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EDITORIAL COMMENT

Disposition Decisions

What Do You Need to Know to Triage Patients With Acute Heart Failure?

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For decades, heart failure (HF) has been a leading cause of health care utilization, causing over 1 million emergency department (ED) visits annually in the United States alone.[1] Of those who presented to the ED with HF, prior studies showed that over 80% were admitted to the hospital.[2] Despite recent advances in pharmacological and device therapies for HF, post-discharge outcomes remain poor with nearly 50% of patients being rehospitalized and 15% dying within 6 months of discharge.[1] While the inpatient phase of care does provide opportunities to positively modify a patient's HF trajectory, not all patients with HF require hospital admission and could be stabilized in other care settings. However, identifying this lower-risk cohort and, in turn, reducing early discharge for the highest-risk cohort have proven to be quite challenging. The stepped-wedge, cluster-randomized Comparison of Outcomes and Access to Care for Heart Failure (COACH) trial demonstrated that systematic use of a multipronged intervention consisting of a validated point-of-care clinical decision support tool (Emergency Heart Failure Mortality Risk Grade [EHMRG] 30-ST) coupled with dedicated and rapid outpatient follow-up led to a 12% lower risk of 30-day all-cause death or hospitalization for cardiovascular causes compared with usual care for patients who presented to Canadian EDs with HF.[3] The EHMRG30-ST risk model is composed of 11 variables that can be obtained from the electronic medical record or from initial ED triage at the time of ED presentation; critiques of the model have been related to the number of inputs required and practicality of use for a busy ED clinician. It is on this background that the authors of the current study aim to fill a practice gap.

In this issue of *JACC: Advances*, Stiell et al[4] aimed to create a more parsimonious risk score to identify patients with HF who are at highest risk for short-term serious outcomes (SSO) upon presentation to the ED. This analysis combined 3 prospective cohorts of patients with HF, totaling 2,246 individuals, enrolled over 12 years at 10 Canadian academic hospital EDs. Notably, patients who were deemed too ill for discharge after up to 12 hours of ED management were excluded. The primary SSO was a composite defined as either all-cause mortality at 30 days or any of the following within 2 weeks of the ED visit: need for noninvasive ventilation or endotracheal intubation after hospital admission, myocardial infarction diagnosed after admission, major cardiovascular procedure (coronary artery bypass graft, percutaneous coronary intervention, valvular surgery, new hemodialysis), or need for hospital admission after initial ED discharge.

The study population was of advanced age (mean 77.4 years) and had HF across the spectrum of left ventricular ejection fraction (mean 45.1%). Forty-nine percent (n = 1,091/2,246) were admitted on the index ED visit, and of these, 14% suffered an SSO, largely driven by the need for a major procedure (5.4%) or death (3.6%). Of the 51% who were discharged from the index ED visit, 11% (n = 124/1,155) suffered an SSO, nearly all of which were hospital readmissions. For generation of the risk score, the authors prespecified 13 variables, chosen a priori based on prior studies and clinical experience, as predictors for their logistic regression model to predict SSO. Predictors

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TABLE 1 Comparison of Clinical Tools Used to Risk Stratify Patients Presenting to the Emergency Department With Acute Heart Failure

