NOL MONITORING IN SPINE SURGERY

Clinical Experience Paper

Introduction

Spinal procedures are generally associated with intense pain in the postoperative period, especially for the initial few days. Adequate pain management in this period has been seen to correlate well with improved functional outcome, early ambulation, early discharge, and preventing the development of chronic pain (Haldar 2015). Barring a few exceptions, spine surgeries are mostly elective in nature (Chou R. 2009). Commonly performed spinal surgeries include laminectomies, discectomies, spinal fusions, instrumentations, scoliosis corrections, and spinal tumor excision (Gabriel K. 2005), (Raw DA. 2003).

Conventional spinal surgeries (non-minimally invasive) often involve extensive dissection of subcutaneous tissues, bones, and ligaments and thus result in a considerable degree of postoperative pain (Paul C. 1998). The pain is severe and typically lasts for 3 days (Bianconi M. 2004). A review of 179 surgical procedures has rated spinal surgeries among the top six procedures causing highest degree of postsurgical pain (Gerbershagen HJ. 2013).

Well planned pain management is imperative to improve the functional outcome after surgery. As inadequately treated postsurgical pain contributes to longer hospital stays, slower progress in ambulation, respiratory complications, venous thrombosis, development of chronicity functional deficits and finally elevated cost of treatment, the importance of managing postsurgical pain following spinal surgery cannot be overestimated.

Adequate pain treatment in these patients is compounded by the fact that the majority of these patients had already suffered from preexisting chronic pain that had been treated with conventional analgesics or narcotics. The preexisting pain along with long-term consumption of analgesics and/or opioids alters pain perception in these patients thereby complicating pain management (Bhaskar SB. 2014), (Loftus RW. 2010). Experts strongly suggest the inclusion of multimodal analgesia for the management of such patients as the quality of analgesia is improved vastly and the side effects of individual drugs diminish. Moreover, the dependence on opioids can also be markedly reduced.

Although multimodal analgesia is the recommended pain management strategy, lack of consensus also exists on the appropriate multimodal analgesia protocols or algorithms (Devin CJ. 2015). Effective pain control supported by objective nociception management during the intraoperative period may help facilitate early mobilization as well as expedite hospital discharge.

The Characteristics of Pain Following Spinal Surgeries

Postoperative pain is the result of activation of various pain mechanisms including nociceptive, neuropathic, and inflammatory (Mathiesen O. 2013). Pain from the back originates from different tissues such as vertebrae, intervertebral discs, ligaments, dura, nerve root sleeves, facet joint capsules, fascia, and muscles (Zeiad AF. 2020).

Various nociceptors and mechanoreceptors that are capable of eliciting pain transmit these sensations. Innervation of these structures is via the posterior rami of spinal nerves connected to sympathetic and parasympathetic nerves.

Mechanical irritation, compression or peri-operative inflammation causes pain. Since extensive cross connectivity of these nerves exists, intraoperative nociception and postoperative pain are a common occurrence. Peripheral as well as central sensitization further contributes to the development of increased pain.

Moreover, the region of surgery does not seem to have a bearing on the pain severity, and it is similar in surgeries of cervical, thoracic or lumbar spine (Bajwa SJ. 2013). Postoperative acute pain differs from chronic pain in that it is transitory, and gradual improvement occurs in due course of time. This characteristic makes it more amenable to medical therapy as compared to chronic pain.

Anaesthesia During Spine Surgery

A stable anaesthetic depth is required in order to ensure that changes to somatosensory or motor evoked potentials (MEP) can be interpreted reliably. An IV technique using propofol is therefore recommended.

Neurophysiologists monitoring MEPs should be made aware of any sudden decrease in arterial pressure, or the need to administer a bolus of adequate opioid concentration or change the anaesthetic depth. Sudden cardiovascular instability during anaesthesia may result from spinal cord and brain stem reflexes, from mediastinal distortion as a result of surgical manipulation, or more commonly from blood loss.

In order to allow neurophysiological monitoring, neuromuscular blocks are typically not administered and regional blocks are not employed, therefore anaesthesiologists need to increase both the level of analgesia and anaesthetic agents in order to maintain stable anaesthesia and prevent acute post-operative pain.

