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Original article

Norton score and clinical outcomes following acute decompensated heart failure hospitalization

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ABSTRACT

Background: Norton scoring system is used to assess frailty of hospitalized patients with various medical conditions. We aimed to evaluate whether admission Norton scoring system predicts adverse outcomes among heart failure patients.

Methods: The study population comprised 4388 acute heart failure patients between the years 2008 and 2017. Patients were allocated to 3 groups according to their admission Norton score [(≤15-low, 16–18-intermediate, and ≥19-high)]. Primary outcome included all-cause mortality at 30, 90 days, and 1 year. Multivariate Cox proportional hazards regression modeling was used to assess the independent association between Norton score and mortality. Net reclassification improvement (NRI) analysis was used to asses Norton's additive predictive ability upon known prognostic factors.

Results: Among 4388 study patients, 32% (n = 1611) had low Norton score, 28% (n = 1384) intermediate score, and 40% (n = 1900) high score. Kaplan–Meier analysis demonstrated significantly higher 30-day mortality among patients with a low Norton score as compared with those with intermediate or high score (2.6%, 6.3%, and 16.1%; log rank $p < 0.001$). A similar trend was noted at 90 days and 1 year. Multivariate analysis found Norton score to be an independent predictor of mortality with each one-point decrement associated with a significant 15% increased risk for 30-day mortality [HR = 1.15 (95% CI, 1.12–1.17) $p < 0.001$]. NRI analysis showed an improvement of 21.5% (95%CI 18.3–25.1%) predicting 1-year mortality.

Conclusion: Our findings show that the admission Norton score is a powerful marker of short- and long-term mortality. These data suggest that the scale should be added as a risk stratification tool in this high-risk population.

Introduction

The Norton scale scoring system [1] was created in 1962 to assess the risk of pressure sores during hospitalization and is still being used nowadays by nurses. It consists of 5 variables: physical and mental condition, activity, mobility, and incontinence. Each variable is graded from 1 to 4 with maximum score of 20 (Online Table 1). Since it was first introduced, almost sixty years ago, the admission Norton scale score has been evaluated as prognostic scoring system in various medical conditions [2,3]. Díez-Manglano et al. [4] found the Norton scale to be a useful predictor of both short- and long-term mortality among patients admitted to an internal medicine department. Recently, low Norton score (defined as below 16) was found to be associated with increased mortality in patients undergoing transcatheter aortic valve replacement [5] and with increased morbidity and mortality following acute myocardial infarction [6].

The heart failure (HF) population is diverse and patients are heterogenous in their co-morbidities, clinical presentation, as well as prognosis. Most current HF prognostic scores rely on clinical, echocardiographic, and laboratory data [7–9], with less emphasis on patients' frailty.

Gastelurrutia et al. [10] evaluated the prognostic significance of frailty among heart failure patients. Frailty which was assessed by 4 validated geriatric questionnaires was found to be an independent predictor of reduced survival among HF patients. McNallan et al. [11] reported high prevalence (74%) of some degree of frailty

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among a community HF population which was associated with increased risk of emergency department visits and hospitalization. Sze et al. [12] found the clinical frailty score (CFS) evaluating functional capacity, level of dependence, and co-morbidities to be an easy-to-use tool assessing frailty among chronic HF patients. These trials have added a new risk stratification tool by incorporating patients' frailty as a predictor of clinical outcomes.

Accordingly, we sought to investigate whether the admission Norton score scale can serve as a predictor of short- (30 and 90 days) and long-term (1 year) clinical outcomes following acute heart failure (AHF) hospitalization in a large contemporary real-world population.

Methods

The study population comprised 10,232 patients who were hospitalized with either AHF, acute on chronic HF, or decompensated HF between January 2008 and March 2017, in a large tertiary hospital, Sheba Medical Center. All patients had a complete physical examination by a physician on admission and underwent a complete blood test, which was analyzed at the center's laboratory. Electrocardiogram was performed at the emergency department and upon admission to the medical ward. Past medical history and current medications were all recorded into an electronic database.

