

Prognostic Utility of BASIC Score and Intramedullary Lesion Length in Late-Presenting Cervical Spinal Cord Injury: A Retrospective Study

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ABSTRACT

Introduction: This study aimed to assess the association of Magnetic Resonance Imaging (MRI) parameters, such as the Brain and Spinal Injury Centre (BASIC) Score and Intramedullary Lesion Length (IMLL) with neurological improvement after surgery in late-presenting cervical spinal cord injury (SCI).

Materials and methods: We retrospectively reviewed 52 patients with traumatic cervical SCI who underwent decompression and stabilisation more than 36 hours after injury. Neurological improvement was defined as at least one-grade increase in the ASIA Impairment Scale (AIS) at 6 months. MRI scans were evaluated using the BASIC Score and IMLL. Logistic regression and ROC analysis were performed.

Results: Of 52 patients, 26 (50%) demonstrated neurological improvement. A mild BASIC Score (0–2) was significantly associated with improvement (OR 6.107, 95% CI 1.836 – 20.315, $p=0.002$). IMLL $<30\text{mm}$ was also associated with better outcomes (OR 3.167, 95% CI 0.993 – 10.101, $p=0.048$). Multivariate analysis confirmed the BASIC Score as an independent predictor ($p=0.008$). Interobserver agreement for MRI readings was substantial ($\kappa=0.72$).

Conclusion: In late-presenting cervical SCI, the BASIC Score and IMLL are associated with neurological improvement after surgery. MRI parameters may aid in early prognosis and patient counselling.

Keywords:

cervical injury, spinal cord injury, classification system, magnetic resonance imaging

INTRODUCTION

In many developing countries, patients with cervical spinal cord injury (SCI) often present late to medical facilities due to geographic and socioeconomic barriers. This delay is concerning, as prior studies emphasise that surgical decompression within 24 hours of injury is associated with better neurological outcomes¹⁻³. In addition, limited public awareness and trust in traditional treatments may lead patients to delay or refuse surgery altogether.

On the other hand, predicting neurological recovery in SCI is complex and multifactorial. Prognostic factors include the initial severity of neurological impairment (typically assessed using the American Spinal Injury Association [ASIA] Impairment Scale), patient age, level of injury, mechanism of trauma, timing of decompression, and presence of associated injuries. Among these, ASIA scoring remains a standard clinical tool for stratifying injury severity. However, it has limitations. It relies on subjective sensory and motor evaluations, which may be inaccurate in patients with polytrauma, altered consciousness, or spinal shock^{4,5}. Moreover, ASIA scores do not directly reflect the underlying structural damage to the spinal cord.

Magnetic Resonance Imaging (MRI) provides a non-invasive and objective method for assessing the structural extent of spinal cord damage. This is regardless of patient co-operation or neurological status⁵. Certain MRI patterns—such as normal signal versus haemorrhagic lesions—have been correlated with neurological prognosis⁵⁻⁹.

Specific MRI parameters, particularly the Intramedullary Lesion Length (IMLL) and Brain and Spinal Injury Centre

(BASIC) score, have shown promise in quantifying injury severity and predicting recovery¹⁰⁻¹². The Intramedullary Lesion Length (IMLL) refers to the vertical (rostrocaudal) extent of the spinal cord lesion as seen on sagittal MRI scans. In contrast, the BASIC Score assesses the severity of spinal cord injury based on transverse (axial) T2-weighted images. It rates the extent of signal abnormality at the injury epicentre using a five-level scale (0 to 4). In summary, a BASIC Score of 0 indicates a normal-appearing spinal cord on T2-weighted imaging, with no detectable intramedullary abnormalities. A score of 1 corresponds to T2 hyperintensity confined mainly to the central gray matter. A score of 2 is given when the T2 hyperintensity extends beyond the gray matter and blurs the gray-white matter boundary, though some peripheral white matter remains unaffected. A score of 3 signifies that the abnormal signal spans the entire cross-sectional area of the cord, leaving no normal white matter visible. Lastly, a BASIC Score of 4 denotes the same pattern as score 3, but with additional distinct hypointense foci, consistent with macroscopic intramedullary haemorrhage (Fig. 1)¹².

