Effect of Frailty on Outcome after Traumatic Spinal Cord Injury

Dan Banaszek,¹ Tom Inglis,¹ Travis E. Marion,² Raphaële Charest-Morin,¹ Eryck Moskven,¹ Carly S. Rivers,³ Dilnur Kurban,³ Alana M. Flexman,^{4,5} Tamir Ailon,⁶ Nicolas Dea,⁶ Brian K. Kwon,^{1,7} Scott Paquette,⁶ Charles G. Fisher,¹ Marcel F. Dvorak,^{1,7} and John T. Street^{1,7}

Abstract

Frailty negatively affects outcome in elective spine surgery populations. This study sought to determine the effect of frailty on patient outcome after traumatic spinal cord injury (tSCI).

Patients with tSCI were identified from our prospectively collected database from 2004 to 2016. We examined effect of patient age, admission Total Motor Score (TMS), and Modified Frailty Index (mFI) on adverse events (AEs), acute length of stay (LOS), in-hospital mortality, and discharge destination (home vs. other). Subgroup analysis (for three age groups: <60, 61–75, and 76+ years), and multi-variable analysis was performed to investigate the impact of age, TMS, and mFI on outcome.

For the 634 patients, the mean age was 50.3 years, 77% were male, and falls were the main cause of injury (46.5%). On bivariate analysis, mFI, age at injury, and TMS were predictors of AEs, acute LOS, and in-hospital mortality. After statistical adjustment, mFI was a predictor of LOS ($p=0.0375$), but not of AEs ($p=0.1428$) or in-hospital mortality ($p=0.1245$).

In patients <60 years of age, mFI predicted number of AEs, acute LOS, and in-hospital mortality. In those aged 61–75, TMS predicted AEs, LOS, and mortality. In those 76+ years of age, mFI no longer predicted outcome.

Age, mFI, and TMS on admission are important determinants of outcome in patients with tSCI. mFI predicts outcomes in those <75 years of age only. The inter-relationship of advanced age and decreased physiological reserve is complex in acute tSCI, warranting further study. Identifying frailty in younger patients with tSCI may be useful for peri-operative optimization, risk stratification, and patient counseling.

Keywords: aging; deficit; frailty; prognosis; spinal cord injury

Introduction

IN THE MEDICAL LITERATURE, the term frailty is defined as “a state of decreased physiologic reserve, with increased susceptibility to external stressors.”¹ This concept has previously been identified as independent from chronological age in terms of patient outcomes.² Its association with poor outcomes has been demonstrated in multiple settings, from the community dwelling population to the surgical population.^{3–10} This relationship appears particularly relevant in patients requiring emergent procedures.^{11,12} In a recent systematic review of the spine surgery literature, frailty has been demonstrated to affect post-operative outcomes such as adverse events (AEs), mortality, and length of stay (LOS).¹³

Although the concept of frailty has been largely accepted, its operational definition is less clear. In most of the spinal literature, the Modified Frailty Index (mFI) has been used as a surrogate measure of frailty. The mFI, a simplified version of the Canadian Study of Health and Aging Frailty Index, is based on the theory of “accumulating deficits.” The mFI includes 11 variables relating to pre-injury deficits including functional independence and 10 comorbid medical conditions.^{14,15}

To our knowledge, the concept of frailty has never been applied to a newly injured (or acute) traumatic spinal cord injury (tSCI) population. Although typically occurring most frequently in younger males from motor vehicle or sports injury, in tSCI there is an epidemiological shift in the population relating to aging “baby

¹Vancouver Spine Surgery Institute, Department of Orthopaedics, University of British Columbia, Vancouver, British Columbia, Canada.

²Division of Orthopaedic Surgery, Northern Ontario School of Medicine, Thunder Bay, Ontario, Canada.

³Rick Hansen Institute, Vancouver, British Columbia, Canada.

⁴Department of Anesthesiology, Pharmacology, and Therapeutics, University of British Columbia, Vancouver, British Columbia, Canada.

⁵Department of Anesthesiology and Perioperative Care, Vancouver General Hospital, Vancouver, British Columbia, Canada.

⁶Vancouver Spine Surgery Institute, Division of Neurosurgery, Department of Surgery, University of British Columbia, Vancouver, British Columbia, Canada.