All patients were assessed by the department nursing staff and were graded according to Norton parameters (Online Table 1) upon admission (day 0). Information regarding patients with cognitive impairment was collected from the patient's caregivers or previous medical records.

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Of the total study population, 4388 patients had a full echocardiogram performed during the index hospitalization with a reported Norton score on admission.

Definitions

AHF was defined as the appearance of signs and symptoms of HF as noted and recorded by the treating physician. All participants had physical examination and chest X-ray upon admission. AHF was recorded in the electronic chart as a primary diagnosis. Subjects were considered to have diabetes mellitus or hypertension if they had previous hospitalization with documented history of either conditions, their primary care physicians treated them for these disorders, or based on self-report. Dyslipidemia was considered positive if patients were treated with relevant medications or based on laboratory results obtained during hospitalization. Values were analyzed based on the European Society of Cardiology guidelines. History of cerebrovascular attack was based on self-report, previous hospitalizations, or head computed tomography/brain magnetic resonance imaging. Ischemic heart disease was considered positive if a patient had documentation of abnormal non-invasive ischemic evaluation test or relevant findings during coronary catheterization. Chronic kidney disease was considered positive if estimated glomerular filtration rate (eGFR) was below 60 ml/min/1.73 m^2. Anemia was defined as hemoglobin $<$11 mg/dL. Atrial fibrillation was based on medical records, self-reporting, or electrocardiographic documentation at arrival.

An echocardiogram was performed to all study patients by an expert cardiologist in the medical center's echocardiographic laboratory. Echocardiographic parameters included biventricular systolic function, left ventricular diastolic function, atrial and ventricular dimensions, as well as systolic pulmonary artery pressure.

The cohort was divided into 3 groups according to admission Norton score: the high-risk (frailer patients) had low Norton score $\leq$15 (low), 16–18 (intermediate), and the low-risk patients had high Norton score $\geq$19 (high). These cut-offs are based on previous trials evaluating Norton as a prognostic scaling score [5,6]. In a secondary analysis the Norton score was assessed as a continuous measure.

All patients were prospectively followed-up through April 2017 for all-cause mortality and recurrent HF hospitalizations. Mortality data was extracted from the Israeli population registry.

Clinical outcomes

The primary endpoint was defined as all-cause mortality at 30, 90 days, and 1 year. The secondary endpoints include: (1) First HF hospitalization following 30 days and 1 year of index hospitalization; (2) Composite endpoint of HF-related hospitalization or death (whichever came first) at 30 days.

In order to assess whether the Norton scoring system can be applied to a wide spectrum of HF patients, a subgroup analysis including: HF with preserved ejection fraction vs. HF with reduced ejection fraction, age, gender, co-morbidities: ischemic heart disease and renal failure was performed.

Statistical analysis

Baseline characteristics, co-morbidities, and echocardiographic parameters were compared according to Norton score at admission. Comparison of categorical variables was performed with chi-square test, and of continuous variables using one-way analysis of variance test. The cumulative probabilities of the primary and secondary end-points by the prespecified Norton score were assessed according to the Kaplan–Meier method, with comparison of cumulative events by the log-rank test.

The first day (day 0) at the Kaplan–Meier curve for the analysis of mortality (Fig. 1) was the day of hospitalization. For the Kaplan–Meier curve of recurrent hospitalizations, the first day was the day of discharge from the initial hospitalization.

