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ORIGINAL RESEARCH

HEART FAILURE AND CARDIOMYOPATHIES

The HEARTRISK6 Scale

Predicting Short-Term Serious Outcomes in Emergency Department Acute Heart Failure Patients

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ABSTRACT

BACKGROUND Acute heart failure (AHF) is a common emergency department (ED) presentation that may have poor outcomes but often does not require hospital admission. There is little evidence to guide dispositional decisions.

OBJECTIVES The authors sought to create a risk score for predicting short-term serious outcomes (SSO) in patients with AHF.

METHODS We pooled data from 3 prospective cohorts: 2 published studies and 1 new cohort. The 3 cohorts prospectively enrolled patients who required treatment for AHF at 10 tertiary care hospital EDs. The primary outcome was SSO, defined as death <30 days, intubation or noninvasive ventilation (NIV), myocardial infarction, or relapse to ED <14 days. The logistic regression model evaluated 13 predictors, used an AIC-based step-down procedure, and bootstrapped internal validation.

RESULTS Of the 2,246 patients in the 3 cohorts (N = 559; 1,100; 587), the mean age was 77.4 years, 54.5% were male, 3.1% received intravenous nitroglycerin, 5.2% received ED NIV, and 48.6% were admitted to the hospital. There were 281 (12.5%) SSOs including 70 deaths (3.1%) with many in discharged patients. The final HEARTRISK6 Scale included 6 variables: valvular heart disease, tachycardia, need for NIV, creatinine, troponin, and failed reassessment (walk test). Choosing HEARTRISK6 total-point admission thresholds of ≥1 or ≥2 would yield, respectively, sensitivities of 88.3% (95% CI: 83.9%-91.8%) and 71.5% (95% CI: 65.9%-76.7%) and specificities of 24.7% (95% CI: 22.8%-26.7%) and 50.1% (95% CI: 47.9%-52.4%) for SSO.

CONCLUSIONS Using 3 large prospectively collected datasets, we created a concise and sensitive risk scale for patients with AHF in the ED. Implementation of the HEARTRISK6 scale could lead to safer and more efficient disposition decisions. (JACC Adv 2024;3:100988) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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ABBREVIATIONS AND ACRONYMS

AHF = acute heart failure
ECG = electrocardiogram
ED = emergency department
MI = myocardial infarction
NIV = non-invasive ventilation

Each year, more than 1 million patients with sudden dyspnea due to acute heart failure (AHF) present to U.S. and Canadian hospitals for treatment. AHF is a common and serious condition that frequently results in morbidity and death and is a leading cause of hospital admissions for seniors.[1-4] Physicians treating AHF patients in the emergency department (ED) must make the difficult decision of whether to admit or discharge them. Not all patients will benefit from hospitalization, as many will respond to therapy in the ED. Conversely, many AHF patients may go on to have adverse outcomes due to disease progression, ie, they die, require intensive care therapy, or suffer myocardial infarction (MI) while in the hospital. Further, some patients discharged from the ED after treatment die or relapse back to the ED and require admission. Efficient admission decisions are important because there is frequently a shortage of available beds in hospitals, and many EDs are severely overcrowded. We previously documented that <50% of AHF patients seen in Canadian EDs were admitted to hospitals and that 1 in 10 of those not admitted suffered short-term serious outcomes (SSO).[5,6]

While there are many excellent guidelines on the investigation and treatment of heart failure, there is very limited literature on how to determine if these patients should be admitted or discharged from the ED.[3,7,8] Many risk scoring systems have been proposed for AHF patients, but few have been considered to have a low risk of bias or to be practical for ED use.[9] A concise clinical tool that estimates the risk of poor outcomes could help clinicians with disposition decisions for patients with AHF.

We previously published 2 studies that sought to create a risk scoring tool to assist with disposition decisions for patients with AHF.[5,6] These prospective cohort studies identified simple bedside criteria that could be used to estimate the subsequent risk of SSO. These derived models had 10 variables, which may be too many for optimal use in a busy ED. Consequently, our goal for the current study was to use a much larger patient sample to create a more concise and practical risk scale for AHF patients.

METHODS

DESIGN AND SETTING. We conducted 3 prospective cohort studies of patients with AHF and have pooled the data for the current analysis. The first cohort study (RAD1: 2007-2010) enrolled 559 patients.[5] The second cohort study (RAD2: 2011-2015) enrolled 1,100 patients.[6] The third cohort (2015-2019) has not been published and enrolled 587 patients. All studies were conducted at 10 academic hospital EDs in Canada.

