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STATE-OF-THE-ART REVIEW ARTICLE

ON-Q Intercostal Elastomeric Pump System for Pain Management after Thoracotomy: A Comprehensive Review

PROF DR. YEKTA ALTEMUR KARAMUSTAFAOGLU, MD, FEBTS

Trakya University, Faculty of Medicine, Department of Thoracic Surgery, Edirne, Turkey
E-mail: *altemurk@hotmail.com*

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Abstract

Post-thoracotomy pain is a significant challenge that can severely impact recovery and quality of life. Traditional pain management often relies on high doses of opioids, which may lead to adverse effects like nausea and respiratory depression. The ON-Q elastomeric pump system offers a promising alternative by delivering continuous local anesthetic infusion directly at the surgical site, targeting nociceptive nerve fibers to reduce pain signals. This self-contained system is suitable for outpatient use, minimizing hospital visits, and can significantly lower narcotic use and pain scores. While thoracic epidural analgesia might provide better pain relief, ON-Q is effective with a lower risk of hypotension and easier application. Although the ON-Q system has demonstrated a low incidence of complications and no significant wound-healing issues, further research is needed to assess rare complications and establish standardized protocols. While it may entail higher initial costs, it could lead to savings through reduced opioid use and shorter hospital stays, warranting further economic evaluations to determine its cost-effectiveness compared to other strategies.

The ON-Q system shows promise for managing post-thoracotomy pain, with studies indicating its efficacy in reducing pain and opioid use. However, continued research is vital to understanding long-term effects, optimizing usage, and evaluating cost-effectiveness. This ongoing research is crucial to ensure the best patient outcomes and to further establish the ON-Q system as a safe and effective pain management tool.

Key Words: Analgesia, continuous wound catheter, local anesthesia, pain, surgery, thoracotomy.

Introduction

Post-thoracotomy pain is a significant clinical challenge, often severe and prolonged, impacting patient recovery and quality of life. Traditional methods of pain management, while effective to some degree, usually involve high doses of opioids, leading to a range of adverse effects such as nausea, vomiting, constipation, and respiratory depression [1,2]. The development of the ON-Q elastomeric pump system, which delivers continuous local anesthetic infusion directly to the surgical site, has presented a promising alternative for managing this pain. This review will analyze the available evidence regarding the efficacy and safety of the ON-Q system in post-thoracotomy pain management, with a particular focus on its potential to improve patient recovery and quality of life.

Mechanisms of Action and System Overview

The ON-Q system operates on continuous local anesthetic infusion at the surgical site. Providing a constant supply of anesthetic aims to block nociceptive afferent nerve fibers, reducing pain signals before they reach the central nervous system [3]. This multimodal approach targets multiple sites along the pain pathway, reducing the

reliance on systemic analgesics like opioids [1]. The system typically utilizes catheters placed strategically within the surgical wound, delivering local anesthetics such as bupivacaine or ropivacaine at a controlled rate. The elastomeric pump is a self-contained device requiring no external power source or electronic control, making it suitable for ambulatory settings and reducing the need for frequent hospital visits. This not only enhances patient comfort and convenience but also helps in optimizing hospital resources by reducing the burden on inpatient services [4] (Figure 1). The specific anesthetic and infusion rates can be adjusted based on patient-specific factors and surgical requirements. The On-Q® pain pump (OQPP) catheter is fixed through a small drive lateral to the incision and positioned above the muscle fascia and the skin. A small orifice in the catheter allows local medication delivery to the wound site for 3–4 days postoperatively [5]. However, in our experience, unlike its current use, we placed the catheter at the same level as the intercostal space chosen for 149 consecutive patients who underwent anterolateral thoracotomy under the parietal pleura close to the intercostal nerve root, with under direct vision during the closure of the thoracotomy while keeping the pleura intact, not inserted between skin incision and muscles (Figure 2). Thus, we ensured the drug directly reached the intercostal nerve root in the thoracotomy space.

