Comparison of Sarcopenia with Frailty and Area Deprivation Index for Predicting Postoperative Mortality and Complications in Thoracolumbar Trauma

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INTRODUCTION: Sarcopenia is a progressive musculoskeletal disorder characterized by the loss of muscle mass and function. Recently, it has gained recognition as an important surgical risk factor. Prior studies have demonstrated its association with adverse outcomes in spine surgery for degenerative, deformity, and neoplastic indications. Currently, there is a dearth of literature investigating the role of sarcopenia in thoracolumbar trauma. The purpose of this study was to compare the predictiveness of 1) sarcopenia, 2) frailty, and 3) socioeconomic disadvantage on outcomes after surgical management of thoracolumbar trauma. Specifically, we aimed to investigate rates of mortality, complications, and the need for revision surgery. We hypothesized that all three predictors of interest would be associated with a higher risk of mortality and complications.

METHODS: A retrospective analysis was done on adult patients 18 years or older undergoing instrumentation and stabilization of thoracolumbar spine trauma at an urban academic level-1 trauma center. Inpatient and outpatient data were collected by manual review of the electronic medical record. Sarcopenia was measured using the L3 total psoas area over vertebral body area (L3-TPA/VBA) measured from perioperative computed tomography scans. Area deprivation index (ADI) was determined according to the publicly available Neighborhood Atlas dataset. Frailty was measured using the modified 5-factor frailty index (mFI-5). Statistical analysis consisted of Pearson's chi-squared tests, univariate logistic regression, determination of Spearman's correlation coefficient (r_s), and multivariable logistic regression controlling for demographics and polytraumatic injuries. The primary outcome of interest was postoperative mortality. Secondary outcomes were the need for revision surgery and the occurrence of postoperative complications including urinary tract infection, cardiac arrhythmia, neuropathic pain, delirium, pneumonia, pulmonary embolism, deep vein thrombosis, wound infection, implant failure, and cerebrospinal fluid leak.

RESULTS: A total of 276 patients were included. A total of 22 mortalities occurred (7.7%), with 18 (6.3%) occurring within 90-days postoperatively. On univariate analysis, only the mFI-5 scale was associated with overall mortality (OR=2.29, P<0.001). On multivariate analysis, none of sarcopenia, ADI, or mFI-5 were independently associated with mortality, the occurrence of postoperative complications, or revision. However, sub-analysis showed that patients with an mFI-5 of 2+ had a significantly higher mortality rate (19.4%, P=0.004), and the mortality rate was greatest (25%, P=0.042) in combination with sarcopenia (measured as the lowest quartile of L3-TPA/VBA).

DISCUSSION AND CONCLUSION: Frailty is a better predictor of mortality in thoracolumbar trauma when compared to sarcopenia and ADI. However, an mFI threshold of 2+ may act synergistically with sarcopenia to increase mortality rates. In traumatic spine surgery, the current study is the first to evaluate sarcopenia, mFI-5, and ADI as predictors. The poor association of these indices may be due to the presence of more influential variables in this population. For example, the importance of polytraumatic injuries may outweigh that of sarcopenia, frailty, or socioeconomic disadvantage. This could be why the multivariable analysis found all of the predictors of interest to have no significant association. In addition, there may only be an impact of the predictors beyond certain thresholds, which would explain why the sub-analysis returned greater significance than the correlational and regression analyses. Our results showed that the mFI-5 was significantly associated with mortality in a univariate capacity. Therefore, it would be reasonable to use frailty as a proxy for mortality risk. Additionally, concomitant sarcopenia and/or socioeconomic deprivation may raise further concern. Surgeons may consider these findings when counseling patients on the risks of surgical management.

