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Is the Use of Intraoperative Neuromonitoring Justified During Lumbar Anterior Approach Surgery?

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ABSTRACT

Background: Intraoperative neuromonitoring (IONM) became widely used in spine surgery to reduce the risk of iatrogenic nerve injury. However, the proliferation of IONM has fallen into question based on effectiveness and costs, with a lack of evidence supporting its benefit for specific spine surgery procedures. The purpose of this study was to evaluate the use of IONM and the rate of neurological injury associated with anterior lumbar spinal surgery.

Methods: This was a retrospective study on a consecutive series of 359 patients undergoing lumbar anterior approach surgery for anterior lumbar interbody fusion (ALIF), total disc replacement (TDR), or hybrid (ALIF with TDR) for the treatment of symptomatic disc degeneration. Patients undergoing any posterior spine surgery were excluded. Operative notes were reviewed to identify any changes in IONM and the surgeon's response. Clinic notes were reviewed up to 3 months postoperatively for indications of iatrogenic nerve injury.

Results: There were 3 aberrant results with respect to IONM. Changes in IONM of a lower extremity occurred for 1 patient (0.3%). The surgeon evaluated the situation and there was no observable reason for the IONM change. Upon waking, the patient was found to have no neurological deficit. There were 2 cases of neurologic deficits in this population, which were classified as false-negatives of IONM (0.56%, 95% CI: 0.1% to 1.8%). In both cases, the patients were found to have a foot drop after the anterior approach surgery.

Conclusion: In this study, there was 1 false-positive and 2 false-negative results of IONM. These data suggest that IONM is not beneficial in this population. However, many surgeons may feel obligated to use IONM for medicolegal reasons. There is a need for future studies to delineate cases in which IONM is beneficial and the type of monitoring to use, if any, for specific spine surgery types.

Clinical Relevance: This study questions the routine use of IONM in anterior lumbar approach surgery for the treatment of symptomatic disc degeneration. This has significant implications related to the cost of this practice.

Level of Evidence: 4.

Complications

Keywords: lumbar spine, intraoperative neuromonitoring, anterior approach surgery, iatrogenic nerve injury

INTRODUCTION

One of the greatest concerns with spine surgery is iatrogenic injury to the spinal cord or nerve roots. This is particularly true for complex deformity cases, where extensive use of metallic instrumentation was initiated. Later, the introduction of pedicle screws expanded the applications for posterior instrumentation to common degenerative conditions, posing the risk of misplaced screws breaching the pedicle wall and passing into the central canal or foramen. Several strategies were introduced to address concerns involving neural injury. In the early 1970s, the Stagnara wake-up test was described to check for neurological injury during instrumented scoliosis surgery, which allowed the constructs to be revised as needed intraoperatively.[1] Although this test was effective, it was also inconvenient, particularly when performing it multiple times during a long procedure. Also, during the 1970s, electrical stimulation of the spinal cord to check for nerve injury related to spine surgery was developed.[2] These early concepts and techniques evolved into today's less intrusive intraoperative neuromonitoring (IONM), which provides monitoring of sensory and/or motor neural pathways in order to identify possible neurological injury and reduce the chances of permanent injury. This technique may also mitigate early reoperation performed to address iatrogenic neural compression.

The Scoliosis Research Society issued a statement that neurophysiological spinal cord monitoring should be considered the standard of care in deformity surgery when the spinal cord is at risk.[3] While being established in complex deformity cases, the use of IONM spread to almost all spine surgeries, including cervical fusion, uninstrumented posterior lumbar procedures, anterior lumbar approach surgery, and others. However, the proliferation of IONM has fallen into question based on effectiveness and costs because of a lack of evidence supporting its benefit for specific procedures.[4–8]

One application of IONM that has not been well investigated is during lumbar anterior approach surgery.[9,10] This approach has the benefits of providing broad access to the interbody disc space allowing the implantation of large, lordotic anterior lumbar interbody fusion (ALIF) cages as well as total disc replacements (TDRs). There are complications related to anterior approach surgery such as vascular injury, urethral injury, postoperative hematoma, incisional hernia, retrograde ejaculation, and ileus.[11] However, compared with the posterior approach, the anterior approach avoids paraspinal muscle trauma and denervation and is associated with decreased blood loss.[12] In anterior exposures, damage to neurological structures is rare,[13,14] thus prompting questioning of IONM usage during these cases. The purpose of this study was to evaluate the use of IONM and the rate of neurological injury associated with anterior lumbar spinal surgery.

