Tethered Cord Syndrome—A Study of the Short-Term Effects of Surgical Detethering on Markers of Neuronal Injury and Electrophysiologic Parameters

Ved Prakash Maurya[1], Medha Rajappa[2], Vaibhav Wadwekar[3], Sunil K. Narayan[3], Deepak Barathi[4], Venkatesh S. Madhugiri[1]

■ OBJECTIVE: **Several studies have assessed clinical and radiologic outcomes after detethering of the cord for tethered cord syndrome (TCS). However, no data regarding the impact of detethering on the metabolism or electrophysiologic functioning of the cord are available. The aim of this study was to assess the changes in the cerebrospinal fluid (CSF) levels of markers of neuronal injury and alterations in the electrophysiologic functioning of the spinal cord after detethering.**

■ METHODS: **This prospective study included patients with congenital TCS. Patients underwent clinical assessment, magnetic resonance imaging, somatosensory evoked potentials (SSEP) study, and CSF biochemical analysis (to estimate lactate, glial fibrillary acidic protein, and S100B levels), before and 3 months after surgery. Clinical and radiologic outcomes were assessed. We studied changes in biochemical and electrophysiologic parameters before and after detethering as surrogate markers for the effects of this intervention.**

■ RESULTS: **Twenty-one patients were recruited over 2 years. Detethering led to clinical improvement in 75% of patients with motor deficits, 60% of patients with bladder symptoms, and 50% of patients with gait problems. At 3 months follow-up, 43% (median) of the preoperative vertical tethering was found to be corrected. There was significant reduction in CSF lactate, glial fibrillary acidic protein, and S100B levels as well as a significant decrease in the latencies of the SSEP waves 3 months after surgery.**

■ CONCLUSIONS: **Surgical detethering led to a reduction in the CSF levels of the markers of anaerobic metabolism and neuronal injury. There was also a reduction in the latencies of the SSEP waves, indicating better electrophysiologic functioning of the cord.**

INTRODUCTION

The term tethered spinal cord was originally used to describe the radiologic condition in which the conus medullaris was tethered by a thickened filum (≥2 mm in diameter) and was abnormally low lying.[1] A diagnosis of tethered cord syndrome (TCS) encompasses both the clinical syndromes and asymptomatic radiographic entities. TCS is characterized by a constellation of symptoms and signs that vary with age and the severity of tethering.[1,2] The fundamental pathophysiologic substrate in TCS is believed to be excessive mechanical traction on the caudal end of the spinal cord. Traction is believed to cause neuronal injury and cord dysfunction via several mechanisms, including axonal degeneration, tract demyelination, and stretching of the cord vasculature, resulting in chronic ischemia and impairment of

Key words
- Anaerobic metabolism
- Cord ascent
- Detethering
- GFAP
- Lactate
- Neuronal injury
- S100B
- SSEP
- Tethered cord syndrome

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
EoA: Extent of cord ascent
EoT: Extent of tethering
GFAP: Glial fibrillary acidic protein
LP: Lumbar potential
MRI: Magnetic resonance imaging
PF: Popliteal fossa
S100B: Calcium binding protein S100
SSEP: Somatosensory evoked potentials
TCS: Tethered cord syndrome

From the Departments of [1]Neurosurgery, [2]Biochemistry, [3]Neurology, and [4]Radiodiagnosis, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Pondicherry, India

To whom correspondence should be addressed: Venkatesh S. Madhugiri, M.Ch. [E-mail: vensmad@gmail.com]

Citation: World Neurosurg. (2016) 94:239-247.
http://dx.doi.org/10.1016/j.wneu.2016.07.005

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

oxidative metabolism. The shift to anaerobic metabolism, resulting in the production of lactate and other free radicals, could also contribute to neuronal damage and cord dysfunction.[3,4]

Several parameters have been assessed as surrogate markers of each of these putative mechanisms of neuronal dysfunction in the brain and spinal cord. The shift to anaerobic metabolism would be marked by increased levels of lactate in the cerebrospinal fluid (CSF). Proteins such as S100 calcium binding protein (S100B) and glial fibrillary acidic protein (GFAP) are markers of neuronal/glial damage, and their levels could quantify the extent of cord dysfunction.[5-10] The final result of any insult to the cord would be impaired electrophysiologic functioning of the spinal cord. This would be reflected as abnormalities in the latencies and amplitudes of waveforms in a test designed to assess cord conduction, such as the somatosensory evoked potentials (SSEP).[11]

The definitive management of TCS is surgical detethering of the cord.[12] Several studies have assessed clinical and radiologic outcomes of surgical detethering.[12-15] However, there are limited data about the effects of detethering and the resultant anatomic normalization of the level of the conus on the electrical functioning and metabolism of the spinal cord. In this study, we examined if there were any alterations in the electrophysiologic parameters and biochemical markers of metabolism after detethering of the conus.

