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Beyond Pain Control: The Expanding Perioperative Role of Spinal Cord Stimulation

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ABSTRACT:

Chronic pain remains a major global health challenge and is associated with substantial physical disability, psychological distress, and reduced quality of life. In patients with refractory neuropathic pain syndromes, conventional treatment strategies often fail to provide adequate relief, leading to increasing use of neuromodulation therapies such as spinal cord stimulation (SCS). SCS delivers electrical impulses to the dorsal columns of the spinal cord through implanted epidural electrodes connected to an implantable pulse generator, thereby modulating nociceptive transmission within the central nervous system.

This narrative review summarizes the perioperative implications of SCS therapy and highlights important considerations for anesthesiologists managing patients with implanted stimulators undergoing surgical procedures. A focused literature search of PubMed, MEDLINE, and Scopus databases was conducted for studies published between 2000 and 2025 using keywords related to spinal cord stimulation, neuromodulation, anesthesia, chronic pain, and perioperative management. Priority was given to randomized controlled trials, systematic reviews, consensus recommendations, and clinical practice guidelines relevant to perioperative care.

As the use of neuromodulation therapy continues to expand worldwide, anesthesiologists are increasingly likely to encounter patients with implanted SCS devices presenting for unrelated surgical procedures. Important perioperative considerations include device identification and interrogation, prevention of electromagnetic interference from monopolar electrocautery and defibrillation systems, MRI compatibility assessment, and coordination with pain specialists regarding perioperative device management. Postoperative analgesia may be particularly challenging because many patients have opioid tolerance, altered pain processing, and chronic pain syndromes requiring individualized multimodal pain management strategies.

Recent advances in neuromodulation technology, including high-frequency stimulation, burst stimulation, and closed-loop feedback systems, have expanded the clinical applications of SCS and improved therapeutic outcomes in selected patients. Multidisciplinary collaboration between anesthesiologists,

surgeons, and pain specialists remains essential for ensuring patient safety and optimizing perioperative outcomes. Further research is needed to establish standardized perioperative management protocols for patients with implanted neuromodulation devices.

INTRODUCTION:

Chronic pain affects approximately 20–30% of adults worldwide and remains one of the leading causes of disability, healthcare utilization, and reduced quality of life. Neuropathic pain syndromes are particularly difficult to manage and frequently require multimodal treatment approaches involving pharmacological therapy, physical rehabilitation, behavioral interventions, and interventional pain procedures. Despite these strategies, many patients continue to experience refractory pain that significantly impairs functional independence and psychological well-being (1).

Spinal cord stimulation (SCS) has emerged as an important neuromodulation therapy for patients with chronic neuropathic pain syndromes, particularly failed back surgery syndrome, complex regional pain syndrome, and peripheral neuropathic pain (3). SCS involves implanting epidural electrodes connected to an implantable pulse generator that delivers electrical stimulation to the dorsal columns of the spinal cord. Although the precise mechanisms underlying SCS remain incompletely understood, proposed mechanisms include modulation of dorsal horn wide-dynamic-range neurons, activation of descending inhibitory pathways, alterations in neurotransmitter release, suppression of glial activation, and supraspinal modulation of pain processing in addition to the classical gate control theory of pain modulation (2).

Clinical studies have demonstrated meaningful reductions in pain intensity, improvements in quality of life, and decreased opioid utilization among carefully selected patients receiving SCS therapy (4)(6). However, treatment response varies depending on patient selection, pain etiology, stimulation modality, and duration of follow-up. Systematic reviews suggest that approximately 50–60% of patients experience clinically significant pain reduction following SCS implantation, although definitions of treatment response differ across studies (4).

As the global use of neuromodulation therapy continues to increase, anesthesiologists are increasingly likely to encounter patients with implanted spinal cord stimulators presenting for surgical procedures unrelated to their chronic pain condition. The perioperative management of these patients presents unique challenges, including prevention of electromagnetic interference, management of device-related complications, perioperative analgesia optimization in opioid-tolerant individuals, and coordination with neuromodulation specialists (5).

