

Original Research Article

Evaluation of patients with cervical spine injury and predicting the risk and severity of acute spinal cord injury after a minor trauma

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ABSTRACT

Background: Acute spinal cord injury (SCI) after a minor trauma to the cervical spine has been reported in patients without preceding neurologic symptoms. Spinal canal stenosis may be the reason for the discrepancy between the severity of the injury and that of the trauma. The objective of this study was to investigate MRI parameters of the cervical spine in patients suffering from acute SCI and to investigate the use of these parameters for predicting the risk and severity of acute cervical SCI after a minor trauma to the cervical spine.

Methods: Retrospective radiological study was conducted in Meenakshi Medical College and Research Institute Kanchipuram with fifty patients suffering from acute cervical SCI and 130 patients showing no neurologic deficits after a minor trauma to the cervical spine. The following calculations were performed using measurements from MR images the spinal canal to vertebral body ratio, the space available for the cord, and the canal-to-cord ratio. SPSS version 21 was used for analysis.

Results: All investigated MR image parameters in the SCI group were significantly ($p < 0.001$) smaller compared with the control group. However, there was no significant difference in any parameter among the different American spinal injury association impairment score groups. A cut-off value of 8.0 mm for the minimal sagittal disc-level canal diameter yielded the largest positive predictive value and likelihood ratio for predicting SCI.

Conclusions: Patients at risk of acute SCI after a minor trauma to the cervical spine can be identified by applying a disc-level canal diameter cut-off value measured on MR images. Supplementary factors to the radiological characteristics of the spinal canal affect the severity of acute SCI after trauma.

Keywords: Spinal cord injury, Cervical spine, Trauma, MRI, Spinal canal stenosis

INTRODUCTION

Tetraplegia or paresis after a minor trauma to the cervical spine, causing no osseous or disco ligamentous injury, has been reported to occur in patients without preceding neurologic symptoms.¹⁻³ In these patients, a congenitally narrow spinal canal or degenerative changes may result in spinal canal stenosis that increases the risk of acute spinal cord injury (SCI) after a hyperextension or flexion trauma to the neck in the absence of spinal column injuries.^{4,5}

Different radiographic parameters have thus been investigated as a surrogate for spinal canal stenosis to assess the risk of SCI after a minor trauma to the cervical spine. Presently, the cervical spinal canal to vertebral body ratio is often used to assess spinal canal stenosis on conventional radiographs, which still is the first-line imaging evaluation of the non-traumatic and traumatic cervical spine.⁶⁻⁸ Further-more, the ratio does not consider the spondylotic changes that most commonly occur in the vicinity of the intervertebral disc.⁹ Finally, canal

narrowing caused by soft tissue cannot be assessed on conventional radiographs. Parameters measured on magnetic resonance (MR) images may thus be more meaningful for assessing cervical spinal canal stenosis. Previous authors have demonstrated that MR image parameters are reliable for predicting the occurrence and course of cervical spinal neurapraxia in athletes suffering from sports trauma and chronic spondylotic cervical myelopathy in Asian subjects.^{10,11} However, the relevance of MR image parameters for predicting the risk and severity of acute SCI in patients after a minor trauma to the cervical spine has not yet been established. The rationale behind this study was to investigate the spinal canal diameter and the space available for the cord at the level of the intervertebral disc in patients suffering from acute cervical SCI after a minor trauma to the cervical spine.

METHODS

It was a retrospective radiological based study conducted in Meenakshi Medical College and Research Institute Kanchipuram in department of radio diagnosis. Patients suffering from acute cervical SCI after trauma were identified by reviewing the case histories of consecutive patients who had sustained tetraplegia or paresis and were admitted to hospital from January 2017 to August 2019 for evaluation or rehabilitation. Patients suffering from non-traumatic (vascular, inflammatory, infectious, mass) SCI or with a history of cervical spinal cord disorders and patients without radiological signs of SCI were excluded. The following exclusion criteria were applied to patients who had sustained minor trauma to the cervical spine: fractures (except for isolated fractures of spinous processes and disco ligamentous injuries of the cervical spine (assessed on MR images). A total of 50 patients suffering from acute SCI after a minor trauma to the cervical spine with a mean age of 52.44 years at the time of the accident were thus identified. Patients who had sustained a flexion-extension trauma to the cervical spine without clinical or radiological signs of cervical spinal cord pathology and who were admitted to our institution for evaluation or rehabilitation were allocated to the control group. Patients with a history of cervical spinal cord disorders were excluded. The number of patients thus selected was 150. Finally, patients aged outside the range of 35 to 80 years were excluded.

