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Case Report

The Role of Multimodal Intraoperative Neurophysiological Monitoring in Preventing Neurological Injury During Complex Spinal Deformity Surgeries: A Case-Based Analysis

Yogesh Kumar[1], Ravi Shankar[2*], Saran AK[3] and Athira SB[4]

[1]Professor, Department of Physiology AIIMS Patna, India

[2]Assistant Professor, Department of Physiology AIIMS Patna, India

[3]Senior Resident (Academic), Department of Physiology AIIMS Patna, India

[4]Tutor, Department of Physiology AIIMS Patna, India

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***Corresponding author:** Ravi Shankar, Assistant Professor, Department of Physiology AIIMS Patna, India

ABSTRACT

Background: Idiopathic scoliosis is a structural spinal deformity characterized by a coronal plane curvature with no definite etiology that may lead to neurological complications if left untreated in a fraction of patient. Surgical intervention remains the cornerstone of treatment for severe cases, but the risk of neurological injury necessitates the integration of intraoperative neurophysiological monitoring (IONM) to enhance surgical safety and preserve neural function. This case report underscores the role of multimodal IONM in preventing neurological injury in a 17-year-old male with idiopathic scoliosis and preexisting neurological deficits who underwent scoliosis deformity correction surgery.

Case Presentation: A 17-year-old male presented with progressive gait disturbances, lower limb weakness and sensory deficits over the past 6 months. Preoperative MRI revealed severe leftsided scoliosis with convexity at D8 level. Multimodal IONM, including somatosensory evoked potentials (SSEPs), transcranial motor evoked potentials (TcMEPs) and free-run electromyography (EMG), was employed throughout the procedure. Despite preexisting deficits, postoperative assessment showed 85% deformity correction without any new neurological impairment.

Conclusion: Multimodal IONM is indispensable in complex spinal deformity surgeries, particularly in patients with preoperative neurological compromise. The integration of SSEPs, TcMEPs and EMG enhances the efficacy of intraoperative spinal cord monitoring. These minimizes the risk of neurological injury by allowing surgeons to adjust surgical techniques accordingly bestowing them with the flexibility and precision needed to optimize patient outcomes.

Keywords: Idiopathic scoliosis; Neurological complications; Intraoperative neurophysiological monitoring

Introduction

Scoliosis is a structural spinal deformity defined as the curvature of spine in the coronal plane of Cobb angle more than 10 degrees accompanied by a variable degree of rotation of the spinal column. Progression of curvature during periods of rapid growth can result in significant abnormality, which may be even accompanied by cardiopulmonary compromise[1]. Idiopathic scoliosis is scoliosis for which there is no definite etiology, unlike neuromuscular, congenital or syndromic types. The prevalence of adolescent idiopathic scoliosis is estimated to be 2-3% but only 10 percent of these patients require treatment[2-5]. Surgical Correction for scoliosis is often required for severe cases with significant curvature progression or neurological involvement[6,7]. However, the risk of neurological injury during deformity correction is welldocumented, with reported rates ranging from 0.5% to 17%[8,9]. The risk of neurological injury during scoliosis correction is multifactorial, arising from mechanical stress, vascular compromise and altered spinal cord dynamics. Overcorrection or excessive distraction may lead to ischemia, while tethering effects can further predispose patients to neurological deficits[10,11]. Intraoperative neurophysiological monitoring (IONM) has emerged as a critical adjunct in spine surgery to mitigate spinal cord distress thereby significantly reducing the incidence of postoperative neurological deficits[12,13]. IONM helps assess the integrity of neural structures during complex spine surgeries by real time monitoring of spinal cord function employing multiple modalities including somatosensory evoked potentials (SSEPs), transcranial motor evoked potentials (TcMEP) and electromyography (EMG). This allows surgeons to adjust surgical techniques accordingly bestowing them with the flexibility and precision needed to optimize patient outcomes[14,15].

This case report showcases the critical role of multimodal IONM in a 17-year-old male with idiopathic scoliosis and preexisting neurological deficits undergoing deformity correction by Ponte osteotomy and pedicle screw fixation. By continuously assessing intraoperative electrophysiological responses and analyzing postoperative outcomes, we demonstrate the effectiveness of multimodal IONM in enhancing surgical safety, enabling real-time intervention and preventing further neurological deterioration in complex spinal deformity surgeries.