Despite the growing interest in MRI-based metrics, there remains a lack of consensus on how to integrate these parameters into clinical decision-making, especially for patients undergoing delayed surgery. This study aims to evaluate the prognostic utility of the BASIC Score and IMLL in predicting neurological improvement at six months after surgery in late-presenting cervical SCI.

MATERIALS AND METHODS

This is a retrospective cohort study involving late-presenting traumatic cervical SCI patients undergoing decompression and stabilisation procedure from 2020 until 2024 in our institution. The patients were enrolled consecutively, and research ethics board approval was obtained at the beginning of enrolment. The inclusion and exclusion criteria were described in Table I.

At presentation, parameters recorded included: age, gender, and initial ASIA Score. The surgical procedure performed was decompression and instrumentation using either anterior or posterior approach as indicated and performed by a single operator. The subjects were clinically evaluated post-operatively when discharged and at the outpatient clinic six months after the procedure by a doctor who was blinded from the assessment of IMLL and BASIC Score. Based on comparison of pre-operative and six-month post-operative ASIA Score, patients will be divided into two groups: patients with improved ASIA scale (case group) and without improvement (control group).

All MRI was assessed by two radiologists who were blinded of the subject's clinical condition. Assessment of BASIC Score and IMLL was performed according to method described in previous literature. The BASIC score is a

classification system for assessing severity of cervical trauma based on the pattern of abnormal T2 signal in the axial plane at the epicentrum of the injury. In summary, a BASIC Score of 0 indicates a normal-appearing spinal cord on T2-weighted imaging, with no detectable intramedullary abnormalities. A score of 1 corresponds to T2 hyperintensity confined mainly to the central gray matter. A score of 2 is given when the T2 hyperintensity extends beyond the gray matter and blurs the gray-white matter boundary, though some peripheral white matter remains unaffected. A score of 3 signifies that the abnormal signal spans the entire cross-sectional area of the cord, leaving no normal white matter visible. Lastly, a BASIC Score of 4 denotes the same pattern as score 3, but with additional distinct hypointense foci, consistent with macroscopic intramedullary haemorrhage¹¹. The BASIC Score in our study was divided into 2 categories: BASIC Score (0-2) (mild category) and (3-4) (severe category). Meanwhile, Intramedullary Lesion Length (IMLL) is the rostrocaudal length of lesion as seen on a T2-window MRI midsagittal section. The IMLL value was divided into 2 categories: <30mm and >30mm¹².

All data were analysed using SPSS version 24 [IBM Corp., Armonk, NY, USA]. Continuous variables were presented as means and standard deviations, while categorical variables were presented as frequencies and percentages. Differences between groups were assessed using independent t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables.

Variables with p-values <0.20 in univariate analysis were included in a backward stepwise multivariate logistic regression model to identify independent predictors of neurological improvement. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. The calibration of the logistic regression model was assessed using the Hosmer-Lemeshow goodness-of-fit test. Discrimination ability was evaluated using receiver operating characteristic (ROC) curve analysis, with area under the curve (AUC) reported. A p-value of <0.05 was considered statistically significant, while values between 0.05 – 0.10 were interpreted as showing a trend toward significance.

RESULTS

A total of 52 patients with traumatic cervical spinal cord injury (SCI) were included in this study. Of these, 26 patients (50%) demonstrated neurological improvement at 6-month follow-up, defined as an improvement of at least one grade in the American Spinal Injury Association (ASIA) Impairment Scale (AIS). Baseline characteristics were comparable between the improved and non-improved groups (Table II). The majority of patients were male (73% vs. 77%, $p=0.749$) and underwent posterior surgical approach (76.9% vs. 65.4%, $p=0.358$). Most patients initially presented with severe neurological impairment (ASIA grade A – C) in both groups (80.8% vs. 77%, $p=0.734$).