Multivariate Cox proportional hazards regression analysis was applied to independent predictors for 30-day and 1-year mortality in the total population and within each Norton score category using interaction-term analysis. Prespecified variables introduced to all models included demographic (age, gender), co-morbidities [ischemic heart disease, anemia (hemoglobin $<$11 mg/dL), chronic renal failure (eGFR by MDRD formula $<$60 ml/min/1.73 m^2), chronic obstructive pulmonary disease (COPD)], and echocardiographic parameters (left ventricular ejection fraction $<$40%, systemic pulmonary artery pressure $>$40 mmHg), use of beta blocker and/or angiotensin-converting enzyme inhibitor (ACE-I), as well as implantable cardioverter defibrillator/cardiac resynchronization therapy (ICD/CRT-D) or pacemaker device. In the primary analysis, the Norton score was divided into tertiles, and in a secondary analysis it was assessed as a continuous measure. Interaction-term analysis was carried out to evaluate the association between Norton score and mortality in risk subsets defined by age, sex, left ventricular ejection fraction, and the etiology of HF. We also used C-statistics method to evaluate the strength of the Norton score as a frailty model. Furthermore, in order to examine Norton's additive predictive ability upon other known prognostic factors (age, gender, left ventricular ejection fraction, chronic kidney disease, ischemic heart disease, diabetes mellitus, anemia, COPD, atrial fibrillation, use of beta blockers, ACE-I, and mineralocorticoid receptor antagonists), net reclassification improvement (NRI) analysis for 1-year mortality was performed. All analyses were carried out using SPSS version 23 (2015) (IBM, Armonk, NY, USA). We used R package (Vienna, Austria) survIDINRI for NRI evaluation.

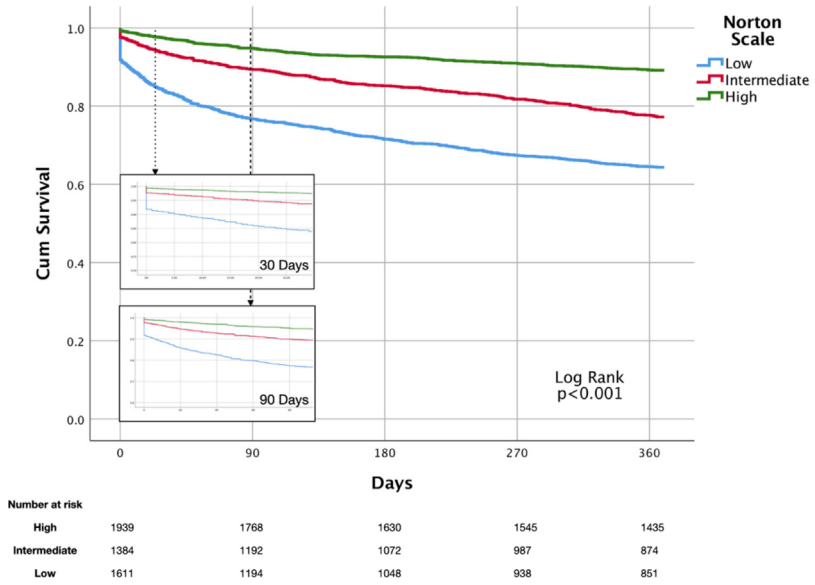


Fig. 1. Kaplan–Meier curves demonstrating 1-year (upper panel), 30-, and 90-day survival (lower panels) among different Norton scores: ≤15 (low score – blue), 16–18 (intermediate score - green), and 19–20 (high score – red). Day 0 = Day of hospitalization.

Results

The study population comprised 4388 patients (Online Fig. 1) – 44% were females, mean age was 76 ± 13 years. The HF population had high burden of comorbidities; above one fifth were diagnosed with either COPD or previous cerebrovascular accident/transient ischemic attack, more than a third presented with diabetes mellitus, chronic renal failure, or atrial fibrillation/flutter. Furthermore, more than half (53%) had ischemic heart disease.

Baseline characteristic by low (≤15), intermediate (16–18), and high (≥19) Norton Score

Baseline characteristics are shown in Table 1. Low Norton score patients were older, with a female predominance, and had higher prevalence of co-morbidities: hypertension, COPD, chronic renal failure, atrial fibrillation/flutter, and anemia (p-value for all <0.001), whereas a lower frequency of cardiomyopathy and ischemic heart disease were noted in the low Norton score group (Table 1).

High Norton score group had higher hemoglobin, albumin, and eGFR levels. No significant difference was found in troponin, low-density lipoprotein, and cholesterol levels. Guidelines-directed medical therapies showed wide variability between the groups (Table 1B), demonstrating a higher frequency of treatment with loop diuretics, ACE-I or angiotensin receptor blockers, and beta blockers in the low Norton group ($p < 0.001$ for all). However, aldosterone antagonists as well as ICD/CRT-D implantation were administered at higher frequency to patients in the high Norton score group (Table 1B).

