Importance of Intraoperative Neuromonitoring in Simultaneous Release of Tethered Cord and Corrective Surgery for Severe Kyphoscoliosis Deformity: A Case Report

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ABSTRACT

Background Data: Kyphoscoliosis in conjunction with tethered cord is a rare and challenging spinal deformity to treat. The availability of intraoperative monitoring in recent times has helped reduce the incidence of operative neurological complications in spine deformity corrective surgery. The present case report underlines the value and utility of intraoperative neuromonitoring in corrective surgery for kyphoscoliosis.

Study Design: Case report.

Purpose: To report the importance of intraoperative neuromonitoring in the release of tethered cord along with deformity correction.

Case Report: A 14-year-old male patient presented with a one-month history of progressive weakness in both lower extremities. Radiographs showed that he had thoracic kyphoscoliosis with a 30-degree scoliotic curve together with a 70-degree kyphotic curve with an apical vertebra of T12. The preoperative MRI and CT showed that the spinal cord was entrapped by the apical vertebra and a butterfly vertebra was noted at T12. This resulted in the right half being smaller in size, with the resultant convexity to the left side. The conus was low-lying and tethered at the L3 level. The patient underwent detethering of the cord with corrective surgery for kyphoscoliosis in the same setting under intraoperative neuromonitoring.

Results: Scoliosis was corrected to 20 degrees and kyphosis was corrected to 40 degrees. The motor evoked potentials (MEPs) that previously showed very feeble tracings now showed persistent positive potentials. The SSEPs remained constant and the same as baseline throughout. The patient’s spinal cord function improved from Frankel C to Frankel D. A good trunk balance was evident at the two-month follow-up.

Conclusion: Intraoperative neuromonitoring allowed safe and effective detethering and maintained correction of the kyphoscoliosis. (2021ESJ234)

Keywords: Kyphoscoliosis, Deformity, Tethered cord syndrome, Neuromonitoring, Spine

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INTRODUCTION

Kyphoscoliosis in conjunction with tethered cord is a rare and challenging spinal deformity to treat. Tethered cord is a progressive condition caused by anchoring of the spinal cord due to various developmental anomalies or pathologies, which results in a spectrum of neurological deficits and spinal deformities. Classically, it is a constellation of signs and symptoms that occurs due to longitudinal traction on the caudal end of the spinal cord (the conus medullaris). Kyphoscoliosis is defined as the deviation of the normal curvature of the spine in the sagittal and coronal planes and can include rotation of the spinal axis. The range of Cobb's angle for moderate kyphoscoliosis is from 25 to 100 degrees, whereas that of severe kyphoscoliosis is greater than 100 degrees. Tethered cord as a direct cause of scoliosis was first demonstrated by Mclone et al. in 1990. There was partial regression of scoliosis in patients following surgery for myelomeningocele repair and the release of the tethered cord. The availability of intraoperative monitoring in recent times has helped reduce the incidence of operative neurological complications in spine deformity corrective surgery. Reliable intraoperative monitoring enables surgeons to perform these complex and challenging surgical procedures, which involve significant manipulation of the spinal cord with a greater degree of safety. The present case report underlines the value and utility of intraoperative neuromonitoring in the corrective surgery for kyphoscoliosis.

Case Report:

A 14-year-old male patient presented to our institute with a one-month history of progressive weakness in both lower extremities. He had normal gestation and development only except for a small hump on his back at birth, which was not associated with any abnormal skin signs such as dermal sinus tracts, hairy patches, or skin appendages. At the age of 4 years, the patient was formally diagnosed with scoliosis, which was treated with brace therapy at a local hospital. This treatment proved unsuccessful in the prevention of the curve progression. At the first visit to our clinic, the patient presented with progressive weakness in both lower limbs with jerky movements suggestive of severe spasticity with a spastic gait. The patient had marked kyphoscoliosis in the thoracic spine with a global lower extremity weakness. The left side was weaker than the right side. He was able to walk with support at the first visit, but the spastic paraparesis progressed to make the patient wheelchair-bound in the next three weeks. The patient did not give any history of backache or bowel and bladder disturbances. On physical examination, there was a prominent hump in the thoracic spine with no abnormal cutaneous manifestations. The right lower limb motor power was 3/5 and the left lower limb motor power was 2/5. There was no visible atrophy. The deep tendon reflexes were exaggerated, and the Babinski sign was present bilaterally. There was no significant sensory loss detected. Radiographs showed that he had thoracic kyphoscoliosis with a 30-degree scoliotic curve and a 70-degree kyphotic curve with an apical vertebra of T12 (Figure 1). The preoperative MRI and CT showed that the spinal cord was entrapped by the apical vertebra, and a butterfly vertebra was noted at T12 (Figure 2). This resulted in the right half being smaller in size, with the resultant convexity to the left side. The conus was low-lying and tethered at L3 level and there was also an associated syrinx was seen from D7 to L2 level. The patient was planned for detethering of cord with corrective surgery for the kyphoscoliosis in the same setting. The report was approved by our Institutional Review Board, and the family gave written informed consent before the surgery. The report was conducted according to the WMA Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects.
Surgical Technique:
A posterior midline incision was made from T6 to L4 level. An L3 to S1 laminectomy was performed, and the tethered filum terminale was released after the dissection and confirmation under electrophysiological monitoring (Figure 3). Pedicle screws were placed in T8, T9, T10, L1, L2, and L3 on the right side and T9, T10, L1, L2, and L3 on the left side using the freehand technique. Corpectomy of the malformed D11 and D12 vertebral bodies was performed. A titanium cage was used at the corpectomy site at D11-D12, applying a compressive force on the temporary rod on the convex side and a distractive force on the concave side. The permanent rod was anchored thoroughly to the pedicle screws.

