ORIGINAL ARTICLE

Role of Magnetic Resonance Imaging in Acute Spinal Cord Trauma

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ABSTRACT

Background: Trauma to spinal cord is a main source of morbidity and mortality worldwide. Globally commonest mechanisms are road traffic accidents and falls. Magnetic resonance imaging plays a pivotal role in evaluation of patients with spinal trauma. Marrow changes, soft tissue and ligamentous injury and cord abnormalities which are not well evaluated by other modalities, can be very well delineated by magnetic resonance imaging. Moreover, it has additional advantages of absence of ionizing radiations, improved contrast resolution and multiplanar, multisequencial capabilities. Cord abnormalities detected on magnetic resonance imaging in spinal trauma patients help in predicting prognosis of patients.

Aim: To correlate cord abnormalities detected on magnetic resonance imaging with clinical examination findings and clinical outcome of spinal trauma patients.

Methods: This descriptive analytical study was conducted in Department of Radiology, RMU and Allied Hospitals, Rawalpindi over a period of six months from 1st January to 30th June-, 2018. A total of 30 patients of spinal trauma were included in the study. Magnetic resonance imaging spine of study patients was performed to detect cord abnormalities. Detailed physical examination of the patients was done at the time of presentation and again at the time of discharge from hospital. The extent of neurological deficit was determined using American Spinal Injury Association (ASIA) impairment scale (AIS). Magnetic resonance imaging (MRI) findings were correlated with AIS scale at the time of hospital admission and discharge to see the relationship between cord findings and clinical outcome of patients thus determining diagnostic and prognostic role of MRI in spinal trauma patients.

Results: It is found that patients with cord hemorrhage and cord edema>3cms present with complete paralysis (high initial AIS scales) and do not show any significant clinical improvement with cord hemorrhage having worst prognosis. Patients with cord edema < 3cms showed improvement and better clinical outcome. Patients without any radiographically detected abnormality had excellent prognosis.

Conclusion: Magnetic resonance imaging (MRI) is an outstanding imaging modality in the assessment of patients with spinal cord trauma and can predict clinical outcome of patients.

Key words: Magnetic resonance imaging, Spinal trauma, Outcome, Cord abnormalities

INTRODUCTION

Trauma spinal cord is a main source of morbidity and mortality with a global incidence of 10.5 per 100,000 persons.[1] The incidence is higher in developing countries as compared to the developed world.[1-,2,3]. Spinal cord trauma most commonly involves young individuals. Globally commonest mechanisms are road traffic accidents and falls.[1,4-,5,6]. Persons with injuries to the spinal cord are two to five times more prone to die early than persons without spinal cord injuries, with poorer survival rates in developing countries.[5-,6,7]. Traumatic cord injury results in disturbance of sensory, autonomic and motor systems and the deficit can be transient, incomplete or complete. It has significant psychosocial impact as well due to high morbidity associated with it.[8]. Complete evaluation and efficient management of patients with spinal trauma is required as it imposes significant financial burden on patient and community.[9].

Magnetic resonance imaging (MRI) has a very vital role in evaluation of patients with spinal trauma.[10,11] Marrow changes, soft tissue and ligamentous injury and cord abnormalities which are not well evaluated by other modalities, can be very well delineated by MRI.[12]. Moreover it has additional advantages of absence of ionizing radiations, improved contrast resolution and multiplanar, multisequencial capabilities. This helps in effective and efficient management of patients and prevents unwarranted surgeries. The MRI appearances of damaged spinal cord correlates with the extent of neurologic deficit at the time of injury as well as with the clinical outcome.[12,13]. The extent of neurological deficit is graded by American spinal injury association impairment scale (AIS). Spectrum of

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abnormalities on MRI of acute spinal cord trauma include; spinal cord concussion, spinal cord edema, spinal cord hemorrhage and spinal cord transection. Spinal cord appears normal on MRI.[14]. Spinal cord edema appears as low signal on T1WI and high signal on T2WI. It may or may not be associated with cord swelling. Length of cord edema is important in predicting prognosis of patient. Cord edema significantly varies in first 2 weeks after trauma. It is characterized by focal increase in diameter of cord and is best seen on T1WI[15 15]