Echocardiographic parameters according to low, intermediate and high Norton score

Echocardiographic parameters obtained during the index hospitalization are shown in Online Table 2. Frailer patients in the low Norton score group had a higher mean left ventricular ejection fraction (51.1 ± 14.5%, 49.4 ± 15.3%, and 44.4 ± 16.6%, respectively, $p < 0.001$), lower mean left ventricular end systolic and diastolic diameters, and a lower mean left atrial area as well as higher pulmonary systolic artery pressure.

Primary endpoint by Norton score

Kaplan–Meier survival analysis demonstrated both short- (30 and 90 days) and long-(1 year) term higher mortality among frailer patients with low and intermediate Norton score as compared with high score Norton group. The low Norton group had more than 5 times mortality rate as compared to high Norton group at 30-day follow up (16.1%, 6.3%, 2.6%, log rank $p < 0.001$). Separation of the curves was more pronounced immediately after admission and remained constant after the AHF event (Fig. 1). During 90 days of follow-up, mortality rate in the low Norton group reached 23.2% whereas in the high Norton group was as low as 5.2% (log rank $p < 0.001$). Similar trends were seen at 1-year follow-up (10.2%, 21.3%, and 23.2%; log rank $p < 0.001$).

Consistent with previous findings, multivariate Cox proportional hazards regression modeling (Table 2) showed that a low Norton score was associated with a 4-fold increased risk of all-cause mortality at 30 days (HR 4.17; 95%CI 3.16–5.05, $p < 0.001$) following hospitalization compared to high Norton Score and about 3-fold risk for mortality (HR 3.11; 95%CI 2.53–3.82, $p < 0.001$) at 1-year follow-up. Similar results were found in the intermediate group (compared to the high Norton score group) with 2-fold increase for mortality at 30 days and 1 year (Table 2). Furthermore, multivariate analysis including the Norton score as continuous measure showed that each one-point decrement in the Norton score was independently associated with a significant 15% increased risk for 30-day mortality (HR 1.15; 95%CI, 1.12–1.17, $p < 0.001$). Similar results were seen at 1 year with 11% increased risk for mortality (95%CI 1.09–1.13, $p < 0.001$) (Table 2).

Prediction ability of the Norton model

Performing C-statistics for the Norton score (continuous) have yielded 0.735 (95% CI: 0.709–0.76; $p < 0.001$) for 30-day and 0.711 (95% CI: 0.689–0.733; $p < 0.001$) for 90-day all-cause mortality. At 1 year, a similar trend was noted with 0.684 (95%CI: 0.666–0.702, $p < 0.001$).

Table 1
Baseline characteristics.

	Total $N = 4934$	Low Norton Score (≤15) $N = 1611$	Intermediate Norton Score (16–18) $N = 1384$	High Norton Score (≥19) $N = 1939$	p-Value
Age, Years (Mean ± SD)	76 ± 12.74	81.1 ± 10.9	77.9 ± 11.5	70.5 ± 12.8	<0.001*
Age Above 75 years (%)	60.7	77.1	68.3	41.8	<0.001*
Gender (Female, %)	44	56.5	48.8	30.1	<0.001*
BMI (Mean ± SD)	28.4 ± 5.8	28.2 ± 5.9	28.8 ± 6.4	28.2 ± 5.3	0.012
EF (Mean ± SD)	48 ± 15.9	51.2 ± 14.5	49.4 ± 15.3	44.4 ± 16.7	<0.001
A. Co-Morbidities					
Diabetes Mellitus (%)	39.6	40.2	40.9	38.3	0.263
Hypertension (%)	66.6	70.9	71.2	59.8	<0.001
Hyperlipidemia (%)	44.1	41.7	46.4	44.5	<0.001
COPD (%)	16	19.4	17.2	12.3	<0.001*
Anemia (%)	30	37	31.1	22	<0.001*
Chronic Renal Failure (%)	34	41.1	33.5	28.4	<0.001*
CVA/TIA (%)	17.6	25.5	16.9	11.6	<0.001*
Atrial Fib/Flutter (%)	40	42.4	39.8	37.4	0.011*
Prior IHD (%)	52.4	50	51.7	55.4	0.002
Prior MI (%)	25.6	26	22.9	27.2	0.91
Prior Cardiomyopathy (%)	9.1	4.7	7.4	13.9	<0.001*
ICD/CRT-D (%)	3.1	1.5	2.2	5.1	<0.001
PPM/CRT-P (%)	12.2	11.7	11.0	13.5	<0.001*
B. Medications					
Beta Blockers (%)	35	39	38	31	<0.001*
ACE/ARB (%)	51	54	51	48	0.001*
Statins (%)	55	55	57	53	0.071
Loop diuretics (%)	43	49	45	37	<0.001*
Aspirin (%)	51	53	51	49	0.068*
OAC (%)	25	24	24	26	0.469
Anti-Arrhythmias (%)	15	13	14	16	0.093*
Class III (%)	12	11	11	14	0.008*
Aldosterone blockers (%)	16.2	16	15.6	16.8	0.627

