

Development of a Clinical Tracheostomy Score to Identify Spinal Cord Injury Patients Requiring Prolonged Ventilator Support

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- No relationships to disclose

Spinal Cord Injury: A Rare but Devastating Trauma

- 56.4/1,000,000 in the US annually
- 144/1,000,000 in males 15-19
- 50% are cervical spinal cord injuries (CSCI)
- High mortality

Table 1. Number of Patients in Nationwide Inpatient Samples With Acute Traumatic Spinal Cord Injury in the United States, 1993-2012

Year	Spinal Cord Injury as Primary Diagnosis			Spinal Cord Injury as Any Diagnoses
	No. of Patients	Age, Mean, y	Male, %	No. of Patients
1993	2659	40.5	73.5	3279
1994	2680	40.5	75.5	3355
1995	3112	40.9	72.1	3895
1996	2983	42.0	73.2	3808
1997	3048	41.8	72.4	4094
1998	2848	42.5	73.2	3539
1999	2946	42.1	72.8	3867
2000	2849	43.3	74.7	3574
2001	2611	44.7	73.6	3248
2002	3025	44.8	72.8	3823
2003	3180	45.1	71.2	4050
2004	3993	44.2	71.3	4713
2005	3021	44.8	71.3	3770
2006	3453	46.3	72.5	4310
2007	3357	46.8	72.3	4180
2008	3274	48.8	70.0	4128
2009	3217	49.3	69.7	4183
2010	4106	48.6	71.1	5115
2011	3354	51.1	70.1	4373
2012	3393	50.5	70.7	4339

Jain et al, 2015

CSCI: High Morbidity and Mortality

- Rarely single system trauma

But, even if it is...

- Phrenic nerve nucleus C3/4/5
- Accessory muscles C5/6/7/8

Actions and innervation of the inspiratory muscles (diaphragm, external intercostals, scalenes, sternocleidomastoid, upper trapezius, and parasternal part of the internal intercostals) and expiratory muscles (internal intercostals, rectus abdominus, obliques, pectoralis, and latissimus dorsi)

Muscle	Quiet inspiration	Forced inspiration	Quiet expiration	Forced expiration	Cough	Innervation	Action
Diaphragm	✓	✓			✓	Phrenic nerve (C3-C5)	Descends enlarging thoracic cavity
External intercostals	✓	✓			✓	Intercostal nerve (T2-T6)	Elevation of the ribs
Scalenes		✓			✓	Spinal nerves C2-C7	Elevation of the 1st rib
Sternocleidomastoid		✓			✓	Cranial nerve XI (accessory nerve)	Elevation of the upper ribs and sternum
Upper trapezius		✓			✓	Cranial nerve XI (accessory nerve)	Elevation of the ribs
Internal intercostals	✓ ^a	✓		✓	✓	Spinal nerves T1-T6	Reduce thoracic cavity
Rectus abdominus				✓	✓	Spinal nerves T5-L1	Reduce thoracic cavity
External obliques				✓	✓	Lower 6 intercostal nerves and subcostal nerve	Reduce thoracic cavity
Internal obliques				✓	✓	Lower 6 intercostal nerves and subcostal nerve	Reduce thoracic cavity
Pectoralis major (clavicular portion)				✓		Spinal nerves C5-C7	Reduce thoracic cavity
Latissimus dorsi				✓		Spinal nerves C6-C8	Reduce thoracic cavity

^aParasternal part of the internal intercostals

Terson et al, 2011

High Morbidity and Mortality

- Poor cough and clearance of secretions
- Reduced vital capacity and chest wall compliance
- Atelectasis, pneumonia in more than half
- 20% of CSCI overall undergo tracheostomy



Who Gets a Tracheostomy in PA? C1-C4

Patients with Complete C1-C4 Spinal Cord Injury

≥7 Ventilator Days	79.8% (95% CI 74.5-84.3%)		
Surgical Airway	67.4% (95% CI 61.5-72.9%)		
Demographic	≥ 7 Days on Ventilator	≤ 6 Days on Ventilator	Significance
Mean Age in Years	52	59	p=0.064
Highest Spinal Fracture	C3	C4	p=0.039
Median ISS	35	21	P<0.001
Median GCS	8.5	15	P<0.001
Median GCS Motor	1	6	P<0.001
Received Surgical Airway	83.0% (95% CI 83.7-94.2%)	6.0% (95% CI 0% to 31.6%)	p<0.0001
Mean Ventilator Days	25.9	3.2	p<0.0001