Spinal cord hemorrhage is invariably associated with cord edema. It appears as a focus of low signal surrounded by a high signal thick rim on T2WI. Gradient echo sequences are best for determining the true extent of spinal cord hemorrhage which may be underestimated on routine spin echo sequence[12 12] While spinal cord edema considerably increases in the initial time period following trauma, cord hemorrhage fairly stays static.[16]. Spinal cord transection implies complete disruption of the spinal cord and is the most severe form of cord injury. CSF appearing

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~~hyperintense on T2WI is appreciated between the disrupted cord ends.~~

The MRI appearances of spinal trauma patients help in predicting prognosis of patients. Cord concussion with no detectable radiological abnormality has the most favorable prognosis[12]. Other prognostic factors include length of spinal cord edema and cord hemorrhage; with spinal cord hemorrhage associated with poor clinical outcome[17].

MATERIAL AND METHODS

This descriptive analytical study was conducted in Department of Radiology, RMU and Allied Hospitals, Rawalpindi over a period of six months from 1st January to 30th June 2018. A total of 30 patients of spinal trauma were included. All patients with traumatic spinal injuries having MRI scan within 2 weeks following trauma were included in the study. Patients with spinal cord trauma having MRI after 2 weeks of injury and non-traumatic spinal cord damage were excluded. All patients had a detailed history regarding age, mode of trauma, date of trauma along with clinical examination. MRI of spine was performed on 1.5 Teslamachine. Sagittal T1 weighted (T1WI) and T2 weighted (T2WI) spin echo sequences(SE), gradient recalled echo (GRE) sequence, and sagittal short tau inversion recovery (STIR) sequences, as well as axial T2W and T2*W GRE sequences were performed. T1WI help to evaluate anatomy and bony fractures. STIR sequences are best for detecting edema, soft tissue and ligamentous injury.[18] Cord edema is best seen on T2WI and cord hemorrhage is best evaluated on GRE sequence.[18] Diffusion tensor imaging is recently being used to evaluate and detect injuries not detected on conventional MRI.[19,20] It is recommended that ideally MRI should be done within first 72 hours following trauma as edema appearing hyperintense on T2WI improves the detection of soft tissue and ligamentous injuries; later on as edema disappears detection of ligament injuries becomes difficult[21]. ~~MRI scans of study patients were assessed and following imaging features were considered; normal cord, cord edema > 3 cms in length, cord edema < 3 cms in length and cord hemorrhage.~~ Detailed physical examination of the patient was done at the time of presentation and again at the time of discharge from hospital. The degree of neurological deficit was determined using American Spinal Injury Association (ASIA) impairment scale (AIS). AIS has two major components; sensory and motor and is described as follows; (a) complete: in the sacral segments S4-S5, no sensory and motor function is conserved, (b) incomplete: in the sacral segments S4-S5, sensory function is conserved but motor function is not preserved below the neurologic level (c) motor function is conserved below the neurologic level, and less than half of the key muscles below the neurologic level have a muscle grade of less than 3, (d) Incomplete: Motor function is conserved below the neurologic level with at least half of key muscles below the neurologic level having a muscle grade of 3 or more and (e) normal: motor and sensory function are normal. MRI findings were correlated with ASIA impairment scale (AIS) of study patients at the time of presentation and discharge to determine the diagnostic and prognostic role of MRI in spinal trauma patients. The data was entered and analyzed through SPSS-20.

