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Evaluation of the Role of Magnetic Resonance Imaging in Acute Traumatic Spinal Injuries: Literature Review

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Abstract

Background: Acute trauma is a common cause of Spinal cord injury (SCI) that results in life-threatening and/or severely disabling injuries. Initial assessment of traumatic SCI is usually done through X-ray radiography and computed tomography (CT). Although spinal integrity could be sufficiently evaluated using CT scans to direct surgical interventions, the superior capabilities of magnetic resonance imaging (MRI). **Objectives:** In this paper, we will review the available literature discussing the role of MRI in emergency spinal injuries. **Methodology:** We conducted the literature search within the PubMed database using the keywords: "cord contusion" and "cord edema" and "cord hematoma" and "cord hemorrhage" and "cord transection" and "magnetic resonance imaging" and "neurological deficit" and "spinal cord injury" and "spinal trauma" and "trauma" with dates from 1990 to 2020.
Review: There are multiple indications of spinal MRI in acute spinal injury. One major indication is that initial findings obtained from X-ray and/ or CT scans suggest injury to the ligaments. MRI is superior to conventional CT scans in the evaluation of TDH as it provides exceptional contrast between the different anatomical structures. **Conclusion:** In conclusion, MRI has transformed the way physicians approach acute traumatic SCIs by supplying them with an effective instrument that has allowed them to rapidly obtain high-quality data and act on it.

Keywords: cord contusion, cord edema, cord hematoma, cord hemorrhage, cord transection, magnetic resonance imaging, neurological deficit, spinal cord injury, spinal trauma, trauma.

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Introduction

Acute trauma is a common cause of Spinal cord injury (SCI) that results in life-threatening and/or severely disabling injuries (Fiaad et al., 2020; Mostafa Elkatatny et al., 2019; Khezri et al., 2018). Due to the high prevalence of acute trauma (e.g. traffic accidents, violence, sports, and falls) among the young, SCI resulting from acute trauma is more prevalent in that demographic. Data show that males are twice more likely to be affected by SCI. Old adults (i.e. over the age of 60 years) face worse outcomes than younger patients (Singh et al., 2015).

The extent and location of the SCI significantly correlate with the clinical outcomes. Injuries to the lower thoracic region of the spinal cord lead to the development of paraplegia while injuries to the cervical region result in quadriplegia (Wilson et al., 2012). By far, cervical level injuries are the most commonly affected level among all traumatic SCI (Hachem et al., 2017).

Initial assessment of traumatic SCI is usually done through X-ray radiography and computed tomography (CT). Although spinal integrity could be sufficiently evaluated using CT scans to direct surgical interventions, the superior capabilities of magnetic resonance imaging (MRI) in terms of contrast resolution increased its utilization in emergency settings. (Hachem et al., 2017; Rajasekaran et al., 2017).

Medical imaging such as MRI is a vital tool in the identification and assessment of acute traumatic SCI. MRI is far more superior than other radiological modalities (e.g. computed tomography) in detecting abnormalities in the spinal cord and its adjacent anatomical structures (e.g. soft-tissue and spinal cord). MRI can expedite the access to early diagnosis and subsequently prompt management (Rajasekaran et al., 2017).

MRI imagining provide higher resolution in addition to the ability to provide multiple planes that are extremely useful in complex injuries. MRI can also provide an excellent insight into neural and extra-neural injuries which might indicate surgical interventions. For example, vertebral disk herniation and hematomas (Saifuddin, 2001).

The majority of clinically-relevant information in acute spinal injuries is obtained from sagittal images. Among all MRI modalities and planes, the sagittal T1-weighted by far the most reliable and accurate for providing an overall view of anatomical structures while axial planes provide a supplemental role. Subluxation, vertebral fractures, epidural fluid collections, disc herniations, cord compression can all be visualized reliably. In contrast, sagittal T2-weighted radiographs show most abnormalities including spinal cord edema, injury to ligaments, and disk herniation (Curiel et al., 2007).

The rapid enchantments and evolution of MRI in emergency stentings has prioritized its role in the management of patients presenting with acute SCI. Therefore, in this paper, we will review the available literature discussing the role of MRI in emergency SCI.

Methodology:

We conducted the literature search within the PubMed database using the keywords: “cord contusion” and “cord edema” and “cord hematoma” and “cord hemorrhage” and “cord transection” and “magnetic resonance imaging” and “neurological deficit” and “spinal cord injury” and “spinal trauma” and “trauma” with dates from 1990 to 2020. We also used the Google Scholar database for additional literature searches. After reading the abstracts, we manually selected the relevant papers for this review. In regards to the inclusion criteria, the articles were selected based on the inclusion of one of the following topics; magnetic resonance imaging and emergency spinal trauma. Exclusion criteria were all other articles that did not have one of these topics as their primary endpoint.

