Prospective evaluation and comparison of the predictive ability of different frailty scores to predict outcomes in geriatric trauma patients

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BACKGROUND: Different frailty scores have been proposed to measure frailty. No study has compared their predictive ability to predict outcomes in trauma patients. The aim of our study was to compare the predictive ability of different frailty scores to predict complications, mortality, discharge disposition, and 30-day readmission in trauma patients.

METHODS: We performed a 2-year (2016–2017) prospective cohort analysis of all geriatric (age, >65 years) trauma patients. We calculated the following frailty scores on each patient; the Trauma-Specific Frailty Index (TSFI), the Modified Frailty Index (mFI) derived from the Canada Study of Health and Aging, the Rockwood Frailty Score (RFS), and the International Association of Nutrition and Aging 5-item a frailty scale (FS). Predictive models, using both unadjusted and adjusted logistic regressions, were created for each outcome. The unadjusted c-statistic was used to compare the predictive ability of each model.

RESULTS: A total of 341 patients were enrolled. Mean age was 76 ± 9 years, median Injury Severity Score was 13 [9–18], and median Glasgow Coma Scale score was 15 [12–15]. The unadjusted models indicated that both the TSFI and the RFS had comparable predictive value, as indicated by their unadjusted c-statistics, for mortality, in-hospital complications, skilled nursing facility disposition and 30-day readmission. Both TSFI and RFS models had unadjusted c-statistics indicating a relatively strong predictive ability for all outcomes. The unadjusted mFI and FS models did not have a strong predictive ability for predicting mortality and in-hospital complications. They also had a lower predictive ability for skilled nursing facility disposition and 30-day readmissions.

CONCLUSION: There are significant differences in the predictive ability of the four commonly used frailty scores. The TSFI and the RFS are better predictors of outcomes compared with the mFI and the FS. The TSFI is easy to calculate and might be used as a universal frailty score in geriatric trauma patients. (*J Trauma Acute Care Surg.* 2019;87: 1172–1180. Copyright © 2019 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic, level III.

KEY WORDS: Frailty scores; Trauma-Specific Frailty Index; Modified Frailty Index; Rockwood Frailty Score; Frail Scale.

According to the United States (US) Census Bureau, the number of geriatric (≥65 years) Americans is expected to increase to more than double by the year 2060, and their share of the total population is projected to rise from 15% to 24%.[1] This trend highlights the urgent need to accurately and thoroughly assess frailty in older patients. Frailty is a widely used term that describes a multidimensional syndrome characterized by loss of physiological reserve.[2–4] The clinical aspect of frailty manifests as increased vulnerability to illness, impaired capability to withstand intrinsic and environmental stressors, and limited capacity to maintain physiological hemostasis.[5] Evaluation of a patient's frailty is a valid and clinically important tool, which yields useful predictive information that aids clinical judgments.[6]

In a clinical setting, the assessment of frailty needs to be operationally quantified. Combining several frailty characteristics together into a score would render it a good predictor of adverse clinical outcomes.[7,8] While many frailty scores have been proposed over the years, there is no consensus on which assessment tools is superior, as these scores have been developed in different settings and targets different subsets of the geriatric population.[9] For example, including both psychological and physical components of frailty is not applicable in the acute trauma settings and using a precise assessment tool with high predictive power seems more feasible.[10–12]

Identifying which of the frailty measurement tools is the most applicable among older adult trauma patients is a topic of heated debate. On one hand, multiple frailty reviews have advocated for a standardized measurement tool of frailty in clinical practice.[13,14] On the other hand, different frailty scores and indexes have been developed to evaluate the physiologic reserve (frailty) in different patient populations. To the best of our knowledge, no study has compared the predictive ability of these various tools to predict outcomes in trauma patients.

We aimed to compare the predictive ability of different frailty scores when predicting complications, mortality, discharge disposition, and 30-day readmission in trauma patients. We hypothesized that the Trauma-Specific Frailty Index (TSFI) has a reliable predictive power compared with other commonly used frailty scores.

