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PERSPECTIVES

Ligaments disruption: a new perspective in the prognosis of spinal cord injury

The worldwide prevalence of spinal cord injury (SCI) ranges from 233 to 755 per million inhabitants, whereas the reported incidence lies between 10.4 and 83 per million inhabitants annually (Wyndaele and Wyndaele, 2006). Thus, the socioeconomic impact of SCI associated with cervical trauma is high enough that it could become an important concern in the vast majority of developed countries.

The ability to predict recovery following SCI is an important part of the physician's role in providing the best care and guidance to patients and families during recovery. The diagnosis of cervical spine injury is an essential aspect of the trauma evaluation. This task is especially difficult in patients whose clinical examinations are not reliable in the midst of distracting painful injuries, intoxication, or concomitant head injury (Levi et al., 2006; Hasler et al., 2011). For this population, the use of radiology is essential. In particular, magnetic resonance imaging (MRI) has become the tool of choice for the diagnosis and management of cervical spine injury after trauma (Levi et al., 2006; Boese and Lechler, 2013).

Several studies have been designed to find an association between neurological outcome and a specific radiological finding (Kulkarni et al., 1988; Silberstein and Hennessy, 1993; Flanders et al., 1996; Tewari et al., 2005; Miyanji et al., 2007). Larger lesions and hemorrhage within the spinal cord have been classically described as predictors of bad clinical outcomes in most of these (Kulkarni et al., 1988; Silberstein and Hennessy, 1993; Flanders et al., 1996). Because of its accuracy in detecting soft tissue injuries, MRI is a useful and well-known tool in the management of cervical trauma, particularly in cases of doubtful structural stability (Pizones et al., 2012a). However, there is a lack of knowledge about the prognostic role of ligament injuries (Song et al., 2008). In previous work, disruptions of the ligamentum flavum, anterior longitudinal ligament, and posterior longitudinal ligament were found to be statistically associated with bilateral facet dislocation (Vaccaro et al., 2001). A systematic review that included 1,132 cases of spinal cord injury without radiological abnormalities (SCIWORA) showed that patients with extraneural abnormalities had worse prognoses than patients without abnormalities in their MRIs, but better prognoses than patients with intraneural abnormalities such as edema or hemorrhage (Boese and Lechler, 2013). We recently added substantial information to this topic. In a group of 108 patients with SCI after a cervical trauma (Martinez-Perez et al., 2013), we demonstrated that a specific pattern of ligamentous injury is correlated with the length of spinal cord lesions seen in MRIs. Our results showed that ligamentum flavum injury is independently associated with larger lesions measured at high signal intensity within the spinal cord on T2 sequences. At this point, interpretation of our results should be viewed with caution, because lesion length represents the degree of SCI but is not a measure of neurologic outcome at follow-up. Subjectivity associated with neurological examinations and difficulties with statistical interpretation

Figure 1 Colour scheme showing cervical spine after blunt trauma.
Ligamentum flavum is disrupted and associated with intramedullary abnormalities and spinal cord injury.

dictate the use a continuous scale of quantitative variables to analyze the role of soft tissues in SCI.

In our opinion, there are two mechanisms that synchronically act to produce greater spinal cord lesions when the ligamentum flavum is damaged. First, the elastic nature of the ligamentum flavum implies that more pressure is required to disrupt it, and these forces are also transmitted to the spinal cord (Figure 1). Secondly, posterior elements are associated with increased instability and therefore with greater SCI. This theory may explain why there are patients without evidence of trauma on radiological imaging, but who manifest neurological deficits secondary to SCIWORA, and why there are patients with different grades of SCI in this subgroup of patients. In fact, we are trying to elucidate a specific pattern of soft tissue injuries in those patients diagnosed with SCIWORA and more severe neurological deficits.

The different mechanisms of injury play unclear roles in the development of SCI (Allen et al., 1982; Alday, 1996 ; Vaccaro et al., 2007). We may be able to provide a basis of understanding of the association between a specific mechanism of injury and the degree of SCI, which should be corroborated in future studies. Allen and associates (Allen et al., 1982) established a classification based on the mechanism of trauma. In the distractive flexion injuries, failure of the posterior ligamentous complex, including the ligamentum flavum, resulted from a major injury vector directed away from the trunk. The degree of these ligamentous failures was sequentially greater with the grade of Allen classification, and was associated with the progressive severity of SCI (Allen et al., 1982). However, this association is not seen only in flexion injuries. Song and associates (Song et al., 2008) used a group of patients with distractive extension injuries to classify, in grades of progressive severity, the patterns of soft tissue injuries. They found that injuries Grade IV and above, which included damage to the ligamentum flavum, showed increased signal cord changes.

Most of the relevant predictors of SCI (edema or intramedullary hemorrhage) are well identified in sagittal T2-weighted images (Silberstein and Hennessy, 1993; Flanders et al., 1996). This sequence should be included in all protocols of cervical trauma for assessing the integrity of soft tissues (Bozzo et al., 2011). However, some authors believe that this may not be enough, and that the standard MRIs have low to moderate specificity in discriminating ligament disruption (Goradia et al., 2007). Fat-suppressed T2 images (Short T1 Inversion Recovery (STIR) sequences) have been used to more accurately rule out ligament disruption (Pizones et al., 2012a, 2012b). Regretfully, STIR is not available in all protocols, and T2 sagittal images are the minimum needed in cervical trauma MRIs.

The timing of the MRI is a potential source of critical bias. A literature review by Bozzo and associates (Bozzo et al., 2011) concluded that, for prognostication, MRI should be done in the acute period following SCI. It has been recommended that the first MRI be performed 24–72 hours post injury (Bondurant et al., 1990). There is a lack of evidence supporting a more precise guideline (Goradia et al., 2007; Bozzo et al., 2011). According to previous reports, the extent of lesion is related to the clinical prognosis of SCI when the MRI is performed in the acute phase (Tewari et al., 2005; Miyanji et al., 2007). However, we should take into consideration the findings of other investigators who have found that lesion length changes over time and depends on the length of time between trauma and MRI (Leypold et al., 2008). Most of patients with SCI after cervical trauma are managed in intensive care units under unstable conditions, so performing an MRI, especially within the first days after trauma, can sometimes be challenging, and can worsen the clinical condition of the patient. Ligament disruption is a more stable finding and its detection can be useful in predicting neurological prognosis when the MRI must be delayed.

In conclusion, in the past, the role of the ligamentum flavum in the development of SCI has been underestimated. In the future, more effort should be put forth in detecting this injury pattern, particularly in patients whose clinical conditions impede an MRI in the acute phase, and when the classical predictors are not as useful. The MRI is the gold standard to detect and to identify ligament disruption, but most useful sequences, such as STIR, are not included in all cervical trauma protocols.

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