	EHMRG	OHFRS	EHMRG-ST	STRATIFY	MEESSI-AHF	KPNC AHF	HEARTRISK6
Publication year	2012	2013, 2017	2014	2015	2017	2020	2024
Study design	Retrospective cohort study for derivation and validation	Initial retrospective cohort study for derivation, with second prospective cohort study for validation	Prospective cohort study for derivation	Prospective cohort study for derivation	Prospective cohort study for both derivation and validation	Retrospective cohort study for derivation	Pooled retrospective cohort study
Study center							
N	86	6	86	4	34	21	10
Country	Canada	Canada	Canada	United States	Spain	United States	Canada
Sample size, n	Derivation: 7,433 Validation: 5,158	Derivation: 559 Validation: 1,100	8,772	1,033	Derivation: 4,867 Validation: 3,229	26,189	2,246
Study population	Patients ≥18 y of age presenting to ED with AHF	Patients ≥50 y of age presenting to ED with AHF	Patients ≥18 y of age presenting to ED with AHF, with ECG completed during ED visit	Patients ≥18 y of age presenting to ED with AHF	Adult patients presenting to ED with AHF	Patients ≥18 y of age presenting to ED with AHF	Patients ≥50 y of age presenting to ED with AHF
Exclusion criteria	Palliative, DNR before arrival, transferred from acute care hospital, dialysis dependent	Oxygen saturation ≤85% on room air or home oxygen, HR >120 beats/min, SBP <85 mm Hg, confusion/dementia, ischemic chest pain requiring nitrates, acute ST-segment changes on arrival, terminal status, arrival from nursing home or chronic care facility, dialysis-dependent	ST-segment elevation on ECG, complete bundle branch block, electronically paced, DNR, dialysis-dependent	Not reported	Concurrent diagnosis STEMI	Not reported	Oxygen saturation ≤85% on room air or home oxygen, HR >120 beats/min, SBP <85 mm Hg, confusion/dementia, cardiac ischemia, STEMI, terminal diagnosis, arrival from nursing home or chronic care facility, on chronic hemodialysis
Population characteristics							
Age, y	Derivation: 75.4 ± 11.4 Validation: 75.7 ± 11.4	Derivation: 76.0 ± 10.6 Validation: 77.7 ± 10.7	78 (68, 84)	64 (53, 75)	Derivation: 79.7 (SD not reported) Validation: Not reported	76 (66, 85)	77.4 ± 10.6
Male, %	Derivation: 51.5 Validation: 51.6	Derivation: 56.4 Validation: 53.1	46.6	57	Derivation: 42.9 Validation: Not reported	48.3	54.5
Race, %	Not reported	Not reported	Not reported	44 (Black/African American)	Not reported	60.7% (White/European)	No race demographics
Heart failure history							
Pre-existing HF diagnosis, %	Not reported	Derivation: 66.4 Validation: 76.7	26.7% LVEF ≤50%	74	Not reported	18.6% with LVEF <50%	72.9
LVEF on presentation, %	Not reported	Not reported	Not reported	Not reported	Derivation: 41.5% with LVEF <50% Validation: Not reported	Not reported	45.1% ±16.1%
GDMT at time of presentation							
Beta-blocker, %	Derivation: 44.7 Validation: 48.1	Derivation: 64.6 Validation: 69.1	45.5	66.0	Derivation: 52.4 Validation: Not reported	60.2	67.5
RAASi %	Derivation: 57.6 Validation: 58.8	Derivation: 45.8 Validation: 42.5	55.6	44.0	Derivation: 62.9 Validation: Not reported	46.7	43.0 (ACEI only)
MRA, %	Not reported	Not reported	6.8	Not reported	Derivation: 29.1 Validation: Not reported	Not reported	Not reported
SGLT2i, %	N/A	N/A	N/A	Not reported	Not reported	Not reported	Not reported