STUDY POPULATION. We included consecutive visits of patients ≥50 years of age who presented to the ED with shortness of breath (<7 days duration) due to AHF. Eligibility of patients was reviewed by the study steering committee. For all studies, we included both patients subsequently admitted to the hospital and those discharged from the ED, as inclusion of both groups of patients allows us to better model the risk of SSO for all patients. As there is no gold standard for the diagnosis of heart failure, we used the criteria recommended by the Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure of the European Society of Cardiology.[2] To be eligible, patients had to have appropriate symptoms (shortness of breath or fatigue) with clinical signs of fluid retention (pulmonary or peripheral) in the presence of an underlying abnormality of cardiac structure or function. In instances where doubt remained, a beneficial response to treatment (eg, a brisk diuresis accompanied by improvement in breathlessness) was considered. We did not use NT-proBNP measurements as most Canadian EDs did not have access to this test, and same-day echocardiography is rarely available.

We excluded patients who did not fit the definition of AHF or who were clearly too ill to be considered for discharge after 2 to 12 hours of ED management: 1) resting oxygen saturation <85% on room air or after being on home oxygen level for 20 minutes; 2) heart rate ≥120 beats/min; 3) systolic blood pressure <85 mm Hg; 4) confusion, disorientation, dementia; 5) primary presentation is for ischemic chest pain requiring treatment or with acute ischemic ST-T changes on initial electrocardiogram (ECG); 6) ST-segment elevation MI on initial ECG; 7) terminal status: death expected within weeks from chronic illness; 8) from nursing home or chronic care facility (not the senior's residence); 9) enrolled in the previous 2 months; or 10) on chronic hemodialysis. No patients who were discharged home were excluded.

DATA COLLECTION. Patients were assessed for standardized clinical variables by ED staff physicians (all certified in emergency medicine) or by supervised residents in emergency medicine training programs, who were trained by means of a 1-hour practical session. The variables were assessed and interpreted at a target of 2 to 8 hours after ED treatment (to a maximum of 12 hours) and recorded on a physician data form. Research assistants collected other clinical and laboratory results from the electronic patient

records including standardized variables from the history, clinical examination, routine laboratory values, cardiac troponins (initial and repeat <6 hours within the ED), chest x-ray, and initial and repeat ECG. NT-proBNP values were not used in our modeling as they were only available for a minority of patients. Patients were reassessed after treatment and were considered "successful" if they could start and complete a walk test, during which they were asked to walk at their own pace in the ED for a period of 3 minutes, regardless of the distance covered.[5] Patients were considered "unsuccessful" if they were too ill to start or complete the walk test due to abnormal vital signs (SaO_2 < 90% on room air or usual O_2, or HR >110 beats/min, or respiratory rate > 28).

OUTCOME MEASURES. The primary outcome was the composite short-term serious outcome defined as:

a) Death from any cause within 30 days of the index ED visit, or

b) Any of the following within 14 days of the ED visit, regardless of whether initially admitted: 1) Endotracheal intubation or need for noninvasive ventilation (NIV) after hospital admission (not in the ED), unless on NIV at home; 2) MI diagnosed after admission (not in the ED), as defined by the Joint ESC/ACCF/AHA/WHF Task Force for the Third Universal Definition of Myocardial Infarction[10] (the fourth was not published at the time of patient enrollment);[11] 3) major procedure defined as unplanned coronary artery bypass graft, percutaneous coronary intervention, cardiac valvular surgery, or new hemodialysis; 4) relapse and hospital admission for patients who were discharged on the initial ED visit, defined as a return to the ED for any related medical problem within 14 days resulting in admission to the hospital. We believe that this composite outcome is more meaningful to patients and ED physicians as it represents a pragmatic combination of death and other undesirable outcomes, which we hope can be prevented by admission to the hospital.

The presence of a SSO was verified by a subcommittee of senior investigators blinded to the predictors. This outcome was well defined and easy to verify from the source documents: 1) ED health records; 2) hospital health records; 3) computerized hospital patient tracking and record system; and 4) review of provincial death records. Any remaining patients were followed by telephone after 30 days.

STATISTICAL ANALYSIS. We adhered to the principles of the TRIPOD Statement for reporting of multivariable prediction models.[12] We conducted logistic regression modeling to predict SSO using the 13 variables that were prespecified as predictors for the rule (Supplemental Material). These variables were chosen a priori before model building, based upon those variables evaluated in the 2 prior studies and the clinical experience of the expert investigators.