With many of the patients suffering from chronic pain, determining the appropriate level of analgesia can be complicated. A monitor helping clinicians to personalize analgesia to actual needs and providing feedback to the surgeon on the level of nociception experienced by the patient could therefore provide significant clinical utility both intraoperatively and in post-operative gains.

Nociception Monitoring - NOL® Technology Overview

The PMD-200 system consists of a proprietary monitoring unit, and a unique sensor platform which consists of a reusable non-invasive finger probe and a single-use sensor.

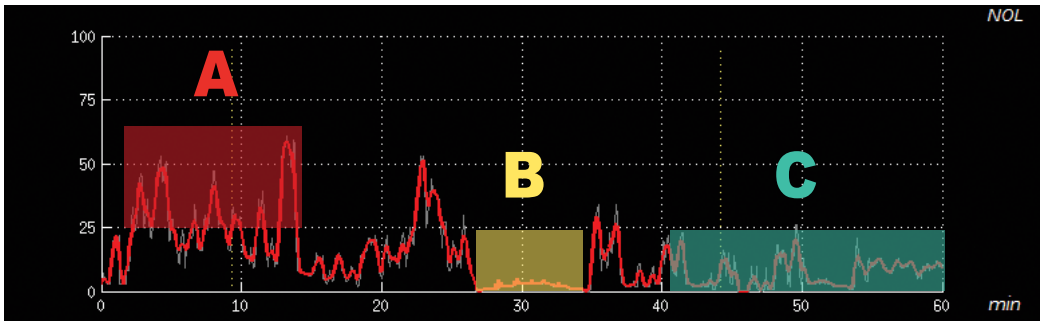
The finger probe and single-use sensor continuously acquire physiological signals through the following four sensors:

- Photoplethysmograph (PPG)
- Galvanic Skin Response (GSR)
- Peripheral Temperature (Temp)
- Accelerometer (ACC)

The NOL algorithm extracts and analyses the following nociception-related physiological parameters: pulse rate, pulse rate variability, pulse wave amplitude, skin conductance level, skin temperature, movement, and their various derivatives.

Using advanced AI algorithms, the system analyzes multiple nociception-related physiological parameters and their various derivatives, which correspond with the autonomic nervous system's response to noxious stimuli, characterizing the patient's pain signature. The monitor displays the NOL index - a relative measure with a range of 0–100, where 0 represents no pain/nociceptive response and 100 represents extreme pain/nociceptive response.

NOL Index Range & Suggested Thresholds



A. NOL trend above 25 for more than one minute (whether constant or fluctuating) may indicate the patient requires additional analgesic therapy. Higher values indicate a stronger nociceptive response.

B. NOL below 10 for more than one minute during a painful stimulation may indicate excessive anti-nociception and reduction of analgesics may be considered. If regional analgesia is used, a low NOL is expected.

C. NOL between 0-25 represents an appropriately suppressed physiological response to noxious stimuli and indicates adequate analgesia.

The NOL index cannot anticipate noxious stimuli and thus a minimal level of analgesics should always be maintained.

Meet the Experts - Carmel Medical Center, Haifa, Israel

Dr. Zeev Goldik,
Head of Anaesthesia, PACU & Pain Service, Past President – ESA,

Dr. Arsen Shpigelman,
Chief of the Spine Unit and Senior Surgeon, Orthopaedic Department

Dr. Michael Grach,
Anaesthesiologist & Pain Specialist

Carmel Hospital is a 477 bed general hospital located in the north of Israel, affiliated with the Rappaport Faculty of Medicine of the Technion. More than 20,000 surgical procedures are performed annually throughout 13 operating rooms. The hospital recently introduced NOL monitoring in major surgeries. A particular focus area for NOL has been in spine surgeries.

Using NOL in Clinical Practice - Expert Insights

Anaesthesia Insights

Spine surgery cases are typically long and complex procedures. Pre-existing chronic pain is a common comorbidity complicating analgesia management, contributing to significant inter-patient variability. In certain surgeries there is a need for fast arousal in order to support neurophysiological monitoring.

Adequate antinociception must be ensured at all times (patients must be adequately anaesthetized or else they risk coughing and dislodging the tube). However, excessive anti-nociception increases the risk of intra-operative arterial hypotension. Somatic potential monitoring precludes the use of muscle relaxants. This adds complexity to the management of hypnotic/opioid interactions and the introduction of multimodal analgesia techniques. NOL technology provides us with a continuous objective measurement of the nociception-anti-nociception balance, an important tool that we did not have at our disposal until now.