BMI, body mass index; EF, ejection fraction; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; TIA, transient ischemic accident; Atrial Fib, atrial fibrillation; IHD, ischemic heart disease; MI, myocardial infarction; ICD, implanted cardioversion device; CRT-D/P, cardiac resynchronization therapy device with defibrillator/pacing; PPM, permanent pacemaker; LV, left ventricle; ACE, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; OAC, oral anti-coagulant.
* p for trend <0.05.

Table 2
Multivariable Cox regression analysis for mortality and HF hospitalization according to admission Norton score.

		HR	95%CI	p-Value
Adjusted# Mortality–compared to high Norton Score				
30 days				
	Intermediate	2.01	1.49–2.72	<0.001
	Low	4.17	3.16–5.05	<0.001
90 days				
	Intermediate	1.62	1.37–1.92	<0.001
	Low	2.38	2.02–2.80	<0.001
1 year				
	Intermediate	1.99	1.61–2.48	<0.001
	Low	3.11	2.53–3.82	<0.001
Mortality-Norton as continues variable (one-point decrement)				
30 days		1.15	1.12–1.17	<0.001
1-year		1.11	1.09–1.13	<0.001
Adjusted# Recurrent HF hospitalization - compared to high Norton				
	Intermediate	1.06	0.78–1.44	0.69
	Low	0.86	0.62–1.18	0.40

Adjusted to age, gender, ischemic heart disease, anemia [hemoglobin <11 mg/dL], chronic renal failure [eGFR by MDRD formula <60 ml/min/1.73 m^2], COPD, left ventricular ejection fraction <40%, systemic pulmonary artery pressure >40 mmHg, beta blocker and/or ACE-I, ICD/CRT-D, and pacemaker device. HF, heart failure; eGFR, estimated glomerular filtration rate; MDRD modification of diet in renal disease; COPD, chronic obstructive pulmonary disease; ACE-I, angiotensin converting enzyme inhibitors; ICD/CRTD, implantable cardioversion device/chronic resynchronization therapy with defibrillation.

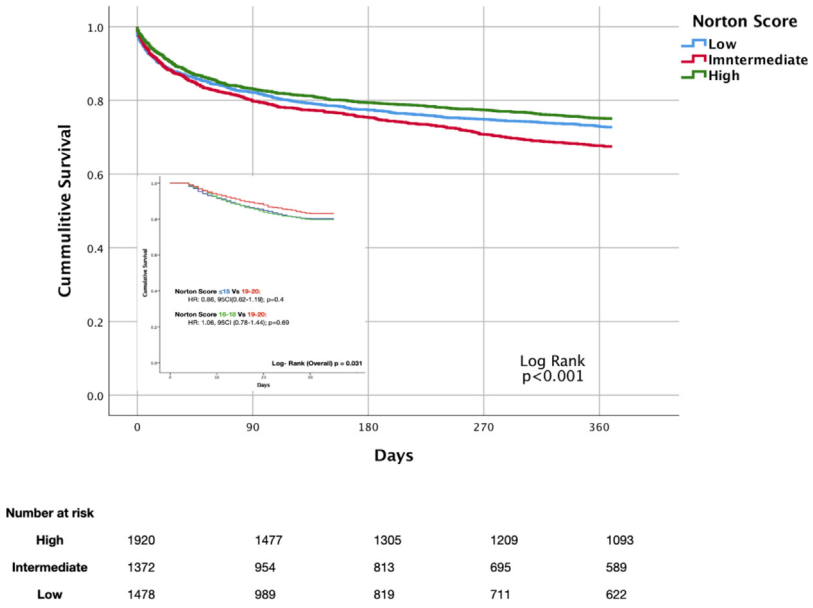
The addition of low Norton score to well-known prognostic factors [age, gender, diabetes mellitus, anemia, chronic kidney disease, COPD, left ventricular ejection fraction (LVEF)] have shown a significantly net reclassification improvement of 21.5% (95% CI 18.3–25.1%) for predicting 1-year mortality.

