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Investigating the link between frailty and outcomes in geriatric patients with isolated rib fractures

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ABSTRACT

Background Studies have shown an increased risk of morbidity in elderly patients suffering rib fractures from blunt trauma. The association between frailty and rib fractures on adverse outcomes is still ill-defined. In the current investigation, we sought to delineate the association between frailty, measured using the Orthopedic Frailty Score (OFS), and outcomes in geriatric patients with isolated rib fractures.

Methods All geriatric (aged 65 years or older) patients registered in the 2013–2019 Trauma Quality Improvement database with a conservatively managed isolated rib fracture were considered for inclusion. An isolated rib fracture was defined as the presence of ≥1 rib fracture, a thorax Abbreviated Injury Scale (AIS) between 1 and 5, an AIS ≤1 in all other regions, as well as the absence of pneumothorax, hemothorax, or pulmonary contusion. Based on patients' OFS, patients were classified as non-frail (OFS 0), pre-frail (OFS 1), or frail (OFS ≥2). The prevalence ratio (PR) of composite complications, in-hospital mortality, failure-to-rescue (FTR), and intensive care unit (ICU) admission between the OFS groups was determined using Poisson regression models to adjust for potential confounding.

Results A total of 65 375 patients met the study's inclusion criteria of whom 60% were non-frail, 29% were pre-frail, and 11% were frail. There was a stepwise increased risk of complications, in-hospital mortality, and FTR from non-frail to pre-frail and frail. Compared with non-frail patients, frail patients exhibited a 87% increased risk of in-hospital mortality [adjusted PR (95% CI): 1.87 (1.52-2.31), p<0.001], a 44% increased risk of complications [adjusted PR (95% CI): 1.44 (1.23-1.67), p<0.001], a doubling in the risk of FTR [adjusted PR (95% CI): 2.08 (1.45-2.98), p<0.001], and a 17% increased risk of ICU admission [adjusted PR (95% CI): 1.17 (1.11-1.23), p<0.001].

Conclusion There is a strong association between frailty, measured using the OFS, and adverse outcomes in geriatric patients managed conservatively for rib fractures.

BACKGROUND

The geriatric population, comprising individuals aged 65 years and older, currently represents approximately 7% of the global population but is estimated to triple in size by 2030.[1] In the USA, it is projected that the geriatric population will comprise nearly 21% of the total population by the same year.[2] With independent and active lifestyles becoming increasingly prevalent in this cohort, the elderly population also face an elevated risk of experiencing traumatic injuries compared with previous years.[2 3]

Trauma patients commonly exhibit injuries to the thoracic cage and its contents.[4] In the geriatric population, these injuries can have a significant negative impact,[5–8] especially among those who are frail. Frailty, which refers to a multidimensional state of physiological decline that reduces the body'‘s ability to withstand stressors, has been strongly linked to negative outcomes in geriatric trauma patients.[9 10] Accurately measuring frailty in this population is also essential to many of the questions identified by the National Trauma Research Action Plan (NTRAP) geriatric research gap Delphi survey.[11] Several frailty scores have been developed and validated for geriatric trauma patients,[12] with one specifically targeted towards geriatric patients with multiple rib fractures.[13] The use of the latter in clinical settings may however be limited due to its complex calculation. Recently, a novel frailty score, the Orthopedic Frailty Score (OFS), consisting of five readily available variables at the time of admission, has been developed and validated in orthopedic patients who experienced traumatic fractures.[14–16] In the current study, we set out to investigate the relationship between the OFS and adverse outcomes in geriatric patients with conservatively managed isolated rib fractures.

METHODS

The current study complied with the Strengthening the Reporting of Observational Studies (online supplemental file 1) in Epidemiology guidelines as well as the Declaration of Helsinki.[17] The study was carried out using The American College of Surgeons Trauma Quality Improvement Program (TQIP) database. The data retrieved included a range of patient characteristics, such as age, sex, race, injury severity, comorbidities, discharge disposition and other outcomes. Only geriatric patients (aged 65 years or older) registered in the 2013–2019 TQIP database with non-operatively managed, isolated rib fractures were considered for inclusion. An isolated rib fracture was defined as an International Classification of Diseases (ICD)-9 or ICD-10 code corresponding to rib fracture, a thorax Abbreviated Injury Scale (AIS) between 1 and 5, an AIS ≤1 in all other regions, as well as the absence of pneumothorax, hemothorax, or pulmonary contusion.