Multicollinearity was examined using a variable clustering algorithm and variance inflation factors. Heart rate and creatinine were log-transformed due to

TABLE 1 Characteristics of Acute Heart Failure Patient Visits (N = 2,246)

Study (%)	
RAD1	559 (24.9)
RAD2	1,100 (49.0)
Cohort 3	587 (26.1)
Hospital site (%)	
Ottawa Hospital Civic Campus - Ottawa	863 (38.4)
Ottawa Hospital General Campus - Ottawa	316 (14.1)
Mount Sinai Hospital - Toronto	304 (13.5)
Kingston General Hospital - Kingston	279 (12.4)
University of Alberta - Edmonton	229 (10.2)
Foothills Medical Centre - Calgary	145 (6.5)
London Health Sciences Centre - London	73 (3.3)
Jewish General Hospital - Montreal	24 (1.1)
Hotel Dieu Hospital - Kingston	8 (0.4)
North East Community Health Centre - Edmonton	5 (0.2)
Demographics	
Age, y	77.4 ± 10.6
Range	49-104
Male (%)	1,224 (54.5)
Arrival status	
Arrival by ambulance (%)	924 (41.1)
Temperature, °C (N = 2,123)	36.2 ± 0.7
Heart rate, beats/min	84.2 ± 20.1
Respiratory rate	22 ± 5.7
Systolic blood pressure, mm Hg	141 ± 27.3
SaO_2 by oximetry	94.6 ± 4.8
Duration of dyspnea, h	62.2 ± 57.1
Canadian Triage Acuity Scale (CTAS)[a]	2 (2-3)
Past medical history (%)	
Heart failure	1,638 (72.9)
Hypertension	1,624 (72.3)
Diabetes	903 (40.2)
Permanent atrial fibrillation	850 (37.8)
Myocardial infarction	736 (32.8)
Coronary artery bypass graft	499 (22.2)
Chronic obstructive pulmonary disease	487 (21.7)
Chronic renal failure	479 (21.3)
Valvular heart disease	420 (18.7)
Pacemaker	358 (15.9)
Stroke or transient ischemic attack	339 (15.1)
Angina	219 (9.8)
Percutaneous coronary intervention	144 (6.4)
Active cancer	118 (5.3)
Peripheral vascular disease (intervention)	103 (4.6)
Dementia	78 (3.5)
Intubation for respiratory distress	22 (1.0)
Smoker: current or former (%)	789 (35.1)
Home oxygen (%)	130 (5.8)
Ejection fraction from medical records (N = 1,617)	45.1 ± 16.1

Continued on the next page

TABLE 1 Continued

Current cardiac medications (%)	
ACE inhibitors	965 (43.0)
Antiarrhythmics	164 (7.3)
Amiodarone	147 (6.5)
Sotalol	11 (0.5)
Propafenone	3 (0.1)
Anticoagulants	927 (41.3)
Warfarin	672 (29.9)
New oral anticoagulant (dabigatran, rivaroxaban, apixaban)	255 (11.4)
Antiplatelet medications	1,019 (45.4)
Beta blockers	1,517 (67.5)
Calcium channel blockers	754 (33.6)
Digoxin	267 (11.9)
Diuretics	1,667 (74.2)
Nitrates	640 (28.5)
Statins	1,326 (59.0)
Vasodilators	97 (4.3)
Emergency department treatment (%)	
Intravenous diuretic	2,009 (89.4)
Sublingual nitroglycerin	167 (7.4)
Intravenous nitroglycerin	69 (3.1)
Noninvasive positive pressure ventilation	116 (5.2)
Laboratory values	
Hemoglobin (g/L)	119.2 ± 20.4
White blood cell (10^9/L)	8.9 ± 5.1
Urea (mmol/L) (N = 2,109)	10.5 ± 6.2
Creatinine (μmol/L)	120.9 ± 67.5
Serum CO_2 (mmol/L)	25.7 ± 3.8
Potassium (mmol/L)	4.3 ± 2.9
Glucose (mmol/L)	7.7 ± 3.4
pCO_2 (mm Hg) (N = 981)	46.5 ± 10.8
pH (N = 980)	7.4 ± 0.1
Troponin on arrival > upper reference level (%)[b]	1,091 ± 48.6
Highest troponin >3× upper reference level (%)[b]	386 ± 17.2
Electrocardiogram findings (%)	
Atrial fibrillation or flutter	837 (37.3)
A-V conduction disturbance	734 (32.7)
Chest x-ray findings (%)	
Cardiomegaly	1,162 (51.7)
Pulmonary congestion	1,466 (65.3)
Pleural effusion	1,248 (55.6)
Pneumonia	130 (5.8)

Values are n (%), mean ± SD, or median (IQR). [a]Canadian Triage Acuity Scale (CTAS) ranges from 1 (most urgent) to 5 (least urgent). [b]Unable to pool troponin values because of different assays used.

