RESEARCH PAPER

Balancing Depth and Signal: The Role of Ketamine in Anesthesia Management for Scoliosis Correction with Intraoperative Neuromonitoring

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ABSTRACT

Marfan's syndrome (MFS) is a genetic connective tissue disorder often complicated by severe, progressive scoliosis, posing significant anesthetic and intraoperative monitoring challenges. We report a 12-year-old male with MFS who underwent elective scoliosis correction utilizing somatosensory and motor evoked potential neuromonitoring. During the initial surgery, profound blood loss resulted in hemodynamic instability and a total loss of intraoperative neuromonitoring (IONM) signals, requiring the procedure to be halted. After reviewing anesthetic and surgical factors, the second-stage operation reduced propofol dosing and added low-dose ketamine to enhance hemodynamic and neurophysiological stability. Reliable intraoperative signals were preserved, facilitating safe completion of surgery without postoperative neurological deficits. This case highlights the critical importance of tailored total intravenous anesthesia, meticulous hemodynamic management, and close multidisciplinary communication to ensure IONM fidelity and patient safety in scoliosis correction for MFS patients. Anesthetic adjustments and vigilant monitoring are pivotal for optimal outcomes in complex connective tissue disorderse..

Keywords: Marfan's syndrome, scoliosis, intraoperative neuromonitoring, total intravenous anesthesia, ketamine

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INTRODUCTION

Marfan's syndrome (MFS) is an autosomal dominant disorder of the connective tissue caused by mutations in the extracellular matrix protein fibrillin. One of the manifestation of Marfan's syndrome is musculoskeletal abnormalities that are characterized by overgrowth of the long bones[1]. Surgical correction is often required for curves approximately 45 or more degrees (causes symptom)[2]. Scoliosis correction surgery in MFS patients requires careful anesthetic management and intraoperative neuromonitoring (IONM) to prevent neurological deficits. The most important tools to enhance patient safety during spine surgery is the combined use of somatosensory (SSEP) and motor evoked potentials (MEP). Total intravenous anesthesia (TIVA) is often preferred over volatile anesthetics because it has minimal impact on SSEP and MEP, enabling more accurate signal interpretation.[3]

The anesthetic team encounters challenges due to the specific requirements of anethesia, the complexity of scoliosis surgery, and factors related to neuromuscular disorders. Successful IONM during scoliosis surgery requires smooth and coordinated communication between surgeons, anesthesiologists, and neurologists.

In this case report, we present the case of 12-year-old male with MFS underwent scoliosis correction with IONM. During pedicle screw placement, a sudden loss of MEP signals was observed. Screw repositioning was followed by significant bleeding and subsequent loss of SSEP signals. The surgeon re-evaluated screw position, the neurophysiologist checked the monitoring leads, and the anesthesiologist reviewed hemodynamic status and anesthetic agents, while resuscitation was performed to stabilize the patient. Intraoperative neuromonitoring signals gradually returned but required approximately 30 minutes to recover. A wake-up test was performed to assess spinal cord motor function; however, the patient exhibited no purposeful movement. As the wake-up test failed to demonstrate an adequate neurological response and available blood products had been depleted, the surgical procedure was subsequently aborted to allow further stabilization and comprehensive evaluation in the intensive care unit (ICU). Additionally, modifications were made to the TIVA agents to optimize neurophysiological monitoring and ensure patient safety in the subsequent procedure.

CASE

A 12-year-old male, weighing forty-seven kilograms, presented with a progressively worsening spinal curvature and a noticeable increase in the prominence of a thoracic hump. The patient also reported a growing discrepancy in lower limb length. Elective posterior spinal fusion was subsequently scheduled to address the severe scoliosis.

Preoperative assessment revealed positive Steinberg and Walker-Murdoch signs, accompanied by a prominent pectus excavatum. Cardiopulmonary evaluation was unremarkable, with no evidence of respiratory or

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cardiovascular compromise. Neurological examination confirmed intact motor function in all extremities, and there were no signs of sensory loss or anesthesia. Laboratory findings were within normal limits. Radiographic imaging demonstrated a double major scoliosis pattern: grade III thoracic dextroscoliosis and grade IV thoracolumbar levoscoliosis, as categorized by the Lippman-Cobb classification, with a maximum Cobb angle of 50 degrees. Preoperative cardiac echocardiography and pulmonary function testing revealed no abnormalities

Figure 1. Clinical findings of patient

Figure 2. Radiologic findings of spine

Anesthetic induction was achieved with intravenous fentanyl (100 mcg), propofol (80 mg), and rocuronium (50 mg). Anesthesia maintenance utilized a target-controlled infusion (TCI) of propofol based on the Schnider pharmacokinetic model at 4 mcg/h, intravenous dexmedetomidine (0.4 mcg/kg/h), and sufentanil (2 mcg/h). The depth of anesthesia was monitored intraoperatively using Bispectral Index (BIS), which remained between 45 to 50 post-induction. Intraoperative monitoring was maintained, including invasive blood pressure monitoring, end-tidal CO_2 (etCO2), electrocardiography (ECG), pulse oximetry, and temperature. The patient was positioned prone and subjected to multimodal IONM, including SSEP and MEP, both of which were initially stable and clearly detectable.