⁷International Collaboration on Repair Discoveries (ICORD), Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada.

boomers” that has increased the average age at injury.^{16,17} By 2032, the greatest proportion of new tSCI is predicted to be in patients over 70 years of age, with an estimated 46% of the newly injured being over the age of 60 years.¹⁸

Injuries in the elderly are most often incurred by falls from a standing height, which may be exacerbated by age-related degenerative disc disease. Older individuals are physiologically less able to improve functional recovery even in the presence of neurological recovery,^{18–20} with recovery being complicated by a higher rate of pre-existing conditions,^{21,22} including degenerative disc disease, and susceptibility to secondary health conditions such as pneumonia and pressure injury.^{23,24} The clinical management of older individuals with new tSCI provides a challenge for clinicians, evidenced by a previous study in which older patients were operated on less frequently, and at a longer interval from admission.¹⁶ Whereas clinical decision-making involves a subjective assessment of risk of poor outcomes with consideration of the overall accumulation of deficit, assessment of frailty would assist in clinical decision-making and risk management.

The objectives of this study were therefore to: 1) describe patient characteristics associated with frailty, and 2) examine the effect of frailty on post-operative outcomes in terms of in-hospital mortality, in-hospital LOS, and in-hospital AEs in a cohort of newly injured tSCI patients.

Methods

Study design

Our study is a retrospective cohort of prospectively collected data.

Study population

The analysis cohort comprised individuals with new tSCI admitted for acute care at a Level 1 trauma, quaternary referral center and enrolled in the Rick Hansen Spinal Cord Injury Registry (RHSCIR), a multi-center, Canadian, prospective, observational registry of adults with new tSCI; full details have been described elsewhere.²⁵ Research Ethics Board (REB) approval was obtained. Study subjects included patients with tSCI injured between 2004 and 2016 who received acute treatment at the study site.

Demographics

Age, gender, and body mass index (BMI) were obtained.

Medical comorbidities

Medical comorbidities at the time of injury were assessed by both the Charlson Comorbidity Index (CCI) and Elixhauser Comorbidity Index (ECI), commonly used indexes that are normally calculated from administrative data codes.^{26,27} A total count of comorbidities was also obtained.

Frailty

The mFI as introduced above includes a question regarding functional independence, and the following medical comorbidities: diabetes mellitus, lung problems, congestive heart failure, myocardial infarction, cardiac problems, hypertension, impaired sensorium, prior transient ischemic attack, history of stroke, and peripheral vascular disease. The number of deficits present divided by 11 gives the mFI score, providing an index with a range of 0 to 1. The mFI was calculated by chart review for assessment of functional status, and comorbid conditions as collected in the RHSCIR. Patients were categorized as not frail (mFI=0), pre-frail (0 <mFI

<0.21), and frail (mFI ≥0.21) based on previous data.²⁸ Comparison of patient groups was also categorized as non-frail (mFI <0.21) and frail (mFI ≥0.21) for analysis purposes.

Injury mechanism

Injury mechanism is recorded as: assault, fall, sport, transport, or other.²⁹

Neurological severity and level

Neurological classification was measured at admission and discharge with the International Standards of Neurological Classification of Spinal Cord Injury (ISNCSCI),³⁰ including neurological severity (American Spinal Injury Association [ASIA] Impairment Scale [AIS]; A/B/C/D), level of injury (high cervical C1–C4; low cervical C5–T1; thoracic T2–T10; thoracolumbar T11–S5), and Total Motor Score (TMS; out of 100).

Outcome measures

Primary study outcome variables included in-hospital patient mortality, acute hospital LOS, and number of AEs during hospital stay. Secondary outcomes included patient characteristic differences between cohorts and discharge destination (home vs. other). AEs were obtained from the previously validated Spinal Adverse Events System (SAVES2) database at our institution and is used to identify and record acute care AEs on all spine patients including those with tSCI. AE data are recorded through a rigorous prospective systematic process previously described.^{31,32} The top five and total number of AEs from SAVES2 were also explored.