Who Gets a Tracheostomy in PA? C5-C7

Patients with Complete C5-C7 Spinal Cord Injury			
≥7 Ventilator Days	61.5% (95% CI 57.7-65.3%)		
Surgical Airway	53.3% (95% CI 49.4-57.2%)		
Demographic	≥ 7 Days on Ventilator	≤ 6 Days on Ventilator	Significance
Mean Age in Years	51	55	p=0.026
Highest Spinal Fracture	C5	C5	p=0.091
Median ISS	29	21	P<0.001
Median GCS	14	15	P<0.001
Median GCS Motor	4	5	P<0.001
Received Surgical Airway	80.0% (95% CI 83.7-94.2%)	8.0% (95% CI 0% to 31.6%)	p<0.0001
Mean Ventilator Days	23.4	2.7	p<0.0001

We Know Who Typically Does Undergo Tracheostomy, Not Who Should

- Tracheostomy in CSCI within 7 days improves ventilator weaning, reduces ICU time and reduces cost of care
- Conflicting research on VAP
- Early identification of patients needing prolonged ventilator support can improve care

Objective

Develop a method of immediately identifying patients with cervical spinal cord injuries (CSCI) who will require ventilator support (VS) for ≥ 7 days and would therefore benefit from early tracheostomy

Retrospective Review of the Pennsylvania Trauma Outcomes Study (PTOS) Database 2005 - 2014

- Inclusion Criteria
 - All patients with cervical spinal cord injuries
- Exclusion Criteria
 - Missing diagnosis data
 - No use of mechanical ventilation
 - Death within 7 days

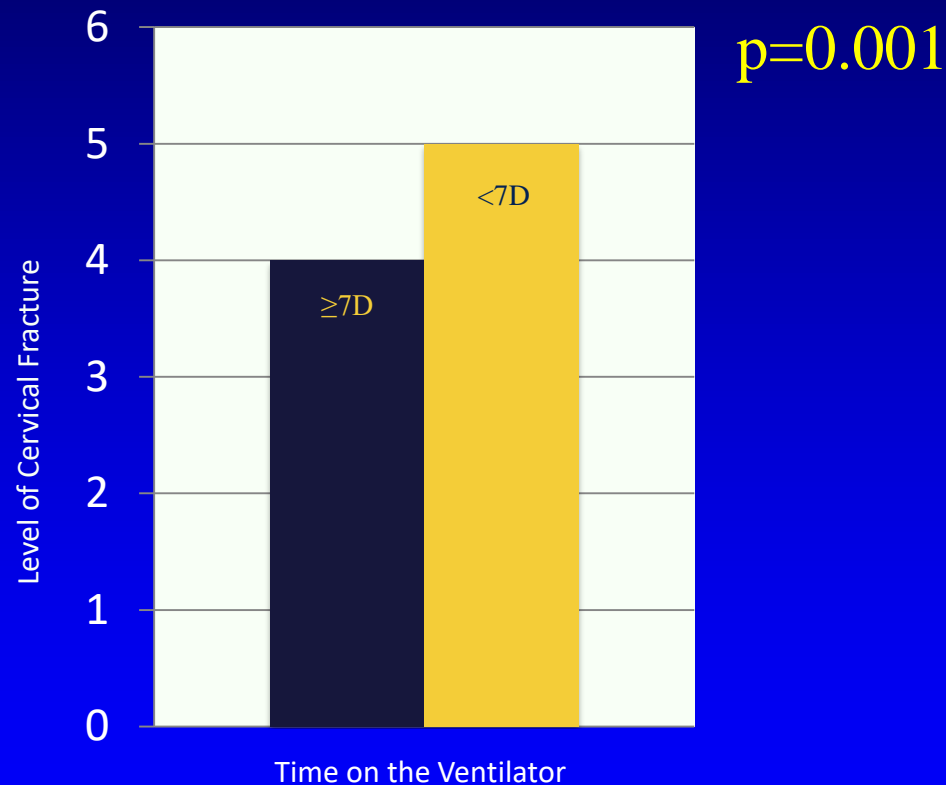
Methods

- Demographics collected included age, GCS, motor GCS, ISS, MOI, AIS head, face, neck, thorax, spine, highest associated cervical fracture level, pre-existing conditions and type of cord injury
- Logistic regression performed to evaluate 37 risk factors for independent prediction of prolonged ventilator support
- Predictive modeling for ≥ 7 days of ventilator support created with univariate and multivariate regression with Hosmer-Lemeshow goodness of fit testing
- Statistical significance set at $P < 0.05$. All calculations were implemented with IBM SPSS Statistics 23