METHODS

We performed a 2-year (2016–2017) observational prospective cohort analysis of all older adult trauma patients admitted to Banner-University Medical Center Tucson after obtaining an approval from the institutional review board at the University of Arizona. We approached all eligible patients for informed consents, those who agreed to participate were included in the study. Banner-University Medical Center Tucson is the only Level I trauma center in southern Arizona. It covers a large area and provides care to a sizable population of Hispanic patients from both southern Arizona and Mexico.

Study Population, Inclusion, and Exclusion Criteria

We approached all older adult trauma patients (age, ≥65 years) admitted to our Level I trauma center. We excluded those who did not consent to be enrolled in the study and those for whom we could not calculate frailty scores (i.e., those who were cognitively impaired, intubated, and non-responsive in the absence of family member to answer the questionnaires) (Figure 1).

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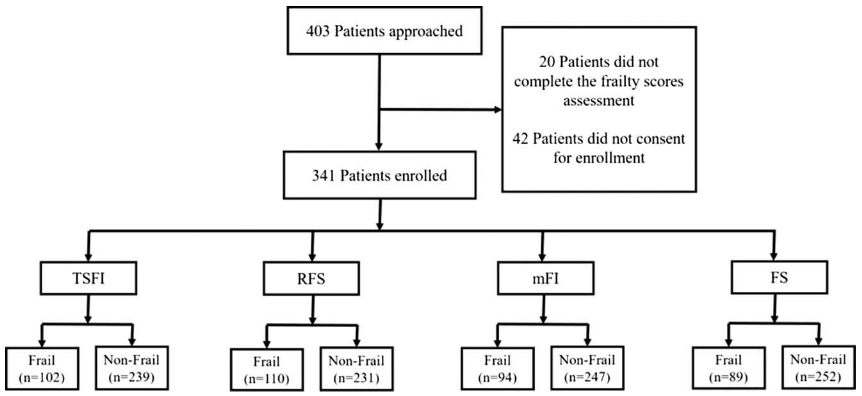

Figure 1. Patient recruitment flow diagram.

Frailty Calculation

We calculated the following frailty scores for each patient: the TSFI, the Modified Frailty Index (mFI) derived from the Canadian Study of Health and Aging (CSHA), the Rockwood Frailty Score (RFS), and the International Association of Nutrition and Aging Five-item frailty scale (FS).

Trauma Specific Frailty Index

The TSFI questionnaire (derived from the Rockwood frailty survey) is a frailty tool that was developed and validated for use with older adult trauma patients at the University of Arizona in 2014.[15,16] It follows the deficit accumulation model of frailty and includes questions that cover the patient's overall health, including comorbidities, activities of daily living, health attitude, function (i.e., sexual activity), and nutritional domain that is assessed using total serum albumin levels. Most of the 15 variables included in the TSFI are dichotomized variables (i.e., their answers are either yes or no), whereas others have multiple categories as shown in the Supplemental Digital Content, Appendix, http://links.lww.com/TA/B470. Each variable is given a score, then individual scores are added up and divided by the maximum score (i.e., 15) to calculate the TSFI, which ranges from 0 to 1 with higher scores indicating a frail status. Patients were then stratified into two groups based on their TSFI: non-frail (TSFI <0.25), and frail (TSFI ≥0.25).[12]

The mFI

The mFI is an 11-variable tool that was derived from the CSHA-FI.[13] It has been applied extensively in diverse surgical settings, including colorectal, vascular and spine surgery.[17–19] For the frailty calculation, each positive comorbidity is equivalent to one point. The sum of the positive points is then divided by the total number of points available. Thus, the mFI score ranges from 0.0 to 1.0, with 1.0 being the frailest. The 11 variables of mFI are demonstrated in the Supplemental Digital Content, Appendix, http://links.lww.com/TA/B470. Patient was stratified as frail (mFI ≥ 0.25) and non-frail (mFI < 0.25).[16,20,21]

Rockwood Frailty Score

The RFS, also known as the Clinical Frailty Scale (CFS), was developed to provide physicians with an objective tool to stratify patients based on their vulnerability level.[22] The RFS been validated on >2000 older adults from the CSHA, and it has been shown to be a reliable predictor of clinical outcomes. It has 9 scores ranging from 1 (very fit) to 9 (terminally ill). The RFS categories are demonstrated in the Supplemental Digital Content, Appendix, http://links.lww.com/TA/B470. As per the scoring system, patients are considered to be frail when their CFS score is ≥5.[23]

