



A Combined Clinical and Imaging Model for Predicting Postsurgical Outcome in Patients with Cervical Spondylotic Myelopathy: Results from the Prospective, Multicenter AOSpine North American Study

Aria Nouri BA, MD; Lindsay Tetreault Bsc; Juan Jose Zamorano MD; Kristian Dalzell; Michael G. Fehlings MD PhD FRCS

FACS

Institute of Medical Science and Division of Neurosurgery, University of Toronto, UHN & Krembil Neuroscience Center



Introduction

Cervical Spondylotic Myelopathy (CSM) is the commonest cause of spinal cord impairment in the elderly population, and is the result of cervical spinal cord compression due to age-related degenerative changes. While MRI is the primary imaging modality for confirming the diagnosis, its role in predicting surgical outcome remains unclear. It is the objective of the present study to determine if baseline MRI assessment can predict surgical outcome in CSM patients.

Methods

278 patients with at least one clinical sign of myelopathy were enrolled and underwent decompression surgery. Complete baseline clinical and MRI data were available for 102 patients. The MRI parameters measured were presence/absence of signal change on T1 and T2, T2 signal quantitative factors, and anatomical measurements. A dichotomized postoperative modified Japanese Orthopedic Association score (mJOA) at 6-months was used to characterize patients with mild myelopathy (≥ 16) and those with substantial residual neurological impairment (< 16). Univariate analysis assessed the relationship between baseline mJOA and MRI parameters with this mJOA outcome. Multivariate logistic regression was conducted following a conceptual division of variables into three key groups: T1 signal analysis, T2 signal analysis and anatomical measurements. Inclusion of variable in the final model was based on practical, clinical and statistical considerations.

Results

T2 signal hyperintensity and T1 signal hypointensity were present in 67.6% and 26.9% patients, respectively. Baseline mJOA ($p < 0.001$; OR=1.644, CI: 1.326-2.037), maximum canal compromise ($p = 0.0322$; OR=0.965, CI: 0.934-0.997), T2 hyperintensity area ($p = 0.0422$; OR=0.67, CI: 0.456-0.986), and maximum height ($p = 0.026$; OR=0.673, CI: 0.475-0.954) were significantly associated with outcome univariately. Four imaging variables and baseline mJOA were initially selected for multivariate logistic regression; however, a more parsimonious (AIC = 94.78 vs 98.29; BIC 104.78 vs 113.29) final model was comprised of T1 hypointensity ($p = 0.029$; OR=0.242; CI: 0.068-0.866), maximum canal compromise ($p = 0.005$; OR=0.940; CI: 0.90-0.982) and baseline mJOA ($p < 0.001$; OR=1.743; CI: 1.353-2.245), yielding an area under the receiver operating characteristic curve (AUC) of 0.845. The likelihood-ratio test indicated superior performance of this model compared with the mJOA-only model ($p < 0.0001$).