Review:

Indications of spinal MRI

There are multiple indications of spinal MRI in acute spinal injury. One major indication is that initial findings obtained from X-ray and/ or CT scans suggest injury to the ligaments. Such findings include hematomas, spondylolistheses, and interspinous widening (Hogan et al., 2005). Further, MRI is indicated in cases where identification of epidural hematomas and/or herniation is needed before the closed reduction of dislocations. Similarly, inconclusive CT scans are an indication of MRI (Hogan et al., 2005).

Additionally, patients presenting with neurological impairments are indicated to undergo an MRI scan to identify any spinal cord pathologies. Likewise, cervical spine instabilities can be examined using an MRI and assess the need for a cervical collar. Lastly, MRI is indicated to distinguish hemorrhagic and non-hemorrhagic spinal cord injuries (Benzel et al., 1996). Table 1 shows the different roles of MRI in various acute traumatic SCI.

Table 1. Different roles of MRI in various acute traumatic SCI.

Injury	Role
Ligamentous injury	Higher sensitivity for detection compared to CT.
Disc herniations	Detection of abnormal disc signal related to traumatic herniations.
Extra medullary hemorrhage	MRI shows the extent of hematoma to help in surgical planning.
Vascular injuries	Enable detection of arterial injuries, which include an intimal flap, pseudoaneurysm, complete occlusion, or active extravasation.
Cord injuries	Detection of hemorrhagic and non-hemorrhagic cord injuries.
Acute vs old vertebral fracture	Age-indeterminate fractures identified on radiography and CT can be classified into acute and old fractures based on the presence or absence of bone marrow edema, respectively.
Benign vs malignant fracture	Differentiation of benign and malignant fractures.

MRI: Magnetic Resonance Imaging, **SCI**: Spinal Cord Injuries

Spine anatomy

The spine largely contains multiple boney parts (i.e. vertebrae) which are stabilized by a large number of connective tissue (i.e. ligaments). By far, the most structurally important ligaments are the: (1) posterior longitudinal ligament, (2) anterior longitudinal ligament (ALL), and (3) ligamentum flavum (Schweitzer et al., 1992).

Superiorly, at the craniocervical junction, several structures are essential to establish stability which are the tectorial membrane, the transverse, and the alar ligaments. MRI can easily visualize the tectorial membrane while the remaining two are more difficult to visualize due to lack of contrast (Kliewer et al., 1993).

Acute traumatic disc herniation

Traumatic disc herniation (TDH) commonly coincides with vertebral fracture and hyperextension injuries. Those injuries damage the annulus fibrosus which leads to nucleus pulposus herniation. The appearance of TDH on MRI is very similar to that of disc herniation that results from non-traumatic mechanisms. TDH can cause acute compression of the spinal cord which leads to the development of central cord syndrome (Pratt et al., 1990). MRI is superior to conventional CT scans in the evaluation of TDH as it provides exceptional contrast between the different anatomical structures. Furthermore, multi-planar MRI scans can be very helpful in evaluating complex and/or large TDH (Vaccaro et al., 1999).

Extra-medullary pathologies

In trauma patients, epidural hematomas are the most encountered type of extramedullary collections while subdural hematomas and subarachnoid hemorrhages are uncommon. Spinal trauma can also result in a dural tear which can, in turn, lead to Pseudo-meningoceles. Despite its ability to visualize different types of hematomas, CT scans lack MRI's ability to better visualize soft tissue in great contrast renders it much more superior. Extradural hematomas typically take an isointense appearance on T1W scans and hyperintense on T2W scans (Sklar et al., 1999; Pan et al., 1988).

Vascular injuries

Traumatic injury to the spinal vasculature could result from blunt and penetrating trauma. Vertebral arteries are more prone to injury in cases of blunt trauma to the neck. Asymptomatic injuries are less likely to be significantly apparent, they still able to produce many adverse effects such as cerebrovascular accidents (Giacobetti et al., 1997). Traumatic injuries to the aorta and its major divisions can result from a traumatic thoracolumbar spine injury.

The majority of vascular cam visualized as irregularity of flow void on T2W images. T1W images provide an enhanced view of intramural hematoma accompanying arterial dissection. In inconclusive cases, CT angiography can provide an advanced modality for further evaluation (Sliker, 2008).

Conclusion:

In conclusion, MRI has transformed the way physicians approach acute traumatic SCIs by supplying them with an effective instrument that has allowed them to rapidly obtain high-quality data and act on it. Physicians and surgeons need to be aware of the vital role that MRI plays in acute traumatic SCIs which will allow them to enhance the quality of care.

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