Care Association position paper on safe discharge of acute heart failure patients from the emergency department. *Eur Heart J Acute Cardiovasc Care*. 2017;6:311-320.
3. Aimo A, Barison A, Mammini C, et al. The Barthel Index in elderly acute heart failure patients. Frailty matters. *Int J Cardiol*. 2018;254:240-241.
4. Formiga F, Chivite D, Conde A, et al. Basal functional status predicts three-month mortality after a heart failure hospitalization in elderly patients—the prospective RICA study. *Int J Cardiol*. 2014;172:127-131.
5. Chivite D, Formiga F, Corbella X, et al. Basal functional status predicts one-year mortality after a heart failure hospitalization in elderly patients—the RICA prospective study. *Int J Cardiol*. 2018;254:182-188.
6. Miró O, Llorens P, Martín-Sánchez FJ, et al. Short-term prognostic factors in elderly patients seen in emergency departments for acute heart failure. *Rev Esp Cardiol*. 2009;62:757-764.
7. Javier Martín-Sánchez F, Gil V, Llorens P, et al. Barthel Index–Enhanced Feedback for Effective Cardiac Treatment (BI-EFFECT) study: contribution of the Barthel Index to the Heart Failure Risk Scoring System model in elderly adults with acute heart failure in the emergency department. *J Am Geriatr Soc*. 2012;60:493-498.
8. 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.
9. Fernández Alonso C, Martín Sánchez FJ, Fuentes Ferrer M, et al. Valor pronóstico de la valoración funcional al ingreso en una unidad de corta estancia de Urgencias. *Rev Esp Geriatr Gerontol*. 2010;45:63-66.
10. Rozzini R, Sabatini T, Cassinadri A, et al. Relationship between functional loss before hospital admission and mortality in elderly persons with medical illness. *J Gerontol A Biol Sci Med Sci*. 2005;60:1180-1183.
11. Alarcón T, Bárcena A, González-Montalvo JI, et al. Factors predictive of outcome on admission to an acute geriatric ward. *Age Ageing*. 1999;28:429-432.
12. Miró Ò, Rossello X, Gil V, et al. Predicting 30-day mortality for patients with acute heart failure in the emergency department. *Ann Intern Med*. 2017;167:698.
13. Herrero-Puente P, Martín-Sánchez FJ, Fernández-Fernández M, et al. Differential clinical characteristics and outcome predictors of acute heart failure in elderly patients. *Int J Cardiol*. 2012;155:81-86.
14. Ho KK, Anderson KM, Kannel WB, et al. Survival after the onset of congestive heart failure in Framingham Heart Study subjects. *Circulation*. 1993;88:107-115.
15. 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.
16. Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J*. 1965;14:61-65.
17. Cabañero-Martínez MJ, Cabrero-García J, Richart-Martínez M, et al. The Spanish versions of the Barthel Index (BI) and the Katz Index (KI) of activities of daily living (ADL): a structured review. *Arch Gerontol Geriatr*. 2009;49:e77-e84.
18. White IR, Royston P, Wood AM. Multiple imputation using chained equations: issues and guidance for practice. *Stat Med*. 2011;30:377-399.
19. Osuna-Pozo CM, Ortiz-Alonso J, Vidán M, et al. [Review of functional impairment associated with acute illness in the elderly]. *Rev Esp Geriatr Gerontol*. 2014;49:77-89.
20. Cook NR. Use and misuse of the receiver operating characteristic curve in risk prediction. *Circulation*. 2007;115:928-935.
21. Covinsky KE, Palmer RM, Counsell SR, et al. Functional status before hospitalization in acutely ill older adults: validity and clinical importance of retrospective reports. *J Am Geriatr Soc*. 2000;48:164-169.
22. Sligl WI, Eurich DT, Marrie TJ, et al. Only severely limited, premorbid functional status is associated with short- and long-term mortality in patients with pneumonia who are critically ill: a prospective observational study. *Chest*. 2011;139:88-94.
23. Shah S, Vanclay F, Cooper B. Improving the sensitivity of the Barthel Index for stroke rehabilitation. *J Clin Epidemiol*. 1989;42:703-709.
24. Pitta F, Troosters T, Probst VS, et al. Physical activity and hospitalization for exacerbation of COPD. *Chest*. 2006;129:536-544.
25. Covinsky KE, Palmer RM, Fortinsky RH, et al. Loss of independence in activities of daily living in older adults hospitalized with medical illnesses: increased vulnerability with age. *J Am Geriatr Soc*. 2003;51:451-458.
26. Martín-Sánchez FJ, Christ M, Miró Ò, et al. Practical approach on frail older patients attended for acute heart failure. *Int J Cardiol*. 2016;222:62-71.
27. Martín-Sánchez F, Rodríguez-Adrada E, Vidan M, et al. Impact of geriatric assessment variables on 30-day mortality among older patients with acute heart failure. *Emergencias*. 2018;30:149-155.


## APPENDIX

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## IMAGES IN EMERGENCY MEDICINE

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**DIAGNOSIS:**

*Necrotizing fasciitis of the thigh as a result of intraperitoneal bowel leak.* The CT demonstrated rectal anastomotic breakdown and gas and fluid communication through the greater sciatic foramen into the lower-extremity musculature, which was concerning for necrotizing fasciitis. He was treated with broad-spectrum antibiotics and taken for emergency debridement. Blood and operative-site cultures grew *Streptococcus anginosus* and *Escherichia coli*.

Although occurrences are rare, pelvic infections may descend into the thigh, causing deep-space infection and necrotizing fasciitis. This phenomenon has been described in individuals without cancer but appears to be more likely in patients with colorectal malignancies.[1-6] In a 2015 report, 7 of 10 case reports found by the authors were associated with such cancers.[7] Typical physical examination findings of necrotizing fasciitis may be delayed, although the association of stooling with thigh pain could alert clinicians to this entity.

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**REFERENCES**

1. Takakura Y, Ikeda S, Yoshimitsu M, et al. Retroperitoneal abscess complicated with necrotizing fasciitis of the thigh in a patient with sigmoid colon cancer. *World J Surg Oncol*. 2009;7:74.
2. Liu SYW, Ng SSM, Lee JFY. Multi-limb necrotizing fasciitis in a patient with rectal cancer. *World J Gastroenterol*. 2006;12:5256-5258.
3. Highton L, Clover J, Critchley P. Necrotising fasciitis of the thigh secondary to a perforated rectal cancer. *J Plast Reconstr Aesthet Surg*. 2009;62:17-19.
4. Park SH, Choi JR, Song JY, et al. Necrotizing fasciitis of the thigh secondary to radiation colitis in a rectal cancer patient. *J Korean Soc Coloproctol*. 2012;28:325-329.
5. Stevens DL, Bryant AE. Necrotizing soft-tissue infections. *N Engl J Med*. 2017;377:2253-2265.
6. Hua J, Yao L, He Z-G, et al. Necrotizing fasciitis caused by perforated appendicitis: a case report. *Int J Clin Exp Pathol*. 2015;8:3334-3338.
7. Evans WDG, Winters C, Amin E. Necrotising fasciitis secondary to perforated rectal adenocarcinoma presenting as a thigh swelling. *BMJ Case Rep*. 2015;2015:bcr2014208312.