Figure 1.
(A) Lat: X-ray thoracolumbar spine measuring sagittal Cobb’s angle = 70 degrees. (B) AP: X-ray thoracolumbar spine measuring coronal Cobb’s angle = 30 degrees.

Figure 2. (A) CT 3D reconstruction for thoracolumbar kyphoscoliosis deformity. (B) MRI full spine T2W showing kyphoscoliosis at the thoracolumbar junction.
The surgery was performed with continuous electrophysiological monitoring. The MEPs were not recordable at the time of incision (Figure 5). The SSEP recordings were normal. The detethering was uneventful without any changes noted on SSEPs and MEPs (Figure 6). Fixation and reduction were made with constant monitoring of SSEP and MEP tracings. We noted intermittent positive potentials in the MEP recording. The temporary rod was then replaced with a contoured permanent rod. Total surgical time was 358 minutes and approximate blood loss was 900 ml. Immediately postoperatively, we were pleasantly surprised to note very encouraging MEP tracings. The patient’s postoperative course was uneventful. The patient could walk independently at the end of the 5th week postoperatively. The postoperative scans showed that the scoliosis was corrected to 20 degrees and kyphosis was corrected to 40 degrees. The MEPs, previously showing very feeble tracings, now showed persistent positive potentials. The SSEPs remained constant and the same as baseline throughout (Figures 7 and 8). The patient’s spinal cord function improved from Frankel C to Frankel D. A good trunk balance was evident at the 2-month follow-up.

Figure 3. (A) Surgical prone position showing surgical markings. (B) Intraoperative surgical wound where transpedicular screws are inserted and rod insertion with correction: the corpectomy is shown at mid fixation level posteriorly and posterior laminectomy is shown where the detethering occurred. (C) Fluoroscopy-guided image showing transpedicular screws in place and corpectomy pyramesh cage in place.
Figure 4. (A) Postoperative AP X-ray thoracolumbar junction showing coronal Cobb's angle correction up to 20 degrees. (B) Postoperative Lat. X-ray thoracolumbar junction showing sagittal Cobb’s angle correction up to 40 degrees.

Figure 5. Baseline MEPs before proceeding with the surgery.
Figure 6. SSEPs and MEPs during laminectomy and fixation.

Figure 7. Postoperative SSEPs.
DISCUSSION

Neuromuscular scoliosis is a deformity that is difficult to treat. It is seen to progress even after skeletal maturity. This is associated with limited mobility of the spinal column and flexion increases the traction on the spinal cord. Decision-making in congenital kyphoscoliosis depends on the natural history of progression; clinical and radiological assessment is absolutely essential. Detection of the intraspinal and other associated anomalies becomes relevant in deciding appropriate surgical management. The goals of surgery are to correct the deformity, produce a balanced spine and a leveled pelvis, and obtain a solid spinal fusion. In the rare situation of treating kyphoscoliosis with a concomitant tethered cord, there are two schools of thought. One school of surgeons considers that it is unnecessary to perform detethering of the cord until the patient develops any symptoms. The other school of thought advocates a 2-stage strategy of deformity correction between 3 and 6 months after detethering of cord. This is done to avoid undue stretching and traction on the already deformed spinal cord. Detethering the cord followed by corrective surgery for the kyphoscoliosis at the same sitting has not been reported in the literature review. Therefore, this case has been reported as a novel approach to deal with this unusual presentation.