International Association of Nutrition and Aging 5-item FS

The FS was created at a consensus meeting of the International Academy on Nutrition and Aging Task Force.[24] The foundation of the FS model and its variables are heavily derived from Fried's phenotypic model. It is composed of five domains (resistance, fatigue, weight loss, ambulation, and illness). Each item on the scale is scored as a binary outcome. The summed score ranges from 0 to 5. A 0 indicates an absence of frailty, and scores greater than 2 indicate frailty.[25] The FS items are demonstrated in the Supplemental Digital Content, Appendix, http://links.lww.com/TA/B470.

Study Protocol and Outcomes

Two investigators approached all eligible trauma patients after identifying them during the morning sign-outs. After obtaining informed consent, we explained the frailty questionnaires in detail and filled them out for each patient. The inter-rater reliability was assessed between the two investigators and Cohen's κ coefficient was calculated κ = 0.83 indicating a substantial agreement. We collected data points via electronic medical records, including demographics, injury parameters, admission vitals, components of frailty scores not covered in the questionnaires, complications (deep vein thrombosis, unplanned intubation, myocardial infarction, cardiac arrest, pneumonia, acute kidney injury, pulmonary embolism, sepsis, acute respiratory distress syndrome, compartment syndrome, cerebrovascular accident, deep organ/space infection, and osteomyelitis), limiting life-sustaining treatment (hospice care or do not resuscitate order), and hospital course. Data points regarding the occurrence of a readmission within 30 days of discharge were also abstracted from the electronic health record. In the event that the patient could not be tracked this way, phone calls were made by one of the two investigators who were performing the frailty assessment. Outcome measures were complications, mortality, discharge disposition, and 30-day readmission.

Statistical Analysis

Data points were reported as mean ± standard deviation (SD) for continuous normally distributed variables, as median [interquartile range] for continuous variables without normal distribution, and as proportions (%) for categorical variables. To assess the predictive value of each score for the analyzed outcomes, univariate and multivariate analyses were performed. Variables with a *p*-value ($p < 0.2$) association on the univariate analysis were then used in a multivariate logistic regression model with each outcome adjusted for patient characteristics, injury parameters, emergency department (ED) vitals, and overall comorbidities.

The C-statistics (area under the receiver-operating characteristics curve) was performed to compare the predictive power of the four frailty scores assessed. C-statistics ranges from 0 to 1, with 0.50 indicating that the model performed no better than chance alone, and values of 0.70 or greater are generally accepted as strong models.[26] For model calibration and goodness of fit, we applied Hosmer-Lemeshow statistics. Additionally, Spearman's correlation was used to measure rank of correlation. In our study, alpha was set at 5%, and a value of *p* less than 0.05 was considered statistically significant. All statistical analyses were performed using the Statistical Package for Social Sciences (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.).

RESULTS

A total of 341 elderly trauma patients were enrolled in the study. The mean age was 76 ± 9 years, 32% were female, and 81% were white. Prior to their injuries, the patients included in the study had a wide array of different comorbidities. Hypertension was the most common comorbidity (30%), followed by diabetes (26%) and functional dependence (14%). In terms of injury parameters, the Injury Severity Score (ISS) was in the moderate range with a median of 13 [9–18], and a minimally affected neurological status as the median Glasgow Coma Scale (GCS) score was 15 [12–15]. The majority of patients sustained injuries secondary to falls (62%), while motor vehicle collisions were a less common mechanism of injury (23%). On evaluation in the ED, most patients were hemodynamically maintained with a mean systolic blood pressure of 144 ± 25 mm of Hg and a mean heart rate of 84 ± 15 bpm. Regarding their in-hospital stay, the mean intensive care unit (ICU) length of stay (LOS) was 2 ± 2 days and the mean hospital LOS was 5 ± 3 days (Table 1).