Patients with a thorax AIS of 6 were excluded as these injuries are generally not considered survivable.

Calculating the Orthopedic Frailty Score

The OFS was calculated for each patient based on five binary variables, including congestive heart failure, a history of malignancy, institutionalization, non-independent functional status, and an age of 85 years or above. Patients were defined as institutionalized if they were admitted from a nursing home, long-term care facility, or other group living arrangement, identified using the ICD place of occurrence external cause code. Patients received one point for each variable present, with a maximum possible score of 5.[14]

Calculating the Revised Cardiac Risk Index

The Revised Cardiac Risk Index (RCRI) was calculated according to a previous study validating it for patients with geriatric rib fracture.[18] Patients received one point for each of the following variables: history of ischemic heart disease, congestive heart failure, cerebrovascular disease, renal insufficiency (defined as acute kidney injury or chronic kidney disease), and diabetes mellitus. No point was awarded for high-risk surgery (any intraperitoneal, intrathoracic, and suprainguinal vascular procedure) as all patients were conservatively managed, resulting in a maximum potential score of 5.

Calculating the 5-Factor Modified Frailty Index

The 5-Factor Modified Frailty Index (5-mFI) was determined based on the presence of the following variables: congestive heart failure, non-independent functional status, hypertension, respiratory pathology (chronic obstructive pulmonary disease or ongoing pneumonia), and diabetes mellitus. For each variable present patients received 1 point, resulting in a maximum possible score of 5.[19]

Calculating the Johns Hopkins Frailty Indicator

According to the Johns Hopkins Frailty Indicator, patients are classified as either non-frail or frail based on the presence of at least one frailty defining diagnosis. These diagnoses include nutritional marasmus, other severe protein-calorie malnutrition, senile dementia with delusional or depressive features, senile dementia with delirium, profound visual impairment, decubitus ulcer, incontinence without sensory awareness, continuous urinary leakage, abnormal loss of weight and underweight, feeding difficulties and mismanagement, fecal incontinence, lack of housing, inadequate housing, inadequate material resources, difficulty in walking, abnormality of gait, fall on stairs or steps, or fall from wheelchair.[20,21]

Statistical analysis

Patients were grouped based on their OFS: non-frail (OFS 0), pre-frail (OFS 1), and frail (OFS ≥2).[14,16,22] Continuous variables were summarized as medians and IQRs, while categorical variables were organized as counts and percentages. The Kruskal-Wallis test was employed to evaluate the statistical significance of differences between continuous variables and either the χ^2 test or Fisher's exact test for categorical variables. The primary outcome of interest was in-hospital mortality, with secondary outcomes consisting of any in-hospital complication [myocardial infarction, cardiac arrest with cardiopulmonary resuscitation, stroke, deep vein thrombosis, pulmonary embolism, acute respiratory distress syndrome, urinary tract infection, pneumonia, sepsis, decubitus ulcer, unplanned intubation, unplanned admission to the intensive care unit (ICU)], failure-to-rescue (FTR), ICU admission, as well as hospital length of stay (LOS). FTR was defined as in-hospital mortality following a complication.

Due to the lack of the exact dates of the outcomes of interest, the associations between frailty and in-hospital mortality, complications, FTR, and ICU admission were assessed using prevalence ratio (PR) instead of incidence rate ratio. PRs were determined using Poisson regression models and robust standard errors were used to calculate their 95% CIs.[23] The Poisson regression models included the OFS as well as other covariates as explanatory variables to adjust for potential confounding. These covariates consisted of age, sex, race, highest AIS in each region, injury pattern, hypertension, previous myocardial infarction, history of peripheral vascular disease, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, smoking status, chronic renal failure, diabetes mellitus, cirrhosis, coagulopathy, drug use disorder, alcohol use disorder, major psychiatric illness, and advanced directives limiting care.

A quantile regression model was used to determine the association between frailty and hospital LOS. The model was adjusted for the same potential confounders as the Poisson regression models and results are presented as the change in median LOS along with 95% CIs.

In order to compare the OFS ability to predict in-hospital mortality with other risk scores used in patients with rib fracture, as well as other frailty indices, the permutation importance (PI) method was employed.[24] The PI was determined by estimating how much a specific value [1−area under the receiver operating characteristic curve (AUC)] was reduced by the omission of a given variable. This omission was performed by permuting the variable's values to mask the association between the variable and the outcome. This process was repeated 10 times to account for the inherent variability associated with this process. The relative importance of each variable was presented as the average increase in 1−AUC compared with the AUC in a model including all variables without masking. In addition to the OFS, the 5-mFI, RCRI, and Johns Hopkins Frailty Indicator were also included in this analysis.

