NOL MONITORING IN THORACIC SURGERY

Clinical Experience Paper

Introduction

Although chronic pain is a recognized problem after different surgical procedures, it is particularly common after thoracic surgery (Vasilopoulos T. 2021). A meta-analysis performed in 2014 estimated the incidence of chronic pain at 3 and 6 months after thoracotomy at 57% and 47% respectively (Bayman EO. 2014). These rates have been mostly stable since the 1990s, despite improvements in perioperative care.

Over the past three decades, there has been a shift towards minimally invasive approaches to thoracic surgery, such as video-assisted thoracoscopic surgery (VATS), and more recently, robotic-assisted thoracoscopic surgery (RATS) with the da-Vinci surgical system (Bayman EO. 2014). However, use of the robotic technique is quite limited globally, in part because of the high costs of the system and consumable equipment needed.

Thoracic pain after surgery is partly nociceptive (somatic), related to the area of skin incision, and partly neuropathic, resulting from peripheral nerve (e.g. intercostal nerve) damage (Nakazawa S. 2016), (Blichfeldt-Eckhardt MR. 2018). The former is part of the acute pain response, while the latter has been suggested as the major cause of post-thoracotomy pain syndrome (PTPS), that is, in the subacute or chronic phase.

Intense early postoperative pain is thought to cause neuroplastic changes, resulting in central sensitization (Macrae WA. 2008), (Wildgaard K. 2012), (Katz J. 2009). Regional local anaesthetic (LA) techniques [thoracic epidural analgesia (TEA) or paravertebral blocks (PVBs)] are well established in the field of thoracic anaesthesia and particularly effective in limiting the development of chronic pain. The use of LA techniques suppresses the nociceptive input in the acute postoperative period, which is believed to prevent central sensitization (Crumley 2018).

Intraoperative Nociception Levels in Thoracic Surgery

Objectively assessing nociception induced by (and during) surgery has been challenging to achieve. Here the distinction between pain and nociception needs to be made. Pain is the conscious perception of (potentially) noxious stimuli (Ghanty I. 2019). Therefore, during the unconscious state of anaesthesia, we refer to nociception, that is, the neural conduction and processing of noxious stimuli in the central nervous system. During surgery, there is ideally a 'balance' between the degree of nociceptive stimuli and the antinociceptive component of GA (Ghanty I. 2019). Currently, intraoperative administration of analgesia in thoracic surgery is mainly driven by opioid analgesia and LA infusions, typically para-vertebral blocks or epidural analgesia in open thoracotomies. Adjustments to dosing are based on the patient's physiological responses such increases in heart rate (HR) or blood pressure (MAP), and the anaesthetist's clinical impression or experience.

Inadequate opiate dosage intraoperatively may be associated with postoperative complications. For example, insufficient opiate use may lead to delayed recovery, prolonged hospital stays and chronic postoperative pain syndromes. Conversely, excessive opiate administration can result in nausea/vomiting, respiratory depression and hyperalgesia (Joly V. 2005), (Fechner J. 2013).

The success of LA infusions on the other side, depend on the accuracy in placing blocks and the effectiveness of dosing the LA drugs. Furthermore, the intensity of early postoperative pain correlates with the risk of developing a chronic pain state (Gan TJ. 2017). Monitoring quantitative measures of the 'nociception-antinociception' balance may allow more personalised titration of opiate analgesia, thereby avoiding over or underdosing of opioids and other pain modulating agents, like ketamine or dexmedetomidine, minimizing respective complications.

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.

Using the sensor platform and advanced algorithms, the system processes signals from four signals and analyzes multiple nociception-related physiological parameters and their various derivatives, which correspond with the autonomic nervous system's response to noxious stimuli.