During the intraoperative period, transient loss of MEP signals was observed for several minutes during pedicle screw placement, which coincided with acute, significant hemorrhage of approximately 1,000 mL within a matter of minutes. The surgical team immediately evaluated the positioning of the screw; however, this event not only resulted in the loss of MEP signals but was also followed by a subsequent absence of SSEP signals. The intraoperative course remained stable until a cumulative estimated blood loss of 3,000 mL precipitated a drop in systolic blood pressure, with mean arterial pressure (MAP) declining to 60–65 mmHg and BIS values falling to 30–40. Hemodynamic status was restored following prompt administration of whole blood transfusion. Despite this stabilization, the neurologist observed a complete loss of SSEP and MEP signals for approximately 30 minutes, however, the signals gradually reappeared with low amplitudes following screw revision and hemodynamic optimization

Time (hh:mm)	**HR (x/min)**	**SBP/DBP (mmHg)**	**MAP (mmHg)**	**SpO_2 (%)**	**$EtCO_2$ (mmHg)**	**BIS**	**Remark**
07:30 (baseline)	82	131/82	98	99	37	60	Before induction
08:00	90	123/76	92	99	36	45	After induction
08:45	80	120/70	87	99	35	48	Skin incision
10:45	88	118/65	83	99	32	45	Pedicle screw placement, MEP loss
10:55	105	90/55	67	99	30	42	Acute bleeding 1,000 mL, SSEP loss
11:00	112	85/50	62	98	33	35	Ongoing resuscitation, total bleeding approximately 3,000 ml
11:15	98	110/69	83	99	35	46	Hemodynamics stabilized, SSEP gradually return
11:30	90	112/70	84	99	36	45	MEP reappeared with low amplitudes
12:00	88	115/75	88	99	35	55	Wake-up test, no purposeful movement
13:30	86	118/76	90	99	35	45	Procedure aborted, transfer to ICU

A wake-up test was performed to assess spinal cord motor function; however, the patient exhibited no purposeful movement. In response to this event, both the surgical and anesthesiology teams conducted a comprehensive evaluation, which included scrutiny of screw positioning, assessment of the IONM device, and analysis of the patient's hemodynamic status and anesthetic regimen, all of which could have contributed to the loss of evoked potentials. The surgical procedure was subsequently aborted to enable further stabilization and assessment in the intensive care unit (ICU). Following a thorough review of the intraoperative events, including significant hemorrhagic episodes and anesthetic considerations, a revised protocol was adopted for the planned secondary surgery to mitigate the risk of IONM signal loss.

Three days later, the patient underwent the second stage of corrective surgery using the modified anesthetic protocol.

Anesthesia was maintained with TCI propofol (2.5 mcg/h) guided by the Schnider model, intravenous dexmedetomidine (0.4 mcg/kg/h), sufentanil (2.5 mcg/h), and adjunctive intravenous ketamine (0.5 mg/kg/h). Hemodynamic stability was ensured with MAP maintained above 80 mmHg and BIS values within 40–50. Intraoperative blood loss was compensated with whole blood transfusion.

During this procedure, a transient MAP decrease to 65–70 mmHg was promptly corrected and did not result in any loss of SSEP or MEP signals, which remained reliably present throughout the surgery. The operation concluded without major complications, and the patient was transferred to the ICU for postoperative monitoring. Hemodynamic parameters and laboratory assessments remained within normal ranges during the postoperative period.

DISCUSSION

Intraoperative neuromonitoring is now considered an essential tool in scoliosis correction surgery, allowing real-time detection of imminent spinal cord injury and enabling prompt intervention to avert permanent neurological deficits.[4,5] Multimodal neuromonitoring approaches such as MEP and SSEP are associated with high negative predictive value; sustained, stable evoked potentials correlate strongly with preserved postoperative neurological function, while significant alterations in signal typically warrant staged corrective maneuvers or reversal of the causative step.[4,6]

Optimal reliability of IONM is intrinsically linked to anesthetic technique, with TIVA regimens, commonly propofol in combination with an opioid demonstrating minimal depressive effects on SSEP and MEP and enabling accurate monitoring.[2,7] In contrast, volatile anesthetics are known to attenuate signal amplitude and prolong latency, complicating intraoperative interpretation.[2] Numerous factors may precipitate transient or sustained loss of SSEP/MEP signals, including technical issues (electrode displacement, cable faults), physiological derangements (hypotension, hypoxemia, hypothermia, anemia), residual neuromuscular blockade, excessive volatile agents, or direct surgical factors such as aggressive correction maneuvers and screw malposition.[4,8] Implementation of structured 'alarm checklists' and immediate corrective protocols are vital for identifying reversible causes and facilitating timely intervention.[8,9]