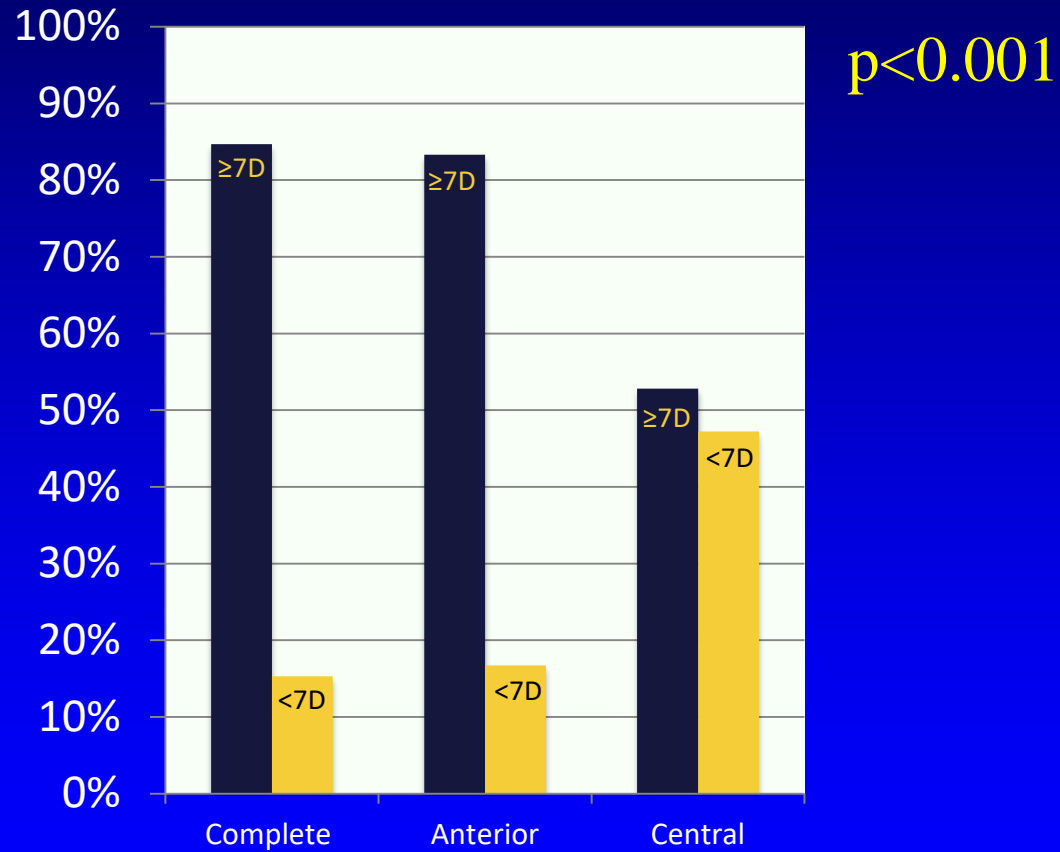
Results

- 495 patients were identified meeting inclusion criteria
- 220 C1-C4 and 275 C5-7 CSCI patients were included
- 3 factors were associated with ≥ 7 days VS: type of cord injury (TCI, $p < 0.001$), highest cervical spine fracture level (HCFL, $p = 0.001$) and AIS face ($p = 0.007$)