Table I: Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
1. Age >18 years old	1. Co-existing head injuries
2. Body Mass Index (BMI) of 18.5-25kg/m ²	2. Tetraparesis or tetraplegia caused by non-traumatic aetiologies
3. Received the NASCIS protocol according to indications.	3. Sharp trauma to the spine
4. Definitive surgery performed >36 hours treatment	4. Life-threatening injuries which prevent early definitive after injury.
5. Pre-operative T2-weighted MRI axial and sagittal views showing SCI between level C2-C7.	5. Comorbidities including diabetes mellitus, malnutrition autoimmune disease, hormonal disorders, malignancy, and other metabolic disorders
6. Patient or Proxy willing to provide consent for enrolment.	6. Congenital musculoskeletal disorders
	7. Sustain other injuries during follow-up period

Table II: Baseline characteristics of subjects.

Variable	ASIA score improvement		p-value
	Yes (n=26)	No (n=26)	
Sex (male)	19 (73%)	20 (77%)	0.749
Age (years)	54.81 ± 15.315	54.85 ± 11.925	0.252
Initial ASIA Score			0.734
A-C	21 (80.8%)	20 (77%)	
D-E	5 (19.2%)	6 (23%)	
ASIA Score after 6 months			0.532
A-C	18 (69.2%)	20 (77%)	
D-E	8 (30.8%)	6 (23%)	
Operation Approach			0.358
Anterior	6 (23.1%)	9 (34.6%)	
Posterior	20 (76.9%)	17 (65.4%)	

Table III: MRI parameters in relation with improvement of the ASIA scale.

Variable	ASIA Score Improvement		p-value	OR (95% CI)
	Yes	No		
BASIC Score				
0-2	19 (73%)	8 (30.77%)	0.002	6.107 (1.836 – 20.315)
3-4	7 (27%)	18 (69.23%)		
Intramedullary Lesion Length				
<30 mm	14 (53.85%)	7 (27%)	0.048	3.167 (0.993 – 10.101)
>30 mm	12 (46.15%)	19 (73%)		

Table IV: Logistic regression analysis of risk factors for ASIA improvement.

Risk Factors	p	Exp(B)	95% CI for Exp (B)	
			Lower	Upper
IMLL	0.165	2.44	0.693	8.57
BASIC Score	0.008	5.31	1.554	18.16

MRI parameters showed significant association with neurological recovery (Table III). Interobserver agreement between the two radiologists was substantial, with an estimated kappa value of 0.72. Univariate analysis showed that a mild BASIC Score was associated with a sixfold higher odd of improvement (OR 6.107, 95% CI 1.836 – 20.315, $p=0.002$), and IMLL <30mm was associated with threefold higher odds of improvement (OR 3.167, 95% CI 0.993 – 10.101, $p=0.048$). In a separate ROC analysis of

IMLL, the AUC was 0.288 (95% CI 0.145–0.432) when neurological improvement was specified as the positive outcome.

Multivariate logistic regression confirmed that a mild BASIC Score remained an independent predictor of neurological improvement ($p=0.008$) (Table IV). Calibration of the multivariate model was good, as indicated by the Hosmer-Lemeshow test ($p=0.994$). Using this model, the