TABLE 1. Patient Characteristics for Different Frailty Scores

Frailty Scale	TSFI		mFI		FS		RFS	
Patient Characteristics	Frail (n = 102)	NF (n = 239)	Frail (n = 94)	NF (n = 247)	Frail (n = 89)	NF (n = 252)	Frail (n = 110)	NF (n = 231)
Age, mean ± SD	77 ± 8	75 ± 7	78 ± 9	75 ± 8	77 ± 7	74 ± 7	76 ± 8	75 ± 6
Female, %	31%	33%	36%	31%	35%	32%	34%	32%
Whites, %	82%	81%	78%	82%	83%	80%	82%	80%
Mechanism of injury, %								
Fall	66%	60%	67%	59%	65%	60%	67%	59%
MVC	22%	23%	25%	22%	20%	24%	19%	24%
Other	12%	17%	8%	19%	15%	16%	14%	17%
ISS, median [IQR]	12 [9–18]	12 [10–17]	13 [8–18]	13 [9–17]	13 [9–18]	12 [8–17]	14 [9–18]	13 [8–17]
Vital parameters								
ED SBP, mm Hg mean ± SD	142 ± 26	145 ± 28	138 ± 24	147 ± 29	143 ± 25	145 ± 27	142 ± 25	146 ± 26
ED HR, BPM, mean ± SD	85 ± 18	83 ± 16	86 ± 17	84 ± 15	83 ± 17	82 ± 15	86 ± 16	84 ± 15
GCS, median [IQR]	15 [12–15]	15 [13–15]	15 [11–15]	15 [13–15]	15 [12–15]	15 [12–15]	15 [13–15]	15 [11–15]
Comorbidities, %								
DM	29%	25%	31%	24%	30%	25%	33%	23%
CHF	8%	5%	10%	5%	11%	4%	12%	3%
CKD	12%	11%	15%	10%	12%	11%	14%	10%
CAD	21%	9%	18%	10%	25%	8%	20%	11%
HTN	38%	26%	34%	28%	31%	29%	36%	26%
COPD	19%	10%	20%	10%	17%	11%	21%	7%
Delirium	6%	3%	7%	3%	8%	2%	5%	3%
Stroke/TIA	7%	6%	9%	5%	12%	4%	10%	4%
CLD	12%	8%	11%	8%	15%	7%	14%	7%
Functionally dependent	25%	10%	18%	13%	20%	12%	23%	10%
Hospital characteristics: mean ± SD, d								
Hospital LOS	6 ± 4	4 ± 2	5 ± 4	3 ± 1	5 ± 3	3 ± 2	6 ± 3	4 ± 1
ICU LOS	3 ± 2	2 ± 1	3 ± 2	1 ± 1	3 ± 1	1 ± 1	2 ± 1	2 ± 2
LLST	6%	0.8%	4%	2%	6%	2%	5%	2%

NF, non-frail; SD, standard deviation; MVC, motor vehicle collision; IQR, interquartile range; ED SBP, ED systolic blood pressure; ED HR, ED heart rate; bpm, beats per minute; DM, diabetes mellitus; CHF, congestive heart failure; CKD, chronic kidney disease; CAD, coronary artery disease; HTN, hypertension; COPD, chronic obstructive pulmonary disease; TIA, transient ischemic attack; CLD, chronic liver disease; LLST, limited life-sustaining treatment.

A larger number of patients were classified as frail when using the RFS (32%) and the TSFI (30%) assessment tools in comparison to the mFI (28%) and the FS (26%) assessment tools. Patients classified as frail across all frailty measurement tools were more likely to be older, have higher rates of all assessed comorbidities, and were more likely to sustain falls leading to a significantly higher ISS. No significant differences were found between frail and non-frail patients across all frailty assessment tools in terms of gender, race, systolic blood pressure, heart rate, and admission GCS. Regarding the in-hospital duration of patients classified as frail across all frailty assessment tools, they had a significantly higher ICU LOS and hospital LOS.

The overall rate of in-hospital complications was 22%. Adverse discharge disposition was 32%, and 30-day readmission was 22%. In-hospital mortality was 10%. A larger number of frail patients were found to have in-hospital complications, skilled nursing facility (SNF) disposition, mortality, and 30-day readmission when using the RFS and the TSFI to dichotomize the sample based on frailty status in comparison to the mFI and the FS assessment tools. Therefore, the TSFI and RFS had a higher sensitivity for detecting the four major outcomes reported. In a similar way, when using the TSFI and RFS as frailty stratification tools, a lower number of non-frail patients did not have in-hospital complications, had a non-SNF discharge disposition, did not have 30-day readmission, and survived their in-hospital stay. Therefore, the TSFI and the RFS achieved a higher specificity for ruling out the occurrence of the four major outcomes reported (Table 2).