RESULTS

There were 21 (70%) male and 9 (30%) were female patients. 17 (56.6%) patients were between 21-~~40years~~ 40 years age group, 6(20%) patients were between 41-60 years age group, 4 (13.3%) patients were below the age of 20 years and 3 (10%) patients were more than 60 years old (Table 1). Spinal cord abnormalities were seen in 16 out of 30 study patients, rest had no abnormal MRI findings. Six (37.5%) patients had isolated involvement of thoracic spinal cord, 2 (12.5%) patients had only lumbar cord involved, 2 (12.5%) patients had cervical and thoracic cord involvement and 6 (37.5%) patients had involvement of both thoracic and lumbar spinal cord (Table 2).Cause of trauma was road traffic accidents in 15 (50%) patients; fall in 12 (40%) patients and sports injury in 3 (10%) patients (Fig. 1).

Abnormal cord findings were seen in 16(53.3%) study patients while 14(46.6%) patients had no abnormal MRI findings. Commonest abnormality was cord edema>3cms, followed by cord edema<3cms and cord hemorrhage. 7(23.3%) patients had cord edema>3cms, 5(16.6%) patients had cord edema<3cms and 4(13.3%) patients had cord hemorrhage while 14(46.6%) had no abnormal MRI finding (Table 3).

Most common abnormal MRI finding was cord edema>3cms seen in 7 patients (Fig. 2). Out of these, 5 patients at the time of hospital admission had AIS scale A, 1 had AIS scale B and one had AIS scale C. Out of 5 patients with AIS scale A, 3 patients showed no clinical improvement while one patient improved to AIS scale B and one improved to AIS scale C. Cord edema<3cms was seen in 5 patients (Fig. 3). Out of these 3 patients initially had AIS scale D, one had AIS scale C and one A. 2 patients with AIS scale D showed clinical improvement to AIS scale E while one patient did not show improvement. One patient with AIS scale C improved to AIS scale D at the time of discharge while patient with initial AIS scale A did not show any clinical improvement.

Fig. 2: Sagittal T2WI and STIR sequences of 32 years old male patient with history of road traffic accident showing fractures of D-12 and L-1 vertebra. There is retropulsion of LV1 fracture fragment resulting in cord edema with length more than 3 cms. Hyperintense signals are also seen in the spinous processes of DV12 and LV1 on STIR sequence representing marrow edema.

Cord hemorrhage was seen in 4 patients. All patients with cord hemorrhage had AIS scale A at the time of admission. Only one patient improved to AIS scale B at the time of discharge while remaining 3 did not show any clinical improvement. In our study, neurological deficit was graded as AIS scale A in 10 patients, AIS scale B in2 patients, AIS scale C in 4 patients, AIS scale D in 7 patients and AIS scale E in7 patients at the time of admission. At the time of discharge 7 patients had AIS scale A, 2 had AIS scale B, 2 had AIS scale C, 6 had AIS scale D and 13 had AIS scale E (Fig. 4).

It was found in our study that of 10 patients with AIS scale A, only 3 (30%) patients showed clinical improvement; 2 patients to AIS scale B and one to AIS scale C. 2 patients with AIS scale B improved to AIS scale C and D i.e. 100%. Out of 4 patients with AIS scale C all

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showed clinical improvement to AIS scale D i.e. 100%. Out of 7 patients with AIS scale D, 6(86%) improved to AIS scale E while one(14%) patient did not show clinical improvement (Fig, 5).

Fig. 3: Sagittal T2WI showing burst fracture of D-12 vertebra with retropulsion of fracture fragment and resultant hyperintense signal in cordat this level with length of <3cms representing cord edema

Table 1: Frequency and percentage of age of the patients (n=30)

Age (years)	No.n	%age
<20	4	13.4
21-40	17	56.6
41-60	6	20.0
>60	3	10.0

Table 2: Frequency of part of spinal cord involved (n=16)

Part of cord involved	No.n	%age
Cervical	-	-
Thoracic cord	6	37.5
Lumbar cord	2	12.5
Cervico-thoracic	2	12.5
Thoraco-lumbar	6	37.5

Table 3: MRI Findings in patients with spinal cord damage

MRI Findings	n	%age
Cord Edema <3 cms	5	16.6
Cord Edema >3 cms	7	23.3
Cord Hemorrhage	4	13.3
Normal	14	46.6