Figure 1. Measurement of L3 Total Psoas Area Over Vertebral Body Area (L3-TPA/VBA)

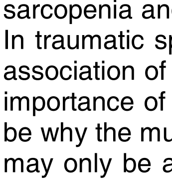

Table 1. Population Characteristics

Variable	Number	% or CI
Total Patients	276	
Average Age (Years)	50.0	95% CI: [47.7-52.4]
Sex		
Male	197	(71.4%)
Female	79	(28.6%)
Race		
White	183	(66.3%)
Black	56	(20.3%)
Asian	5	(1.8%)
Other	30	(10.9%)
Average Body Mass Index (BMI)	31.2	95% CI: [27.4-35.1]
Average Injury Severity Score (ISS)	20.5	95% CI: [19.1-21.9]
Fusion	154	(55.8%)
No Fusion	122	(44.2%)
Smoking History		
Current	71	(25.7%)
Former	40	(14.5%)
Never	165	(59.8%)
Surgical History		
Prior Spine Surgery	14	(5.1%)
No Prior Spine Surgery	262	(94.9%)
Polytrauma		
None (Isolated Spine Injury)	77	(27.9%)
Any	199	(72.1%)
Head	73	(26.4%)
Thoracic Cavity	154	(55.8%)
Abdominal Cavity	61	(22.1%)
Pelvic Cavity	30	(10.9%)
Extremity	94	(34.1%)
Spinal Cord Injury		
Any	106	(38.4%)
Complete	43	(15.6%)
Incomplete	63	(22.8%)
Diagnosis*		
Compression Fracture	10	(3.6%)
Burst Fracture	103	(37.3%)
Flexion-Distraction	53	(19.2%)
Extension-Distraction	62	(22.5%)
Fracture Dislocation	48	(17.4%)
Other/Unspecified Unstable Fracture	47	(17.0%)
Levels Instrumented		
Average	3.3	95% CI: [3.2-3.5]
1-2	86	(33.2%)
3-4	144	(52.1%)
5-6	36	(13.0%)
7+	6	(2.2%)
Average Follow-Up (Months)	14.0	95% CI: [3.9-24.1]

CI; Confidence Interval
*Operative diagnoses are not mutually exclusive

Table 2. Predictors of Interest in Study Sample

Predictor	Patients	% or Range
L3-TPA/VBA Quartile*		
1st Quartile	69	2.63 to 4.95
2nd Quartile	69	2.11 to 2.63
3rd Quartile	69	1.64 to 2.11
4th Quartile	69	0.55 to 1.64
Median Value	2.11	
mFI-5*		
0	182	(65.9%)
1	63	(22.8%)
2	24	(8.7%)
3	7	(2.5%)
4	0	(0%)
5	0	(0%)
Median	0	
ADI Quartile*		
1 to 25 (Least Deprivation)	105	(36.2%)
26 to 50	110	(39.1%)
51 to 75	48	(17.0%)
76 to 100 (Most Deprivation)	18	(6.5%)
Missing	3	(1.1%)
Median ADI (Out of 100)	33	2 to 98

L3-TPA/VBA; L3 Total Psoas Area Over Vertebral Body Area, mFI-5; 5-Factor Modified Frailty Index, ADI; Area Deprivation Index
*Measures of sarcopenia, frailty, and socioeconomic disadvantage, respectively. Sarcopenia quartiles divided in relation to the study sample. ADI quartiles divided in relation to national percentiles of the general population.

Table 3. Total Observed Adverse Events and Univariate Analysis of Predictor Thresholds*