Case Report

A 17-year-old male presented with progressive difficulty in walking, lower limb weakness (right > left) and sensory deficits over six months. Neurological examination revealed reduced muscle strength in the lower limbs, with hip flexors graded at 2/5 and distal muscles at 4/5. Reflexes were brisk, with exaggerated knee jerk (3+) and ankle jerks accompanied by well sustained clonus (4+) bilaterally. The Babinski sign was positive bilaterally and sensory deficits were observed corresponding to L3 dermatome and below. Upper limb muscles were normal with normal tone and reflexes. Preoperative MRI revealed severe left-sided scoliosis with a maximum convexity at D8 level. **(Figure 1)**.

The patient underwent Ponte osteotomy at multiple levels by removing the spinous processes, laminae and facet joints, followed by pedicle screw fixation from D3 to L4. After rod placement, convex compression followed by concave distraction was applied, achieving 85% correction of the scoliotic curve. Multimodal IONM was employed throughout the surgery to monitor spinal cord integrity. Both preoperatively and perioperatively, SSEPs were well-formed in the upper limbs but poorly formed or absent in the lower limbs. TcMEPs were recordable from the abductor pollicis brevis and rectus abdominis but non-recordable from the lower limb muscles (vastus lateralis, tibialis anterior, abductor hallucis longus and anal sphincter), consistent with preexisting deficits. During rod fixation, a transient decrease in rectus abdominis amplitude (<50%) was noted, but no significant intraoperative alarms were triggered. Free-run EMG revealed no neurotronic or abnormal discharges, suggesting the absence of nerve root irritation or injury. Anesthetic induction was done using intravenous agents, Fentanyl 140 mcg and Propofol 140 mg and was maintained with air, oxygen, isoflurane (MAC 0.2-0.3) and propofol infusion. Lighter plane of anesthesia was maintained throughout the surgery by monitoring the train-of-four stimulus (TOF). Hemodynamic parameters remained stable throughout the surgery.

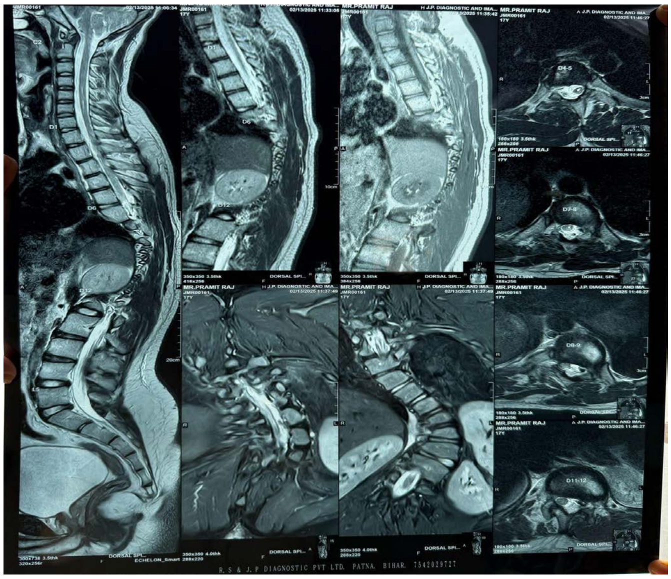

Figure 1: Preoperative MRI revealed severe left-sided scoliosis with maximum convexity at D8.

Postoperative Outcome

The patient was monitored closely postoperatively. Clinical examination on POD 7 revealed no new neurological deficits were observed and preoperative symptoms remained stable. Radiographs confirmed 85% deformity correction **(Figure 2)**. The integration of IONM allowed real-time assessment of spinal cord function, enabling proactive intervention and ensuring optimal surgical outcomes.

Discussion

The prevention of neurological injury during spinal deformity correction requires a multimodal approach, particularly in patients with preexisting deficits[9,10]. SSEPs assess dorsal column function, TcMEPs evaluate corticospinal tract integrity and EMG detects nerve root irritation or injury[16]. In this case, the absence of lower limb SSEPs and TcMEPs preoperatively underscored the severity of neurological compromise, necessitating vigilant intraoperative monitoring[17]. The transient decrease in rectus abdominis amplitude during rod fixation was promptly identified and continuously monitored which enabled intraoperative adjustments to prevent potential postoperative deficits **(Figure 3)**.

Figure 2: Free Run and TcMEP and IONM and SSEP recording during surgery.