Fig. 1: Cause of spinal cord injury

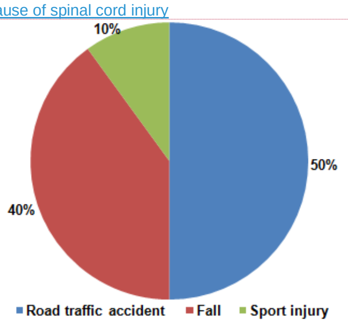

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Fig. 4: ASIA Impairment Scale (AIS) at the time of hospital admission and discharge in patients of spinal cord damage ~~Fig. 3: Sagittal T2WI showing burst fracture of D-12 vertebra with retropulsion of fracture fragment and resultant hyperintense signal in cordat this level with length of <3cms representing cord edema~~

Fig. 5: Clinical outcome according to ASIA Impairment Scale (AIS)~~**Fig. 4:** ASIA Impairment Scale (AIS) at the time of hospital admission and discharge in patients of spinal cord damage~~

~~**Fig. 5:** Clinical outcome according to ASIA Impairment Scale (AIS)~~

DISCUSSION

In this study, correlation of MRI findings with AIS scale at the time of hospital admission and discharge of patients concluded that cord hemorrhage had worst prognosis followed by cord edema having length of greater than 3 centimeters. All 4 patients with cord hemorrhage had initial AIS scale A (complete paralysis) at the time of hospital admission. Out of these only 1 (25%) showed clinical improvement while remaining 3 showed no improvement at the time of discharge. This implies that patients with cord hemorrhage have high grade of neurological deficit i.e. complete paralysis the time of presentation. Moreover, it implies that patients having high grade AIS scales do not express any substantial improvement.

Out of 7 patients having cord edema>3cms, 5 had initial AIS scale A. Only 2 out of these 5 patients showed clinical improvement. It is thus suggested that patients with cord hemorrhage and cord edema >3cms present with complete paralysis and also patients with high initial AIS scales do not show any significant clinical improvement.

Out of 5 patients having cord edema <3cms, 3 patients had initial AIS scale D, 1 had AIS scale C one had AIS scale A. This suggested that patients with small length of cord edema had less severe grade of AIS at the time of admission. Three out of these 5 patients showed clinical improvement implying that small length of cord edema had favorable prognosis.

The results were similar to already published data on this subject. In a study the researchers determined the diagnostic and prognostic role of MRI by correlating MRI findings with AIS scales of patients at time of admission and discharge. It was concluded in the study that patients having cord hemorrhage and large lengths of cord edema usually present with complete paralysis and poor clinical outcome while patients with small cord edema usually show improvement on follow up.[12] Similar results were shown in another study conducted by Parashari et al.[13].

Another study showed the effect of hemorrhage on clinical outcome. The study showed that patients with cord hemorrhage usually have complete paralysis on follow-up suggesting poor prognosis.[22].

Andreoli et al. also studied the diagnostic and prognostic role of MRI in patients with spinal trauma and found that MRI findings correlated well with clinical findings of patients graded according to AIS scale and ~~that~~ patients with cord hemorrhage had severe initial AIS scale with poor clinical outcome.[23].

Another study conducted by Tewari et al showed that cord hemorrhage was associated with poor prognosis while patients with minimal cord findings on MRI had good clinical outcome followed by patients with small lengths of cord edema.[24]. Another study by Miyangi et al also concluded that spinal cord hemorrhage and large lengths of cord edema had poor clinical outcome.[25].

CONCLUSION

In this study, correlation of MRI findings with AIS scale at the time of hospital admission and discharge of patients concluded that cord hemorrhage had worst prognosis followed by cord edema having length of greater than 3 centimeters. Patients with cord edema <3cms showed improvement and better clinical outcome. Patients without any radiographically detected abnormality had excellent prognosis. Thus, MRI is an excellent imaging modality in evaluating patients with spinal trauma and can predict clinical outcome of patients.

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