Our team has found NOL simple to use and to integrate into our clinical reasoning and it takes away some of the guesswork, allowing us to personalize analgesia to patients' actual needs. We see that we are able to reduce the amounts of opioids we have been giving, with patients experiencing a more comfortable recovery with less pain but also less side effects associated with excessive opioids such as post-operative nausea and vomiting (PONV).

Surgeon Insights

From the surgeon's perspective, the main goals related to analgesia in spine surgery are keeping the patient comfortable during surgery and maintaining a stable, low blood pressure (typical target of a MAP of 100mmHg) so as to prevent excessive bleeding.

Fast arousal after surgery is a priority to allow a neurological examination of the patient approximately one hour after the surgery. If the patient has received excessive hypnotic and opioid medication and is somnolent he is less able to cooperate with the exam.

Fast mobilization of the patient is very important for the recovery process and in most surgeries, patient is expected to begin ambulating 12 hours post surgery. Excessive anaesthesia medication can create challenges in the recovery process.

In addition to providing an objective measure guiding the anaesthesiologist, resulting in lower opioid dosing, NOL monitoring may also be of assistance to the surgeon, for instance, in quantifying the nociceptive response to cage insertion.

We are planning further studies to deepen our knowledge around the level of nociception associated with the different surgical procedures that we perform.

At our hospital the majority of the spine surgeries are degenerative lumbar spine disease cases. Our goal is to help patients rid themselves of debilitating chronic pain and enjoy an improved quality of life. NOL provides us with an important tool to personalize analgesia to patient's actual needs and help achieve the best clinical results for our patients.

Case Report

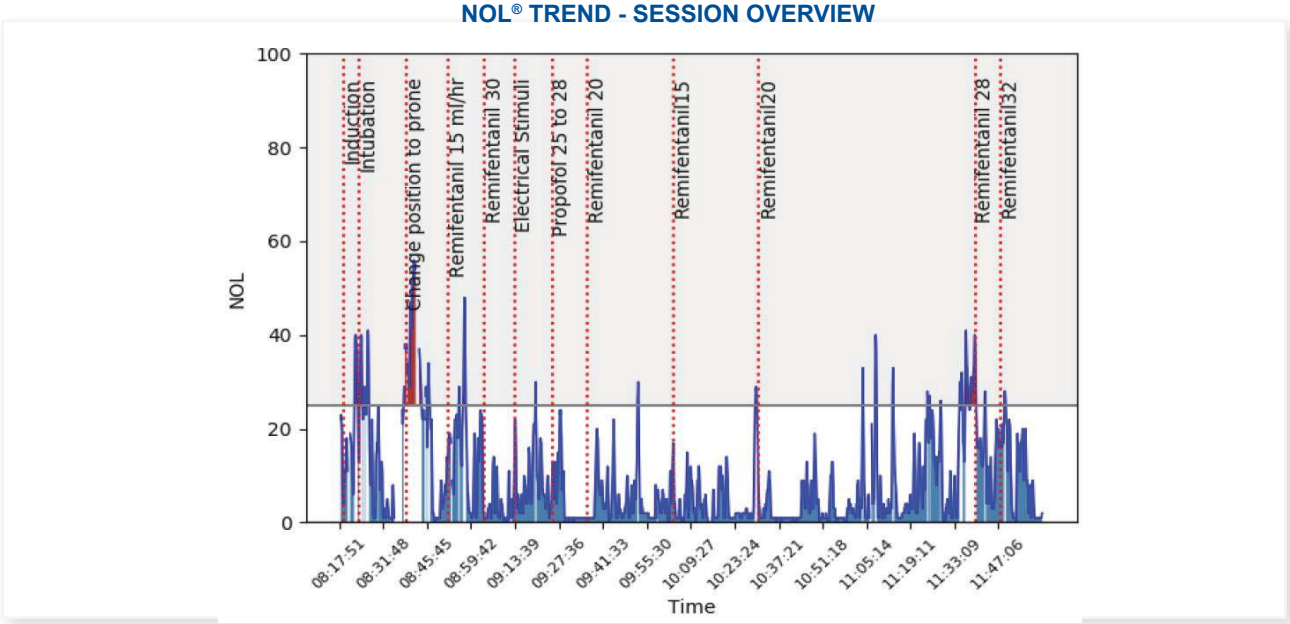
Confident Analgesia Management During Spine Surgery

Female 71-year-old diabetic patient.
Spinal fusion T10-L2 laminectomy T11+T12.