TABLE 2 Outcomes of Acute Heart Failure Patient Visits (N = 2,246)

Admitted to hospital on index emergency department visit (%)	1,091 (48.6)
Noninvasive ventilation required after admission (N = 1,091)	43 (3.9)
Intubation required after admission (N = 1,091)	15 (1.4)
Myocardial infarction after admission (N = 1,091)	33 (3.0)
Major procedure (N = 1,091)	59 (5.4)
Coronary artery bypass graft	13 (1.2)
Percutaneous coronary intervention	14 (1.3)
Valvular cardiac surgery	17 (1.6)
New hemodialysis	14 (1.3)
Death after admission (N = 1,091)	39 (3.6)
Death after discharge within 30 days (N = 1,091)	14 (1.3)
Discharged from the emergency department	1,155 (51.4)
Relapse back to emergency department within 14 days (%) (N = 1,155)	246 (21.3)
Dyspnea	189 (16.4)
Chest pain	45 (3.9)
Inability to ambulate	12 (1.0)
Fever	8 (0.7)
Sepsis	2 (0.2)
Other	80 (6.9)
Relapse and admitted to hospital within 14 days (%) (N = 1,155)	120 (10.4)
Admitted to intensive care unit (N = 120)	11 (9.2)
Death within 30 days (%) (N = 1,155)	17 (1.5)
Short-term serious outcomes (%)	281 (12.5)
Admitted patients (N = 1,091)	157 (14.4)
Discharged patients (N = 1,155)	124 (10.7)
Total deaths, inside and out of hospital (%)	70 (3.1)

Values are n (%).

their skewed distributions. Prior to logistic regression analysis, we generated 10 multiple imputation-completed datasets, employing the method of predictive mean matching and using the bootstrap to approximate the process of drawing predicted values from a full Bayesian predictive distribution.[13] The imputation model consisted of all candidate predictor variables, the outcome, and auxiliary variables (see Supplemental Material). The fully prespecified model with 13 predictors (where age, CO_2, and SaO_2 are modeled using restricted cubic spline functions with 3 knots, and log heart rate, and log creatinine with 5 knots) was fitted separately to each of the 10 multiple imputation-completed datasets, and the results were combined across the datasets using Rubin's rules. Further, we used an Akaike information criterion-based stepdown procedure to reduce the number of variables in the model.[14,15] We used bootstrap internal validation, generating 1,000 bootstrap samples and calculating optimism-corrected performance. Using regression coefficients, we then created a scoring grid, assigning points for different levels of the predictor variables and evaluating the observed and estimated risks for each score total. Next, calibration plots were created for the final model. We then calculated the impact on sensitivity and specificity for SSO, as well as on potential hospital admissions. Finally, we compared various cut-points of the total score to current clinical practice.

RESEARCH ETHICS. The research ethics boards of 2 hospitals determined that written informed consent was required, whereas those at the other sites waived

the need for written consent for this observational study. Patients were not involved in the design, conduct, or interpretation of this study.

RESULTS

In total, 2,246 patients from the 3 cohorts (n = 559, n = 1,100, and n = 587) (Supplement Figure 1) at 10 hospital sites were included. The patients had a mean age of 77.4 years, 54.5% were male, 41.1% arrived by ambulance, 37.3% were found to be in permanent atrial fibrillation or flutter, and the mean ejection fraction was 45.1% (**Table 1**). In the ED, most (89.4%) received IV diuretics, 5.2% received NIV, and 3.1% were given IV nitroglycerin. Almost one-half (48.6%) had initial ED troponin levels greater than the upper reference level. Another 2,132 eligible patients who were not enrolled were very similar except for a higher proportion admitted (Supplemental Table 1).

