Editorial for "Altered Brain Function in Pediatric Patients With Complete Spinal Cord Injury: A Resting-State Functional MRI Study"

The frontiers of functional magnetic resonance imaging (fMRI) are continually advancing, in recent years importantly propelled by the increased implementation of resting-state fMRI (rs-fMRI) techniques into research and clinical practice. A significant advantage of rs-fMRI over traditional task-based methods is its ability to circumvent the necessity for patient cooperation, allowing namely the study of young children.[1] A recent survey has estimated that more than half of neuroradiology centers globally have incorporated rs-fMRI into their research and/or clinical practice.[2] Due to the growing interests in rs-fMRI, further developments in this field are expected in the forthcoming years.

In the current issue of JMRI, Wang et al[3] present an exploration into alterations in the functional connectivity of the brain after spinal cord injury (SCI) in pediatric patients. Specifically looking into the amplitude of low-frequency fluctuation (ALFF), fractional ALFF, and regional homogeneity (ReHO), the authors provide important information about brain functional reorganization that had previously been described in volumetric brain studies.[4,5]

Despite a recent study that supports the active search and intervention in SCI-related cognitive changes,[6] there is a significant lack of understanding of the biological substrates of that type of impairment.

The present study documents alterations in sensory-motor-related brain regions. Pediatric SCI patients averaging around 8 years old exhibited a noteworthy decrease in ALFF in the primary sensory cortex (S1). This finding mirrors evidence from animal studies, indicating that immediate SCI leads to a drastic reduction in cortical spontaneous activity in S1.[7]

Additionally, the study unveiled increased ALFF in the cerebral subcortex (including the caudate, thalamus, and mid-cingulate cortex) and cerebellar lobules IV-VI in pediatric SCI patients. These regions play pivotal roles in sensorimotor processing and motor control, and such overexcitation in subcortical areas may translate an attempt to compensate for the diminished function of the primary sensorimotor cortex, possibly contributing to clinical symptoms like spasticity and high muscle tone.

Beyond sensory motor domains, the study offers insights into the cognitive and emotional aspects of pediatric SCI, with significant reductions in ALFF within the left superior temporal gyrus (STG) and the right orbitofrontal cortex (OFC), which are integral to emotional regulation, behavior, and high-level cognitive functions. These findings may be linked with potential cognitive and emotional impairments in these patients, mirroring observations in conditions like depression and anxiety disorders.

Possible compensatory mechanisms within the brain were also noted. Increased ReHo in the cerebellum Crus II, which is implicated in social cognition, could be a response to reduced ALFF in the STG and OFC, suggesting the brain's capacity for functional reorganization in the face of injury. Furthermore, heightened ReHo was noted in the left Brodmann Area 21 (BA21), a region associated with auditory and language processing, that the authors suggest could be a possible compensatory mechanism to address the dysfunction observed in pediatric SCI patients.

Additionally, the authors adopted the receiver operating characteristic (ROC) curve analysis, a widely used statistical approach to locate important brain regions with altered functional characteristics in rs-fMRI studies. Specifically, ROC can be employed to identify potential imaging targets that hold promise for the treatment of this neurological dysfunction disorder. These findings may serve as a foundational tool for future therapeutic interventions, offering hope and improved quality of life for pediatric SCI patients.

In conclusion, the authors of this work demonstrated insights on the adaptive capacities of the pediatric brain following SCI. These findings underscore the importance of holistic rehabilitation approaches, encompassing sensory motor and cognitive training, to address the multifaceted challenges faced by these patients.[8] With the rapid development of rs-fMRI techniques, understanding the neural mechanisms underlying these adaptations will open new avenues

for therapeutic interventions, offering hope and improved quality of life for these young patients.

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References

1. Lee MH, Miller-Thomas MM, Benzinger TL, et al. Clinical resting-state fMRI in the preoperative setting. Top Magn Reson Imaging 2016;25: 11-18.
2. Duarte Armindo R, Zaharchuk G. Clinical applications of resting-state fMRI. *Advances in resting-state functional MRI*: Cambridge, Massachusetts: Elsevier; 2023. p 335-356.
3. Wang L, Wang S, Zheng W, et al. Altered brain function in pediatric patients with complete spinal cord injury: A resting-state functional MRI study. J Mag Reson Imaging. https://doi.org/10.1002/jmri.29045.
4. Guo Y, Gao F, Guo H, et al. Cortical morphometric changes associated with completeness, level, and duration of spinal cord injury in humans: A case-control study. Brain Behav 2021;11(4):e02037.
5. Zheng W, Wang L, Yang B, et al. Specific brain gray matter volume changes in pediatric complete spinal cord injury without fracture or dislocation using voxel-based morphometry analysis: Preliminary results. J Neurotrauma 2022;40(9–10):931-938.
6. Sachdeva R, Gao F, Chan CCH, Krassioukov AV. Cognitive function after spinal cord injury: A systematic review. Neurology 2018;91(13):611-621.
7. Aguilar J, Humanes-Valera D, Alonso-Calvino E, et al. Spinal cord injury immediately changes the state of the brain. J Neurosci 2010;30(22): 7528-7537.
8. Massagli TL. Medical and rehabilitation issues in the care of children with spinal cord injury. Phys Med Rehabil Clin North Am 2000;11(1): 169-182.

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