

Case Report

Intraoperative upper limb somatosensory evoked potentials alert during lower cord surgery: A diagnostic challenge with therapeutic resolution

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ABSTRACT

Intraoperative neurophysiological monitoring plays a pivotal role in spinal dysraphism surgery, enabling real-time surveillance of neural pathway integrity and early detection of reversible insults. While lower cord procedures typically impact caudal pathways, upper limb (UL) alerts are rare and diagnostically perplexing. We report the case of a 10-year-old child undergoing surgical repair of a lipomyelomeningocele with cord detethering in the prone position. Baseline somatosensory evoked potentials (SSEPs) from both upper and lower limbs were stable following positioning. However, a sudden and severe loss of the left ulnar SSEP was identified approximately 53 min after the last confirmed intact signal. During this interval, continuous electrocautery for soft-tissue exposure precluded meaningful SSEP acquisition, obscuring the precise timing of signal change. No surgical manipulation occurred near the cervical spine or brachial plexus level. Suspecting a positional cause, the left wrist and cubital fossa were cushioned using water-filled gloves, and axillary positioning was adjusted to alleviate potential brachial plexus compression. These measures resulted in an instantaneous and complete recovery of the left ulnar SSEP, with no subsequent neurophysiological alerts or post-operative deficits. This case highlights the importance of considering position-related peripheral nerve compromise when unexpected UL SSEP alerts arise during lower spinal procedures. Prompt recognition, vigilant interpretation of neurophysiological data and targeted positional interventions can reverse insults and prevent iatrogenic neurologic deficits, ensuring safe surgical outcomes.

Keywords: Delayed intraoperative signal change, Intraoperative neurophysiological monitoring, Positioning-related nerve injury, Somatosensory evoked potentials, Spinal dysraphism

INTRODUCTION

Intraoperative neurophysiological monitoring (IONM) has become indispensable in spinal dysraphism surgeries, providing real-time surveillance of neural integrity and enabling early intervention against reversible insults.^[1] During these procedures, IONM alerts typically manifest in caudal (lower limb/bowel bladder) sensorimotor pathways.^[2-4] However, isolated upper limb (UL) somatosensory evoked potentials (SSEP) alerts, especially delayed ones, during lower cord surgeries present a rare but critical diagnostic challenge, as they may imply position-related peripheral neuropathies rather than cord compromise.^[5,6] The prone 'superman' position, frequently employed in paediatric spinal surgery, there is risk of neural compromise due to stretch or compression at known anatomical entrapment sites, including the brachial plexus at the axilla and the ulnar and

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median nerves at the cubital tunnel/fossa and wrist due to shoulder rotation, arm abduction and elbow/wrist compression. While previous studies describe IONM changes from limb malpositioning [7-9] there is a paucity of literature documenting delayed and complete unilateral upper limb signal loss with immediate recovery post-intervention in 'non-cervical' spine surgeries. This gap underscores the need for detailed case analyses for establishing troubleshooting/diagnostic protocols and intervention algorithms. We present a paediatric case of tethered cord syndrome secondary to spinal lipoma, where delayed, complete unilateral ulnar SSEP loss occurred well after positioning. The event developed despite stable anaesthesia, absent cervical/spinal manipulation and normal baseline post-positioning UL signals. Through systematic exclusion of technical factors (electrode impedance verification, stimulation confirmation via train-of-four [TOF]) and identification of positional compromise, targeted repositioning achieved immediate signal restoration. This case exemplifies three critical aspects: (1) the vulnerability of paediatric patients to delayed positional neuropathy due to extrinsic compression, (2) the role of UL SSEPs as early sentinels for extra-spinal/peripheral nerve compromise and (3) the reversibility of complete signal loss with prompt intervention. The findings reinforce the dual role of IONM in detecting both surgical and non-surgical neural insults, while highlighting the necessity of structured response algorithms in such perplexing scenarios.