METHODS

After exemption by an Institutional Review Board was obtained, surgical records from a multisite spine specialty group were reviewed for the period between January 2020 and December 2021 to identify the consecutive series of patients who underwent anterior approach lumbar spine surgery. Patients were included in the study if they: (1) underwent lumbar anterior approach for TDR, ALIF, or hybrid surgeries (TDR and ALIF), (2) had surgery performed on 1, 2, or 3 lumbar levels, and (3) were at least 18 years old at the time of surgery. Patients were excluded if they (1) underwent a posterior or lateral approach surgery during the same operative setting or planned staged settings or (2) underwent anterior lumbar surgery for fracture, tumor, or infection. All surgeries were performed for symptomatic degenerative conditions unresponsive to nonoperative care.

Data were collected from medical records, including patient characteristics such as age, sex, body mass index, height, and weight. Operative data including surgery type (ALIF, TDR, and hybrid), level(s) operated, and blood loss were recorded. Each operative report was analyzed for any change in IONM and, if applicable, the surgeon's response to the change. A change in IONM was described as a change from the baseline of somatosensory-evoked potential (SSEP), either intermittent or sustained. An IONM technician was present in the operating room for every surgery, with a physician interpreting these results from a remote location in real time. Clinic notes were reviewed up to approximately 3 months postoperatively for indications of iatrogenic nerve injury.

Table. Description of patient population.

Variable	*n* (%)[a]
Age, y, mean (SD)	44.1 (10.5)
BMI, mean (SD)	27.8 (5.7)
Sex	
Female	158 (44.0%)
Male	201 (56.0%)
Surgery type	
ALIF	95 (26.5%)
TDR	238 (66.3%)
Hybrid	26 (7.2%)
Number of levels	
1	256 (71.3%)
2	94 (26.2%)
3	9 (2.5%)

Abbreviations: ALIF, anterior lumbar interbody fusion; BMI, body mass index; TDR, total disc replacement.
[a]Data presented as *n* (%) except where otherwise noted.

Statistical Methods

Descriptive data were reported using means for continuous variables and counts with percentages were calculated for categorical variables. All data analyses were performed using SPSS version 28.0 (IBM, Inc.).

RESULTS

This study was based on a consecutive series of 359 patients. The Table provides a description of the study group. There were 3 aberrant results with respect to IONM. Changes in IONM of a lower extremity occurred in 1 patient (0.3%). This patient was a 38-year-old man undergoing TDR surgery at L5-S1. Preparation of the disc space and device placement were undertaken routinely; however, toward the end of the case, changes in the IONM of the left lower extremity were noted. The surgeon paused to evaluate the situation and determined that no action was to be taken as there was no observable reason for the IONM change. Upon waking, the patient was evaluated and found to have no neurological deficit. This case was classified as representing a false-positive change in IONM.

There were 2 cases of neurologic deficits in this population, which were classified as false-negatives of IONM (0.56%, 95% CI: 0.1% to 1.8%). In both cases, the patients were found to have a foot drop after the anterior approach surgery that was not present preoperatively.

The first case involved a 45-year-old man with a surgical history of L4-5 laminectomy and discectomy approximately 12 years earlier and the same procedure at L5-S1 2 years before that. The current surgery was a hybrid procedure with TDR at L4-5 and ALIF at L5-S1. The procedure was performed uneventfully, and throughout the case, there was no change in IONM with SSEP and electromyography (EMG) being used during the surgery. Postoperatively, the patient complained of the inability to dorsiflex his left foot. The patient also complained of loss of bowel/bladder control, retrograde ejaculation, and a sensation of heaviness in the groin area (these symptoms were resolved). Magnetic resonance imaging found no neural compression. EMG was obtained indicating chronic denervation changes in the peroneus longus and acute denervation changes in the tibialis anterior with no evidence of recruitment or reinnervation in the tibialis anterior. The patient was fitted for an ankle-foot orthosis. Over time there was some improvement, but at the most recent office follow-up of 18 months postoperative, the foot drop had not resolved.

The second case of false-negative IONM involved a 36-year-old woman undergoing TDR at L4-5 with no history of prior spine surgery. The monitoring remained stable throughout the procedure, which was completed without event. Postoperatively, the patient reported left leg pain and difficulties with dorsiflexion of her left lower extremity. An ankle-foot orthosis was ordered on the second day after surgery. By the third week after surgery, she had improved tibialis anterior strength. At 3 months after surgery, she had near-normal strength, was doing well, and had returned to full-duty work.

DISCUSSION

In this large consecutive series of 359 patients undergoing anterior approach lumbar spine surgery, there was only 1 IONM change, which did not result in an alteration to the surgical procedure and the patient had no postoperative indication of neurological injury. Additionally, there were 2 patients who had a foot drop postoperatively, but in neither of these cases was a change in IONM noted during surgery. One patient's foot drop resolved within 3 months. The other patient had other approach-related problems that were resolved, but the foot drop was still present at the most recent office visit at 18 months after surgery, possibly representing a more significant injury despite the lack of change in IONM. The precise etiology for these deficits is unknown, but based on the authors' experience, the prevailing opinion is that these deficits may be due to aberrant retractor placement into the neuroforamen.

