Hyperextension Injuries in Patients with Ankylosing Spine Disorder: Impact of Pre-Injury Mobility Status on Mortality

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INTRODUCTION:

Diffuse idiopathic skeletal hyperostosis (DISH) and ankylosing spondylitis (AS) are the primary ankylosing spinal disorders (ASDs). ASDs share key clinical features, including functional spinal ankylosis, poor bone quality, advanced age, and multiple associated medical comorbidities which contributes to an increased risk of fractures, as the rigid, ankylosed spinal column amplifies the effect of even minor trauma. These fractures lead to significantly higher rates of neurologic compromise, morbidity, and mortality as compared to hyperextension injuries in the absence of ASD. This study evaluates the impact of pre-injury ambulation status on mortality rates for hyperextension injuries in patients with ASD.

METHODS:

A retrospective cohort study of patients with ASD who sustained hyperextension injuries that were surgically treated at a single Level 1 trauma center was conducted for the years 2005 - 2020. Patients were divided into cohorts based on their pre-injury ambulatory status (independent ambulators vs those that used assistive devices including gait aids such as canes / walkers or wheelchairs). Demographic data including age, body mass index (BMI), sex, type of ASD, pre-operative American Society of Anesthesiologists Physical Status (ASA PS), American Spinal Injury Association (ASIA) Impairment Scale (IS), fracture location, injury type (single level vs multi-level vs combined spine and pelvic injury) mechanism of injury, and Surgical Invasiveness Index (SII) were collected. The primary outcome was mortality. Secondary outcomes included post-operative ambulatory status as well as reoperations within 90 days. Statistical analysis was conducted using JASP [JASP Team (2024). JASP (Version 0.19.3)]. Demographic data was analyzed using Mann-Whitney U test, Student T-Test, and Chi-Squared tests as appropriate. Kaplan-Meier estimates were constructed. The primary outcome was analyzed using a cox proportional hazard model. In the model, age and ASA PS class (transformed from ordinal to continuous data) were used as covariates and pre-operative ambulation status and 90-day reoperation were factors. The proportional hazard assumption was tested using Kaplan-Meier transformation. A p-value less than 0.05 was considered statistically significant. Biases were not addressed a priori. A power analysis was not performed.

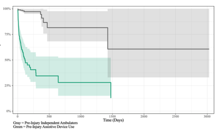
RESULTS:

387 patients were included; 288 (72.5%) were independent ambulators and 109 (27.5%) used an assistive device. Independent ambulators were significantly younger and had a greater proportion of ASA PS class II (Table 1). No differences in BMI, sex, ASD type, pre-operative ASIA IS, fracture location, injury type, mechanism of injury, or mean SII were identified between the two cohorts (Table 1). Using an assistive device pre-operatively was significantly associated with mortality (Figure 1; $p < 0.001$). 90-day mortality rate was 1.39% (4/288) and 58.7% (64/109) for those that were independent ambulators pre-operatively and for those that used an assistive device, whereas 1-year mortality rate was 2.08% (6/288) and 68.8% (75/109), respectively. Increased age and ASA PS class were associated with increased risk for mortality (Tables 2 – 3; $p < 0.001$ and 0.012). Each increase in ASA PS class was associated with a 67.7% increased risk of mortality and each year in age was associated with a 4.6% increased risk of mortality (Table 3). Of patients that were ambulatory before injury, 121 (42.0%) used an assistive device at last follow up. 69 (17.8%) patients underwent re-operation within 90 days, of which 51 (73.9%) were for a surgical site infection. Re-operation was not associated with an increase in mortality (Figure 1; Tables 2 – 3). The proportional hazards assumption test results are provided in Table 4.

DISCUSSION AND CONCLUSION:

Patients with ASD that use an assistive device pre-injury, are older, and/or have increased medical comorbidities are at increased risk for mortality following a hyperextension injury. Those patients that used an assistive device pre-injury had a one-year mortality rate of 68.8% compared to 2.08% in the independent ambulatory cohort. Many patients that were once ambulatory, require an assistive device after recovery. These data offer valuable prognostic insights, helping to facilitate improved guidance for patients and their families who are navigating treatment and recovery for these injuries.