A two-sided p value <0.05 was considered to be statistically significant. To manage missing data, multiple imputation by chained equations was employed. Seven imputed datasets were generated through five iterations of imputations. Models were fitted to each imputed dataset and the results were pooled by calculating the average coefficients and SEs across all models. Analyses were performed using statistical software R version 4.0.5, with the tidyverse, haven, mice, sandwich, quantreg, and DALEX packages.[25]

RESULTS

A total of 65 375 patients met the study's inclusion criteria. According to their OFS, 60.5% (n=39 546) were non-frail, 28.0% were prefail (n=18 315), and 11.5% were frail (n=7514). Frail patients were on average older (85 years vs 74 years, p<0.001), more often female (58.4% vs 45.8%, p<0.001), and white (89.8% vs 85.3%, p<0.001), compared to non-frail patients. All comorbidities were more prevalent among frail patients except for liver cirrhosis and substance use disorders (table 1). Frail patients were less severely injured than non-frail patients (thorax AIS ≤2: 44.6% vs 42.6%, p<0.001), with sternum fractures being less common among frail patients (2.4% vs 9.1%, p<0.001) (table 2).

Crude in-hospital mortality (2.8% vs 1.2%, p<0.001) and complication rates (4.1% vs 2.6%, p<0.001) were significantly

Table 1 Demographics of geriatric patients with non-operatively managed isolated rib fractures

	Non-frail (n=39 546)	Pre-frail (n=18 315)	Frail (n=7514)	P value
Age, median (IQR)	74 (69–79)	84 (76–87)	86 (83–88)	<0.001
Sex, n (%)				<0.001
Female	18 125 (45.8)	9876 (53.9)	4385 (58.4)	
Male	21 413 (54.1)	8433 (46.0)	3127 (41.6)	
Missing	8 (0.0)	6 (0.0)	2 (0.0)	
Race, n (%)				
White	33 727 (85.3)	16 158 (88.2)	6747 (89.8)	<0.001
Black	2173 (5.5)	814 (4.4)	313 (4.2)	<0.001
Asian	963 (2.4)	379 (2.1)	140 (1.9)	<0.001
American Indian	154 (0.4)	57 (0.3)	12 (0.2)	0.005
Pacific islander	69 (0.2)	26 (0.1)	11 (0.1)	0.617
Other	1882 (4.8)	658 (3.6)	216 (2.9)	<0.001
Missing	381 (1.0)	158 (0.9)	37 (0.5)	
Hypertension, n (%)	24 983 (63.2)	12 925 (70.6)	5498 (73.2)	<0.001
Previous myocardial infarction, n (%)	735 (1.9)	439 (2.4)	210 (2.8)	<0.001
Congestive heart failure, n (%)	0 (0.0)	3295 (18.0)	3019 (40.2)	<0.001
History of peripheral vascular disease, n (%)	520 (1.3)	369 (2.0)	236 (3.1)	<0.001
Cerebrovascular disease, n (%)	1743 (4.4)	1339 (7.3)	628 (8.4)	<0.001
Dementia, n (%)	2012 (5.1)	2588 (14.1)	2094 (27.9)	<0.001
Non-independent functional status, n (%)	0 (0.0)	4692 (25.6)	5038 (67.0)	<0.001
Institutionalized, n (%)	0 (0.0)	1083 (5.9)	2664 (35.5)	<0.001
History of malignancy, n (%)	0 (0.0)	796 (4.3)	488 (6.5)	<0.001
COPD, n (%)	5879 (14.9)	3588 (19.6)	1651 (22.0)	<0.001
Current smoker, n (%)	4392 (11.1)	1297 (7.1)	307 (4.1)	<0.001
Chronic renal failure, n (%)	941 (2.4)	729 (4.0)	420 (5.6)	<0.001
Diabetes mellitus, n (%)	10 844 (27.4)	5167 (28.2)	2101 (28.0)	0.123
Cirrhosis, n (%)	481 (1.2)	224 (1.2)	65 (0.9)	0.028
Coagulopathy, n (%)	2901 (7.3)	1914 (10.5)	810 (10.8)	<0.001
Drug use disorder, n (%)	634 (1.6)	247 (1.3)	68 (0.9)	<0.001
Alcohol use disorder, n (%)	1948 (4.9)	550 (3.0)	101 (1.3)	<0.001
Major psychiatric illness, n (%)	4090 (10.3)	2318 (12.7)	1243 (16.5)	<0.001
Advanced directive limiting care, n (%)	1244 (3.1)	1470 (8.0)	1302 (17.3)	<0.001