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

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

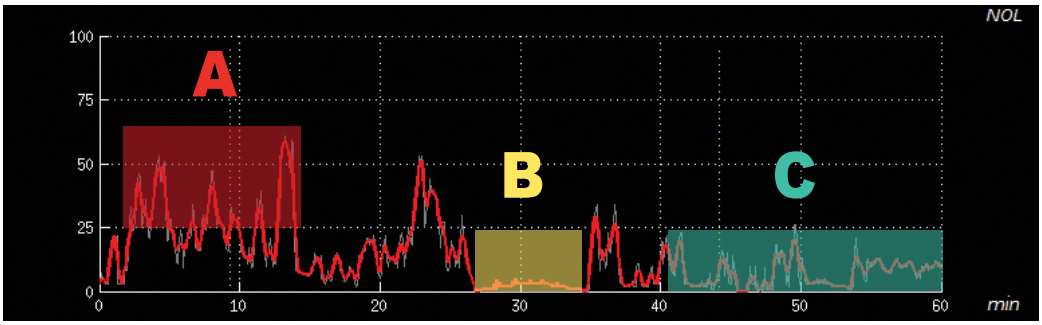
From these four sensors the NOL algorithm extracts and analyses the following nociception-related physiological parameters: pulse rate, pulse rate variability, pulse wave amplitude, skin conductance level, skin temperature, movement, and their various derivatives.

NOL Index Range & Suggested Thresholds

The NOL index is a relative measure with a range of 0–100, where 0 represents no pain /nociceptive response and 100 represents extreme pain/nociceptive response.

The NOL index and trend are intended to support clinical decisions concerning the administration of analgesic medications.

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

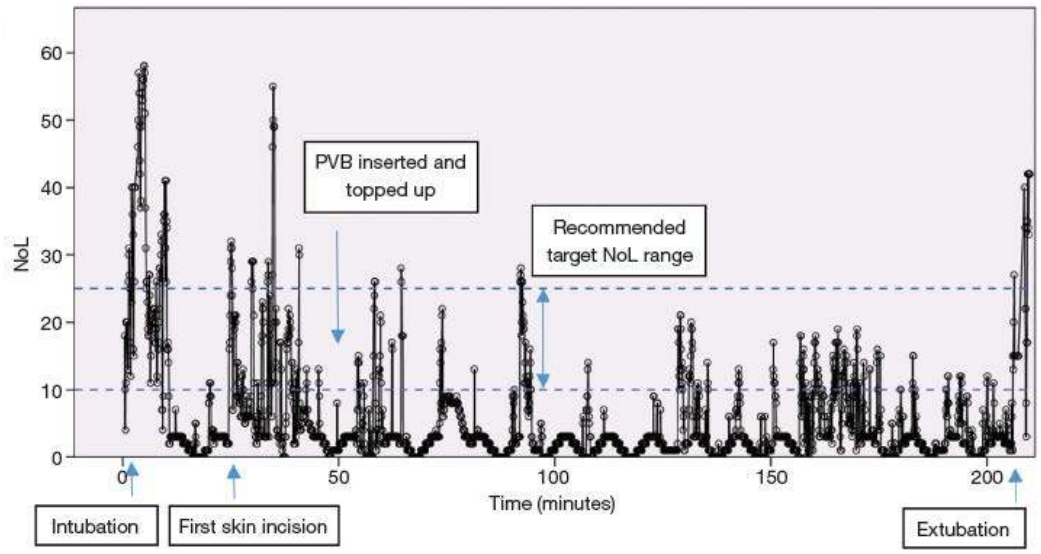


A. NOL trend above 25 for more than one minute (whether constant or fluctuating) may indicate the patient requires additional analgesic therapy. Higher values indicate a stronger nociceptive response.

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 trend during a RATS lobectomy case (Ghanty I. 2019)



The NOL trend above has been reproduced from the Ghanty and Schraag (2019) paper. During the RATS lobectomy, 3 peaks on the NOL index can be seen corresponding to the timings of intubation, first skin incision and extubation. For the majority of the case, the NOL remained within target ranges of 0 to 25, suggesting the patient's nociceptive response was well controlled likely due to a well working paravertabral block.