This narrative review examines the expanding perioperative role of spinal cord stimulation and highlights important anesthetic considerations in the preoperative, intraoperative, and postoperative management of patients with implanted SCS devices.

Literature Search Strategy

A focused narrative literature review was conducted using the PubMed, MEDLINE, and Scopus databases to identify studies on spinal cord stimulation, neuromodulation, and perioperative anesthetic management. Search terms included “spinal cord stimulation,” “neuromodulation,” “perioperative management,” “chronic pain,” and “anesthesia considerations.”

Articles published between 2000 and 2025 were screened for relevance. Priority was given to randomized controlled trials, systematic reviews, meta-analyses, consensus recommendations, and clinical practice guidelines addressing spinal cord

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stimulation and perioperative care. Additional references were identified through manual review of cited literature.

Given the narrative nature of this review and the heterogeneity of available evidence, a formal systematic review methodology and quantitative meta-analysis were not performed. The findings were synthesized qualitatively to provide a clinically focused overview relevant to anesthesiology practice.

Perioperative Considerations in Patients With Spinal Cord Stimulators

Clinical Effectiveness of Spinal Cord Stimulation

Multiple clinical trials have demonstrated that spinal cord stimulation provides meaningful pain relief in patients with refractory chronic neuropathic pain syndromes (2). Systematic reviews suggest that approximately 50–60% of carefully selected patients experience clinically significant reductions in pain scores following SCS implantation compared with conventional medical management, although response rates vary depending on pain etiology, patient selection criteria, stimulation modality, and duration of follow-up (4).

Long-term follow-up studies additionally report improvements in functional capacity, sleep quality, psychological well-being, and health-related quality of life among patients receiving neuromodulation therapy (6). SCS has also been associated with reductions in opioid consumption in selected patient populations, further supporting its role within multimodal chronic pain management strategies (10).

Indications for SCS Therapy

Common indications for spinal cord stimulation include:

- Failed back surgery syndrome
- Complex regional pain syndrome
- Peripheral neuropathic pain
- Ischemic limb pain

Evidence suggests that SCS is most effective in patients with neuropathic pain syndromes who have not responded to conservative treatment approaches (7).

Preoperative Assessment

Preoperative evaluation of patients with implanted spinal cord stimulators should include a structured assessment of device characteristics, pain history, and perioperative risks. Important considerations include identification of the device manufacturer, device model, lead placement location, stimulation settings, battery status, MRI compatibility, and the contact information of the patient's pain management specialist or implanting physician (5).

Coordination with the pain management team is recommended prior to surgery to determine whether device interrogation, reprogramming, or temporary deactivation is necessary during the perioperative period. In many cases, the stimulator should be deactivated before surgery to minimize electromagnetic interference and reduce the risk of unintended stimulation or device malfunction.

Patients receiving chronic neuromodulation therapy frequently have long-standing opioid exposure, opioid tolerance, central sensitization, and multiple comorbid pain conditions that may complicate perioperative analgesia planning. Therefore, preoperative evaluation should also include assessment of baseline opioid requirements, prior analgesic response, psychological comorbidities, and previous perioperative pain management experiences.

Suggested Preoperative Checklist

- Device manufacturer and model
- Date of implantation
- Lead placement level
- Battery status

- Current stimulation parameters
- MRI compatibility status
- Presence of abandoned leads
- Contact information for pain specialist/device representative
- Baseline opioid consumption
- Planned perioperative device management strategy

Intraoperative Considerations

The intraoperative management of patients with implanted spinal cord stimulators requires careful attention to electromagnetic interference, device safety, and perioperative analgesia.

Electrocautery and Electromagnetic Interference

Electromagnetic interference generated by electrocautery devices may interfere with stimulator function and potentially result in unintended stimulation, device malfunction, thermal injury, or damage to surrounding neural tissue. Bipolar electrocautery is generally preferred because it limits current dispersion and reduces the risk of interference with implanted neuromodulation systems. If monopolar electrocautery is necessary, the lowest effective energy settings should be used, and the grounding pad should be positioned as far as possible from the pulse generator and leads to minimize current transmission through the device system (5).