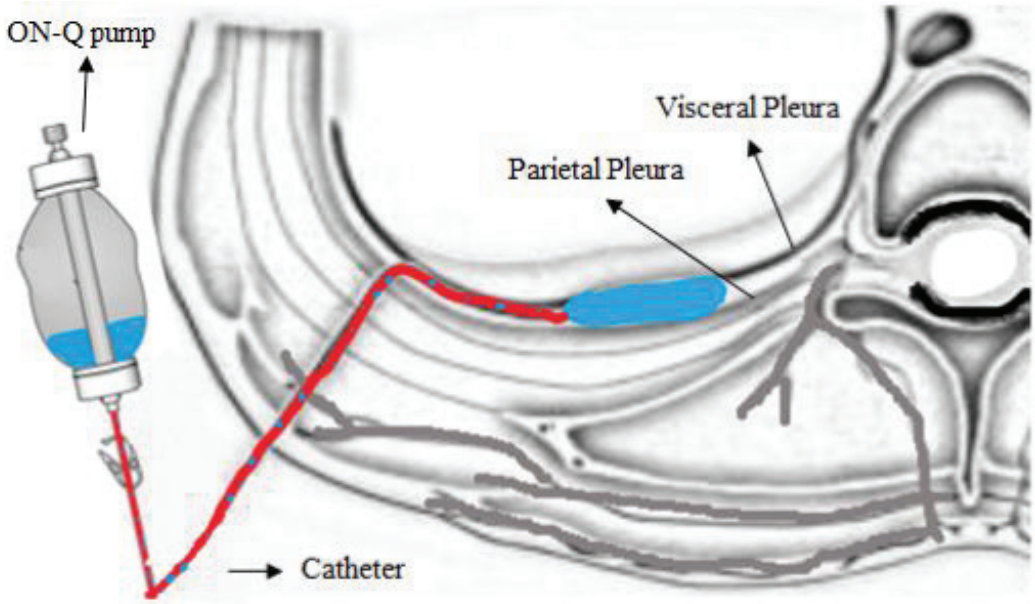


Figure 1: Picture shows the ON-Q system and placement of the catheter between the visceral pleura and the parietal pleura.

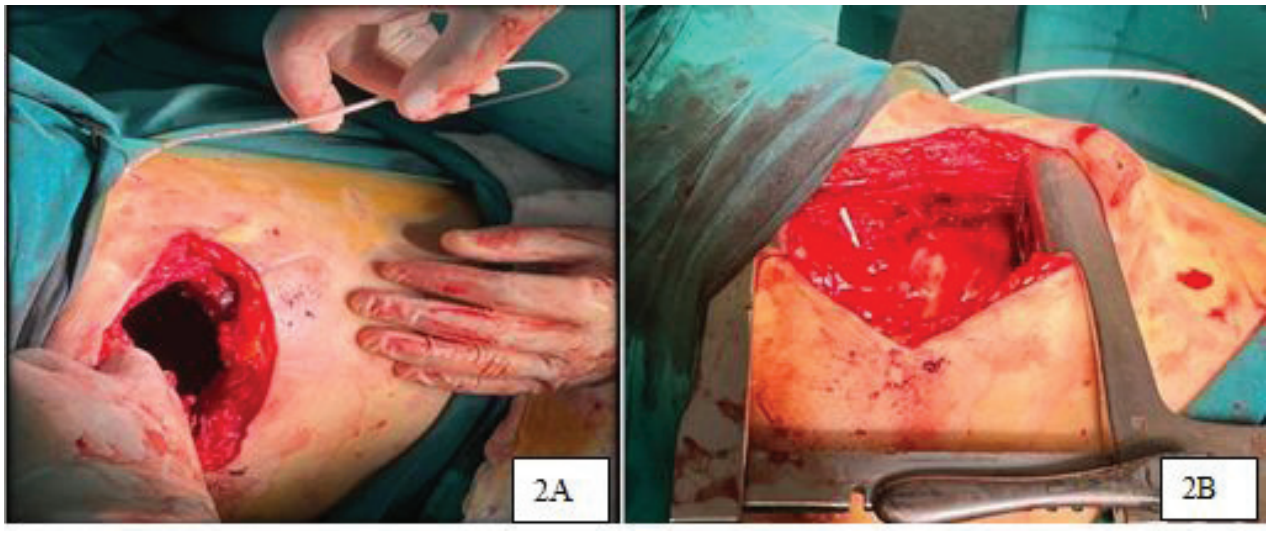


Figure 2A: Placement of the ON Q catheter **2B:** The picture shows the catheter inserting the parietal pleura close to the intercostal nerve root, with under direct vision during the closure of the thoracotomy while keeping the pleura intact.

Efficacy Studies: Pain Scores and Opioid Consumption

Several studies have directly assessed the impact of the ON-Q system on post-thoracotomy pain scores and opioid consumption. A comparative analysis of 40 patients found significantly reduced narcotic use and pain scores in the ON-Q group compared to the traditional pain management group [6]. Similarly, a retrospective study comparing the ON-Q system to intravenous tramadol found significantly lower pain scores at various time points (2, 12, 24, 48, and 72 hours) in the ON-Q group, along with significantly lower rescue opioid consumption [7]. This reduction in opioid use is a crucial finding, given the well-documented side effects of opioids and the potential for addiction [1]. The benefits of reduced opioid use extend beyond avoiding these adverse effects. They also include faster recovery, reduced risk of postoperative complications, and improved patient satisfaction [1]. Another study comparing the ON-Q system to thoracic epidural analgesia demonstrated that while thoracic epidural analgesia provided superior analgesia, the ON-Q system offered a comparable alternative with a lower incidence of hypotension and easier technical application [8]. These findings highlight the potential of the ON-Q system as an effective and safer alternative to traditional methods, especially considering the potential benefits of reduced opioid use. However, it is crucial to note some inconsistencies across studies. While most studies demonstrate reduced pain scores and opioid requirements with the ON-Q system, the magnitude of this reduction varies. This variation may be attributed to differences in patient populations, surgical techniques, anesthetic protocols, and study methodologies. Therefore, more rigorous, standardized studies are needed to establish a clear consensus on the optimal parameters for ON-Q usage and its comparative effectiveness across different clinical scenarios [9]. Furthermore, the studies cited above used different local anesthetics and infusion rates, challenging direct comparisons.