Extensive clinical evidence supports the role of multimodal IONM in reducing postoperative neurological deficits in scoliosis surgery[18,19]. In a landmark multicenter study, Nuwer, et al[20]. demonstrated a significant reduction in paralysis risk with the integration of IONM, reinforcing its indispensable role in deformity correction procedures. Additionally, Thirumala, et al[21]. found that the combination of SSEPs and TcMEPs improved diagnostic accuracy in detecting intraoperative spinal cord distress. Our findings align with these reports, reinforcing the necessity of real-time intraoperative monitoring. Notably, in this case, preoperative TcMEPs were absent in the lower limbs, emphasizing the severity of the patient's neurological compromise. Despite this, careful monitoring and intraoperative adjustments facilitated successful correction without exacerbating neurological deficits, further validating the efficacy of IONM in high-risk cases.

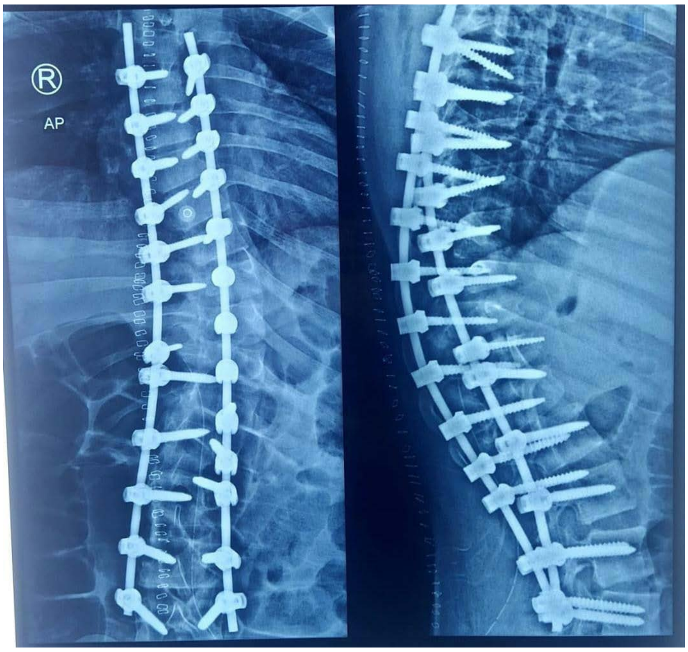

Figure 3: X-Ray Image showing 85% correction of the spinal deformity postoperatively.

Despite the benefits, IONM has limitations, including variability in interpretation and false- positive or false-negative results[22]. Factors such as anesthetic variability, patient factors such as positioning and body temperature and underlying pathology may influence signal reliability[23]. Anesthetic management is critical for IONM reliability, as high-dose inhalational agents can suppress SSEP and TcMEP signals. TIVA with propofol and remifentanil is preferred for signal preservation, while precise neuromuscular blockade titration maintains EMG responsiveness[24-26]. Standardization of monitoring protocols and improved signal-processing algorithms could further refine its diagnostic precision. Also, studies have emphasized the fact that the combined use of SSEPs, TcMEPs and EMG enhances diagnostic precision, mitigating these challenges[27,28].

Conclusion

This case report underscores the indispensable role of multimodal IONM in mitigating neurological injury during complex spinal deformity surgeries. The integration of somatosensory evoked potentials (SSEPs), transcrania motor evoked potentials (TcMEPs) and electromyography (EMG) facilitates real-time assessment of spinal cord function, enabling early intervention and optimizing patient outcomes. Given its demonstrated efficacy, multimodal IONM should be regarded as a standard of care in scoliosis surgery and should be routinely adopted, particularly in patients with preexisting neurological deficits.

References

1. Kane WJ. Scoliosis prevalence: a call for a statement of terms. Clin Orthop Relat Res 1977;126:43-46.
2. Roach JW. Adolescent idiopathic scoliosis. Orthop Clin North Am 1999;30(3):35365.
3. Gore DR, Passehl R, Sepic S, Dalton A. Scoliosis screening: results of a community project. Pediatrics 1981;67(2):196-200.
4. Miller NH. Cause and natural history of adolescent idiopathic scoliosis. Orthop Clin North Am 1999;30(3):343-352.

5. Weinstein SL. Adolescent idiopathic scoliosis: prevalence and natural history. Instr Course Lect 1989;38:115-128.

6. Nuwer MR, Dawson EG, Carlson LG, Kanim LE, Sherman JE. Somatosensory evoked potential spinal cord monitoring reduces neurologic deficits after scoliosis surgery: results of a large multicenter survey. Electroencephalogr Clin Neurophysiol 1995;96(1):6-11.

7. MacDonald DB, Skinner S, Shils J, Yingling C. Intraoperative motor evoked potential monitoring - a position statement by the American Society of Neurophysiological Monitoring. Clin Neurophysiol 2013;124(12):2291-2316.