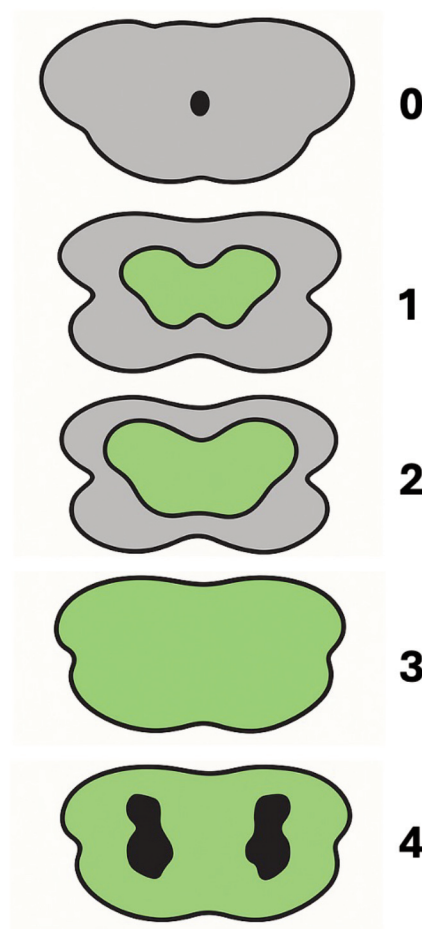


Fig. 1: BASIC Score classification system based on axial T2-weighted MRI at the epicentre of spinal cord injury. Score 0: Normal spinal cord appearance with no intramedullary signal changes. Score 1: T2 hyperintensity confined to the central gray matter. Score 2: Hyperintensity extends beyond the gray matter, obscuring the gray-white boundary, but with preserved peripheral white matter. Score 3: Diffuse hyperintensity involving the entire cross-sectional area with no residual normal-appearing white matter. Score 4: Same as Score 3, with additional intramedullary hypointense foci representing macroscopic haemorrhage.

estimated probability of neurological improvement was 29.75% for patients with a mild BASIC Score and 6.56% for those with a severe BASIC Score.

DISCUSSION

This study investigated the prognostic value of magnetic resonance imaging (MRI) parameters, specifically the Brain and Spinal Injury Centre (BASIC) Score and Intramedullary Lesion Length (IMLL), in predicting neurological improvement following surgery in late-presenting cervical spinal cord injury (SCI). Our findings suggest that MRI features, particularly the BASIC Score, are associated with neurological recovery at six months.

In the cases of spinal cord compression after trauma, the timing of surgical decompression is regarded as the most important predictor of outcome. Previous literature found that acute SCI patients who underwent surgery within 24 hours after injury experienced more significant neurologic

improvement^{1,13-16}. Early surgical decompression and stabilisation hindered secondary injury from taking place and improved the motor function in patients with incomplete SCI¹⁷. However, this benefit persisted until 36 hours after injury, after which the effect of time plateaued¹⁸. Both groups in this study underwent surgery more than 36 hours from the time of trauma. Despite the worse prognosis, neurological improvement is still considered possible.

Similar to previous study¹⁹, ignorance of injury severity, and the strong beliefs in traditional healing method are the main factors which cause the delay of treatment in our institution. When the patients finally reach our institution, there is still reluctance towards surgery. Therefore, doctors need to have strong basis to support the recommendation of operative treatment and to gain trust from family members so that they will be fully committed in the perioperative rehabilitative treatment. Recent studies discovered controversies in using conventional clinical parameters such as initial ASIA Scale to predict neurological improvement in traumatic cervical SCI.

The use of the initial ASIA scale to predict improvement of neurological status has been controversial. Khorasanizadeh *et al* found that possibility of neurological recovery was in the order of: C > B > D > A. The chance of recovery as determined by the ASIA or Frankel scale conversion increased significantly as the severity of injury decreased, except in patients on the ASIA D scale, compared to ASIA B and C scales. The reason for the lack of improvement in patients on the ASIA D scale is known to be related to ceiling effect, which is measurement limitations when the measurement instrument reaches or almost reaches the highest value⁶.

In addition, some investigators have found that the improvement reported by patients with complete SCI may be the result of misclassification of patients with incomplete SCI. This misclassification might occur due to inaccurate initial neurological examination, i.e. in the conditions of head injury, intoxication, sedation or paralysis, mechanical ventilation, spinal shock, hemodynamic instability, severe pain, decreased mental status, and psychological stress, especially when performed at early hours after the injury²⁰.