When looking at the correlation between the TSFI and the remaining three frailty indexes, the results signify that across the 4 major outcomes reported the TSFI achieved a strong positive monotonic correlation with the other indexes as demonstrated by the Spearman correlation coefficient ($r_S > 0.7$). Furthermore, the TSFI appears to be more strongly correlated with the RFS index ($r_S > 0.9$) across all 4 outcomes, followed by the mFI ($0.843 \geq r_S \geq 0.822$), and then the FS ($0.804 \geq r_S \geq 0.787$). The strongest correlation was found between the TSFI and the RFS in patients who did not survive their in-hospital stay ($r_S = 0.938$), followed by patients who were readmitted within 30 days ($r_S = 0.927$; $p = 0.001$). The TSFI mostly correlated with the FS index in patients who did not survive their in-hospital stay ($r_S = 0.804$), as was the case with the mFI ($r_S = 0.843$) (Table 3).

The unadjusted models indicated that both the TSFI and the RFS had comparable predictive value, as indicated by their c-statistics for mortality (unadjusted c-statistic: TSFI, 0.759; RFS, 0.751), in-hospital complications (unadjusted c-statistic: TSFI, 0.711; RFS, 0.723), SNF disposition (unadjusted c-statistic: TSFI, 0.757; RFS, 0.745) and 30-day readmission (unadjusted c-statistic: TSFI, 0.711; RFS, 0.698). Both TSFI and RFS models had c-statistics indicating a relatively strong predictive ability, which was significantly stronger than the mFI and the FS for all outcomes in the unadjusted models. Furthermore, the TSFI and the RFS indexes appear to better predict mortality as well as SNF disposition relative to in-hospital complications and 30-day readmission. The unadjusted mFI and FS models did not have a have strong predictive ability for predicting mortality (c-statistic: mFI, 0.668; FS, 0.655) and in-hospital complications (c-statistic: mFI, 0.645; FS, 0.591). They also had a lower predictive ability for SNF disposition (c-statistic: mFI, 0.584; FS, 0.510) and 30-day readmissions (c-statistic: mFI, 0.588; FS, 0.525) compared with the TSFI and RFS (Table 4).

TABLE 3. Correlation Between TSFI and Other Frailty Scores (Spearman's Correlation)

Outcome	TSFI: mFI	TSFI: FS	TSFI: RFS
In-hospital complications	0.833*	0.795*	0.930*
SNF disposition	0.822*	0.787*	0.919*
Mortality	0.843*	0.804*	0.938*
30-d Readmission	0.829*	0.790*	0.927*

*$p < 0.05$.

DISCUSSION

The early identification and assessment of vulnerable patients are critical to optimize outcomes in geriatric trauma patients. Currently, several frailty measurement tools have been developed and validated in different patient cohorts including trauma. However, there is no consensus regarding the usage of a universal frailty score.[15] The results of our study show that there is a significant difference between four commonly used frailty scores in predicting outcomes in trauma patients. The TSFI and RFS were superior to the FS and mFI in predicting outcomes including mortality, in-hospital complications, SNF disposition and 30-day readmission. Even though the proportion of patients considered to be frail differed depending on the frailty scoring system used, these differences did not reach statistical significance ($p = 0.304$). The proportion of frail patients was therefore the same regardless of the frailty score used. This indicates that the 4 scores are equivalent in terms of their ability to diagnose frailty. However differences in frailty dimensions have expanded the ability of some scores to predict pertinent clinical outcomes more accurately than others.