Secondary endpoints by Norton score

Kaplan–Meier survival analysis for 30 days of HF hospitalization have shown that 84.9% of patients with high Norton score were hospital-free at 30 days compared to 81.7% in the intermediate group and 82.6% in the low group (log rank $p = 0.031$) (Fig. 2). After adjustments, no difference was observed between the three groups. One-year follow up revealed significantly higher HF rehospitalizations among low and intermediate score group as compared to high Norton score (26.3%, 32.5%, 24.9%, $p < 0.001$). Combined endpoints of HF hospitalization or mortality (whichever came first) at 30 days have resulted in 39.9% events in the low Norton group compared to 32.8% at intermediate and 26.4% in high Norton group (log rank $p < 0.001$) (Online Fig. 2). These results are mainly driven by mortality.

Subgroup analysis

The consistency of the association between the Norton score and long-term mortality was evaluated in prespecified risk subsets (Fig. 3). This analysis showed that a low Norton score



Number at risk					
High	1920	1477	1305	1209	1093
Intermediate	1372	954	813	695	589
Low	1478	989	819	711	622

Fig. 2. Kaplan–Meier Curve for 1-year (upper panel) and 30-day (lower panel) rehospitalizations among the different Norton scores: low (blue), intermediate (green), and high (red). Day 0 = Day of discharge from initial hospitalization.