Statistical analysis

Descriptive statistics were used to describe the demographics and injury characteristics of the cohort. Participant characteristics were compared between those deemed as frail and not frail by mFI to determine if there is significant difference between these two groups of participants. The comparison was made using either *t* test or Wilcoxon rank sum test for normally distributed versus non-normally distributed continuous variables, respectively. Comparisons between two categorical variables were assessed using a chi-square test (or Fisher's exact test if the expected cell counts were five or less). Pearson correlations were obtained to examine linear relationship between mFI, age at injury, and TMS at admission with three primary outcomes of interest. Age was selected due to an observed complex relationship between age and mFI, whereas TMS was used to minimize the risk of confounding in terms of patient outcome. These associations were re-examined in multi-variable analysis after adjusting for relevant covariates. Goodness-of-fit tests were performed for all models. Associations with a *p*-value <0.05 were considered statistically significant. All analyses were performed using SAS software, version 9.4 of the SAS System for Windows © 2013 (SAS Institute, Inc., Cary, NC).

Results

Patient characteristics

A total of 634 patients with tSCI were identified in our database during the study period. The most common mechanism of injury was falls (295, 46.5%). Neurological injury showed AIS Grade A to be the most common (245, 39.1%), followed by AIS D (206, 32.9%), AIS C (123, 19.7%), and AIS B (52, 8.3%). Most patients presented with either high (C1–C4, 237, 37.4%) or low (C5–T1, 230, 36.3%) cervical injuries. The remainder of characteristics are summarized in Table 1.

TABLE 1. PATIENT CHARACTERISTICS FOR THE ANALYSIS COHORT (N=634) AND THE FRAIL (MFI >0.21; N=76) AND NON-FRAIL (MFI ≤0.21; N=353) COHORTS

Variable	Analysis cohort, n=634	Frail cohort, n=76	Non-frail cohort, n=353	P-value
Age at injury (years); mean (SD)	50.3 (19.8)	70.6 (11.0)	42.0 (17.5)	<0.0001
Male, n (%)	488 (77.0)	59 (77.6)	275 (77.9)	0.9587
BMI, mean (SD)	25.2 (4.3)	27.3 (4.2)	24.6 (4.0)	<0.0001
Mechanism of injury, n (%)				<0.0001
Falls	295 (46.5)	56 (73.7)	112 (31.7)	
Transport	160 (25.2)	13 (17.1)	97 (27.5)	
Sports	134 (21.1)	3 (3.9)	113 (32.0)	
Other	45 (7.1)	4 (5.3)	31 (8.8)	
Neurological severity of injury (AIS), n (%)				0.2410
A	245 (39.1)	24 (32.0)	156 (44.6)	
B	52 (8.3)	6 (8.0)	27 (7.7)	
C	123 (19.7)	16 (21.3)	61 (17.4)	
D	206 (32.9)	29 (38.7)	106 (30.3)	
Neurological level of injury, n (%)				0.0002
High cervical (C1-C4)	237 (37.4)	39 (51.3)	116 (32.9)	
Low cervical (C5-T1)	230 (36.3)	30 (39.5)	127 (36.0)	
Thoracolumbar (T2-S5)	167 (26.3)	7 (9.2)	110 (31.2)	
Total Motor Score admission, mean (SD)	46.6 (31.2)	41.8 (30.1)	47.9 (31.5)	0.1529
Charlson Comorbidity Index, mean (SD)	0.6 (1.1)	2.1 (1.4)	0.2 (0.6)	<0.0001
Elixhauser Comorbidity Index, mean (SD)	1.0 (1.1)	1.8 (1.2)	0.5 (0.8)	<0.0001
mFI, mean (SD)	0.1 (1.1)	0.3 (0.1)	0 (0.0)	<0.0001
Count of comorbidities, n (%)				<0.0001
None	180 (47.4)	1 (2.0)	152 (73.8)	
1–2	155 (40.8)	23 (45.1)	52 (25.2)	
3+	45 (11.8)	27 (52.9)	2 (1.0)	
Top 3 comorbidities; n (%)				
Diabetes	52 (13.7)	26 (51.0)	2 (1.0)	<0.0001
Osteo/degenerative arthritis	23 (6.1)	3 (5.9)	6 (2.9)	0.3873
Any malignancy	20 (5.3)	7 (13.7)	6 (2.9)	0.0016
Top 5 adverse events, n (%)				
UTI	273 (43.1)	31 (40.8)	151 (42.8)	0.6576
Pneumonia	267 (42.1)	39 (51.3)	137 (38.8)	0.0463
Neuropathic pain	259 (40.9)	29 (38.2)	159 (45.0)	0.2053
Cardiac arrest/failure/arrhythmia	143 (22.6)	25 (32.9)	76 (21.5)	0.0373
Delirium	136 (21.5)	32 (42.1)	51 (14.4)	<0.0001

Bold indicates statistical significance.