Non-frail, pre-frail, and frail are defined as OFS 0, OFS 1, and OFS ≥2.
COPD, chronic obstructive pulmonary disease; OFS, Orthopedic Frailty Score.

higher among frail patients than non-frail patients. The crude rate of FTR was also the highest among frail patients (1.0% vs 0.4%, p<0.001). Frail patients were more likely to require ICU care (24.8% vs 20.8%, p<0.001) and tended to have a longer LOS (4 days vs 3 days, p<0.001) (table 3). Compared to non-frail patients, after adjusting for potential confounding, frail patients exhibited a 87% increased risk of in-hospital mortality [adjusted PR (95% CI): 1.87 (1.52-2.31), p<0.001], a 44% increased risk of complications [adjusted PR (95% CI): 1.44 (1.23-1.67), p<0.001], a doubling in the risk of FTR [adjusted PR (95% CI): 2.08 (1.45-2.98), p<0.001], and a 17% increased risk of ICU admission [adjusted PR (95% CI) 1.17 (1.11-1.23), p<0.001]. Frail patients also had a median LOS that was 0.75 days longer [change in median LOS (95% CI): 0.75 (0.67-0.82), p<0.001] compared to non-frail patients (table 4). The OFS was also found to be the most important variable for predicting in-hospital mortality, when compared with the 5-mFI, RCRI, and Johns Hopkins Frailty Indicator (figure 1).

DISCUSSION

The OFS revealed a notable correlation with adverse outcomes in geriatric patients who have sustained isolated traumatic rib fractures and were managed non-operatively. Compared with non-frail patients, the frail patients had a significant increase in overall ICU utilization and hospital LOS, as well as a 44% and 87% increased risk of composite in-hospital complications and mortality, respectively.

Geriatric trauma patients frequently experience rib fractures.[8 26] Several studies have demonstrated that being 65 years or older is associated with an increased risk of adverse outcomes.[27 28] The burden of morbidity and mortality due to rib fractures often arises from respiratory complications, caused by both the direct trauma and subsequent pain-induced hypoventilation. These conditions may be devastating in the frail geriatric patient with diminished physiological reserves. In a study by Bulger *et al*, up to one-third of geriatric trauma patients with rib fractures developed pneumonia with a mortality rate over 20%.[8]

Frailty is a common condition in geriatric patients, with a reported incidence of between 23% and 52% in the geriatric population.[29] It is a multidimensional phenotype that measures the state of possessing a diminished physiological reserve, a reserve that is essential for recovery to the pre-injury functional level.[29] There is a strong association between frailty and adverse outcomes in trauma patients.[9 12 14] Mortality rates as high as 13% have been reported in frail patients with rib fracture, compared with 1.3% among non-frail patients.[13] The overall mortality

Table 2 Clinical characteristics of geriatric patients with non-operatively managed isolated rib fractures