CASE REPORT

Patient information

A 10-year-old male child, with a congenital swelling over the lower back, developed faecal urgency and incontinence over the last 6 months without any other sensorimotor or bladder involvement. Anal sphincter tone and voluntary contraction were preserved, with normal perianal reflexes. Magnetic resonance imaging of the lumbosacral spine demonstrated a spinal lipoma extending from the inferior border of L2 to the superior border of L5, with a low-lying conus medullaris terminating at the L3 level and a bony defect consistent with spina bifida beginning at L4 and extending caudally, and a dural defect at the L3 level [Figure 1]. In view of the progressive bowel dysfunction and imaging findings suggestive of tethered cord syndrome, the patient was scheduled for surgical resection of the spinal lipoma and detethering of the filum terminale.

IONM protocol

Multimodal IONM, comprising motor evoked potentials (MEPs), SSEPs, bulbocavernosus reflex (BCR), electroencephalogram (EEG), electromyogram (EMG) and TOF, was performed using the Medtronic NIM Eclipse system to ensure neural safety during surgery. MEPs were elicited



Figure 1: Magnetic resonance imaging of lumbosacral spine demonstrated a spinal lipoma extending from the inferior border of L2 to the superior border of L5, with a low-lying conus medullaris terminating at the L3 level.

using stimulation electrodes at M3 and M4, with responses recorded from multiple bilateral lower limb muscles and the anal sphincter, as the surgical focus was on the cauda equina region. Bilateral hand muscles served as a physiological control. SSEPs were elicited through bilateral posterior tibial nerve stimulation to monitor lower limb sensory pathways, while bilateral ulnar nerve stimulation served as UL controls. Scalp recordings were obtained through subdermal corkscrew electrodes placed at CPz, Fpz, CP₃, and CP₄, in accordance with the 10–20 EEG system. Twisted subdermal electrodes were used for SSEP stimulation and MEP recording. BCR monitoring was performed using adhesive surface electrodes over the dorsum of the penis for stimulation, to assess the integrity of the sacral reflex arc with recording from the anal sphincter. EMG included both spontaneous and triggered modalities, using monopolar flush-tip and concentric bipolar probes for intraoperative nerve root mapping. Depth of anaesthesia was titrated using raw EEG and its spectral derivatives. TOF from bilateral ulnar and tibial nerve stimulation was used to monitor residual neuromuscular blockade, ensuring optimal conditions for accurate and reliable neurophysiological data acquisition.

Intraoperative course

Total intravenous anaesthesia was administered to facilitate optimal neurophysiological monitoring, and an intermediate-acting neuromuscular blocking agent was used for intubation.

The patient was intubated with a flexometallic endotracheal tube to reduce the risk of airway kinking, and a bite block was placed to prevent dental or tongue injury during MEP stimulation, which can provoke strong jaw contractions. All IONM electrodes were placed while the patient was in the supine position, ensuring secure placement. The patient was then carefully turned to the prone position, with both arms placed in the 'superman' position (abducted and flexed at the shoulders and elbows).

Following final prone positioning, baseline neurophysiological signals were acquired. MEPs [Figure 2a] and SSEPs [Figure 2b] from bilateral lower and ULs were clearly and reliably recordable until 24 min after positioning, and served as a functional baseline for intraoperative comparison. BCR responses were also successfully elicited, confirming the integrity of the sacral reflex pathways.

Levels were marked by C-arm imaging. After surgical draping, soft-tissue exposure and dissection were carried out. While exposure was still ongoing, 53 min after the last intact SSEP signal, a sudden and severe loss of the left ulnar SSEP was noted [Figures 3 and 4]. A detailed timeline of intraoperative events and IONM changes is illustrated in Table 1.

Electrocautery was continuously used, which precluded any meaningful SSEP acquisition during this period, obscuring the precise onset of signal change. SSEP responses from

Table 1: Timeline of intraoperative events and IONM changes.