There is no consensus on IONM use during anterior lumbar approach surgery and limited literature is available in this area. Farooq et al reviewed IONM in 111 ALIF procedures, concluding that it was a valuable modality for preventing neurological injury, though there was a difference in the rate of neurological injury among patients who received IONM and those who did not.[9] The authors theorized that the IONM group underwent more complex surgery and the IONM prevented the neurological injury rate from being greater than it was in the group that was not monitored.

The current study had the limitations inherent to a retrospective investigation. IONM was used in all cases, primarily SSEP. The use of other monitoring modalities was not consistently recorded in the clinic medical record notes. The small number of false-positive and false-negative IONM changes encountered precluded the ability to investigate associated risk factors. The strengths of the study were a large sample size and being limited to only ALIF and TDR procedures (excluding posterior procedures). This criterion allowed for a closer evaluation of the neurological injury rate specifically related to this anterior approach without the possible confounding factor of posterior spine surgery, which may be associated with an increased risk of neurological injury.

A key observation of this cohort was the 0.56% rate of neurological injury. Even if additional monitoring methods, such as motor-evoked potentials (MEPs), were utilized for these anterior procedures, neurological damage is atypical, which calls into question the use of IONM in these cases.

There is no consensus on using IONM during anterior lumbar approach surgery and limited literature is available in this area. In a meta-analysis, Alluri et al found that for lateral approach lumbar interbody fusion, IONM, particularly MEP, may be particularly helpful for surgeries involving L4-5, but not for cephalad levels.[15] Another study suggested that MEP be added to SSEP and/or EMG for all spine cases.[16] In contrast, IONM for single-level posterior fusion was discouraged based on a lack of demonstrable benefit and increased cost.[7] One item that should be addressed in studies is the cost-effectiveness of IONM in preventing postoperative neural deficits. Changes in IONM to alert the surgeon of neural injury is not the same as preventing injury that has already occurred to initiate the signal change. However, in cases of malpositioned instrumentation, the alert may prevent subsequent intervention if the implant positioning can be addressed during the index procedure.

There are costs associated with using IONM that warrant demonstrable benefits. Krause et al reported significantly higher overall operative costs using IONM in a lumbar discectomy population ($21,949 with vs $18,064 without), while also showing no difference in neurological outcome with or without its use.[5] Additionally, there is literature suggesting that IONM is cost-ineffective for certain lumbar surgical procedures.[17] There are several variables that can change the costs associated with its use, such as the geographic location of the surgery performed, the type of IONM used, and the duration of its use intraoperatively. Based on the results of the current study, no cost of IONM can be justified for anterior lumbar approach surgery for treating symptomatic disc degeneration. Interestingly, in a recent study investigating patient attitudes toward cost-reducing measures in spine surgery, only slightly more than 20% were uncomfortable with forgoing IONM (described as "protects your spinal cord") including patients undergoing anterior cervical discectomy and fusion.[18]

Surveys of spine surgeons found that the most common reason for using IONM was medicolegal concerns.[19,20] Brook and Irle published an article on the legal perspective of IONM usage, where they reviewed malpractice cases and discussed potential liabilities and benefits to spine physicians handling these types of cases.[21] Some of this discussion was related to complying with the standard of care. However, there is no established standard of care for using, or not using, IONM for specific spine procedures. Similarly, there are no established standards for the patient risk factors that may merit monitoring or the type of monitoring appropriate for specific surgeries. The standard of care issue also arose in a review of 26 legal cases in which IONM or lack thereof was identified as a component of the suits.[22] In 54% of the cases, failure to monitor was the primary issue and in the remaining cases, it was negligent monitoring most frequently related to failure to respond appropriately to changes in monitoring waveforms. It should be noted that most of these were cases with significant complications (81% with paraplegia, quadriplegia, or hemiplegia and nerve root injury in the remaining 19%) and there was no information on the other factors involved in the malpractice claims, though IONM appeared to be the primary factor. The role of IONM as a focal point in some malpractice cases provides a justified sense of obligation for some surgeons who continue to use it, despite the lack of data supporting its benefit for some types of surgeries.

There is a need for future studies in this area to delineate cases in which IONM is beneficial, including the type of monitoring, and when it is not. This information would provide professional societies the evidence needed to generate IONM guidelines in spine surgery, thus progressing toward establishing a consistent standard of care for IONM across various types of spine surgery. This may provide guidance to maximize the combination of patient safety, monitoring costs, and litigation concerns.

CONCLUSION

In this consecutive series of 359 patients, there was 1 false-positive change in monitoring and there was no change in IONM for either of the 2 patients with a postoperative foot drop. Based on these results, IONM does not provide any benefit for lumbar anterior approach surgery performed for the treatment of symptomatic disc degeneration.

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