Adverse Event	Total	Lowest L3-TPA/VBA Quartile	P-Value	mFI-5 of 2+	P-Value	Lower National 50%ile for ADI	P-Value
Total Patients	276	60		31		60	
Overall Mortality	22 (8%)	5 (8.3%)	0.441	**6 (19.4%)**	**0.004**	7 (11.7%)	0.11
1-Month Mortality	12 (4.3%)	2 (3.3%)	1	**4 (12.9%)**	**0.009**	**5 (8.3%)**	**0.029**
3-Month Mortality	18 (6.5%)	4 (6.7%)	0.781	6 (19.4%)	0	5 (8.3%)	0.251
Revision	13 (4.7%)	2 (3.3%)	0.528	2 (6.5%)	0.666	2 (3.3%)	0.739
For Infection	4 (1.4%)	0 (0%)	0.575	2 (6.5%)	0.075	0 (0%)	0.576
For Implant Failure	3 (1.1%)	1 (1.7%)	1	1 (3.2%)	0.411	1 (1.7%)	1
For Persistent Symptoms	2 (0.7%)	2 (3.3%)	0.155	0 (0%)	1	1 (1.7%)	0.559
For Pseudoarthrosis	2 (0.7%)	1 (1.7%)	0.438	0 (0%)	1	0 (0%)	1
For ASD	1 (0.4%)	0 (0%)	1	0 (0%)	1	0 (0%)	1
For Epidural Hematoma	1 (0.4%)	0 (0%)	1	0 (0%)	1	1 (1.7%)	0.238
Any AE	170 (61.6%)	38 (63.3%)	0.475	19 (61.3%)	0.69	34 (56.7%)	0.343
Average Number of AEs	1.6	1.1	0.951	1.1	0.902	1.3	0.44
GI Complication	61 (22.1%)	10 (16.7%)	0.276	4 (12.9%)	0.377	10 (16.7%)	0.26
UTI	56 (20.3%)	**19 (31.7%)**	**0.016**	6 (19.4%)	0.682	8 (13.3%)	0.147
Cardiac Arrhythmia	51 (18.5%)	11 (18.3%)	0.244	7 (22.6%)	0.2	10 (16.7%)	0.972
Neuropathic Pain	43 (15.6%)	11 (18.3%)	0.924	3 (9.7%)	1	11 (18.3%)	0.766
Delirium	26 (9.4%)	6 (10%)	0.812	6 (19.4%)	0.079	9 (15%)	0.174
Pneumonia	19 (6.9%)	1 (1.7%)	0.173	1 (3.2%)	1	6 (10%)	0.326
Pulmonary Embolism	16 (5.8%)	2 (3.3%)	11	1 (3.2%)	12	**8 (13.3%)**	**0.011**
DVT	12 (4.3%)	1 (1.7%)	0.736	1 (3.2%)	1	**6 (10%)**	**0.009**
Wound Infection	9 (3.3%)	0 (0%)	0.118	3 (9.7%)	0.085	3 (5%)	0.448
Implant Failure	7 (2.5%)	2 (3.3%)	1	1 (3.2%)	1	2 (3.3%)	0.672
Traumatic Durotomy	5 (1.8%)	0 (0%)	0.438	0 (0%)	1	2 (3.3%)	0.631

*Thresholds determined as the most hypothesized "at-risk" quartile
L3-TPA/VBA; L3 Total Psoas Area Over Vertebral Body Area, mFI-5 of 2+; 5-Factor Modified Frailty Index score of 2 or greater, ADI; Area Deprivation Index, ASD; adjacent segment disease, AE; adverse event, UTI; urinary tract infection, DVT; deep venous thrombosis
Bolded values represent P-values below 0.05

Table 4. Logistic Regression Analysis

	Univariate Analysis			Multivariable Analysis*		
Outcome	Odds Ratio	95% CI	P-Value	Odds Ratio	95% CI	P-Value
L3-TPA/VBA Quartile						
Overall Mortality	1.38	[0.92-2.07]	0.116	1.03	[0.60-1.76]	0.916
1-Month Mortality	1.33	[0.78-2.27]	0.296	1.12	[0.52-2.45]	0.770
3-Month Mortality	1.27	[0.82-1.97]	0.279	0.93	[0.52-1.67]	0.813
Any Adverse Event	1.01	[0.81-1.26]	0.912	0.86	[0.64-1.15]	0.304
Revision	0.80	[0.48-1.32]	0.377	0.52	[0.25-1.07]	0.075
mFI-5						
Overall Mortality	**2.29**	**[1.46-3.60]**	**<0.001**	1.72	[0.87-3.42]	0.121
1-Month Mortality	**2.42**	**[1.37-4.28]**	**0.002**	1.63	[0.64-4.17]	0.304
3-Month Mortality	**2.61**	**[1.60-4.26]**	**<0.001**	2.04	[0.97-4.31]	0.061
Any Adverse Event	1.15	[0.84-1.58]	0.382	0.93	[0.59-1.45]	0.734
Revision	1.04	[0.52-2.09]	0.910	1.21	[0.46-3.21]	0.702
ADI Quartile						
Overall Mortality	1.52	[0.48-4.81]	0.476	2.25	[0.58-8.72]	0.241
1-Month Mortality	0.92	[0.18-4.69]	0.924	1.83	[0.21-15.82]	0.583
3-Month Mortality	1.12	[0.33-3.78]	0.858	1.45	[0.34-6.1]	0.612
Any Adverse Event	0.81	[0.46-1.43]	0.465	0.94	[0.49-1.79]	0.854
Revision	1.12	[0.33-3.78]	0.858	1.13	[0.28-4.65]	0.861