On the index ED visit, 48.6% were admitted to the hospital, and the remaining 51.4% were discharged home (**Table 2**). Among those admitted, 14.4% suffered a short-term serious outcome after admission (not in the ED) including death (3.6%), NIV (3.9%), intubation (1.4%), MI (3.0%), and/or major procedure (5.4%). Among those initially discharged, 10.7% experienced SSO including death (1.5%) and return visit with admission (10.4%).

A comparison of patients with and without SSO is shown in the Supplemental Table 2. The 281 (12.5%) patients with SSO were more likely to have arrived by ambulance, have a heart rate ≥110 on ED arrival, have a history of valvular heart disease or chronic kidney disease, have elevated creatinine and troponin levels, have received NIV or IV nitroglycerin in the ED, and have failed reassessment (walk test).

Multiple imputations were required for 3 predictor variables with missing values (SaO2 1%, CO2 1%, and troponin 4%; Supplemental Table 3). No problems with multicollinearity were detected among the 13 predictor variables (Supplemental Table 4). The full prediction model of the 13 variables before the step-down procedure is shown in the Supplemental Tables 5 and 6 (C-statistic 0.69 [95% CI: 0.66-0.72]). Across the 1,000 bootstrap samples, a 6-variable model was identified 26% of the time (Supplemental Table 7). **Table 3** shows the 6 independent predictors of SSO in the final clinical model (Supplemental Figure 3).

The "HEARTRISK6" scoring scale, ranging from 0 to 12 total points (**Figure 1**), included a history of moderate-severe valvular heart disease, elevated heart rate on arrival, need for NIV in the first hour, increased creatinine and troponin levels in the ED, and failure of reassessment after ED treatment.

TABLE 3 Independent Predictors of Short-Term Serious Outcomes as Determined by Multiple Logistic Regression Analysis for 2,246 Acute Heart Failure Patient Visits

	Beta (95% CI)	OR (95% CI)	Points
History of valvular heart disease	0.64 (0.34-0.94)	1.90 (1.40-2.56)	1
Heart rate (log-transformed)	0.34 (0.13-0.56)	1.41 (1.14-1.75)	2-3
Treated with noninvasive ventilation	0.95 (0.50-1.40)	2.58 (1.65-4.04)	2
Creatinine (log-transformed)	0.34 (−0.01 to 0.69)	1.40 (0.99-1.99)	2-3
Troponin ≥1 × URL	0.04 (−0.36 to 0.44)	1.04 (0.70-1.56)	0
Troponin ≥2 × URL	0.01 (−0.36 to 0.38)	1.01 (0.70-1.46)	0
Troponin ≥3 × URL	0.40 (−0.18 to 0.98)	1.49 (0.84-2.66)	1
Troponin ≥4 × URL	0.21 (−0.50 to 0.93)	1.24 (0.60-2.54)	1
Troponin ≥5 × URL	0.94 (0.55-1.32)	2.55 (1.74-3.75)	2
Reassessment failed	0.29 (0.02-0.56)	1.34 (1.02-1.75)	1

Area under receiver operating characteristic curve: 0.68 (95% CI: 0.65-0.71).
URL = upper reference level.

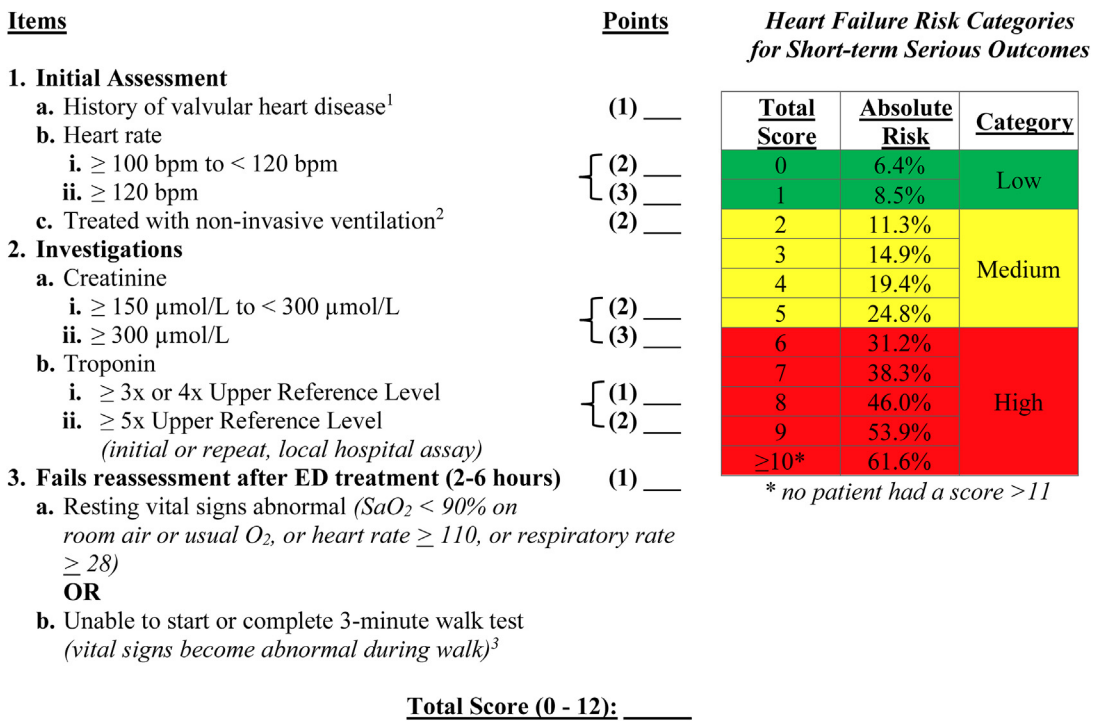
"Moderate-severe valvular disease" was based on a prior diagnosis from cardiology notes, echocardiograph reports, or discharge records.