AIS, American Spinal Injury Association (ASIA) Impairment Scale; BMI, body mass index; IQR, inter-quartile range; mFI, Modified Frailty Index; SD, standard deviation; UTI, urinary tract infection.

Frailty distribution

Table 2 reports frailty status by age group (<60, 61–75, 76+ years); percentage of frail individuals by age group was 2.8%, 27.9%, and 35.6%, respectively. For those aged 61 or older, 30.6% were deemed frail. We noted a complex relationship between frailty and age (Fig. 1). When analyzed as median mFI versus age,

TABLE 2. FRAILITY STATUS BY AGE GROUP: FRAIL (MFI >0.21), PRE-FRAIL (0 <MFI <0.21), AND NON-FRAIL (MFI=0)

Frailty status	<60 years, n=425	61–75, n=136	76+, n=73	61+, n=209
Non-frail, n (%)	302 (71.1)	40 (29.4)	22 (15.1)	51 (24.4)
Pre-frail, n (%)	111 (26.1)	58 (42.7)	36 (49.3)	114 (54.7)
Frail, n (%)	17 (2.8)	38 (27.9)	26 (35.6)	64 (30.6)

mFI, Modified Frailty Index.

peaks were noted for patients aged 61–75, and >75 years. As a result, correlation analysis of variables on outcome was performed according to these age distributions.

Frailty characteristics

Frail patients were older (mean, 70.6 years [standard deviation (SD), 11.0] vs. mean, 42.0 years [SD, 17.5]; $p < 0.0001$), had increased BMI (mean, 27.3 [SD, 4.2] vs. mean, 24.6 [SD, 4.0]; $p < 0.0001$), and were more likely to have suffered their injury as a result of a fall versus transport or sports injury ($p < 0.0001$). Frail patients had higher incidence of high- and low-cervical injuries versus non-frail patients suffering thoracolumbar injuries ($p < 0.0001$). Frail patients also displayed higher accumulation of deficits as per the CCI ($p < 0.0001$) and ECI ($p < 0.0001$), and as per comorbidity counts ($p < 0.0001$). Lastly, frail patients were more likely to have suffered a pneumonia ($p = 0.0463$), cardiac arrest/failure/arrhythmia ($p = 0.0373$), or delirium ($p < 0.0001$) during their inpatient stay.

FIG. 1. Relationship between frailty and age at injury. MFI, Modified Frailty Index.

Frailty on post-operative outcomes: Bivariate analysis

mFI was a strong predictor of increased acute LOS (Pearson's $r=0.163$; $p<0.0001$), number of AEs ($r=0.1664$; $p<0.0001$), and in-hospital mortality ($r=0.155$; $p<0.0001$) for the total cohort (Table 3). Age at injury was also significantly correlated with acute LOS ($r=0.0809$; $p=0.0418$), number of AEs ($r=0.0937$; $p=0.0231$), and in-hospital mortality ($r=0.2639$; $p<0.0001$). Lastly, motor score on admission was also predictive of acute LOS ($r=-0.4749$; $p<0.0001$), number of AEs ($r=-0.3069$; $p<0.0001$), and in-hospital mortality ($r=-0.2249$; $p<0.0001$).

Subgroup analysis was then performed on patients aged <60, 61–75, and >75 years to investigate the complex relationship observed between age and frailty (Table 3). In patients aged <60 years, mFI was strongly predictive of acute LOS ($p=0.0045$), number of AEs

($p=0.0038$), and in-hospital mortality ($p=0.0183$). This was also true for motor score on admission, which was predictive of acute LOS ($p<0.0001$), number of AEs ($p<0.0001$), and in-hospital mortality ($p=0.0136$). Age at injury was not predictive of outcomes in this age cohort.