Within the present case, careful selection of anesthetic agents was central to preserving neurophysiological signal fidelity during IONM. TIVA was chosen to optimize evoked potential monitoring. Of note, recent clinical research increasingly supports the use of low-dose ketamine as an adjunct to TIVA; ketamine may improve analgesia, provide opioid-sparing effects, and help maintain hemodynamic stability, reducing fluctuations that can compromise IONM.[10,11] While current evidence suggests moderate doses typically exert minimal interference with MEP signals, there are pharmacological concerns that higher or prolonged dosing may suppress signal amplitude or prolong latency due to NMDA antagonism.[11] Additionally, ketamine's dissociative effects on EEG and its sympathomimetic properties (elevating blood pressure and heart rate) can pose challenges for anesthetic depth monitoring and spinal perfusion stability, potentially confounding IONM interpretations.[2,11,12] These findings underscore the importance of individualized anesthetic protocols, multidisciplinary collaboration, and vigilant intraoperative observation to maximize patient safety and neurological outcomes in complex spinal deformity corrections.

CONCLUSION

This case underscores the importance of tailored anesthetic strategies, particularly TIVA, in safeguarding intraoperative neuromonitoring signal fidelity during scoliosis correction. Ketamine may also be considered as an adjunct to help maintain IONM wave stability throughout surgery. Careful agent selection and vigilant monitoring are essential to optimize neurological outcomes and patient safety in complex spinal procedures

REFERENCE

1. Marelli, S., Micaglio, E., Taurino, J., Salvi, P., Rurali, E., Perrucci, G.L., Dolci, C., Udugampolage, N.S., Caruso, R., Gentilini, D., Trifirò, G., Callus, E., Frigiola, A., De Vincentiis, C., Pappone, C., Parati, G. and Pini, A., 2023. Marfan Syndrome: Enhanced Diagnostic Tools and Follow-up Management Strategies. Diagnostics, 13(13), p.2284.
2. Reysner, M., et al. (2024) 'The Influence of Anesthesia on Neuromonitoring During Scoliosis Surgery: A Systematic Review', Journal of Clinical Monitoring and Computing, 38(2), pp. 245–259.
3. Kamenova, B. and Morev, E., 2025. Anaesthesia and intraoperative neurophysiological monitoring in surgical correction of idiopathic scoliosis in childhood. Comptes rendus de l'Académie Bulgare des Sciences, 78(5), pp. 700-707.
4. Angelliaume, A., et al. (2023) 'Intraoperative neurophysiological monitoring in scoliosis surgery: threshold values and update'. European Spine Journal. 32(8), pp. 1937–1948.
5. Nassef, M., Splinter, W., Lidster, N., Al-Kalbani, A., Nashed, A., Ilton, S., Vanniyasingam, T. and Paul, J., 2021. Intraoperative neurophysiologic monitoring in idiopathic scoliosis surgery: a retrospective observational study of new neurologic deficits. Canadian Journal of Anaesthesia. 68(4), pp.477-484
6. Reddy, R.P., Sura, S., Mallepally, R.K., Sannidhi, V.K., Aitha, A., and Palaparthy, R., 2023. Transcranial Motor Evoked Potentials as a Predictive Tool for Neurological Deficit After Cervical Spine Decompression Surgery. Asian Spine Journal, 17(6), pp.1083-1090.
7. Zuleta-Alarcón, A., et al. 2015. 'Total intravenous anaesthesia versus inhaled anaesthetics in neurosurgical procedures', Revista Colombiana de Anestesiología, 43(2),

pp. 158–163.
8. Lee, C.S., et al. (2023) ‘Clinical significance of intraoperative SSEP and MEP changes in adolescent idiopathic scoliosis correction: a large cohort analysis’, Spine Deformity, 11(4), pp. 987–995.
9. Ziewacz, J.E., Berven, S.H., Mummaneni, V.P., Tu, T.H., Akinbo, O.C., Lyon, R. and Mummaneni, P.V., 2012. The design, development, and implementation of a checklist for intraoperative neuromonitoring changes. Neurosurgical Focus, 33(5), p.E11.
10. Pathak, S., et al. 2023.‘Effect of Ketamine and Dexmedetomidine as Adjuvant to Total Intravenous Anesthesia on Intraoperative Cranial Nerve Monitoring in the Patients’, MedPulse International Journal of Anesthesiology, 28(1), pp. 51–56.
11. Kim, M.H., et al. (2024) ‘Ketamine and Dexmedetomidine for Neurophysiological Monitoring in Spine Surgery: Results of a Double-Blind, Randomized Controlled Trial’, Korean Journal of Anesthesiology, 77(5), pp. 412–420.
12. Santosa, D.A., Harijono, B., Hamzah, Jasa, Z.K. and Rehatta, N.M. (2018) ‘Anesthesia Management for Cervical 5–6 Intradural Intramedullary (IDIM) Tumor under Intraoperative Neurophysiological Monitoring Guidance’, Jurnal Neuroanestesi Indonesia, 7(3), pp. 144-174