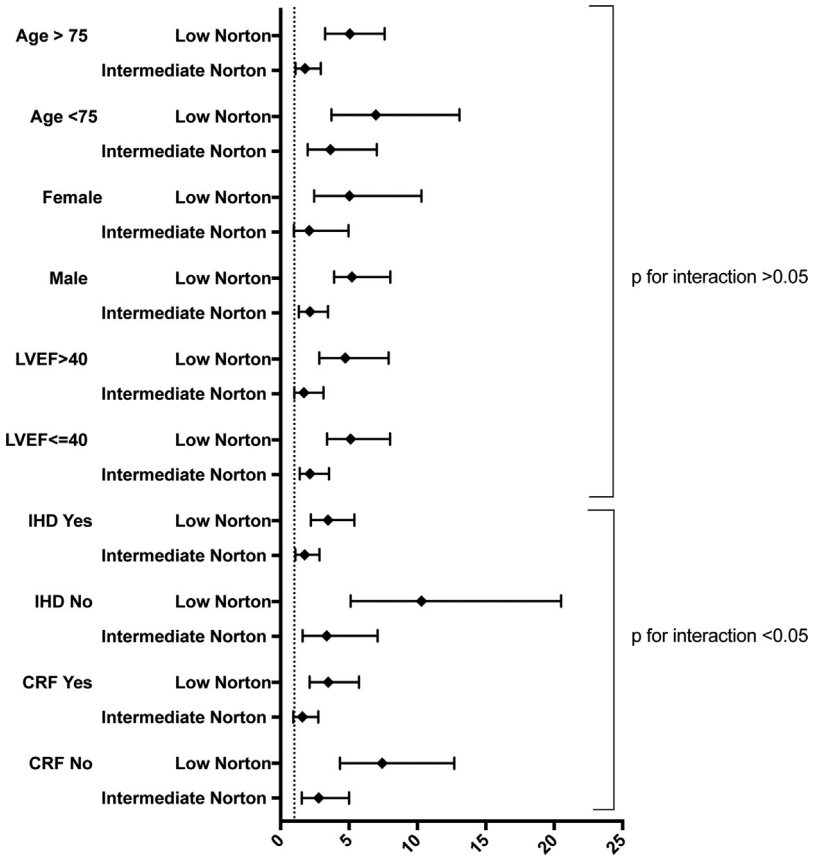


Fig. 3. Subgroup analysis comparing the different Norton scores: low, intermediate, and high. LVEF, left ventricular ejection fraction; IHD, ischemic heart disease; CRF, chronic renal failure.

was independently associated with increased mortality regardless of age, sex, or HF etiology (p-value for interaction >0.05 for all). Furthermore, this association remained consistent in patients with LVEF $\geq 40\%$ and those with reduced LVEF $<40\%$ (Fig. 3).

Discussion

Frailty is common among HF population [13]. Several mechanisms may contribute to high fragility of these patients: reduced skeletal muscle function [14], electrolyte and metabolic

disturbances, autonomic dysfunction, and reduced exercise capacity.

Despite the recognition of frailty as a strong predictor of adverse clinical outcomes among HF patients, current data validating frailty scores in a real-world setting especially focusing on elderly frail patients with acute decompensated HF are limited [15]. Furthermore, previous scores suggested may be labor-intensive for routine clinical practice [15].

The novelty of our study relies on the simplicity and applicability addressing a wide diversity of acute decompensated and frail HF patients. Our study based on a large real-world population of AHF patients provides several important findings regarding risk stratification in this high-risk population. We have shown that: (1) Admission Norton score is a powerful predictor of clinical outcomes among the diverse HF population and a predictor of short- (30- and 90-day) and long- (1-year) term mortality following hospitalization due to AHF. Notably, separation in event rates was more pronounced immediately after admission with AHF events and continued thereafter, suggesting that the Norton score is a reliable marker identifying high-risk population prone to adverse events; (2) The reliability of Norton score as a prognostic marker was maintained when used as a continuous measure, with each one point decrement in the scale corresponding to a significant 15% increased mortality risk at 30 days and 11% at 1 year; (3) The independent association between frailty and mortality in AHF patients appears to be consistent in all risk subsets analyzed, and remained consistent in AHF patients with reduced vs. preserved LVEF; (4) Norton score was found to be an independent predictor of mortality after adjustments to other risk factors (age, pulmonary hypertension, reduced renal function, low ejection fraction, atrial fibrillation, COPD) with an added value identifying patients at high risk when combined with known prognostic factors.

Several clinical prognostic scores were validated in previous clinical trials. The Seattle [7] Heart Failure Model is a well validated model and consists of various clinical and laboratory factors, medication prescribed, and device implanted. The major limitation of the Seattle Heart Failure Model is that it examined a specific HF subpopulation with severe left ventricular dysfunction (EF $<30\%$) and New York Heart Association class IIIb/IV which may not be applicable to other subgroups of HF patients, and while being well validated, the score did not assess patients' frailty.

The Fried phenotype [16] established a phenotype of frailty to provide a standardized definition. Unintentional weight loss, self-reported exhaustion, reduced grip strength, slow walking speed, and low physical activity were found to identify frail patients as well as population at risk. As opposed to the Fried phenotype method, our cohort had its focus on hospitalized patients with AHF. In addition, while the Fried phenotype system predominantly focuses on physical criteria, the Norton score also addresses patients' mental status.

The frailty index score [17] is also a well validated tool. However, its main limitation derives from its complexity, as well as time consuming due to multiple variables to be considered as opposed to the Norton score.