In patients aged 61–75 years, mFI was predictive of acute LOS ($p=0.0220$), but not predictive of number of AEs or in-hospital mortality. TMS remained predictive of LOS ($p<0.0001$), number of AEs ($p=0.0015$), and in-hospital mortality ($p=0.0296$). Age at time of injury was not predictive of any of the three outcomes.

For patients aged >75 years, age at injury was predictive of acute LOS ($p=0.0318$) and number of AEs ($p=0.0009$), but not in-hospital mortality. TMS was predictive of LOS ($p=0.0427$) and in-hospital mortality ($p<0.0001$), but not number of AEs. Finally, mFI in this age cohort was not predictive of any outcome measure.

TABLE 3. BIVARIATE ANALYSIS OF OUTCOMES FOR ANALYSIS COHORT ($N=634$), <60 YEARS ($N=425$), 61–75 YEARS ($N=136$), AND 76+ YEARS ($N=73$) COHORTS

Independent variable	Outcome	Analysis cohort		<60 years		61-75 years		76+ years	
		Correlation coefficient	P-value	Correlation coefficient	P-value	Correlation coefficient	P-value	Correlation coefficient	P-value
mFI	Acute LOS	0.1630	<0.0001	0.1377	0.0045	0.1962	0.0220	0.0642	0.5895
	Number of AEs	0.1664	<0.0001	0.1452	0.0038	0.1565	0.0789	0.1578	0.2056
	In-hospital mortality	0.1550	<0.0001	0.1144	0.0183	0.0745	0.3886	–0.1321	0.2654
Age at injury	Acute LOS	0.0809	0.0418	0.0432	0.3742	0.0431	0.6184	–0.2516	0.0318
	Number of AEs	0.0937	0.0231	0.0648	0.1988	0.1118	0.2109	–0.3977	0.0009
	In-hospital mortality	0.2639	<0.0001	0.0083	0.8648	0.1452	0.0916	0.1363	0.2502
Motor score at admission	Acute LOS	–0.4749	<0.0001	–0.4770	<0.0001	–0.5624	<0.0001	–0.2562	0.0427
	Number of AEs	–0.3069	<0.0001	–0.3538	<0.0001	–0.2920	0.0015	0.0188	0.8874
	In-hospital mortality	–0.2249	<0.0001	–0.1281	0.0136	–0.1962	0.0296	–0.5181	<0.0001

AE, adverse event; LOS, length of stay; mFI, Modified Frailty Index.

TABLE 4. MULTIPLE LINEAR REGRESSION ANALYSIS OF ACUTE LENGTH OF STAY FOR THE ANALYSIS COHORT (N=634)

Parameter	Estimate	Standard error	95% confidence intervals		P-value
Intercept	3.9742	0.1048	3.7683	4.1800	<0.0001
Age at injury	0.0000	0.0019	-0.0038	0.0037	0.9832
Motor score at admission	-0.0185	0.0010	-0.0205	-0.0165	<0.0001
mFI frail	0.1594	0.1167	-0.0699	0.3887	0.1727
mFI pre-frail	0.1955	0.0771	0.0440	0.3469	0.0115
mFI non-frail	Baseline	-	-	-	-

mFI, Modified Frailty Index.

TABLE 5. NEGATIVE BINOMIAL REGRESSION ANALYSIS OF NUMBER OF ADVERSE EVENTS FOR THE ANALYSIS COHORT (N=634)

Parameter	Estimate	Standard error	Wald 95% confidence intervals		P-value
Intercept	1.5154	0.1171	1.2858	1.7449	<0.0001
Age at injury	0.0027	0.0022	-0.0016	0.0069	0.2186
Motor score at admission	-0.0096	0.0013	-0.0120	-0.0071	<0.0001
mFI frail	0.2379	0.1260	-0.0091	0.4850	0.0591
mFI pre-frail	0.0201	0.0867	-0.1498	0.1900	0.8166
mFI non-frail	Baseline	-	-	-	-

mFI, Modified Frailty Index.