Device Deactivation and Interrogation

Many experts recommend temporarily deactivating the stimulator prior to surgery, particularly during procedures involving electrocautery or intraoperative imaging systems. In some cases, formal device interrogation and perioperative reprogramming may be required and should ideally be coordinated with the implanting pain specialist or device representative.

Defibrillation and Cardioversion

External defibrillation and cardioversion may damage implanted neuromodulation systems or alter stimulation settings. When these interventions are necessary, defibrillation pads should be placed as far as possible from the implantable pulse generator, and the lowest clinically effective energy should be used. Post-procedure device interrogation is recommended to confirm appropriate device function.

MRI Considerations

Magnetic resonance imaging presents important safety concerns in patients with implanted SCS systems. While newer MRI-conditional devices permit limited MRI studies under manufacturer-specific conditions, older systems may be MRI unsafe due to risks of lead heating, tissue injury, and device malfunction. Therefore, MRI compatibility must be confirmed before perioperative imaging is performed.

Intraoperative Analgesia

Patients with chronic pain receiving SCS therapy may exhibit opioid tolerance, hyperalgesia, and altered pain processing pathways, complicating intraoperative analgesic management. Multimodal analgesic strategies incorporating nonopioid medications, ketamine infusions, lidocaine infusions, and regional anesthesia techniques may help optimize pain control while minimizing perioperative opioid requirements.

Postoperative Pain Control

Postoperative pain management in patients with implanted spinal cord stimulators can be challenging because many patients have chronic pain syndromes, opioid tolerance, and altered central sensitization pathways.

A multimodal analgesic approach is recommended and may include acetaminophen, nonsteroidal anti-inflammatory drugs, gabapentinoids, ketamine, dexmedetomidine, regional anesthesia techniques,

and carefully titrated opioid therapy. Individualized analgesic planning is particularly important in patients with long-standing opioid exposure.

Regional anesthesia techniques may be considered in selected patients; however, neuraxial procedures require caution due to the risk of lead damage, infection, or interference with implanted hardware. Knowledge of lead location and consultation with the pain management team are recommended prior to neuraxial interventions.

Reactivation of the spinal cord stimulator should generally occur postoperatively once the risk of electromagnetic interference has resolved and device function has been confirmed. Device interrogation may be required in patients exposed to significant electromagnetic interference intraoperatively.

Continued use of neuromodulation therapy may help reduce postoperative opioid requirements and improve functional recovery in selected patients (10).

DISCUSSION

Spinal cord stimulation has become an increasingly important component of chronic pain management and provides an alternative to long-term opioid therapy and repeated surgical interventions in selected patients (3). As the use of neuromodulation devices expands worldwide, anesthesiologists are increasingly likely to encounter patients with implanted stimulators presenting for unrelated surgical procedures.

The perioperative management of these patients requires careful multidisciplinary coordination involving anesthesiologists, surgeons, pain specialists, and device representatives. Electromagnetic interference from monopolar electrocautery, external defibrillation, and magnetic resonance imaging may compromise device functionality and potentially cause thermal injury or device malfunction. Therefore, preoperative device assessment, perioperative planning, and postoperative device interrogation are essential components of patient safety (5).

Recent advances in neuromodulation technology, including high-frequency stimulation, burst stimulation, and closed-loop feedback systems, have improved therapeutic outcomes and expanded the clinical applications of SCS (10). These newer stimulation modalities may also have distinct perioperative considerations related to device programming, patient perception of stimulation, and electromagnetic interference profiles.

Despite these advances, complications such as lead migration, infection, hardware malfunction, and loss of stimulation efficacy remain clinically important (8,9). Lead migration remains one of the most common device-related complications and may present with sudden loss of pain coverage or altered stimulation patterns. Infection may present with localized erythema, wound drainage, fever, or neurological symptoms and may require urgent specialist evaluation and device removal.

In resource-limited settings, access to neuromodulation therapy may be constrained by financial constraints, limited specialist availability, and inadequate support for device programming. These challenges may complicate perioperative management when neuromodulation specialists or manufacturer representatives are unavailable during surgical care.

Future research should focus on establishing standardized perioperative protocols and evaluating the impact of spinal cord stimulation on postoperative recovery, opioid utilization, and long-term surgical outcomes.