8. Schwartz DM, Auerbach JD, Dormans JP, et al. Neurophysiological detection of impending spinal cord injury during scoliosis surgery. J Bone Joint Surg Am 2007;89(11):2440-2449.

9. Langeloo DD, Journée HL, de Kleuver M, Grotenhuis JA. Criteria for transcranial electrical motor evoked potential monitoring during spinal deformity surgery. Eur Spine J 2007;16(2):125-130.

10. Jahangiri FR, Jahangiri RH, Asad H, Farooq L, Khattak WH. Scoliosis Corrective Surgery With Continuous Intraoperative Neurophysiological Monitoring (IONM). Cureus 2022;14.

11. Ma J, Wang J, Yang Y, Wu J, Liu Z, Miao J, Xu Y. Biomechanical study of spinal cord and nerve root in idiopathic scoliosis: based on finite element analysis 2024.

12. Raynor BL, Lenke LG, Kim Y, et al. Can triggered electromyograph thresholds predict safe pedicle screw placement? Spine 2002;27(18):2030-2035.

13. Sala F, Palandri G, Basso E, et al. Motor evoked potential monitoring improves outcome after surgery for intramedullary spinal cord tumors: a historical control study. Neurosurgery 2006;58(6):1129-1143.

14. Fehlings MG, Brodke DS, Norvell DC, Dettori JR. The evidence for intraoperative neurophysiological monitoring in spine surgery: does it make a difference? Spine 2010;35(9):37-46.

15. Holland NR. Intraoperative electromyography and nerve conduction studies. J Clin Neurophysiol 2002;19(5):444-453.

16. Tamkus AA, Rice KS. The impact of intraoperative neuromonitoring alerts and resultant interventions on neurological outcomes in spine surgery: a review of 1444 consecutive patients. Eur Spine J 2014;23(5):1049-1054.

17. Calancie B, Harris W, Broton JG, Alexeeva N, Green BA. Threshold-level repetitive transcranial electrical stimulation for intraoperative monitoring of central motor conduction. J Neurosurg 1998;88(5):820-825.

18. Pelosi L, Lamb J, Grevitt M, Crook TJ, Webb JK. Combined monitoring of motor and somatosensory evoked potentials in orthopaedic spinal surgery. Clin Neurophysiol 2002;113(7):1082-1091.

19. Park JH, Hyun SJ. Intraoperative neurophysiological monitoring in spinal surgery. World J Clin Cases 2015;3(9):765-773.

20. Leppanen RE, Evarts CM, Jacobs RR, Tolo VT, Whitesides TE. Neurologic complications of scoliosis surgery: monitoring with somatosensory evoked potentials. J Bone Joint Surg Am 1987;69(2):209-214.

21. Thuet ED, Chamberlain RH, Emerson RG, et al. Value of intraoperative neurophysiological monitoring for early detection of reversible spinal cord injury during deformity correction surgery. Spine J 2010;10(5):389-399.

22. Kelleher MO, Tan G, Sarjeant R, Fehlings MG. Predictive value of intraoperative neurophysiological monitoring during cervical spine surgery: a prospective analysis of 1055 consecutive cases. J Neurosurg Spine 2008;8(3):215-221.

23. Luedemann W, Laumer R, Weis J, Wörl H, Steudel WI, Kiefer M. Neuromonitoring by motor evoked potentials in spinal dorsal column stimulator implantation. Spine 2003;28(19):391-396.

24. Lee SY. Application of total intravenous anesthesia (TIVA) during intraoperative neuromonitoring (IONM). Korean Intraoperative Neuromonitoring Society 2023;3(1):9-12.

25. Rabai F, Mohamed B, Seubert CN. Optimizing Intraoperative Neuromonitoring: Anesthetic Considerations. Current Anesthesiology Reports 2018;8(3):306-317.

26. Kulkarni AM, Shetty VL. Anesthesia Considerations in Patients Undergoing Spine Surgery with Evoked Potential Monitoring 2024;11(2):56-63.

27. Furlan JC, Fehlings MG. Role of intraoperative neurophysiological monitoring in the surgical treatment of cervical spondylotic myelopathy. Neurosurg Focus 2006;21(1):5.

28. Hilibrand AS, Schwartz DM, Sethuraman V, Vaccaro AR, Albert TJ. Comparison of transcranial electric motor and somatosensory evoked potential monitoring during cervical spine surgery. J Bone Joint Surg Am 2004;86(6):1248-1253.