TABLE 2. Outcomes With Different Frailty Scores

Frailty Scale	TSFI			mFI			FS			RFS		
Outcome Measure, n (%)	Frail (n = 102)	NF (n = 239)	*p*	Frail (n = 94)	NF (n = 247)	*p*	Frail (n = 89)	NF (n = 252)	*p*	Frail (n = 110)	NF (n = 231)	*p*
In-hospital complications	34 (33%)	41 (17%)	0.004	28 (30%)	47 (19%)	0.04	28 (32%)	47 (19%)	0.03	37 (34%)	38 (16%)	0.001
SNF disposition	43 (42%)	66 (27%)	0.01	39 (41%)	70 (28%)	0.03	36 (40%)	73 (29%)	0.04	47 (43%)	62 (27%)	0.004
Mortality	19 (19%)	15 (6%)	0.001	15 (16%)	19 (7%)	0.02	12 (13%)	22 (9%)	0.21	20 (18%)	13 (6%)	<0.001
30-d Readmission	33 (32%)	42 (18%)	0.004	28 (30%)	47 (19%)	0.04	27 (30%)	48 (19%)	0.03	35 (32%)	40 (17%)	0.003

TABLE 4. Comparison of Unadjusted and Adjusted Regression of TSFI, mFI, FS, and RFS

	Unadjusted Model		Adjusted Model	
	C-statistic (CI)	OR (CI)	C-Statistic (CI)	OR (CI)
Mortality				
TSFI	0.759 (0.742–0.824)	18.4 (8.3–26.5)	0.847 (0.823–0.877)	4.2 (2.4–6.2)
mFI	0.668 (0.614–0.715)	13.5 (4.2–25.8)	0.737 (0.711–0.745)	2.1 (1.4–3.5)
FS	0.655 (0.601–0.684)	8.6 (4.1–10.2)	0.701 (0.615–0.712)	1.6 (1.2–2.5)
RFS	0.751 (0.722–0.791)	16.4 (9.2–27.5)	0.851 (0.844–0.891)	4.5 (2.1–5.1)
In-hospital complications				
TSFI	0.711 (0.691–0.725)	15.9 (7.8–21.1)	0.801 (0.789–0.812)	3.5 (2.5–4.8)
mFI	0.645 (0.615–0.716)	11.2 (6.5–16.3)	0.711 (0.709–0.746)	2.2 (1.9–2.8)
FS	0.591 (0.501–0.621)	6.5 (3.5–11.5)	0.701 (0.698–0.745)	1.8 (1.6–2.1)
RFS	0.723 (0.701–0.745)	16.8 (7.4–20.5)	0.811 (0.801–0.832)	3.9 (1.8–4.1)
SNF disposition				
TSFI	0.757 (0.742–0.816)	19.2 (9.2–25.1)	0.841 (0.822–0.846)	3.9 (2.6–4.4)
mFI	0.584 (0.515–0.621)	6.6 (3.4–9.5)	0.658 (0.615–0.678)	1.8 (1.3–2.5)
FS	(0.510) (0.499–0.551)	5.5 (2.7–7.5)	(0.610) (0.598–0.625)	1.4 (1.1–1.8)
RFS	0.745 (0.710–0.784)	19.5 (9.6–24.5)	0.825 (0.810–0.845)	3.7 (2.4–4.5)
30-d Readmission				
TSFI	0.711 (0.687–0.782)	15.3 (7.9–21.6)	0.752 (0.767–0.802)	3.5 (2.4–5.2)
mFI	0.588 (0.545–0.610)	7.1 (3.2–12.7)	0.611 (0.585–0.641)	1.5 (1.2–2.2)
FS	0.525 (0.512–0.615)	6.8 (3.2–11.5)	0.602 (0.498–0.615)	1.4 (1.2–2.1)
RFS	0.698 (0.655–0.712)	14.7 (7.1–20.4)	0.757 (0.700–0.784)	3.5 (2.5–5.1)

CI, confidence interval; OR, odds ratio.