Frailty on post-operative outcomes: Multi-variable analysis

Previous authors have subdivided patients into not frail (mFI=0), pre-frail (0 < mFI < 0.21), and frail (mFI ≥ 0.21) categories.³³ A similar division was made for our tSCI cohort, and association with outcome measures was explored.

Acute hospital LOS was significantly different between frailty categories ($p=0.0134$; Table 4) when controlling for the covariates, the mFI was a significant predictor of LOS ($p=0.0375$), with the pre-frail group having a significantly longer LOS ($p=0.0115$) when compared with the non-frail group.

When unadjusted for other covariates, significant differences exist between all three frailty categories ($p=0.0375$) in terms of median number of AEs. After adjusting for age at time of injury and TMS on admission, the mFI was not a significant predictor for number of AEs; however, the frail group tended to be more likely to

experience an increased number of AEs compared with the non-frail group ($p=0.0591$) (Table 5).

In-hospital mortality was significantly different between frailty categories ($p<0.0001$), with non-frail patients being more likely to survive. However, in multi-variable analysis, age and motor score at admission were predictors of in-hospital mortality, whereas mFI was not ($p=0.1245$) (Table 6).

Discharge destination was grouped into either discharge home, or discharge to a different destination (e.g., long-term care facility; Table 7). A significantly larger proportion of patients with no frailty were discharged home as compared with other frailty categories ($p=0.0315$). After adjusting for age and motor score on admission mFI was no longer predictive of discharge destination ($p=0.5062$). Of note, TMS at admission is strongly predictive of discharge destination on its own.

Discussion

Our study has identified frailty as a risk factor for poor post-operative outcomes in a tSCI patient population, in keeping with previous findings. First described in an intensive care unit (ICU) setting, Fried and colleagues defined frailty as “a clinical picture of loss of physiological and cognitive functioning which leaves patients susceptible to significant deterioration often precipitated by relatively minor stressors, such as infection, surgery, or trauma.”³⁴ With reference to a surgical setting specifically, frailty has been shown to affect post-operative outcomes in multiple specialties,^{35,36} disproportionately affecting in-hospital and long-term mortality, and discharge destination.³⁷

With regard to spine surgery, most studies have similarly linked frailty and worsened post-operative outcomes, mortality, and discharge disposition.^{38,39} Flexman and associates showed higher complication rates, specifically with infection, in a population of elective degenerative spine patients.³³ Ali and co-workers reviewed the 18,294 patients in the National Surgery Quality Improvement Program (NSQIP) database who had undergone spine surgery.⁴⁰ Similar to our own work, this group divided the mFI into low (<2.7) and high (≥2.7) categories, and noted a substantial difference in infection (1.7% vs. 4.1%) and mortality (0.1% vs. 2.3%) rates.⁴⁰ In an adult spinal deformity population, Miller and colleagues noted increased risk of junctional kyphosis (odds ratio [OR] 2.8), pseudarthrosis (OR 13.0), deep wound infection (OR 8.0), and wound dehiscence (OR 13.4) as compared with non-frail patients.⁴¹ A recent systematic review of the literature found that despite discrepancies in measurement tools, frailty is a consistent predictor of mortality, minor and major morbidity, in-hospital LOS, and discharge disposition in patients undergoing spine surgery.⁴²

Traditionally, however, frailty is a concept that has been intimately linked with older age.⁴³ Bagshaw and associates were among the first groups to note that the prevalence of frailty in younger

TABLE 6. MULTIPLE LOGISTIC REGRESSION ANALYSIS OF IN-HOSPITAL MORTALITY FOR THE ANALYSIS COHORT (N=634)

Parameter	Estimate	Standard error	Odds ratio	95% confidence interval		P-value
Intercept	-6.6591	1.2529	-	-	-	<0.0001
Age at injury	0.0790	0.0190	1.0820	1.0430	1.1230	<0.0001
Motor score at admission	-0.0447	0.0106	0.9560	0.9370	0.9760	<0.0001
mFI frail	0.9089	0.5917	2.4810	0.7780	7.9130	0.1245
mFI pre-frail	-0.4829	0.6107	0.6170	0.1860	2.0420	0.4291
mFI non-frail	Baseline	-	-	-	-	-

mFI, Modified Frailty Index.