Events/IONM signal with respect to left UL SSEP	Time	Interval since last event
Patient positioned from supine to prone	7:50 am	-
Baseline	8:02 am	12 min
Last intact SSEP	8:14 am	12 min
Exposure start time	8:15 am	1 min
SSEP drop	9:07 am	53 min since last intact check
Water-filled glove placed under elbow and wrist	~9:10 am	
First detectable recovery	9:10:28 am	almost instantaneously after intervention (3 min 28 s after drop noticed)
Full recovery - back to baseline	9:10:46 am	18 s after first reappearance

IONM: Intraoperative neurophysiological monitoring, SSEP: Somatosensory evoked potentials, UL: Upper limb

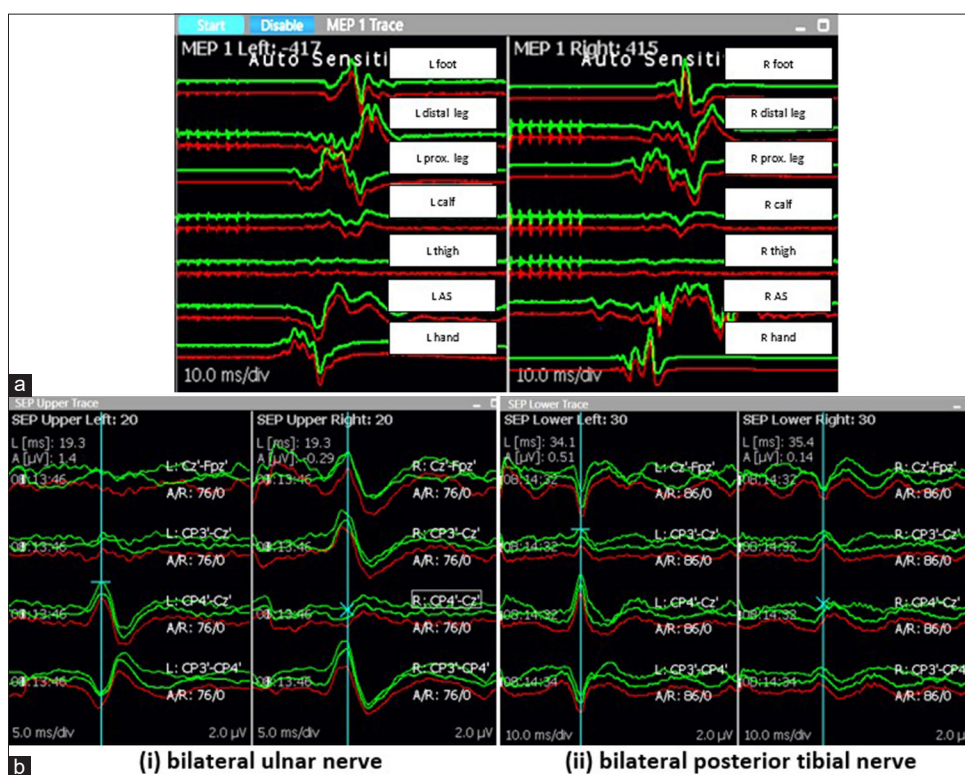


Figure 2: (a) Baseline motor evoked potentials in prone position, prior to surgical incision. (Tracings from left [L] and right [R]), (b) Baseline somatosensory evoked potentials in prone position, prior to surgical incision.

