

High Field MRI of the Acute Stage of Cervical SCI in the Rat

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Introduction: Our previous work [1] has shown that in vivo high field MRI is able to accurately monitor the dynamic changes that occur during the acute and subacute phase of cervical SCI (24 hours to 21 days post injury). The objective of this study was to evaluate the capability of MRI to show the lesion development during the acute stage of cervical SCI. For that we assessed the effect of hypertonic saline (HS) on the development of MRI indices of hemorrhage and edema after SCI. Hypertonic saline is used clinically to reduce intracerebral edema.

Methods: MRI on a 4.7T /40 cm Bruker system was performed immediately after injury in 12 rats that received a unilateral 12.5mm contusion SCI at C5 [2] and were administered either 0.9% NaCl (n=6; NS) or 5% NaCl (n=6; HS) at 1.2ml/kg IV every hour starting 30min after injury. Consecutive series of axial T1, T2 and PD weighted images were acquired each hour continuously for 8 hours using a home-built transmitter/receiver 3cm Helmholtz coil. T1 weighted (Gradient Echo: TR/TE/flip angle=500/4.9ms/90, 5 averages) and PD weighted (Spin Echo: TR/TE=2000/15ms, 2 averages) images were acquired with 175x175µm in-plane resolution and 1mm slice thickness with a 0.1mm gap in between slices. The 3D T2 images (Spin Echo, TR/TE/RARE factor= 1629.2/59.7ms/16, 2 averages) were acquired with 179x175x 625µm resolution.

Results: Representative images at the epicenter of the injury are shown in Figure 1 for both groups (NS left, HG right) immediately after injury, 2, 4 and 8 hrs post injury. Immediately after SCI, there is significant swelling of the spinal cord at the lesion center and extending rostrally and caudally. A hypointense core (suggestive of hemorrhage) is visible from the first series in all T1, PD, and T2 weighted images. Over time this hypointense core reduces in size (data not shown) and in some animals is no longer clearly recognizable as hypointense core by the 8th hour after SCI. Significant swelling of the injured spinal cord occurs almost immediately, with a prominent ring of T2 weighted image hyperintensity, characteristic of edema, which surrounds the core of hypointensity. This hyperintense ring is already detectable 30min after SCI. The cord swelling does not increase significantly during the remainder of the study period. The hypertonic saline (HS) appears to reduce whole cord volume both early and late following acute SCI (Figure 2). This effect appears most pronounced around the lesion at the early time point (Figure 3).

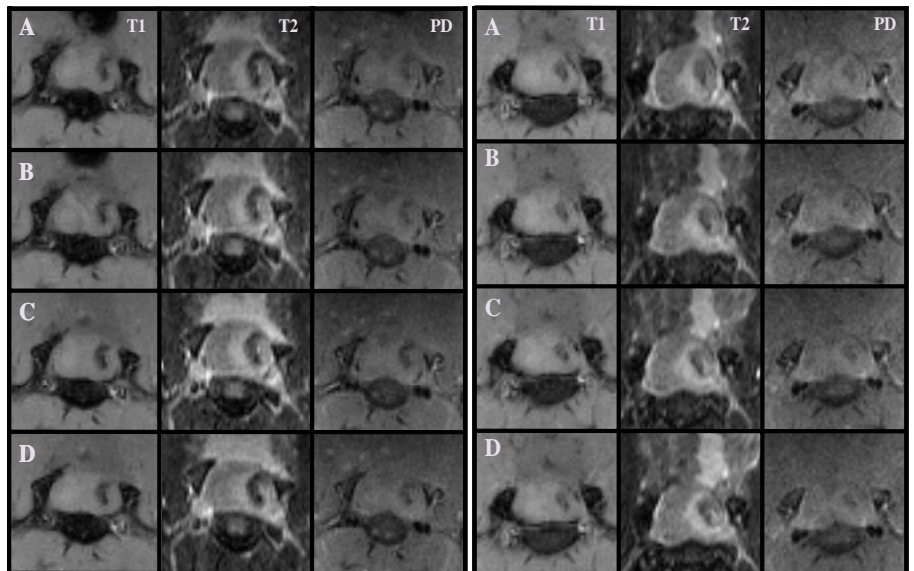


Figure 1. T1, T2 and PD MR images depicting the time evolution of cervical SCI, immediately after injury (approximately t=50min, A), 2 hrs after SCI (B), 4 hrs after SCI (C) and 8 hrs after SCI (D). A hypointense core develops immediately after injury, and in some animals reduces in size (NS group, left) or disappears throughout this time course (HS group, right). The images on the left show an example of an animal that received 0.9%NaCl, while the right group shows images of an animal that received 5%NaCl.

Discussion: In this study we demonstrate that MRI is capable to monitor and depict changes that occur immediately after cervical SCI. MRI showed the development of edema and hemorrhage after SCI and (partial) resolution of hemorrhage within the 8 hour time window. The differences in cord swelling and edema between the NS (0.9%NaCl) and HS (5%NaCl) groups suggest that in vivo MRI can be used to monitor therapies and treatments aimed at reducing secondary injury in SCI.

References:

- [1] G. Mihai et al. *J Neurotrauma* (in press) 2007.
- [2] J.C. Gensel et al. *J Neurotrauma* 23:36-54, 2006.

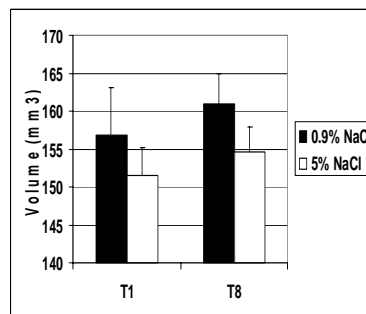


Figure 2. Volume (mm³) of the whole cord for both groups of rats determined from 15 slices by MRI at the time of the first scan (T1) and the last scan (T8). Black = 0.9% NaCl; White: 5% NaCl.

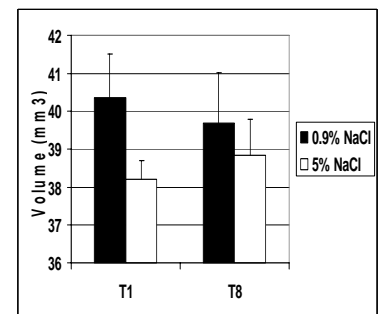


Figure 3. Volume (mm³) of the whole cord at the level of the lesioned area for both groups of rats determined from 5 slices by MRI at the time of the first scan (T1) and the last scan (T8). Black = 0.9% NaCl; White: 5% NaCl.