	Non-frail (n=39 546)	Pre-frail (n=18 315)	Frail (n=7514)	P value
Head AIS, n (%)				<0.001
Injury not present	35 344 (89.4)	16 569 (90.5)	6694 (89.1)	
1	4202 (10.6)	1746 (9.5)	820 (10.9)	
Face AIS, n (%)				<0.001
Injury not present	34 919 (88.3)	16 397 (89.5)	6630 (88.2)	
1	4627 (11.7)	1918 (10.5)	884 (11.8)	
Neck AIS, n (%)				<0.001
Injury not present	39 191 (99.1)	18 197 (99.4)	7479 (99.5)	
1	355 (0.9)	118 (0.6)	35 (0.5)	
Spine AIS, n (%)				<0.001
Injury not present	39 121 (98.9)	18 158 (99.1)	7469 (99.4)	
1	425 (1.1)	157 (0.9)	45 (0.6)	
Thorax AIS, n (%)				<0.001
1	6146 (15.5)	2953 (16.1)	1278 (17.0)	
2	10 722 (27.1)	5078 (27.7)	2077 (27.6)	
3	22 447 (56.8)	10 198 (55.7)	4133 (55.0)	
4	189 (0.5)	73 (0.4)	26 (0.3)	
5	42 (0.1)	13 (0.1)	0 (0.0)	
Abdomen AIS, n (%)				<0.001
Injury not present	36 722 (92.9)	17 293 (94.4)	7105 (94.6)	
1	2824 (7.1)	1022 (5.6)	409 (5.4)	
Upper extremity AIS, n (%)				0.004
Injury not present	32 914 (83.2)	15 434 (84.3)	6312 (84.0)	
1	6632 (16.8)	2881 (15.7)	1202 (16.0)	
Lower extremity AIS, n (%)				<0.001
Injury not present	33 877 (85.7)	16 124 (88.0)	6606 (87.9)	
1	5669 (14.3)	2191 (12.0)	908 (12.1)	
External/Other AIS, n (%)				<0.001
Injury not present	37 861 (95.7)	17 607 (96.1)	7266 (96.7)	
1	1685 (4.3)	708 (3.9)	248 (3.3)	
Number of rib fractures, n (%)				0.409
Single	6535 (16.5)	2993 (16.3)	1279 (17.0)	
Multiple	33 011 (83.5)	15 322 (83.7)	6235 (83.0)	
Flail chest, n (%)	451 (1.1)	207 (1.1)	67 (0.9)	0.160
Sternum fracture, n (%)	3592 (9.1)	992 (5.4)	183 (2.4)	<0.001
Regional analgesia, n (%)	377 (1.0)	184 (1.0)	84 (1.1)	0.399
Epidural analgesia, n (%)	184 (0.5)	79 (0.4)	34 (0.5)	0.852
Spinal analgesia, n (%)	174 (0.4)	75 (0.4)	20 (0.3)	0.097

Non-frail, pre-frail, and frail are defined as OFS 0, OFS 1, and OFS ≥2.
AIS, Abbreviated Injury Scale; OFS, Orthopedic Frailty Score.

rate in the current study was 1.5%, likely due to the population being limited to isolated rib fractures, thereby excluding those with extrathoracic or intrathoracic injuries which could add to the increased risk of adverse outcomes. However, the crude mortality rate was still more than twice as high in frail patients compared with non-frail patients, increasing from 1.2% to 2.8%; this resulted in an increase in the adjusted mortality risk by 87% among those considered frail according to the OFS.

Several studies have employed various tools to assess frailty and predict negative outcomes in patients with rib fractures. For instance, Feng *et al* focused on elderly patients with rib fracture, using the Clinical Frailty Scale, and discovered a correlation between frailty and a prolonged hospital stay and an elevated rate of discharge to skilled nursing facilities.[30] Similarly, Schmoekel *et al* also examined elderly patients with rib fracture using the 11-factor Modified Frailty Index, revealing that frail patients were more susceptible to developing complications.[31] Saraswat *et al* instead focused on patients with rib fracture who underwent surgical stabilization; employing the 5-mFI, they identified that frail patients suffered from an increased likelihood of ICU admission and non-home discharge.[32] Furthermore, in a large study by Choi *et al*, geriatric patients admitted with multiple rib fractures were included in the development of the Rib Fracture Frailty Index, which showed associations with an elevated mortality risk, higher intubation rates, prolonged hospitalization, and an increased risk of non-home discharge.[13] On the other hand, Kishawi *et al* investigated single rib fractures and developed a nomogram that further found that congestive heart failure was significantly linked to adverse events, while weight loss, another indicator of frailty,[33–36] was also associated with adverse outcomes such as an increased risk of tracheostomy, pneumonia, prolonged hospitalization, and death.[37]

The physiological stress reaction, with its associated release of catecholamines and stress hormones, is a natural response to any

Table 3 Crude outcomes in geriatric patients with non-operatively managed isolated rib fractures