The SSEPs assess the functional integrity of the sensory pathways from the peripheral nerve through the dorsal column and to the sensory cortex. Monitoring the dorsal column integrity with SSEP is the most commonly used technique in spinal surgery. Since the mid-1990s, combined MEP and SEP monitoring has been routinely used for spinal surgeries. The motor potentials are evoked with transcranial electrodes placed on the scalp over the motor cortex area of the skull. Intraoperative neurophysiologic monitoring...
allows the assessment of the integrity of the spine through the surgical period with real-time feedback to allow for interventions if needed, all with the goal of minimizing neurologic injury. The significant findings requiring intervention include unilateral or bilateral amplitude changes greater than 50%. In such situations, it is advisable to stop and wait for recordings to recover, which is often done. Transient stopping the surgical manipulations may immediately recover the MEP spontaneously. Other maneuvers include irrigating the surgical field with warm saline solution, local application of papaverine, increasing the mean arterial pressure to more than 90 mmHg, and increasing body temperature. If all these methods have failed to regain MEP, the applied correction is reduced or the hardware is removed in case of the correction of the spinal deformity. A steroid bolus could be considered if there is no significant signal recovery despite these measures.

In the reported case, the patient showed a good postoperative result after performing a one-stage procedure. Continuous SSEP monitoring is an essential tool to warn the surgeon about compromising the integrity of the neural tissues. The improvement in MEPs during the surgical procedure helped optimize the reduction process and eliminate the risk of added neurological deficits.

**CONCLUSION**

Intraoperative neuromonitoring made the simultaneous surgeries in the same setting feasible and safely detether the spinal cord along with obtaining safe maximal correction for kyphoscoliosis. In addition, MEPs showed a critical sign of improvement, which optimized the correction process.

**RECOMMENDATIONS**

Intraoperative neuromonitoring is an essential modality in patients undergoing cord detethering and deformity correction. It is a tool that cannot simply be substituted for its reflective results over spinal cord functions in a live feed mode intraoperatively.

**REFERENCES**


**الملخص العربي**

أهمية المراقبة العصبية أثناء الجراحة المتزامنة لتحرير للحبل الشوكي المربوط تصحيح للتشوه الحاد في تقوس العمود الفقري . تقرر حالة:

**البيانات الخلفية:** يعد تقوس العمود الفقري حالة جراحية تقدمية ترتبط بحبل الشوكي. الحبل المربوط هو حالة تقدمية ناتجة عن تثبيت الحبل الشوكي بسبب العديد من التشوهات النموية أو الأمراض التي تؤدي إلى مجموعة من العيوب العصبية وتشوهات العمود الفقري. كلسيكيًا، هو عبارة عن مجموعة من الأعراض والأعراض التي تحدث بسبب نقص الطول على الطرف العلوي للنخاع الشوكي. ساعد توافر المراقبة العصبية أثناء الجراحة في التقوس في تقليل حدوث مضاعفات العصبية الجراحية في الجراحة التصحيحية لتشوه العمود الفقري. تمكن المراقبة الموثوقة أثناء الجراحة الجراحين من أداء هذه الإجراءات الجراحية المعقدة والصعبة والتي تتطلب على معالجة كبيرة للحبل الشوكي بدرجة أكبر من الأمان. يؤكد تقرير الحالة الحالي على قيمة وفائدة المراقبة العصبية أثناء الجراحة في الجراحة التصحيحية لتشوه العمود الفقري.

**تصميم الدراسة:** تقرر حالة:

**الغرض:** الإبلاغ عن أهمية المراقبة العصبية أثناء جراحة تحرير الحبل الشوكي المربوط مع تقوس تشوهات العمود الفقري.

**المريض والطريق:** مريض يبلغ من العمر 14 عامًا يعاني منذ شهر واحد من الضعف التدريجي في كلا الطرفين السفليين. أظهرت الصور السطحية أن الحبل الشوكي الصدري مع منحنى منحنى جنفي 30 درجة مع منحنى 70 درجة و 312. أظهر الاصطدام بالطرف المغناطيسي والتصوير المقطعي قبل الجراحة أن الحبل الشوكي محصور بالقشرة العصبية الثالثة عشرة. خضع المريض لفك الحبل من خلال جراحة تقوس العمود الفقري في نفس المكان تحت المراقبة العصبية أثناء الجراحة.

**النتائج:** تم تحسين الحالة إلى 20 درجة والتحدون إلى 40 درجة. أظهرت إشارات الرياضيات العصبية ضعيفة للغاية، التي إيجابية مستمرة. ظل الأعراض الجانبية لثاني مدة حسباً ووظيفة الأذن الشوكي للمريض من فرانكل سي إلى فرانكل د في توازن جيد في الحبل الشوكي بعد شهر من المتابعة.

**الخلاصة:** سمحت المراقبة العصبية أثناء الجراحة بفك الارتباط لحبل الشوكي الآمن جنبًا إلى جنب مع التصحيح الآمن لتشوهات العمود الفقري.