Table 4 shows the observed incidence of SSO at each cut-point level, as well as sensitivity, specificity, and projected admission levels, compared to the actual practice of the treating physicians (Supplemental Table 8). For example, if admission to the hospital was suggested for patients with a total score of ≥1, then the sensitivity for SSO would be 88.3%, the specificity 24.7%, and the proportion admitted 76.9%. Alternately, a threshold score of ≥2 would yield sensitivity 71.5%, specificity 50.1%, and proportion admitted 52.6%. These compare to existing Canadian clinical practice, which had a much lower sensitivity of 55.9%, a similar specificity of 52.5%, and lower admissions of 48.6%. We also demonstrated good calibration for the clinical model with the slope of the observed vs expected graph very close to 1.0 (Supplemental Figure 2).

DISCUSSION

We included 2,246 patients seen in multiple EDs with a wide range of severity of acute heart failure. With a large number of serious short-term outcome cases, we were able to derive a robust predictive model that demonstrated good calibration and potentially better performance than current practice. Over 10% of those initially discharged from the ED went on to have serious short-term outcomes. The derived HEARTRISK6 Scale, comprised of 6 routine ED criteria, can be applied very quickly, estimates the risk of a poor outcome, and gives attending physicians important medical information upon which to make disposition decisions. In settings where admission for AHF is

FIGURE 1 The HEARTRISK6 Acute Heart Failure Risk Scale



[1]History of valvular heart disease: moderate or severe valvular heart disease from prior cardiology or imaging notes. [2]Treated with noninvasive ventilation: BiPAP within 1 hour of initial assessment. [3]Unable to start or complete a 3-minute walk test (vital signs become abnormal during the walk test): score if patient's O_2 drops below 90%, heart rate ≥110 beats/min, respiratory rate ≥28 during walk test, or if patient is unable to complete due to fatigue or dyspnea. ED = emergency department.

TABLE 4 Estimated Probability of Having Short-Term Serious Outcomes for 2,246 Acute Heart Failure Patients Visits

Current Practice	Number of Visits (N = 2,246)	Score-Specific Incidence of SSO (%) (n = 281, 12.5%)	Threshold Sensitivity % 55.9% (95% CI: 49.9%-61.8%)	Threshold Specificity % 52.5% (95% CI: 50.2%-54.7%)	Threshold Admission (N = 48.6%)
Score	2,246				
0	518	33 (6.4)	100 (98.7-100)	-	100
1	547	47 (8.5)	88.3 (83.9-91.8)	24.7 (22.8-26.7)	76.9
2	379	43 (11.3)	71.5 (65.9-76.7)	50.1 (47.9-52.4)	52.6
3	396	59 (14.9)	55.2 (49.1-61.1)	67.1 (65.0-69.2)	35.7
4	206	40 (19.4)	37.0 (31.4-43.0)	84.6 (84.6-86.2)	18.1
5	116	29 (24.8)	24.2 (19.3-29.6)	93.3 (92.1-94.4)	8.9
6	45	14 (31.2)	10.0 (6.7-14.1)	97.2 (96.3-97.8)	3.7
7	25	10 (38.3)	5.0 (2.8-8.2)	98.7 (98.1-99.2)	1.7
8	7	3 (46.0)	1.4 (0.4-3.6)	99.5 (99.1-99.8)	0.6
9	5	3 (53.9)	1.1 (0.2-3.1)	99.8 (99.5-99.9)	0.3
≥10	2	1 (61.6)	-	100 (99.8-100)	0.1