Therefore, a more objective assessment is needed. BASIC Score was developed based on the pathophysiological changes that can be observed in the transverse sections of the spinal cord. Earlier studies found it to be highly correlated with neurological outcome^{10,12,21}. However, classifying injury of spinal cord in axial view is prone to subjectivity. Assessing the precise transverse extent of hyperintensity signal is difficult due to the size of spinal cord, especially using scanner with magnetic effect of 1.5 Tesla. Therefore, we modified the scoring from five categories into only two categories. BASIC Score of 3 and 4 were put into one category since they were linked with ASIA Scale of A and B at the end of treatment period¹². Another reason for categorising BASIC Score 3 and 4 is because the appearance is similar in terms of the involvement of the whole cross-section of spinal cord. In our study, reducing the number of categories improved the interobserver difference.

The second investigated MRI parameter was IMLL, which objectively measures the length of spinal cord lesion on sagittal MRI scans. Assessment of the extent of spinal cord injury in the sagittal section was found to be ideal because the number of segments affected by SCI correlates well with neurological outcome²². Patients with complete SCI tend to have a more elongated sagittal hematoma than those with incomplete injuries and did not show ASIA Scale improvement at follow-up²³. In a study by Dobran *et al*²⁴ and Tarawneh *et al*²⁵, it was concluded that the length of the spinal cord lesion, the diameter of the canal at the level of maximal spinal cord compression, and the presence of intramedullary lesion were all significantly associated with the score at the Spinal Cord Independence Measure (SCIM) questionnaire at one year follow-up.

In clinical practice, we should know which IMLL cut-off is most correlated with the ASIA scale improvement. Previous study found that the mean difference of IMLL measurements between the groups with improvement and without improvement was 31.79 mm, with higher IMLL scores at risk of not experiencing neurological improvement¹⁰. In this study, ROC curve analysis demonstrated poor discriminatory ability (AUC 28.8%), suggesting limited utility in defining optimal cutoff thresholds in this cohort. Therefore, the 30mm cutoff was retained based on previously published clinical standards¹¹.

Furthermore, the discrepancy between univariate and multivariate analysis of IMLL showed that only BASIC Score can be used to predict neurological outcome. IMLL quantifies the length of T2 hyperintensity on sagittal MRI, which can be nonspecific and influenced by edema alone. This does not consistently reflect injury severity. Prior studies have shown wide variability in outcomes among patients with similar IMLL values⁴. In contrast, the BASIC Score is derived from axial MRI, which more directly captures the extent of transverse cord disruption and has been shown in translational models to correlate better with histopathology and functional recovery¹².

There are two important prerequisites of a prediction system: (1) high accuracy, defined by common interpretation when assessing a specific injury; and (2) applicable, defined by high correlation between the recommendation and the actual management. In addition, for a classification system to be widely used in the clinical setting, a high degree of practicality supported with straightforward method is needed. The current scoring or classification systems for SCI, such as ASIA Impairment Scale (AIS), Frankel scale, ASIA motor score (AMS) is still irreplaceable in the setting of the emergency unit as a form of initial assessment. However, their major limitations such as subjectivity should be complemented with other system that is more pathological based.

This study is subject to various limitations. The limited number of subjects and retrospective study design might complicate the analysis. However, statistical analysis proved our current sample size was enough to draw a valid conclusion. Prospective studies involving more subjects are warranted in the future.

CONCLUSION

MRI Parameters, especially BASIC Score, is good predictor for neurological improvement in traumatic cervical SCI patients presenting late to the hospital. However, there was a void in terms of synthesising this discovery into a clinical tool which is practical and has high impact for cervical trauma management. Our study offered a systematic approach to interpret MRI into quantitative data which can

later be utilised to guide treatment, rehabilitation, and our communication with patients. These MRI parameters help doctors in encouraging patients who present late to hospital that operative treatment might result in improvement. The

second benefit is for patients who have better possibility of improvement, medical providers would be more aware and stricter in providing rehabilitative effort.

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