Comprehensive frailty assessment should take into account several factors that might affect the patient's physiologic reserve, including comorbidities, nutritional status, and other functional aspects that make the patient vulnerable to stressors. The TSFI components include five main domains that account for comorbidities, daily activities, health attitude, functionality, and nutrition. Similarly, the RFS accounts for a patient's comorbidities, functional status, and cognitive function. In our analysis, the TSFI and RFS have a comparable predictive power and they outperformed the mFI and FS in terms of predicting mortality, in-hospital complications, 30-day readmission, and adverse discharge disposition. There are many reasons that could potentially explain these findings knowing that certain scores account for more frailty dimensions and therefore capture the state of depleted physiological reserve more comprehensively. Unlike the FS, and mFI, the TSFI tool accounts for nutritional status represented by serum albumin levels. This could be one of the reasons behind the differences in performance noticed in light of the existing body of literature describing the deleterious effect of undernutrition on outcomes in older adults. For example, Buys et al. and Yang et al. have demonstrated that nutritional risk and undernutrition were associated with increased rates of mortality as well as increased SNF admissions.[19,22] Malnourished patients also have a higher risk of readmission,[24] and postoperative in-hospital complications.[24,26–29] Knowing that the TSFI has more granularity regarding the nutritional status of patients this could one of the contributing factors why it was superior in predicting the similar outcomes assessed in this study such as mortality, readmission, and in-hospital complications. Although weight loss is one of the components of the FS, this might not reflect the overall nutritional status in older adults as multiple comorbid factors such as malignancy and sarcopenia can independently contribute to weight loss.

Other than nutritional status, the TSFI and the RFS are also more comprehensive in other frailty dimensions. The calculation of both the TSFI and RFS entails a comprehensive assessment of functional status. For instance, the RFS accounts for functional status by stratifying frailty according to symptoms that limit daily activities as well as activities that involve high levels of functionality (e.g., finance, heavy housework, and taking medications). The TSFI accounts for functional status and social vulnerability by using several questions that target daily activities, health attitude, and sexual activity. Multiple studies have highlighted that decreased physiological reserve in frail patients makes them vulnerable to social stressors and social vulnerability has been shown to be associated with adverse outcomes in geriatric patients.[30] Additionally, older adults are at an increased risk of functional decline especially after trauma[31,32] and our group has shown previously that frailty is associated with overall decline in functionality and impaired functional recovery in trauma patients.[33] This subsequently entails an increased risk of mortality, major complications,[34] discharge to a facility,[35] and hospital readmission, independent of patient demographics and other clinical factors.[36] Frailty indices that place more emphasis on the functionality and social vulnerability dimensions of frailty are expected to better predictors of outcomes such as SNF disposition, 30-day readmission, and mortality that we assessed in our study. The mFI assesses the functional status through only one variable, that is, functional dependency. Regarding the FS, it is not clear how functional status is assessed and it could be partially represented in the resistance and ambulation domains of the score.

Chong et al.[37] conducted a prospective cohort study of 210 geriatric patients to compare the performance of four frailty indices: FS, RFS, Tilburg Frailty Indicator (TFI), and the 5-item scale of fatigue, resistance, ambulation, illnesses, and loss of weight (FRAIL). The four scores were compared against an adopted gold standard which was the Frailty Index (FI). Considering only the frailty scores common between the two studies, the results of the multivariable logistic regression and ROC curve analysis indicate that the CFS was superior than the FI in terms of predicting in-hospital mortality and this is in line with the findings in this study. In terms of in-hospital complications, Valdatta et al.[38] concluded that the FS is an accurate predictor of surgical complications and mortality with a significant odds ratio and goodness of fit in elderly patients undergoing reconstructive surgery. However, there is scarce literature demonstrating the association of frailty measured using the FS (with mortality and in-hospital complications) among trauma patients. As postulated earlier, the low predictive ability of the FS for SNF disposition and 30-day readmission could be explained by its limitation in capturing functional and nutritional status compared with the RFS and TSFI.

In our analysis, we have found that the mFI model does not have a strong ability (unadjusted c-statistic ≥ 0.7) for predicting mortality and in-hospital complications. In addition, it has a lower predictive ability for SNF disposition and 30-day readmissions compared with the TSFI and RFS. It is relatively less accurate in predicting postdischarge outcomes and this could be explained by its excessive reliance on the comorbidities dimension at the expense of capturing more diverse indicators of depleted physiologic reserve such as functionality. Other reasons for this could be related to the fact that the mFI was developed by mapping the National Surgical Quality Improvement Program (NSQIP) dataset variables to those of the CSHA-FI. This enables it to be utilized in a retrospective fashion using different datasets including the NSQIP and Nationwide Inpatient Sample (NIS)[39] and its performance in a prospective analysis may not be as optimal as previously described.[14–16]