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TABLE 1 Continued

	EHMRG	OHFRS	EHMRG-ST	STRATIFY	MEESSI-AHF	KPNC AHF	HEARTRISK6
AHF definition	ICD-10-code for heart failure, verified by Framingham criteria	Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure of the European Society of Cardiology	Framingham criteria and ICD-10 code for heart failure on discharge	Framingham Criteria (modified to exclude circulation time, vital capacity, and weight loss in response to treatment)	Framingham criteria	Author-derived processing algorithm designed using a combination of ICD-10 codes, ED chief complaints, NT-proBNP, and Framingham criteria	Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure of the European Society of Cardiology
Primary outcome	7-d mortality	30-d mortality and 14-d SAE: Admission to a monitored unit, endotracheal intubation/NIV, MI after admission, major unplanned cardiac procedure, return to ED with subsequent admission for any medical problem	30-d mortality	30-d hierarchal SAE (ordinal assignment): ACS (1) PCI/CABG (2) Emergent dialysis (2) Intubation/NIV (3) MCS (4) Cardiopulmonary resuscitation (5) Death, all cause (5)	30-d mortality	30-d SAE: Death or CPR, intra-aortic balloon pump, endotracheal intubation, renal failure requiring dialysis, ACS	30-d mortality and 14-d SAE: Endotracheal intubation/NIV, MI after admission, major unplanned cardiac procedure, return to ED with subsequent admission for any medical problem
Input	Age, method of arrival to study center, SBP, HR, oxygen saturation, creatinine, potassium, troponin, malignancy, outpatient metolazone	History of stroke/TIA, intubation for respiratory distress, HR, oxygen saturation, walk-test reassessment, ischemic ECG, BUN, CO_2, troponin, NT-proBNP	Age, method of arrival to study center, SBP, HR, oxygen saturation, creatinine, potassium, troponin, malignancy, outpatient metolazone, ST-segment depression on initial ED ECG	Age, BMI, NT-proBNP, BUN, dialysis-dependent, DBP, sodium, supplemental oxygen, outpatient ACEI, QRS duration, RR, SaO_2	Barthel index score on admission, SBP, age, NT-proBNP, potassium, troponin, NYHA functional class IV disease on admission, RR, low output symptoms, ACS presentation, LVH on ECG, creatinine	13 input variables of STRATIFY, with 58 additional variables including medications, socioeconomic status, and echocardiogram data	Valvular heart disease, tachycardia, need for NIV, creatinine, troponin, failed clinical reassessment
Outcome incidence	Derivation: 247 deaths (2.0%) Validation: 112 deaths (2.2%)	Derivation: 13 deaths (2.3%), 65 other SAEs (11.6%) Validation: 41 deaths (3.7%), 171 other SAEs (15.5%)	728 deaths (8.3%)	43 deaths (4.2%) 83 other SAEs (8.0%)	500 deaths (10.3%)	4,923 SAE (18.8%)	281 SAE (12.5%)
C-statistic	Derivation: 0.81 Validation: 0.83	Derivation: 0.77 Validation: Not reported	0.80	0.68	Derivation: 0.84 Validation: 0.83	0.85	0.69

ACEI = angiotensin-converting enzyme inhibitor; ACS = acute coronary syndrome; AHF = acute heart failure; BUN = blood urea nitrogen; CABG = coronary artery bypass grafting; CO_2 = carbon dioxide; CPR = cardiopulmonary resuscitation; DBP = diastolic blood pressure; DNR = do not resuscitate; ECG = electrocardiogram; ED = emergency department; EHMRG = Emergency Heart Failure Mortality Risk Grade; GDMT = guideline directed medical therapy; HR = heart rate; ICD = International Classification of Diseases; LVEF = left ventricular ejection fraction; LVH = left ventricular hypertrophy; MCS = mechanical circulatory support; MI = myocardial infarction; MRA = mineralocorticoid receptor antagonist; NIV = noninvasive ventilation; NT-proBNP = N-terminal pro-B-type natriuretic peptide; PCI = percutaneous coronary intervention; RAASi = renin-angiotensin-aldosterone system inhibitors; RR = respiratory rate; SAE = serious adverse event; SaO_2 = oxygen saturation; SBP = systolic blood pressure; SGLT2i = sodium-glucose cotransporter-2 inhibitors; STEMI = ST-segment elevation myocardial infarction; TIA = transient ischemic attack.

were further narrowed via bootstrapped internal validation and stepwise selection, ultimately yielding the HEARTRISK6 score. The 6 independent predictors in the model included a history of moderate-severe valvular disease, tachycardia on arrival, need for noninvasive ventilation within 1 hour of arrival, increased troponin and creatinine in the ED, and failure of reassessment after treatment in the ED based on either abnormal resting vital signs or inability to execute a 3-minute walk test. Overall, the HEARTRISK6 score yielded a modest C-statistic of 0.69 and high sensitivity but low specificity, suggesting it could be a robust score for identifying those at high risk for subsequent SSO but would lead to a higher-than-average hospital admission rate.