Values are n, n (%), or % (95% CI).
SSO = short-term serious outcomes.

relatively high, using a cut-point total score of 1 or more as an indication for admission would yield high sensitivity while allowing one-quarter of patients to be discharged home. In hospitals with typically lower admission rates, using a cut-point of 2 or more would significantly improve sensitivity for SSO with only a slight increase in hospital admissions. To our knowledge, no other risk tools are routinely in use for ED patients with AHF.

PREVIOUS STUDIES. A systematic review by Michaud in 2018 highlighted 9 scales with the purpose of assigning risk for ED patients with AHF.[5,6,9,16-22] The authors conclude that the scales created by Lee and our group had the most robust body of evidence but had important differences between them. The EHMRG scale published by Lee has very recently undergone an implementation trial (COACH), which combined the prediction of risk with rapid cardiology follow-up for intermediate-risk patients.[19,23,24] Concerns with the EHMRG scale include its complexity with 11 variables and the fact that it only predicts death and 30-day return visits without considering serious outcomes that occur within hospitals. The HEARTRISK6 Scale is the successor to our prior models, but it performs better and has fewer variables making it more clinically useful.[5,6] Sister studies to create the Ottawa Chronic Obstructive Pulmonary Disease Scale were larger and more successful.[25-27] Miro, Gil, and Spanish colleagues published an additional paper not included in the Michaud review that analyzed registry data and, interestingly, did not present patient characteristics.[28,29] This scale only predicted mortality and was comprised of 13 variables including NT-proBNP levels.

Society guidelines offer excellent advice on management for patients with AHF but little guidance on short-term risk stratification and disposition from the ED. The European Society of Cardiology gives extensive advice on AHF treatment but does not discuss disposition from the ED.[7] The 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure implies that all patients with AHF will be admitted and does not discuss alternative dispositions.[8] The Canadian Cardiovascular Society guidelines provide detailed instruction on the diagnosis and management of AHF but do not address ED disposition decisions.[3]

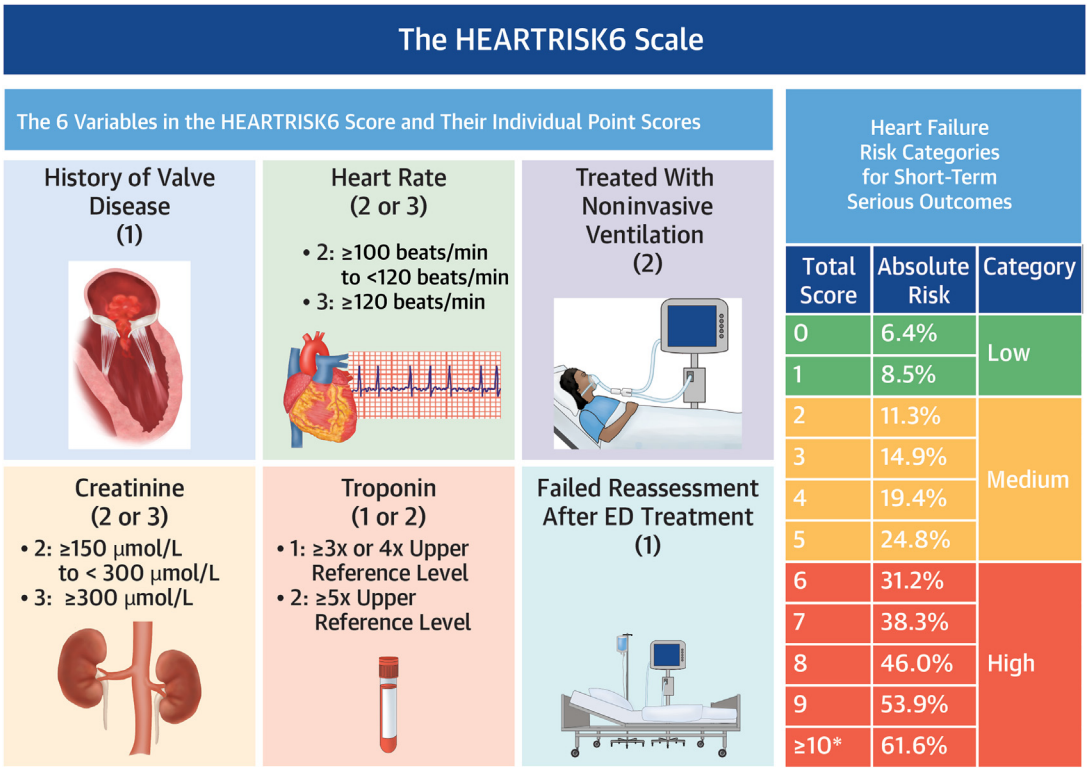
STUDY LIMITATIONS AND STRENGTHS. Our study has some limitations. While we have demonstrated the potential for improved patient outcomes with the use of the HEARTRISK6 Scale, this has yet to be shown in an implementation trial. We used robust internal validation rather than split-sample validation, which is an inefficient and outdated approach,[30] but future external validation by an independent group is recommended. We note that our 2 most recent cohorts prospectively evaluated all 6 variables in the final HEARTRISK6 Scale, ie, we have introduced no new criteria. Finally, we acknowledge that when the study was first designed, we did not solicit patient or caregiver input.