This example show the potential benefit of nociception monitoring in thoracic surgery, to establish that the nerve blocks are effective.

Meet the Expert

Dr Ignacio Garutti
Hospital Gregorio Marañón

Hospital General Universitario Gregorio Marañón is located in Madrid and is one of the largest healthcare facilities in Spain. With 1671 beds and over 40 operating rooms, every year approximately 30,000 surgeries are performed, alongside 48,000 hospital admissions and 250,000 emergency cases handled.

Hospital Gregorio Marañón serves as a national reference center for clinical care, education and research. It is affiliated with the Complutense University of Madrid.

Dr Ignacio Garutti, Anaesthesiologist; Thoracic Anaesthesia Group; Area Coordinator for Quality, Training and Research, has been using NOL in daily practice for the last 18 months and provides some of his insights on the clinical value of NOL in thoracic surgery.

NOL in Clinical Practice - Expert Insights

The most effective treatment for lung cancer in its early stages is surgery and for several decades the most common cause of pulmonary parenchyma resection surgery is oncology. In addition, many of our patients have widely recognized risk factors for lung cancer such as tobacco use at some time in their lives, which in addition to producing a decrease in ventilatory function, is associated with other comorbidities such as cardiovascular disease.

The irretrievable loss of part of the pulmonary parenchyma and the injury of the muscles involved in pulmonary ventilation makes these patients more susceptible to a clear worsening of their lung function in the days and weeks following the intervention. Clinically, this is reflected in an increased rate of postoperative pulmonary complications (PPC).

In order to reduce the incidence of PPC, surgeons have adopted the use of less aggressive techniques, such as approaching the chest cavity through video-thoracoscopy or even robotic surgery in the last decade. With these approaches the surgical incisions and damage to the muscles involved in breathing are far less severe than in a classic thoracotomy.

Thoracic surgery has been classically considered one of the most painful surgeries in the postoperative period. In addition, the intensity and characteristics of this pain have been linked to the onset of postoperative pulmonary complications. Anaesthesiologists focus their efforts on trying to attenuate pain intensity, not only to improve patients' postoperative discomfort but also to reduce the levels postoperative respiratory dysfunction, which is initially characterized by hypoventilation, the inability to perform deep inspirations and expel bronchial secretions. This is turn, may lead to heightened risk of post-operative atelectasis and the development of pneumonia.

Due to the influence of postoperative pain on postoperative prognosis following thoracic surgery, anaesthesiologists aim to provide excellent analgesic management throughout the pathway, starting before the surgical incision (preventive regional analgesia) followed by general anaesthesia during surgery.

Throughout the intraoperative period we need to be confident that the analgesic technique is effective and functioning as planned, in order to optimize postoperative pain control to counter the inevitable lung dysfunction of surgery.

Until recently, the intraoperative pain of the patient under general anaesthesia, was evaluated using indirect vital signs, which were not sufficiently accurate and did not provide information in a timely manner. Multiparameter NOL pain monitoring is an important new tool assisting us in the management of intraoperative pain in patients undergoing general anaesthesia, as it provides a quantitative measurement of the intensity of nociception.

Using a simple finger probe it records different physiological parameters related to nociception such as heart rate, heart rate variability, pulse wave plethysmography, skin conductance, peripheral temperature and movement integrating them into a simple index that is easy to integrate into clinical practice. By using this technology, in major procedures performed under general anaesthesia with some form of regional nerve block added to improve analgesic quality and minimize perioperative opioid use, analgesic quality monitoring with NOL provides an excellent new tool to improve the quality of care for patients undergoing thoracic surgery.

Conclusion

The ultimate goal for thoracic surgeons and anaesthetists alike would be to reduce the incidence and severity of chronic pain after thoracic surgery, whether thoracotomy, VATS or RATS. With the continuous innovation in the field of thoracic surgery, pain management is an important component in any chosen approach. NOL provides an objective monitoring tool that will result in improved collaboration with the surgeon leading to higher procedure standardization and improved patient recovery.

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