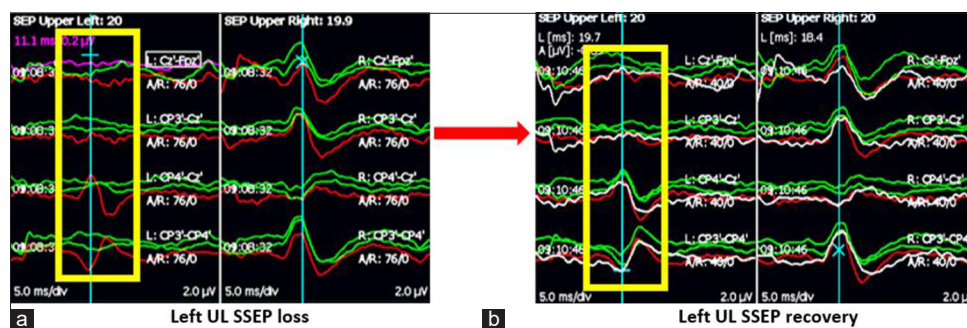


Figure 3: Left upper limb (UL) somatosensory evoked potentials drop (a) followed by immediate recovery (b) adjusting the position and cushioning.

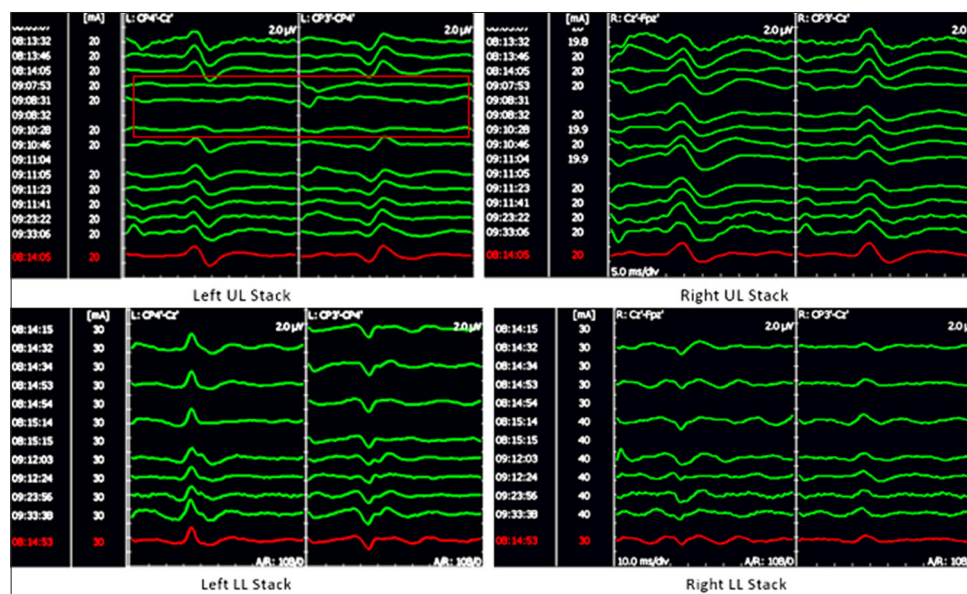


Figure 4: Stack view of somatosensory evoked potentials (SSEPs) from bilateral upper (UL) and lowerlimbs (LL) at the time of the event. Red box indicates drop in the left upper limb SSEP.

the right UL and both lower limbs remained stable, as did MEPs across all monitored muscle groups. Thus, a localised issue was confirmed affecting only the left upper extremity sensory pathway. Importantly, no surgical instrumentation or manipulation had occurred in proximity to the cervical spine or brachial plexus, ruling out direct surgical trauma as a cause. Anaesthetic depth, haemodynamic parameters, and core temperature were all stable. TOF was checked as a surrogate to verify the intactness of stimulation electrodes [Figure 5]. The pattern of isolated left-sided UL SSEP loss, in the absence of corroborative MEP changes or contralateral abnormalities, raised suspicion of a delayed, peripheral positional neuropathy, most likely involving the brachial plexus or ulnar nerve at known vulnerable sites. In view of this provisional diagnosis, a surgical pause was initiated. The senior neurophysiologist went under the drape, and an immediate reassessment of positioning was undertaken. An inspection was done to rule out mechanical