	Non-frail (n=39546)	Pre-frail (n=18315)	Frail (n=7514)	P value
In-hospital mortality, n (%)	466 (1.2)	317 (1.7)	214 (2.8)	<0.001
Missing	3 (0.0)	0 (0.0)	0 (0.0)	
Any complication, n (%)	1012 (2.6)	670 (3.7)	307 (4.1)	<0.001
Myocardial infarction	50 (0.1)	36 (0.2)	13 (0.2)	0.115
Cardiac arrest with CPR	101 (0.3)	55 (0.3)	24 (0.3)	0.468
Stroke	38 (0.1)	29 (0.2)	11 (0.1)	0.101
DVT	76 (0.2)	41 (0.2)	19 (0.3)	0.490
Pulmonary embolism	46 (0.1)	18 (0.1)	6 (0.1)	0.616
ARDS	55 (0.1)	28 (0.2)	12 (0.2)	0.867
Urinary tract infection	139 (0.4)	74 (0.4)	37 (0.5)	0.165
Pneumonia	123 (0.3)	79 (0.4)	24 (0.3)	0.066
Sepsis	66 (0.2)	45 (0.2)	16 (0.2)	0.125
Decubitus ulcer	35 (0.1)	35 (0.2)	21 (0.3)	<0.001
Unplanned intubation	222 (0.6)	106 (0.6)	64 (0.9)	0.010
Unplanned admission to the ICU	437 (1.1)	343 (1.9)	157 (2.1)	<0.001
Failure-to-rescue, n (%)	153 (0.4)	119 (0.6)	75 (1.0)	<0.001
ICU admission, n (%)	8224 (20.8)	4361 (23.8)	1863 (24.8)	<0.001
Length of stay (days), median (IQR)	3.0 (2.0–5.0)	4.0 (3.0–6.0)	4.0 (3.0–7.0)	<0.001
Missing, n (%)	391 (1.0)	149 (0.8)	67 (0.9)	

Non-frail, pre-frail, and frail are defined as OFS 0, OFS 1, and OFS ≥2.
ARDS, acute respiratory distress syndrome; CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis; ICU, intensive care unit; OFS, Orthopedic Frailty Score.

trauma, including rib fractures.[38] However, this hyperadrenergic state can also result in injury to multiple organ systems, leading to an increased risk of morbidity and mortality.[18 38] Frail patients are at a particular risk as they by definition have a reduced physiological reserve to withstand external stressors.[29 33 39] Identifying methods for moderating this stress response could consequently prove beneficial to this population. Of note, within a national cohort of Swedish patients with hip fracture sharing comparable demographic and comorbidity characteristics to those in the present analysis, individuals with ongoing beta-blocker therapy demonstrated a notably elevated survival rate; this effect was most pronounced among the frailest patients.[40] It has been postulated that this positive finding is due to the downregulation of the hyperadrenergic state as a result of beta-blockers inhibiting the sympathetic pathways that mediate this response.[41]

Despite the fact that older patients with rib fractures are often frail and have multiple chronic conditions,[5 18 31 42] they are not frequently treated by specialized teams with geriatric and trauma competence,[43] unlike patients who sustain fractures in the femoral neck with comparable demographic characteristics.[44–46] In the UK, the British Orthopedic Association has acknowledged the need for coordinated and multidisciplinary care for frail trauma patients, emphasizing the importance of comprehensive geriatric assessment, including a frailty assessment, among other components.[47] Many guidelines recommend higher levels of care (eg, ICU admission) for geriatric patients with rib fractures.[27 48 49] However, the adherence to such guidelines in clinical practice may be difficult due to limited resources.[27 50 51] Of the 87 geriatric patients with more than one rib fracture who should have been directly admitted to ICU from the emergency department for the first 24 hours of admission per one level 1 trauma center's guideline, 59 (68%) were not.[27] Of these 59 patients, 6 (9%) were later transferred to the ICU of whom two expired.[27] By conducting an early evaluation of frailty, it may be possible to identify individuals who are at a disproportionate risk of experiencing negative outcomes in order to prioritize them for admission to higher levels of care in hospitals that may have limited resources. An easy tool/scoring system is needed in the clinical

Table 4 Association between frailty and outcomes in geriatric patients with non-operatively managed isolated rib fractures

Adverse outcome	Non-frail	Pre-frail PR (95% CI)	P value	Frail PR (95% CI)	P value
In-hospital mortality	Reference	1.31 (1.12-1.54)	0.001	1.87 (1.52-2.31)	<0.001
Any complication	Reference	1.35 (1.21-1.51)	<0.001	1.44 (1.23-1.67)	<0.001
Failure-to-rescue	Reference	1.52 (1.16-1.99)	0.002	2.08 (1.45-2.98)	<0.001
ICU admission	Reference	1.14 (1.10-1.18)	<0.001	1.17 (1.11-1.23)	<0.001
		Change in median (95% CI)	P value	Change in median (95% CI)	P value
Length of stay (days)	Reference	0.57 (0.52-0.61)	<0.001	0.75 (0.67-0.82)	<0.001