Neuromonitoring of motor evoked potentials was employed during surgery, so total intravenous anaesthesia without muscle relaxation was used. Close titration of analgesic and hypnotic medication is of high importance to maintain adequate anaesthesia and avoid pain-related movement that may cause nerve damage.

The patient was treated with initial boluses of propofol and remifentanil. Propofol and short-acting remifentanil dosing were then adjusted throughout the surgery based on BIS and NOL monitoring, with a BIS target of 40-60 and NOL target of 10-25.

NOL® TREND - SESSION OVERVIEW



Conclusion:

By using NOL to guide remifentanil dosing throughout the procedure, the clinical team could carefully titrate opioid dosages to the patient's needs and objectively assess adequacy of analgesia at all times.

Conclusion

Spine surgeries may be long and complex procedures. Patients undergoing spine surgery are often opioid tolerant due to preexisting chronic pain contributing to particularly high interpatient variability.
Therefore, the use of multimodal analgesia approaches can be beneficial to patients. However, optimizing the drug combination and dosage to patient needs is complex. NOL provides an objective monitoring tool that helps personalize analgesia to actual patient requirements and improve patient recovery.

References

- Bajwa SJ, Kulshrestha A. 2013. "Spine Surgeries: Challenging Aspects and Implications for Anaesthesia." J Spine Neurosurg.
- Bhaskar SB., Bajwa SS.,. 2014. "Pharmaco genomics and anaesthesia: Mysteries, correlations and facts." Indian J Anaesth. 57:336–7.
- Bianconi M., Ferraro L., Ricci R., Zanoli G. Antonelli T., Giulia B., et al. 2004. "The pharmacokinetics and efficacy of ropivacaine continuous wound instillation after spine fusion surgery." Anesth Analg. 98:166–72.
- Chou R., Baisden .J, Carragee EJ., Resnick D.K, Shaffer WO., Loeser JD. 2009. "Surgery for low back pain: A review of the evidence for an American Pain Society Clinical Practice Guideline." (Spine (Phila Pa 1976) 34:1094–109. .
- Devin CJ, McGirt MJ. 2015. "Best evidence in multimodal pain management in spine surgery and means of assessing postoperative pain and functional outcomes." J Clin Neurosci. 22:930–38.
- Gabriel K., Liu P., Wong Hee K.,. 2005. "Video assisted thoracoscopic surgery for spinal conditions." Neurology India Vol 53.
- Gerbershagen HJ, Aduckathil S, van Wijck AJ, Peelen LM, Kalkman CJ, Meissner W. 2013. "Pain intensity on the first day after surgery: A prospective cohort study comparing 179 surgical procedures. ." Anesthesiology 118:934–44.
- Haldar, Sukhminder Jit Singh Bajwa and Rudrashish. 2015 . "Pain management following spinal surgeries: An appraisal of the available options." J Craniovertebr Junction Spine Jul-Sep; 6(3):105-110.
- Loftus RW., Yeager MP., Clark JA, Brown JR., Abdu WA., Sengupta DK., et al. 2010. "Intraoperative ketamine reduces perioperative opiate consumption in opiate-dependent patients with chronic back pain undergoing back surgery." Anesthesiology 113:639–46.
- Mathiesen O, Dahl B, Thomsen BA, Kitter B, Sonne N, Dahl JB, et al. 2013. "A comprehensive multimodal pain treatment reduces opioid consumption after multilevel spine surgery." Eur Spine J. 22:2089–96.
- Paul C., John J., Geis, W., Ira L.,. 1998. "Minimally Invasive Anterior Retroperitoneal Approach to the Lumbar Spine." Spine 1476-1484.
- Raw DA., Beattie JK., Hunter JM.,. 2003. "Anaesthesia for spinal surgery in adults." British Journal of Anaesthesia P. 886–904.
- Zeiad AF., El-Nasri A., Vinay J. 2020. "Clinical Outcome of Spine Surgery Complicated by Accidental Dural Tears: Meta-Analysis of the Literature." Global Spine Journal.