METHODS

This prospective institutional review board approved study protocol (JIP/IEC/2014/1/264) conformed to the ethical guidelines laid down in the Helsinki declaration. Written informed consent was obtained from all participants or their parents/guardians (if minors) before participation in the study. All patients older than 1 year referred during the study period (August 2013 to August 2015) with a diagnosis of TCS were screened for possible inclusion. We set 1 year as the cutoff because it is now generally accepted that the conus ascends to its near adult level in the first few months of life and reaches the adult level by 1 year of age.[16] The inclusion criteria for this study were therefore patients older than 1 year, with primary TCS caused by congenital lesions. The final determinant of inclusion in the study was a low-lying cord, ending below the lower border of the L2 vertebral body on T2 sagittal magnetic resonance imaging (MRI) sequences (**Figure 1**). Patients with acquired tethering resulting from previous surgery and those with a documented remote central nervous system infection were excluded. We also decided a priori that any patient who developed postoperative meningitis would be excluded from the final analysis.

All study participants underwent a set of preoperative investigations before surgery. This included the following:

1) A detailed clinical evaluation.
2) MRI of the spine with cranial screening. T1, T1 with fat suppression, post-gadolinium contrast-enhanced T1, T2 and fluid-attenuated inversion recovery sequences were acquired in all 3 planes and magnetic resonance myelography sequences were performed in a few cases. The extent of tethering (EoT) of the cord in the vertical/sagittal plane at presentation was quantified by measuring the distance below the lower border of L2 where the cord ended.

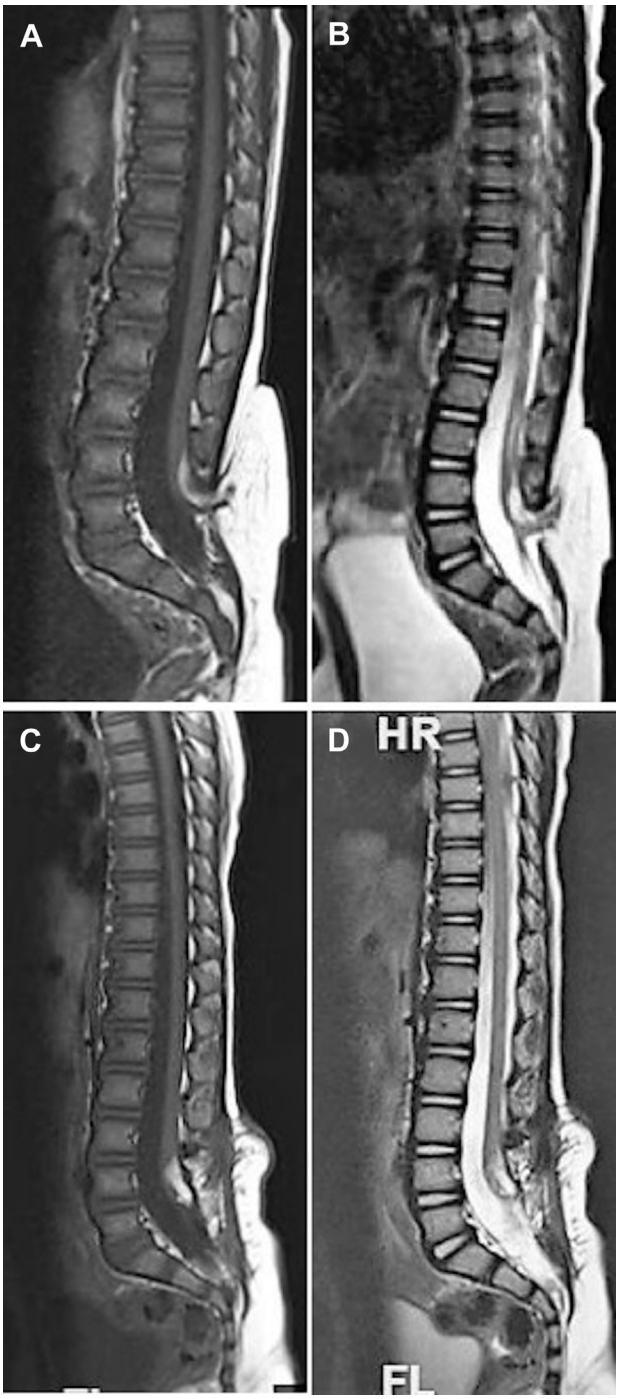

Figure 1. Example of a complex lipomyelocele with tethering. (**A**) Preoperative T1-weighted and (**B**) preoperative T2-weighted sagittal magnetic resonance images. The large subcutaneous lipoma is clearly seen and a portion of the cord is seen to enter the lipoma opposite the L5 vertebral body. The cord continues inferiorly within the dural tube. This patient underwent L5-S1 laminotomy and detethering. (**C**) Postoperative T1-weighted and (**D**) T2-weighted sagittal magnetic resonance images. The cord is seen to be free from the subcutaneous lipoma and the dural tube has been reconstituted. The cord now ends at L4-5. HR, high resolution; FL, fast low angle shot.