Conclusion

Spinal cord stimulation is an effective neuromodulation therapy for patients with refractory chronic pain. As the use of SCS continues to expand, anesthesiologists must become familiar with the

perioperative management of patients with implanted stimulators.

Careful preoperative assessment, intraoperative precautions to prevent device interference, and multimodal postoperative analgesia strategies are essential for ensuring patient safety and optimizing outcomes. Multidisciplinary collaboration between anesthesiologists, surgeons, and pain specialists will be critical in integrating neuromodulation therapies into perioperative care.

AI Use Statement

ChatGPT (OpenAI, San Francisco, CA, USA) was used exclusively for language refinement, grammatical editing, and assistance with manuscript organization. All scientific interpretation, literature review, data synthesis, and final manuscript content were independently reviewed and verified by the authors.

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REFERENCES

1. Deer TR, Mekhail N, Provenzano D, Pope J, Krames E, Leong M, Levy RM, Abejon D, Buchser E, Burton A, Buvanendran A. The appropriate use of neurostimulation of the spinal cord and peripheral nervous system for the treatment of chronic pain and ischemic diseases: the Neuromodulation Appropriateness Consensus Committee. Neuromodulation: Technology at the Neural Interface. 2014 Aug 1;17(6):515-50.
2. Grider JS, Manchikanti L, Carayannopoulos A, Sharma ML, Balog CC, Harned ME, Grami V, Justiz R, Nouri KH, Hayek SM, Vallejo R. Effectiveness of spinal cord stimulation in chronic spinal pain: a systematic review. Pain physician. 2016;19(1):E33.
3. Fishman MA, Antony A, Esposito M, Deer T, Levy R. The evolution of neuromodulation in the treatment of chronic pain: forward-looking perspectives. Pain Medicine. 2019 Jun 1;20(Supplement_1):S58-68.
4. Taylor RS, Van Buyten JP, Buchser E. Spinal cord stimulation for chronic back and leg pain and failed back surgery syndrome: a systematic review and analysis of prognostic factors. Spine. 2005 Jan 1;30(1):152-60.
5. Daniels, A. H., McDonald, C. L., Basques, B. A., & Hershman, S. H. (2022). Perioperative Management of Spinal Cord Stimulators and Intrathecal Pain Pumps. *The Journal of the American Academy of Orthopedic Surgeons*, *30*(17), e1095–e1105. https://doi.org/10.5435/JAAOS-D-22-00053.
6. Kumar K, Taylor RS, Jacques L, Eldabe S, Meglio M, Molet J, Thomson S, O'Callaghan J, Eisenberg E, Milbouw G, Buchser E. The effects of spinal cord stimulation in neuropathic pain are sustained: a 24-month follow-up of the prospective randomized controlled multicenter trial of the effectiveness of spinal cord stimulation. Neurosurgery. 2008 Oct 1;63(4):762-70.
7. North RB, Kidd DH, Farrokhi F, Piantadosi SA. Spinal cord stimulation versus repeated lumbosacral spine surgery for chronic pain: a randomized, controlled trial. Neurosurgery. 2005 Jan 1;56(1):98-107.
8. Berger M, Nadler J, Browndyke J, Posunammy V, Cohen HJ, Whitson HE, Mathew JP. Postoperative cognitive dysfunction: minding the gaps in our knowledge of a common postoperative complication in the elderly. Anesthesiology clinics. 2015 Jul 16;33(3):517.
9. Miękisiak G. Failed back surgery syndrome: no longer a surgeon's defeat—a narrative review. Medicina. 2023 Jul 6;59(7):1255.

10. Kapural L, Yu C, Doust MW, Gliner BE, Vallejo R, Sitzman BT, Amirdelfan K, Morgan DM, Brown LL, Yearwood TL, Bundschu R. Novel 10-kHz high-frequency therapy (HF10 therapy) is superior to traditional low-frequency spinal cord stimulation for the treatment of chronic back and leg pain: the SENZA-RCT randomized controlled trial. Anesthesiology. 2015 Oct 1;123(4):851-60.