TABLE 7. MULTIPLE LOGISTIC REGRESSION ANALYSIS OF DISCHARGE TO HOME INCLUDING FRAILTY STATUS (FRAIL: mFI >0.21, N=76; NON-FRAIL: mFI ≤0.21, N=353) FOR THE ANALYSIS COHORT (N=634)

Parameter	Estimate	Standard error	Odds ratio	95% confidence interval		P-value
Intercept	-6.6305	0.7631	-	-	-	<0.0001
Age at injury	-0.0117	0.00975	0.988	0.970	1.007	0.2306
Motor score at admission	0.0840	0.0088	1.088	1.069	1.107	<0.0001
mFI frail	-0.4093	0.6157	0.664	0.199	2.220	0.5062
mFI pre-frail	-0.5799	0.3700	0.5600	0.271	1.156	0.1171
mFI non-frail	Baseline	-	-	-	-	-

mFI, Modified Frailty Index.

patients is not only underappreciated, but perhaps especially damaging.⁴⁴ According to Smart and co-workers, this phenomenon of frailty in the young becomes particularly important in a surgical emergency scenario.⁴⁵ Although it is clear that the aging process is a contributor, there are many other patient and environmental factors that can drain physiological reserve in response to stressors.⁴⁶

In our study, frailty was predictive of poor outcome in the entire cohort, but not in the subgroup of the most elderly (≥75 years). As a result, we can conclude that there must exist a more complex relationship between age and frailty than is noted in previous studies. Our work also implies that younger, “frail” individuals are likely at particular risk for AEs, complications, and death as compared with their young, non-frail counterparts. In a tSCI population, when an individual is faced with such a devastating injury after reaching a certain age, physiological reserve likely loses its importance.

To our knowledge, no current work has looked at frailty in a tSCI cohort. Of note, our tSCI population had a much higher degree of frailty than other studied populations. In a cohort of patients over the age of 65 years undergoing elective surgery for degenerative conditions of the lumbar spine, modified frailty score was 0.09, with 59.8% being not frail, 20.6% pre-frail, and 19.6% frail.³⁸ In our cohort of patients over the age of 61 years, 30.6% were frail. When comparing the tSCI population with the elective surgery cohort, despite having a lower age limit of 61 versus 65 years, frailty is 1.5 times more common.³⁸ This difference is striking, particularly as the main cause of injury is through falls in our cohort, which may occur in more frail individuals. With the increase in the older population, this problem will likely be exacerbated and should be considered in future planning.

Multiple measures of frailty are used in research and published in the literature, and simplified measures such as the mFI and Charlson and Elixhauser comorbidity indexes are not nuanced enough to capture important physiological changes that underpin the multi-dimensional concept of frailty, such as nutritional status, cognitive impairment, and poor performance status.⁴² Additionally, cutoff frailty values as used in this and other studies may not apply to tSCI. The insult of the tSCI itself may be so great that it may affect outcomes to a higher degree than values currently used.

The strengths of our study include its large sample and the robust nature of our database. The benefits of the SAVES reporting system have been outlined in our previous work.⁴⁷ Data were gathered from a single institution, and may not accurately reflect the experience of other centers. Due to varying definitions, our selection of a threshold value for mFI may not be directly applicable to other published reports.

Conclusions

The link between frailty, the aging process, and poor post-operative outcomes has been well-established through research.

When faced with an injury as physiologically taxing as a tSCI, however, the effect of deficit accumulation loses importance. This work will aid in surgical decision-making and risk stratification in tSCI patients. Future efforts should be directed toward the identification of a more accurate tool for measurement of frailty in the elderly, as well as toward finding in a younger population specific risk factors contributing to poor outcomes.

Author Disclosure Statement

No competing financial interests exist.

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Address correspondence to:

John T. Street MD, PhD, FRCSI
 Combined Neurosurgical and Orthopaedic Spine Program
 Department of Orthopaedic Surgery
 University of British Columbia
 Vancouver Spine Surgery Institute
 Blusson Spinal Cord Center
 818 West 10th Avenue
 Vancouver, British Columbia V5Z 1M9
 Canada

E-mail: john.street@vch.ca