Figure 1. Quantitative methods of MRI assessment

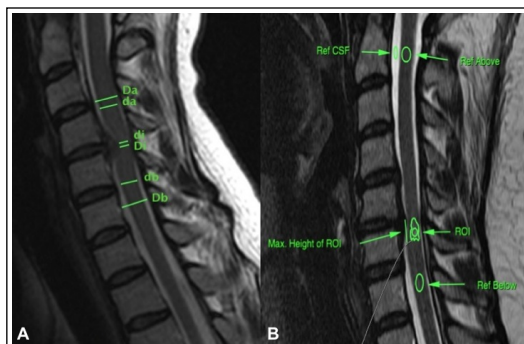


Table 1. General characteristics

General Characteristics (n=114)	
Age (years)	55.75±11.84 (29-86)
Sex (M/F)	71/43
Duration of symptoms (months)	26.55±34.24 (1-240)
Baseline mJOA	12.81±2.74 (5-18)
Smoking status (Y/N)	30/84
Imaging	
T2-WI Hyperintensity (Y/N) (n=111)	75/36
T1-WI Hypointensity (Y/N) (n=108)	29/79
Arvin's Signal Change Ratio (n=111)	0.43±0.13 (0.21-0.92)
Wang's Signal Change Ratio (n=111)	1.49±0.41 (0.91-3.1)
New Signal Change Ratio (n=111)	1.42±0.38 (0.89-2.97)
MSCC (%) (n=108)	33.91±15.34 (-4.60-64.86)
MCC (%) (n=108)	49.24±12.95 (16.12-75.33)
Height of T2-signal change (n=111)	
Group 1 = 0 (n=36)	0
Group 2 >0, ≤0.75cm ² (n=23)	0.58±0.12
Group 3 >0.75, ≤1.50cm ² (n=24)	1.15±0.20
Group 4 >1.50cm ² (n=28)	2.17±0.74
Area of T2-signal change (n=111)	
Group 1 = 0 (n=36)	0
Group 2 >0, ≤0.20cm ² (n=33)	0.13±0.04
Group 3 >0.20, ≤0.35cm ² (n=22)	0.26±0.04
Group 4 >0.35cm ² (n=20)	0.51±0.16
Outcome	
mJOA at 6-months (n=101)	15.16±2.73 (2-18)
≥16	55 (45.54%)
<16	46 (54.46%)

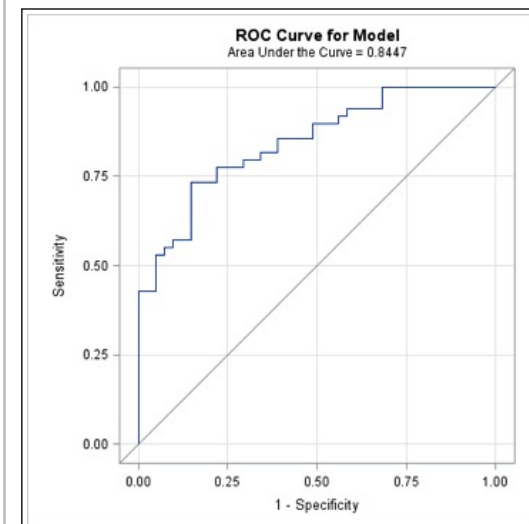
Table 2. Univariate and multivariate relationship between parameters and mJOA outcome at 6-months

Imaging Predictor (Univariate)	Odds Ratio
T2-WI Hyperintensity (n=98)	0.545 (CI: 0.231, 1.285)
T1-WI Hypointensity (n=95)	0.586 (CI: 0.230, 1.495)
T2 signal hyperintensity height (n=98)	0.673 (CI: 0.475, 0.954)
T2 signal hyperintensity area (n=98)	0.670 (CI: 0.456, 0.986)
New signal change ratio (n=98)	0.421 (CI: 0.147, 1.208)
Wang's Ratio (n=98)	0.411 (CI: 0.155, 1.090)
Arvin's Ratio (n=98)	0.178 (CI: 0.009, 3.571)
Maximum spinal cord compression, MSCC (n=96)	0.985 (CI: 0.959, 1.012)
Maximum canal compromise, MCC (n=96)	0.965 (CI: 0.934, 0.997)
Final Model Predictors (Multivariate) n = 90	
Baseline mJOA	1.743 (CI: 1.353, 2.245)
T1 signal hypointensity	0.242 (CI: 0.068, 0.866)
Maximum canal compromise, MCC	0.940 (CI: 0.900, 0.982)
mJOA-only Model n = 90	
Baseline mJOA	1.644 (CI: 1.326, 2.037)

Conclusions

Baseline mJOA is a strong predictor of postsurgical outcome in CSM at 6-months. However, a model inclusive of maximum canal compromise and T1 hypointensity assessment provides superior predictive capacity. This suggests that MRI analysis has a significant role in predicting surgical outcome.

Figure 2. Receiver operating characteristic curve of the final model



Learning Objectives

- 1) Understand the importance of baseline MRI analysis in predicting postsurgical outcome
- 2) Describe which MRI factors are important predictors of postsurgical outcome
- 3) Discuss how this information can be useful in clinical practice.

References

- Fehlings MG et al. Efficacy and safety of surgical decompression in patients with cervical spondylotic myelopathy: results... JBJS 2013; 95(18): 1651-8.
- Fehlings MG et al. The optimal radiologic method for assessing spinal canal compromise and cord compression in patients with cervical spinal cord injury.... Spine 1999.
- Arvin B et al. Postoperative magnetic resonance imaging can predict neurological recovery after surgery for cervical spondylotic myelopathy... Neurosurgery 2011; 69(2): 362-8.
- Wang LF et al. Using the T2-weighted magnetic resonance imaging signal intensity ratio and clinical manifestations to assess the prognosis of patients... JNS: Spine 2010.