We have discussed other issues above that some may consider to be limitations: why we chose a composite outcome, that troponin drawn on ED arrival is not both a predictor and an outcome, why we studied both admitted and discharged patients, and how we compare the scale to current clinical practice, which has much lower sensitivity.

Strengths of our study include data that were wholly collected prospectively and a very large cohort. We focused on AHF patients undergoing treatment in the ED, and this is the only study to evaluate response to treatment. Further, our primary outcome includes not just mortality but morbidity at 14 days, which is known to predict poor prognosis. Finally, all 6 components are easy to collect for bedside clinicians and do not require testing such as echocardiography or NT-proBNP levels, which may not be readily available.

CLINICAL IMPLICATIONS. Physicians dealing with AHF patients in the ED often must make difficult disposition decisions. The severity of the acute episode may mandate admission to the hospital. Many patients, however, improve rapidly with diuresis and may be well enough to go home. The HEARTRISK6 Scale provides additional information to the physician in the ED trying to decide whether to admit or discharge (**Central Illustration**). With rapid assessment of the 6 component variables, the attending physician can estimate the risk that their patient will suffer a short-term serious outcome that might be prevented by hospital admission. We recognize that there are other factors for clinicians to consider such as the degree of home support the patient may have and the potential of optimizing medical therapy such as increasing the dosage of diuretics. Moreover, patients may not have early access to either a family doctor or a specialist for

CENTRAL ILLUSTRATION **The HEARTRISK6 Scale: Predicting Short-Term Serious Outcomes in Emergency Department Acute Heart Failure Patients**



Components of the HEARTRISK6 scale. *No patient had a score >11. ED = emergency department.

prompt reassessments to consider further investigations and treatments.[31]

We maintain that the components of the HEARTRISK6 Scale have been sufficiently tested in our 3 cohorts that physicians managing AHF patients in the ED can safely use the scale now to assist with their decisions. The final decision to admit or discharge, of course, relies on the best judgment of the most responsible physician in consultation with the patient and family. The scale can assist cardiologists, internists, hospitalists, and emergency physicians.

RESEARCH IMPLICATIONS. Important next steps include an implementation trial to evaluate the actual impact of using the HEARTRISK6 Scale on patient outcomes. This could be accompanied by the development of best practice guidelines for the management of AHF patients in the ED.

CONCLUSIONS

Using 3 large, prospectively collected datasets, we created a more concise and sensitive risk scale to assist with complex admission decisions for patients with acute heart failure in the ED. Implementation of the HEARTRISK6 Scale could lead to safer and more efficient disposition decisions, with more high-risk patients being appropriately

admitted and more low-risk patients being safely discharged.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE: The HEARTRISK6 Scale identified determinants of SSO in patients with AHF in the ED. It could be used for disposition decisions, with more high-risk patients being appropriately admitted and more low-risk patients being safely discharged.

TRANSLATIONAL OUTLOOK: There are opportunities to evaluate the potential impact and physician acceptability of incorporating the HEARTRISK6 Scale into clinical care. Implementation studies could evaluate the impact on patient outcomes as well as barriers to use in practice.

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KEY WORDS **acute heart failure, emergency department, patient safety**

APPENDIX **For supplemental tables and figures, please see the online version of this paper.**