compressive factors such as an unreleased tourniquet, tight taping/velcro belt or blood pressure cuff on the affected limb at the time of signal change. A detailed algorithm for diagnosis/intervention for positioning-related IONM change is illustrated in Figure 6, proposed by the authors based on the present case and collective institutional experience. The left wrist and cubital fossa were cushioned using water-filled gloves [Figure 7]. Axillary support over the chest bolsters was modified by slightly adjusting the shoulder into internal rotation and adduction, along with minor depression. This repositioning manoeuvre plausibly reduced overall brachial plexus tension by correcting the observed excessive abduction and relieving focal pressure over the axilla. These corrective measures were carried out carefully without compromising the sterile surgical field. These adjustments resulted in the immediate and complete restoration of the left ulnar SSEP, strongly confirming the diagnosis of delayed position-induced reversible ulnar

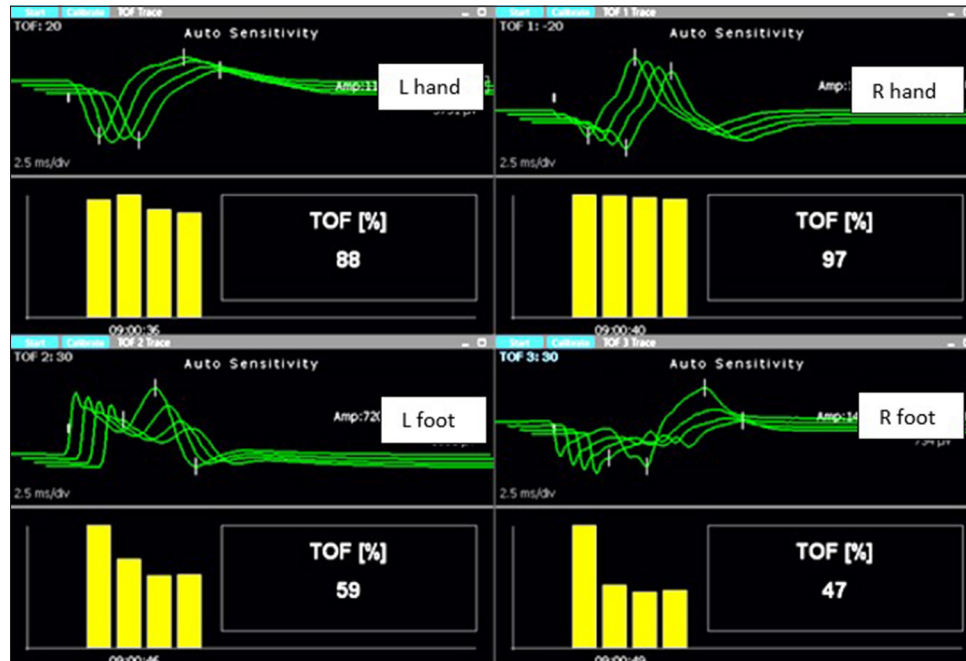


Figure 5: Intact left hand (top left) train-of-four (TOF) at the time of somatosensory evoked potentials (SSEPs) drop implying intact stimulus delivery for SSEPs. (scale: x-axis: 25 ms/window; y-axis: 5 mV/window)

nerve compromise. The prompt response to these simple mechanical corrections highlights the diagnostic value of continuous IONM in identifying extra-spinal, posture-related neural threats, particularly during prolonged prone surgeries. No additional neurophysiological alerts were noted for the remainder of the procedure. The surgical team proceeded with microsurgical resection of the spinal lipoma and detethering of the filum terminale. Triggered EMG mapping was employed throughout using both monopolar flush-tip and concentric bipolar probes, allowing precise localisation of functional nerve roots and enabling safe resection of dysplastic tissue. There was occasional traction-related neurotonic EMG activity.

At the conclusion of surgery, bilateral SSEPs and MEPs from upper and lower limbs remained robust and symmetrical. BCR responses were also reproducible bilaterally, indicating preserved somatic and autonomic pathway integrity. The patient was extubated uneventfully and transferred to recovery with no new neurological deficits noted on post-operative examination.