The strengths of the HEARTRISK6 score are its pooled design and potential ease of use with only 6 variables. Other similar published ED-based scores for HF risk stratification require more input variables and/or focus only on mortality outcomes (Table 1), so Stiell et al have expanded the horizon of risk prediction for this patient population. However, there are aspects of the model generation and patient population that deserve discussion.

In the current model, all patients are not similarly eligible for all SSO components, ie, patients who were discharged from the index ED presentation only remain eligible for the relapse and hospital admission component of the SSO. This introduces outcome heterogeneity and may impact generalizability of the model. The number of patients who declined a recommended hospital admission (ie, discharge against medical advice) was not disclosed; these patients may have been more likely to return to the ED and/or get admitted, which would separately bias the SSO measurement. The timeframe for completion of the walk test, a component of the risk score, was 2 to 12 hours, which is a broad window in which time-dependent interventions like intravenous diuretics can alter a patient's clinical trajectory and, therefore, disposition. The authors state that they avoid using split-sample validation as it is considered inefficient and outdated, but their stepwise selection procedure could be critiqued similarly. Comparison of multiple models using stepwise selection and other feature selection strategies such as lasso or ridge regression, given the authors' goals of creating a more parsimonious model, would be of interest.

Regarding the study population, the cohort was on average slightly older than other similar cohorts[2] (mean age 77.4 years) with a high burden of comorbidities (72% hypertension, 22% chronic obstructive pulmonary disease, and 21% chronic renal failure). Patients with HF with reduced (HFrEF) and preserved ejection fraction (HFpEF) are often multimorbid, and these comorbidities negatively impact the natural history of their disease.[5] Notably, 33% of patients who were discharged represented to the ED within 14 days for "other" reasons that are not further described. Reducing the ED/hospital readmission risk for patients with HF must include strategies to address the burden of noncardiovascular causes of decompensation, including exacerbations of chronic lung disease, worsening renal failure, frailty, and deficits in cognitive function. While the lack of inclusion of N-terminal pro-B-type natriuretic peptide may make this score more generalizable in a global, resource-limited context, assessment of natriuretic peptides is supported by the most recent comprehensive American Heart Association/American College of Cardiology/Heart Failure Society of America,[6] European Society of Cardiology,[7] and Canadian Cardiovascular Society[8] HF guidelines. Natriuretic peptides have been shown to be independently prognostic in HF, and its exclusion from this risk score, though justified here, precludes us from a full understanding of the incremental value of this risk score.

Additionally, patients with HF across the range of left ventricular ejection fraction were included (mean 45.1%), though 28% were missing echocardiographic data. Though the proportions of patients with HFrEF vs HFpEF were not provided, medical management in this cohort was relatively poor with only 43% being on an angiotensin-converting enzyme inhibitor and 67% being on a beta blocker. The most contemporary cohort was enrolled between 2015 and 2019, but the proportions of patients on guideline-directed medical therapy with mineralocorticoid receptor antagonists, angiotensin receptor/neprilysin inhibitor,[9] and sodium-glucose cotransporter 2 inhibitors[10] were not disclosed, suggesting low uptake of contemporary medical therapies that reduce HF hospitalizations and mortality in patients with HF, both of which are included as SSOs in this study. Moreover, the prevalence of implantable cardioverter defibrillator use was not provided, an especially important consideration given that sudden cardiac death is a common mode of death in HF. Finally, 27% of the cohorts were perhaps patients with de novo HF who may have been more likely to be admitted for expedited evaluation and treatment.

Stiell et al remind us that accurate identification and risk stratification of patients with acute HF who present to the ED remains a significant patient care and health economic challenge. As our health care systems become increasingly complex, tools to support busy clinicians in making triage decisions should be further explored and validated. In parallel, creating multilayered care paradigms that intervene early in the postdischarge course for high-risk patients with HF, ensure optimization of guideline-directed medical therapy, and address noncardiovascular comorbidities may ultimately be the keys to modify disease trajectory.

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