L3-TPA/VBA; L3 Total Psoas Area Over Vertebral Body Area, mFI-5; 5-Factor Modified Frailty Index, ADI; Area Deprivation Index, CI; Confidence Interval
Bolded values represent P-values below 0.05
*Controlling for: age, sex, race, body mass index, injury severity score, levels instrumented, fusion, smoking status, polytraumatic injuries, and spinal cord injury

Table 5. Sub-Analysis of Combined Groups

Adverse Event	Total	Lowest L3-TPA/VBA Quartile and mFI-5 of 2+	P-Value	Lowest L3-TPA/VBA Quartile and Lower National 50%ile for ADI	P-Value
Total Patients	276	8		10	
Overall Mortality	22 (8%)	**2 (25%)**	**0.042**	**2 (20%)**	**0.037**
1-Month Mortality	12 (4.3%)	1 (12.5%)	0.163	2 (20%)	**0.011**
3-Month Mortality	18 (6.5%)	**2 (25%)**	**0.03**	**2 (20%)**	**0.03**
Revision	13 (4.7%)	0 (0%)	1	0 (0%)	1
For Infection	4 (1.4%)	0 (0%)	1	0 (0%)	1
For Implant Failure	3 (1.1%)	0 (0%)	1	0 (0%)	1
For Persistent Symptoms	2 (0.7%)	0 (0%)	1	0 (0%)	1
For Pseudoarthrosis	2 (0.7%)	0 (0%)	1	0 (0%)	1
For ASD	1 (0.4%)	0 (0%)	1	0 (0%)	1
Epidural Hematoma	1 (0.4%)	0 (0%)	1	0 (0%)	1
Any AE	170 (61.6%)	5 (62.5%)	0.271	7 (70%)	0.101
Average Number of AEs	1.6 [1.4-1.7]	1.4 [1.2-1.5]		1.3 [1.2-1.4]	
GI Complication	61 (22.1%)	2 (25%)	0.624	2 (20%)	0.669
UTI	56 (20.3%)	1 (12.5%)	0.58	2 (20%)	0.642
Cardiac Arrhythmia	51 (18.5%)	2 (25%)	0.201	1 (10%)	1
Neuropathic Pain	43 (15.6%)	1 (12.5%)	1	2 (20%)	0.341
Delirium	26 (9.4%)	**3 (37.5%)**	**0.006**	**3 (30%)**	**0.006**
Pneumonia	19 (6.9%)	0 (0%)	1	1 (10%)	0.313
Pulmonary Embolism	16 (5.8%)	1 (12.5%)	0.303	1 (10%)	0.2
DVT	12 (4.3%)	1 (12.5%)	0.259	1 (10%)	0.17
Wound Infection	9 (3.3%)	0 (0%)	1	0 (0%)	1
Implant Failure	7 (2.5%)	0 (0%)	1	0 (0%)	1
Traumatic Durotomy	5 (1.8%)	0 (0%)	1	0 (0%)	1

*Thresholds determined as the most hypothesized "at-risk" quartile
L3-TPA/VBA; L3 Total Psoas Area Over Vertebral Body Area, mFI-5 of 2+; 5-Factor Modified Frailty Index score of 2 or greater, ADI; Area Deprivation Index, ASD; adjacent segment disease, AE; adverse event, UTI; urinary tract infection, DVT; deep venous thrombosis
Bolded values represent P-values below 0.05