The usefulness these scores in the day-to-day care of elderly injured patients remains primarily for providing objective criteria for prognostication, risk stratification, resource allocation and guiding acuity of care. The literature highlights the potential role of sarcopenia as a useful indicator of frailty and the two concepts have been studies in parallel over the past decades.[40] Findings by Wallace et al. indicate that reduced masseter muscle mass measured on head imaging in elderly severe traumatic brain injury patients has been associated with 2-year mortality.[41–43] However, there are also reports that consider sarcopenia as a clinical sign that is not specific for the elderly[44] and others reporting that sarcopenia as an individual marker may not be an effective screening tool.[45] Even though sarcopenia can be measured quickly, the advantage of frailty is that it is more comprehensive and multidimensional this can may provide greater relevance for the clinician than the unidimensional approach of sarcopenia.[44]

The identification of frail patients using frailty scores is crucial because frail patients would benefit from multiple interventions. Engelhardt et al.[46] described a novel frailty pathway to reduce length of stay and 30-day readmission rates for frail trauma and acute care surgery patients after frailty assessment using the TSFI. The frailty pathway described is multimodal, multidisciplinary, and successfully improved outcomes. It includes early hospitalist consultation to tackle the complex medical needs of the elderly along with consultation of a palliative care specialist's service for patients with certain medical conditions and poor prognostic criteria.[46] In addition, the pathway includes the expedited utilization of physical and occupational therapy services to reduce the risk of falls and difficulty with activities of daily living. Upon admission, a standardized admission order set was adopted to avoid polypharmacy and treatments that can lead to confusion, delirium, and other described neuropsychiatric sequelae. There is also a focus on the cautious use of fluids, nursing care, early engagement of social workers, avoidance of certain medications, and multimodal pain management. Finally, the pathway emphasizes a rigorous postdischarge follow-up.[46] Lenartowicz et al. suggested a model of care that incorporates proactive geriatric consultation. This has led to a reduction in the incidence of in-patient delirium and discharge to facilities.[46] This was further supported by findings reported by Tillou et al.[47] who added that a comprehensive geriatric assessment may even improve functional recovery following injury.

Our study has strengths and limitations. The strengths emerge from it being a prospective study. Additionally, rigorous procedures for enrollment and frailty screening were performed using previously validated robust frailty tools. The limitations of our study are that it was a single-institutional study (limiting the generalizability of our results) and that for long-term outcomes we only assessed the 30-day readmission. The overall mortality rate may have been underestimated knowing that in-hospital mortality can be a small fraction of the long term mortality.[48] Even though we collected information about the decision to limit life-sustaining treatment among the patient sample, those who were transferred to hospice or had their status converted to do not resuscitate and subsequently died were counted as part of the in-hospital mortality. This could be a limitation in light of the study by Kozar et al.,[49] who highlighted the impact of discharge to hospice on the performance metrics of the Trauma Quality Improvement Program centers and mentioned the need to adjust mortality rates whether hospice cases were treated as survivors rather than deaths.[49,50] Additionally, the morbidity outcomes we assessed, such as complications, readmission, and SNF disposition, are subject to survivor bias. We have only compared four of the most commonly used frailty scores that were developed on different patient population. Nonetheless, we believe that these are the most applicable frailty scores for the trauma patient population due to their simplicity and the feasibility of calculation in acute settings.

CONCLUSION

In our prospective cohort analysis of geriatric trauma patients, we found significant differences regarding the predictive ability of four commonly used frailty scores. Although all four scores showed some correlation with outcomes, TSFI and RFS had the highest predictive power. The TSFI is easy to calculate and has a strong predictive ability, thus it might be used as a universal frailty score for prognostication and risk stratification in geriatric trauma patients.

AUTHORSHIP

K.H., B.J., Z.H., A.S., M.H., M.Z., and L.G. designed this study. K.H., B.J., Z.H., A.S., M.H., N.K., and A.T. searched the literature. K.H., B.J., Z.H., A.S., M.H., M.Z., and L.G. collected the data. K.H., B.J., Z.H., A.S., M.H., and M.Z. analyzed the data. All authors participated in data interpretation and article preparation.

DISCLOSURE

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