When applying the Norton scoring system to assess patients' prognosis, one cannot overlook the difference in baseline characteristics between the groups. Our cohort represents real world data. As such, HF patients have multiple co-morbidities, cardiovascular risk factors, and guideline-directed medical therapy is far from ideal. Thus, frailer patients (lower Norton score) are older, have significant higher prevalence of co-morbidities, lower hemoglobin and albumin levels, and were less likely to be treated with ICD/CRT-D implantation probably due to their fragility. In accordance with our findings, Pandey et al. [15] reported female predominance and higher burden of comorbidities among frail patients using the validated Fried criteria. Cacciatore et al. [18] reported older age and higher prevalence of co-morbidities among frailer HF patients. Tanaka et al. [19] reported lower body mass index, lower hemoglobin, and reduced renal function in frailer HF patients based on gait speed, handgrip strength, serum albumin, and activities of daily living status. The lower prevalence of CRT-D/ICD implantation among the lower Norton score group emphasizes the high frailty and fragility of this subgroup. A main issue is to identify a subgroup of patients in whom implantation of guide-lines-directed medical therapy may be more harmful than beneficial. As expected, the lower the Norton, the lower the chance to undergo invasive procedures.

Despite the differences in baseline characteristics we would like to emphasize Norton's prognostic effect across a wide spectrum of HF patients whose phenotype can be complex. This observation derives from multiple etiologies, age at diagnosis and co-morbidities. A recent Heart Failure Association/European Society of Cardiology position paper [20] defined frailty as a multidimensional dynamic state independent of age that makes the individual with HF more vulnerable to stressors. Norton model's ability to predict adverse outcomes was clearly demonstrated in the subgroup analysis regardless of patient's chronological age, gender, co-morbidities, and HF etiology (ischemic vs non ischemic). These results are in accordance with the current approach of holistic, patient-centered assessment instead of disease-centered approach as stated by Vitale et al. [21].

An important issue concerning our findings is the non-significant difference in 30-day HF rehospitalization rate between the groups. We would like to emphasize the higher short-term mortality among HF patients with low Norton score, a finding which is well illustrated in Kaplan-Meyer analysis (high mortality on day 0). This observation further strengthens the relationship between the Norton score and the severity of HF. Furthermore, 1-year follow up revealed higher HF rehospitalizations incidence among low and intermediate Norton group as compared to high Norton group. The higher rate of rehospitalizations among the intermediate as compared to the low group may be explained by the higher mortality on day 0 among the latter group. These patients were excluded for further statistical analysis. In addition, rehospitalizations data were limited to a single medical center.

During the past decade, the concept of frailty has gained a lot of attention. While medical staff (physicians, nurses, social workers) can assess frailty intuitively, there is a growing need as stressed by Afilalo et al. [22] to establish a measurement tool of frailty which might lead us to therapeutic success.

McNallan et al. [11] have raised the possibility of intervention aimed at reducing frailty and decreasing the high healthcare utilization and cost associated with HF. Reeves et al. [23] suggested an early rehabilitation intervention for older and frail patients after acute decompensated HF hospitalization. After 12 weeks of rehabilitation, these patients had higher physical performance and a lower 6-month rehospitalization rate. Taylor et al. [24] have stressed the beneficial effect of cardiac rehabilitation reducing overall and HF readmissions without mortality benefit. Further prospective randomized trials with long-term follow up focusing on rehospitalizations and early intervention are warranted.

Limitations

First, the trial is a retrospective analysis of AHF patients admitted to a single large tertiary center (more than 1700 hospital beds). Second, we had to exclude about a half of our cohort due to lack of Norton data at admission. Third, the reported diagnosis of HF was based on clinical judgment of the treating physician in a real-world setting. Fourth, we were blinded for any data from outside our institute, thus some of the patients might have been

hospitalized without our knowledge. Fifth, as in all retrospective studies not all confounders were captured or adjusted for.

A potential criticism of this prognostic system is that it is not specific to the HF population. Even if this model is not related (or related only in part) to HF, it provides valuable information about patient's vulnerability to different stressors (definition of frailty). The Norton score well represents the shifting paradigm of managing HF patients which relies on patients' wellbeing as well as treating the patient and not the disease.

Conclusion

The Norton admission score can be used to identify HF patients prone to adverse outcomes. Frailty is a major predictor of short- and long-term mortality and should be incorporated in the general assessment of HF patients.

Conflict of interests

None declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jjcc.2020.05.016.

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