Figure 1: Kaplan-Meier Survival Plot



Gray = Pre-Injury Independent Ambulators
Green = Pre-Injury Assistive Device Use

Table 1: Baseline Characteristics

	Pre-Injury Independent Ambulator N = 288 (72.5%)	Pre-Injury Assistive Device Use N = 109 (27.5%)	p
Mean Age [Years] (SD)	67.9 (13.5)	75.4 (11.38)	**< 0.001***
Mean BMI (SD)	32.1 (7.47)	30.9 (7.99)	0.176^
Sex			0.597&
Female	43 (14.9%)	14 (12.8%)	
Male	245 (85.1%)	95 (87.2)	
Type of Ankylosing Spine Disorder			0.336&
Ankylosing Spondylitis	121 (42.0%)	40 (36.7%)	
DISH	167 (68.0%)	69 (63.3%)	
Pre-Operative ASA PS Class			**0.004&**
I	3 (1.0%)	0 (0%)	
II	47 (16.3%)	5 (4.59%)	
III	169 (58.7%)	63 (57.8%)	
IV	68 (23.6%)	41 (37.6%)	
V	1 (0.347%)	0 (0%)	
Pre-Operative ASIA IS	n = 265	n = 85	0.196&
A	26 (9.81%)	10 (11.8%)	
B	8 (3.02%)	1 (1.18%)	
C	12 (4.53%)	9 (10.6%)	
D	40 (15.1%)	15 (17.6%)	
E	179 (67.5%)	50 (58.8%)	
Cervical Fracture	127 (44.1%)	49 (45.0%)	0.878&
Thoracic Fracture	180 (62.5%)	69 (63.3%)	0.883&
Lumbar Fracture	23 (7.99%)	10 (9.17%)	0.702&
Injury Type			0.789&
Single Level	247 (85.8%)	91 (83.5%)	
Multi-Level	30 (10.4%)	14 (12.8%)	
Combined Spine + Pelvis	11 (3.82%)	4 (3.67%)	
Mechanism of Injury			0.147&
High Energy	137 (47.6%)	66 (60.6%)	
Low Energy	151 (52.4%)	43 (39.4%)	
Mean Surgical Invasiveness Index (SD)	13.8 (5.93)	14.3 (6.74)	0.479^

Note: Standard Deviation (SD) / Body Mass Index (BMI) / Diffuse Idiopathic Skeletal Hyperostosis (DISH) / American Society of Anesthesiologists Physical Status (ASA PS) / American Spinal Injury Association (ASIA) Impairment Scale (IS)

Statistical Methods: * Mann-Whitney U Test / ^ Student's T-Test / & Chi-Squared Tests

Table 2: Survival Analysis – Cox Proportional Hazards Estimates

Model		Estimate	Standard Error	95% CI Lower	95% CI Upper	z	p
H_1	Age	0.045	0.012	0.022	0.069	3.827	**< .001**
	ASA PS Class	0.517	0.207	0.112	0.923	2.500	**0.012**
	90-days Re-operation (Yes=1; No=0) (1)	-0.234	0.286	-0.795	0.326	-0.820	0.412

Note. Results are stratified via: Pre-op Ambulation Simple (1 = Pre-Injury Assistive Device Use; 2 = Pre-Injury Independent Ambulator). Confidence Interval (CI)

American Society of Anesthesiologists Physical Status (ASA PS)

Table 3: Survival Analysis - Hazard Ratios Estimates Table

Model		Hazard Ratio	95% CI Lower	95% CI Upper
H_1	Age	1.046	1.022	1.071
	ASA PS Class	1.677	1.118	2.516
	90-days Re-operation (Yes=1; No=0) (1)	0.791	0.452	1.386

Note: American Society of Anesthesiologists Physical Status (ASA PS). Confidence Interval (CI)

Table 4: Survival Analysis – Proportional Hazards Assumption Test Table

	Chi Square	df	p
Age	3.870	1	**0.049**
ASA PS Class	1.870	1	0.171
90-days Re-operation (Yes=1; No=0) (1)	9.897	1	**0.002**
Global	12.693	3	**0.005**

Note: Degrees of freedom (df). American Society of Anesthesiologists Physical Status (ASA PS)