Methodology

Measurements were taken by two observers using the Phoenix PACS software (version 3.20.34233; Phoenix PACS GmbH, Freiburg, Germany) and recorded to the nearest 0.1 mm. On the MR images, the following parameters were measured the sagittal diameter of the vertebral body, the sagittal outer diameter of the subarachnoid space at the midpoint of the vertebra (mid vertebral canal diameter), the sagittal outer diameter of the subarachnoid space at the level of the intervertebral disc (disc-level canal diameter), and the sagittal diameter of the spinal cord at the levels C2 and T1. Spinal cord

measurements were not taken at the affected levels to minimize measuring errors as a result of the signal changes after SCI. The sagittal diameter of the spinal cord decreases gradually, but only slightly from C2 to T1, and the cervical enlargement does not affect the sagittal diameter of the cord. The median of the two values was thus used for sub-sequent calculations. The following calculations were performed using the measurements from the MR images: the spinal canal to vertebral body ratio (TPR-MRI) was calculated by dividing the mid vertebral canal diameter by the diameter of the vertebral body; the space available for the cord was calculated by subtracting the diameter of the cord from the disc-level canal diameter and the canal-to-cord ratio was calculated by dividing the disc-level canal by the diameter of the spinal cord.

Statistical analysis

Data were calculated and presented as median and 95% confidence interval (CI). The chi-square and fisher exact tests were used to compare the gender distribution between the groups. Spearman rank-order analysis was used to investigate correlations among variables. A value of <0.05 was considered significant for all statistical analyses. Statistical analyses were performed using SPSS software (version 21.0). And all patient data were made anonymous and kept confidential.

RESULTS

As per Table 1, out of 180 patients, twenty eight percent patients had SCI. The study was male preponderance, but the injury was comparable in both as it was not significant. Control group has higher age and weight, but it was not significant. This concludes that anthropometric factors have no role in SCI.

Table 1: Gender and anthropometric characteristics of the patients (n=180).

Variables	SCI (n=50)	Control (n=150)	P value
Gender			
Male	40	90	0.27
Female	10	40	
Age in years (mean±SD)	47.4±8.9	51.2±6.8	0.42
Height (cm)	176±15.8	174±14.6	0.31
Weight (kg)	72±4.6	74±3.8	0.24

As per Table 2, the most common cause of SCI was found to be falls in 50% of cases, followed by traffic accidents 42%. In control group the most common cause of injury was traffic accidents 47%, followed by falls. Mostly patients have no neurological deficits but in falls and traffic accidents, complete and partial neurological deficit was seen. TPR CR (Torg-Pavlov ratio value on conventional radiographs); TPR MRI (Torg-Pavlov ratio value on magnetic resonance images); CD DM (sagittal

disc-level canal diameter) CD (MVM) sagittal mid vertebral canal diameter; PPV, positive predictive value; NPV, negative predictive value.

Table 2: Causes of sustained cervical injury in both groups.

Causes	SCI (n=50)	Control (n=130)	Complete/partial/no neurological deficit
Falls	25	42	3/0/0
Traffic accidents	19	60	3/6/0
Winter sports	2	14	0/0/6
Diving	3	10	0/0/6
Flying accidents	1	4	0/0/4

Table 3: Effectiveness of radiological parameters in predicting SCI.

Parameters	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
TPR (CR)	68	70	64	74
TPR (MRI)	74	94	72	88
CD (DM)	78	96	82	90
CD (MVM)	56	95	76	84

As per Table 3, different radiological parameters were studied to determine the risk of SCI. Canal diameter at disc level shows the best sensitivity and specificity 78%, followed by TPR based on MRI images 74%. So overall, the best parameter was found to be canal diameter at disc level.