Non-frail, pre-frail, and frail are defined as OFS 0, OFS 1, and OFS ≥2.
PRs are calculated using Poisson regression models with robust standard errors. Change in median length of stay is calculated using a quantile regression model. Missing values were managed using multiple imputation by chained equations. All analyses were adjusted for age, sex, race, highest Abbreviated Injury Scale in each region, injury pattern, hypertension, previous myocardial infarction, history of peripheral vascular disease, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, smoking status, chronic renal failure, diabetes mellitus, cirrhosis, coagulopathy, drug use disorder, alcohol use disorder, major psychiatric illness, and advanced directives limiting care.
ICU, intensive care unit; OFS, Orthopedic Frailty Score; PR, prevalence ratio.

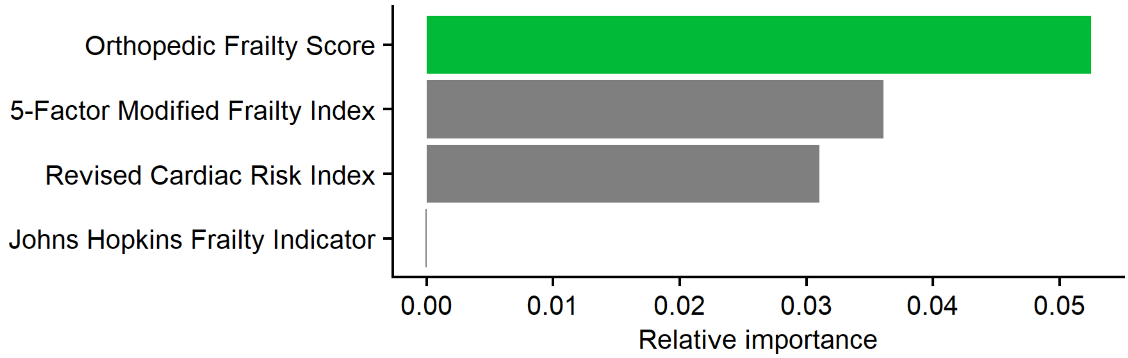

Figure 1 Relative importance of the Orthopedic Frailty Score, 5-Factor Modified Frailty Index, and Johns Hopkins Frailty Indicator for predicting in-hospital mortality.

setting in order to achieve this goal. The most recent Eastern Association for the Surgery of Trauma guidelines for non-surgical management and analgesia strategies for older adults with multiple rib fractures refrained from recommending ICU admission for all patients older than 65 years of age; however, they did recommend considering this for patients with specific conditions.[52] These conditions include frailty, hypoxemia (room air oxygen saturation <93%), more severe chest injury (chest AIS score >3), use of a walker, and smoking.[52]

A comprehensive approach that includes higher level of care, multimodal analgesia, pulmonary therapy, and in selected cases early surgical stabilization of rib fractures, is necessary to reduce pulmonary complications and mortality in this vulnerable patient population.[48 49] Early use of a frailty scoring tool in the clinical setting could aid in the development of institutional protocols to allocated patients to the appropriate level of care and facilitate potential treatments, as well as enable the physicians in charge to discuss prognoses with the patients and their relatives. This makes the OFS, which only requires five readily available variables at time of admission, appealing for clinical use.

As with all register studies, there are inherent limitations to the current investigation that need to be highlighted. Despite TQIP being a validated American College of Surgeons-approved database, the analyses are still reliant on the accuracy of the data that were gathered and recorded. The absence of certain variables, such as pulmonary toilet and cause of death, which are not routinely collected in TQIP, may also limit the conclusions that can be drawn from analysis conducted using this dataset. Furthermore, the laterality and location of the rib fractures could not be accurately determined for all patients, as a result of the structure of the dataset. While the OFS was initially developed for patients with hip fracture,[14 15] the findings of subsequent research including the current investigation suggest that it can be applied to other trauma populations with fractures,[16] and may be a useful tool for assessing frailty and guiding clinical decision-making.

CONCLUSION

There is a strong association between frailty, measured by the OFS, and adverse outcomes in geriatric patients managed conservatively for isolated rib fractures. Including an early assessment of frailty in this patient population in order to determine allocation to a higher level of care may be beneficial. These findings need to be validated using an appropriately designed, prospective study.

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