Safety and Complications

A key consideration in evaluating any pain management technique is its safety profile. Studies on the ON-Q system have reported a low incidence of complications. In the study by Salvemini et al. [6], no wound-healing complications or infections were associated with using the pump. Similarly, Wheatley et al. [10] found no wound-healing complications or infections in their study. Elder et al. [11] also reported no complications attributable to the device in their study on lumbar fusion surgery. These findings suggest a favorable safety profile, but larger, long-term studies are needed to assess the potential for rare or delayed complications definitively. The potential for local anesthetic systemic toxicity (LAST) remains a concern, although studies employing continuous infusion suggest that the risk is minimized with careful dosing and monitoring [12].

Comparison with Other Techniques

The ON-Q system is not the only approach to post-thoracotomy pain management. Other commonly used techniques include thoracic epidural analgesia, paravertebral blocks, and various combinations of systemic analgesics. Direct comparisons between the ON-Q system and these different modalities are important for assessing its advantages and disadvantages. The study by Sagiroglu et al. [8] compared the ON-Q system to thoracic epidural analgesia, showing that while epidural analgesia provided better pain relief, the ON-Q system was a viable alternative with a simpler application and lower incidence of hypotension. This highlights the potential of the ON-Q system as a less invasive alternative when epidural placement is contraindicated or poses higher risks. Further research comparing the ON-Q system to other regional anesthetic techniques, such as paravertebral blocks, is needed to fully delineate its role in the broader context of post-thoracotomy pain management [13]. Also, Salvemini [6] has shown decreased narcotic use and lower pain scores in patients who underwent main pulmonary resection due to lung cancer when an incisional infusion with the OQPP System is compared with other intravenous opioids.. In their review, Liu et al. [14] highlighted that this technique's success may be related to the type of surgery and the tissue level where the infiltration occurs. Especially if the catheter is inserted subcutaneously, there is no healing of postoperative pain. Patient-specific factors, including comorbidities, surgical complexity, and individual preferences, should guide the choice of technique.

Long-Term Effects and Chronic Pain

The long-term consequences of acute post-surgical pain are significant, with the potential for the development of chronic pain syndromes. While the ON-Q system focuses on acute pain management, its impact on the incidence and severity of chronic post-thoracotomy pain (CPTP) requires further investigation. Lu et al. [13]

demonstrated a correlation between acute pain management and the occurrence of chronic pain, suggesting that effective acute pain control may reduce the risk of chronic pain development. This implies that successful implementation of the ON-Q system could improve long-term outcomes, but prospective, long-term studies are needed to confirm this hypothesis [15]. Further research should explore the potential role of the ON-Q system in preventing the development of chronic post-thoracotomy pain syndrome (PTPS), a debilitating condition affecting a substantial proportion of patients undergoing thoracotomy [1].

Cost-Effectiveness

The economic aspects of pain management are becoming increasingly important, with healthcare systems seeking cost-effective solutions that do not compromise patient outcomes. While the initial cost of the ON-Q system may be higher than some traditional methods, the potential for reduced opioid consumption, shorter hospital stays, and fewer complications could lead to overall cost savings [3]. The study by Forastiere et al. [3] demonstrated cost savings associated with using the ON-Q system in open nephrectomy, suggesting that similar cost benefits may apply to thoracotomy procedures. Further economic analyses are needed to compare the ON-Q system to other pain management strategies to fully quantify its cost-effectiveness in post-thoracotomy care [7].

Conclusion

The ON-Q elastomeric pump system shows promise as a valuable tool in managing post-thoracotomy pain. Numerous studies demonstrate its efficacy in reducing pain scores and opioid consumption, suggesting a safer and potentially more effective approach compared to traditional methods. The system's favorable safety profile and ease of use enhance its appeal. However, further research is needed to fully understand the ON-Q system's long-term effects on chronic pain development, optimize its parameters for various surgical procedures, and rigorously assess its cost-effectiveness compared to other pain management strategies. The information provided here should be interpreted in the context of ongoing research and clinical practice guidelines.

This comprehensive review highlights the potential benefits of the ON-Q intercostal elastomeric pump system for managing post-thoracotomy pain. While the available evidence suggests significant advantages, further research is crucial to solidify its role in clinical practice and to optimize its use for improved patient outcomes.

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ORCID iD

Yekta Altemur Karamustafaoglu

https://orcid.org/0000-0002-5491-1219

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