Table 4: Correlation among different radiological parameters.

Parameters	Correlation coefficient (r)	
	SCI	Control
TPR(CR) vs TPR (MRI)	0.22	0.20
TPR(CR) vs CD (DM)	0.05	0.03
TPR(CR) vs CD (MVM)	0.11	0.13
TPR(MRI) vs CD (DM)	0.71	0.56
TPR(MRI) vs CD (MVM)	0.03	0.07
CD (DM) vs CD (MVM)	0.04	0.17

As per Table 4, there were significant and positive correlations between investigated parameters (i.e., mid vertebral and disc-level canal diameters, TPR-MRI). No significant correlations between any of the parameters and height or weight were detected. Furthermore, there was no significant correlation between any of the parameters and the ASIA motor or sensory score.

DISCUSSION

Torg et al have reported an increased risk of cervical cord neurapraxia recurrence in athletes with decreasing spinal canal diameter measured on MR images.¹⁰ Present prediction values for the disc-level canal diameter are superior to those reported in the literature for the TPR CR and the space available for the cord.¹² A mid vertebral canal diameter less than 12 mm and 10 mm is ‘stenotic’ and a ‘risk of acute SCI’ respectively.^{6,13,14} All five MR image parameters investigated in the present study were characteristic for patients suffering from acute SCI after a minor trauma to the cervical spine. The median disc-level canal diameter measured 9.0 mm (minimal value 6.9 mm) in the SCI group, which is comparable with results in athletes suffering from cervical cord neurapraxia after a sports trauma (9.6 mm).¹⁰ The disc-level canal diameter was significantly smaller compared with the mid vertebral diameter in both groups. Reported values of the mid vertebral canal diameter vary widely as a result of methodical differences. Mean values in Asian patients suffering from chronic spondylotic myelopathy derived from conventional radiographs range from 9-18 mm.¹⁵ No investigated parameter was a meaningful predictor of the severity of the neurologic deficit after the accident which is in accordance with other studies.¹⁶ The discrepancy between the degree of canal narrowing and the severities of the neurologic deficit may be the result of other factors involved. The type and severity of the trauma, the extent of irreversible Nerve cell injury, and the vascular status also play a role in the development of SCI.^{15,16} Alternatively, the investigated parameters may not be ideal for identifying anatomical features influencing the severity and duration of symptoms. The spinal cord area for example, has been reported to correlate with the course of symptoms and surgical outcome.^{1,7}

Finally, dynamic changes of the cervical spinal canal diameter during a hyperextension trauma may temporarily result in critical canal stenosis leading to SCI.¹⁷ The correlation between the TPR CR and the TPR MRI was moderate, but the correlations with the other MRI parameters were weak. Other authors have reported similar correlations between the TPR CR and the TPR MRI or among the other MR image parameters.¹⁶ Age, weight, and height of the patients had no or only a negligible effect on the investigated parameters in the present study. Reported results are conflicting, showing no or strong effects of these parameters.^{9,10,16} The risk of trauma-induced SCI can be assessed by calculating the TPR CR from measurements on conventional radiographs, as this is the first-line imaging evaluation of the traumatic and non-

traumatic cervical spine.^{7,8} The specificity can be improved slightly by assessing congenital canal narrowing on MR images (i.e. TPR MRI, mid vertebral canal diameter), but the sensitivity is still inadequate. Therefore, spinal canal narrowing in the Caucasian population should not be assessed solely using the TPR or the mid vertebral canal diameter because canal narrowing in the vicinity of the disc as a result of spondylotic changes or soft-tissue protrusion is not considered.⁹ The analysis of the disc-level canal diameter measured on MR images entailed a false negative and positive rate of 20% and 5%, respectively, and the proportion of true positive test results was 84%.

CONCLUSION

This study showed that patients at risk of acute SCI after a minor trauma to the cervical spine can be identified by applying a disc-level canal. Additional factors to the radiological characteristics of the cervical spinal canal affect the severity of acute SCI after a minor trauma to the cervical spine.

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