DISCUSSION

Positioning-related peripheral nerve injury (PPNI) is an uncommon yet significant cause of iatrogenic neurologic morbidity in surgical patients. The reported incidence of PPNI varies widely, from as low as 0.03% in large, mixed-surgery datasets,^[10] to as high as 26% for ulnar neuropathy in certain high-risk contexts such as cardiac surgery.^[11] Despite

their relative rarity, they account for a disproportionately high percentage of iatrogenic malpractice claims unrelated to surgical technique in Western countries, highlighting their impactful burden on patient outcomes and healthcare systems.^[12,13] The true incidence of PPNI remains uncertain, influenced by multiple variables - including patient anatomy and comorbidities, type and duration of the surgical procedure, positioning techniques, use (or absence of) of standard operating protocols specific to avoiding positioning-related injuries, definition of nerve injury (temporary/permanent), IONM protocols-alarm criteria used and anaesthetic techniques.^[14] Available data, such as those from Atesok *et al.* and Chung *et al.* on non-cervical spine surgeries, are derived from heterogeneous single-centre cohorts, reporting rates of approximately 4–5% in monitored populations.^[5,6] These figures may not reflect the natural incidence in unmonitored patients. There are no robust systematic reviews, meta-analyses or large-scale datasets, particularly from regions such as India, where surgical practices are diverse, complex, and often under-reported even in institutional clinical audits. A comprehensive and nuanced analysis of the literature within the context of a specific surgical setting is necessary for interpreting the incidence figures of PPNI. The complexity and heterogeneity of this topic make it a compelling subject for a dedicated epidemiological study.

IONM is vital in spinal dysraphism surgeries for early detection of neural injury. While caudal pathway changes are expected during detethering, isolated UL signal loss is uncommon and diagnostically challenging.^[5,6] Available

Stepwise Action Plan Algorithm for Intraoperative SSEP Signal Drop	
1. Confirm Signal Drop	<ul style="list-style-type: none"> • Recheck raw traces for artifact/noise • Confirm amplitude reduction >50% or complete loss
2. Technical Check	<ul style="list-style-type: none"> • Recording Electrodes: <ul style="list-style-type: none"> - Verify impedance - Re-secure/replace if needed • Stimulating Electrodes: <ul style="list-style-type: none"> - Confirm secure placement - Use TOF or peripheral check
3. Exclude External Factors	<ul style="list-style-type: none"> • Check for tight IV lines, BP cuffs, tourniquets, tapes • Loosen compressive dressings/tubing
4. Clinical Evaluation	<ul style="list-style-type: none"> • If technical issues and external factors ruled out → TRUE SSEP DROP
5. Repositioning Protocol	<ul style="list-style-type: none"> • Upper Limb: Re-pad wrist/cubital fossa/axilla, use gel pads • Lower Limb: Reassess hip/knee flexion, peroneal nerve, ankle padding
6. Monitor Recovery	<ul style="list-style-type: none"> • Watch for immediate/gradual return • Document all interventions & responses

Figure 6: Proposed algorithm for identification/intervention for positioning-related intraoperative neurophysiological monitoring change. SSEP: Somatosensory evoked potentials

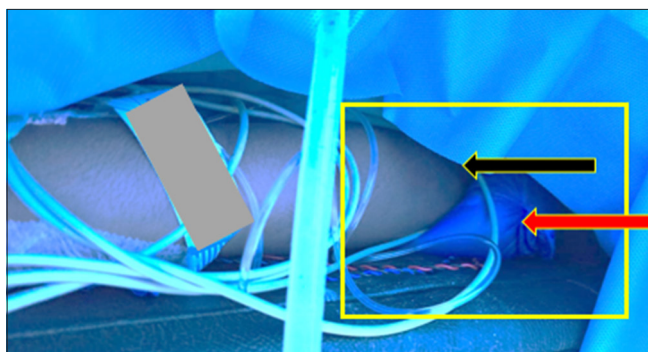


Figure 7: Water filled gloves (red arrow) placed under elbow (black arrow).