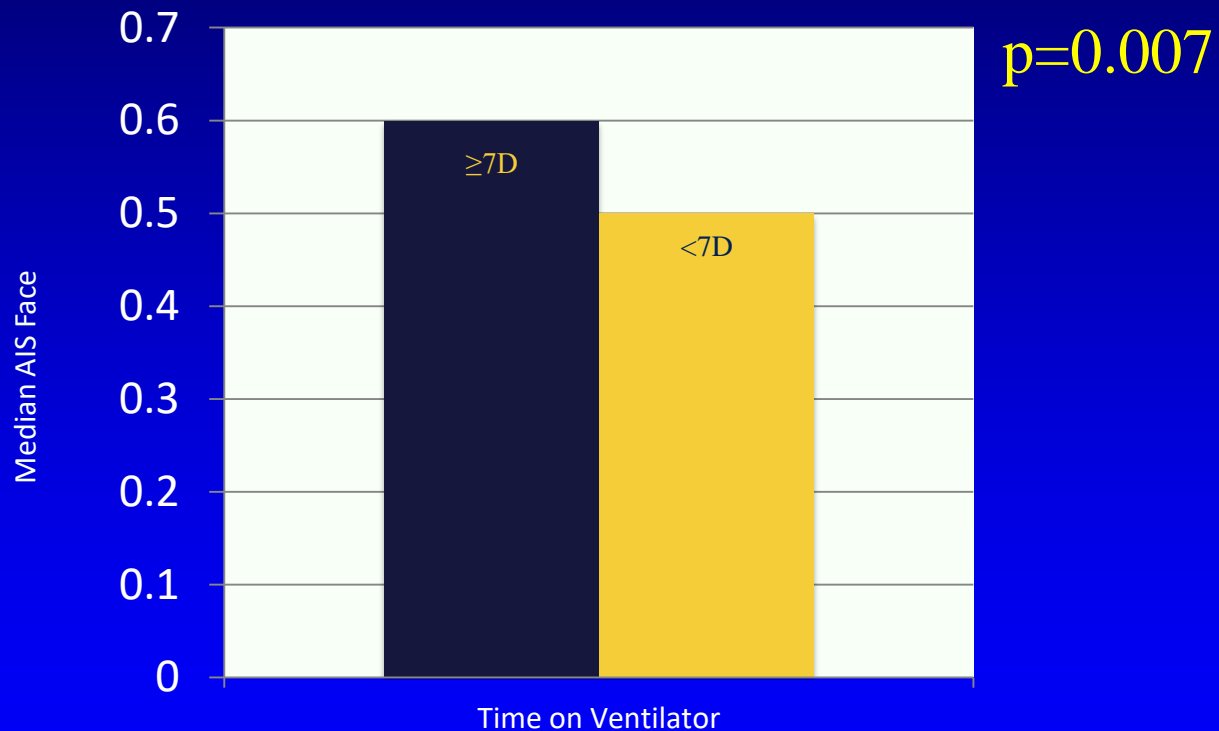
Highest Level of Associated Cervical Spine Fracture (H-CFL)



Type of Cervical Spinal Cord Injury



Mean Abbreviated Injury Score of the Face



Results

Our clinical tracheostomy score was obtained from this equation: $4.138 - 0.981(\text{TCI}) - 0.344(\text{HCFL}) + 0.419(\text{AIS face})$. TCI was complete = 1, anterior = 2 or central = 3

The equation positive predictive value for ≥ 7 days of VS is **82.3%** for a score ≥ 1

Conclusions

- Use of the Clinical Tracheostomy Score identified the majority of patients requiring prolonged ventilator support in our study
- An early tracheostomy protocol could using predictive modeling could aid in reduction of ICU length of stay and improving ventilator weaning in these patients
- Prospective study needed to determine other impacts
- External verification of this predictive tool and of an early tracheostomy protocol is needed

Next Steps

- External verification
- Formula simplification
- App creation

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Thank You!



Demographic	C1-C4 Complete	C1-C4 Anterior	C1-C4 Central
% Prolonged VS	93.6%	66.7%	60%
Median Highest CFL	4	3	3
Median Age	44	57	67
Median ICU LOS	21	8	13
Median Number PEC	1	3	2
Median ISS	75	34	21
Median AIS Head	1	4	1
Median AIS Face	0	1	1
Median AIS Neck	0	0	0
Median AIS Spine	6	4	4
Median AIS Thorax	0	3	0

Demographic	C5-C7 Complete	C5-C7 Anterior	C5-C7 Central
% Prolonged VS	78.6%	100%	38%
Median Highest CFL	5	6	5
Median Age	42	57	71
Median ICU LOS	19	39	9
Median Number PEC	1	5	1.5
Median ISS	30	41	24
Median AIS Head	1	0	0.5
Median AIS Face	0	0	0.5
Median AIS Neck	0	0	0
Median AIS Spine	5	4	4
Median AIS Thorax	0	4	0