literature supports that cervical spine surgeries carry a higher risk of positioning-related neural compromise. Consequently, greater clinical emphasis is placed on detecting IONM changes in these procedures compared to surgeries involving other spinal regions.^[15,16] In our case, a delayed, sudden, and complete loss of the left ulnar SSEP occurred 53 min into the procedure, with stable MEPs and right UL and bilateral lower limb SSEPs. Continuous electrocautery during exposure had temporarily obscured real-time acquisition, delaying detection. Once reacquired, the flat waveform suggested either a technical issue or a true neural compromise. Technical factors were ruled out by ensuring intact stimulus delivery using TOF and low impedances for scalp recording electrodes. Given the absence of local mechanical compressive causes or surgical activity near the cervical or brachial plexus

and preserved contralateral signals, a position-related peripheral ulnar neuropathy was diagnosed. Crucially, our team performed immediate positional correction, involving reinforcement of padding at the left wrist, cubital fossa, and axillary region. This led to instantaneous and complete recovery of the ulnar SSEP, strongly indicating a reversible, position-induced nerve conduction block. While position-related IONM changes have been reported in literature^[7-9] the unique contribution of our case lies in the real-time documentation of a flat-line SSEP recovering fully and immediately following positional correction, in this surgery of the lower cord. Beyond its technical relevance, this event carries significant patient-centered implications. Had the positional neuropathy gone undetected or uncorrected intraoperatively, the patient might have awakened with a new, unexplained UL sensory deficit, which could have progressed to a motor deficit as well. From the patient or family's perspective, this would be puzzling- 'You operated on my lower back; why is my hand numb/weak'? Such unexplained post-operative deficits, even if transient, can lead to loss of trust, patient morbidity and dissatisfaction, medicolegal scrutiny, particularly in paediatric or adolescent cases where expectations are high and communication is closely monitored by caregivers.

This reinforces the argument that IONM is not merely a tool for surgical guidance—it is also a protective layer for patient safety and surgical accountability. Early recognition and correction of position-induced changes not only preserves neural integrity but also prevents post-operative surprises that can undermine the perceived success of an otherwise uneventful surgery. Furthermore, this case highlights the importance of monitoring ULs not only as controls but also as early warning systems for position-related, extra-spinal compromise, particularly in prolonged prone surgeries. Our ability to correlate delayed neurophysiological changes with real-time corrective measures—and to document full signal recovery—emphasises the value of a vigilant and responsive neurophysiology team.

In resource-limited setups, where IONM is not accessible, direct observation of limb position and standardised positioning protocols can serve as simple yet effective adjuncts to neuroprotection during spine surgery. Ensuring symmetry in limb placement, avoiding excessive abduction, rotation or traction, and confirming adequate padding over vulnerable pressure points are critical components of safe positioning. In the absence of a dedicated IONM team, the use of structured checklists—jointly implemented by the surgical, anaesthesia, and nursing teams—can systematise this process and help detect subtle asymmetries or malalignments that may otherwise go unnoticed. These low-cost, reproducible measures can be seamlessly integrated

into routine intraoperative workflows to reduce the risk of PPNI. However, these precautions cannot replace the sensitivity and real-time diagnostic capability of formal IONM.

CONCLUSION

This case highlights the importance of considering position-related peripheral nerve compromise when unexpected UL SSEP alerts arise during lower spinal procedures. Prompt recognition, proactive troubleshooting, vigilant interpretation of neurophysiological data and targeted positional interventions by a meticulous neurophysiology team, supported by structured intervention protocols and a facilitative neurosurgical team, can reverse insults and prevent iatrogenic neurologic deficits, improving surgical outcomes and preserving patient trust.

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