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Intraoperative neurophysiological monitoring reduces postoperative constipation in unilateral biportal endoscopic lumbar spine surgery

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KEY WORDS

bulbocavernosus reflex, intraoperative neurophysiological monitoring, lumbar degenerative disease, postoperative constipation, unilateral biportal endoscopic spine surgery

ABSTRACT

INTRODUCTION Postoperative constipation is a frequent complication following lumbar surgery under general anesthesia, potentially associated with intraoperative nerve root irritation. However, the incidence of postoperative constipation following unilateral biportal endoscopic (UBE) lumbar surgery and the potential preventive role of intraoperative neurophysiological monitoring (IONM) remain underexplored.

AIM We aimed to evaluate whether the application of IONM, anal sphincter free-running electromyography (frEMG), and the bulbocavernosus reflex (BCR) reduced the incidence of postoperative constipation in patients undergoing UBE lumbar surgery.

MATERIALS AND METHODS This retrospective cohort study included 153 patients who underwent UBE lumbar decompression between January and December 2024. The patients were divided into the IONM group (n = 50) and the non-IONM group (n = 103). Intraoperative frEMG activity and the BCR were recorded. The incidences of postoperative constipation, Visual Analog Scale scores, and perioperative outcomes were compared between the cohorts.

RESULTS Intraoperative frEMG activity and BCR amplitude reductions were observed in response to surgical manipulation. However, all BCR amplitudes returned to baseline prior to surgical closure. The incidence of postoperative constipation was 48% in the IONM group and 65.1% in the non-IONM group ($P = 0.04$). The rate of delayed bowel movements (within 2 days postoperatively) was 64% in the IONM group, as compared with 80.6% in the non-IONM cohort ($P = 0.03$).

CONCLUSIONS The use of IONM provides real-time neurophysiological feedback during UBE lumbar surgery. It facilitates minimization of aggressive nerve root manipulation, which may be associated with a reduced incidence of postoperative constipation.

INTRODUCTION Unilateral biportal endoscopic (UBE) lumbar decompression is an emerging minimally-invasive technique that has been widely adopted in the treatment of lumbar spinal stenosis and lumbar disc herniation, owing to its superior visualization and favorable clinical outcomes.[1,2] Nevertheless, intraoperative instrumentation and decompression carry potential risks of postoperative complications, including nerve root injury, pain, incidental dural tears, and epidural hematoma.[3,4] Furthermore, postoperative constipation is a frequent, yet often underestimated, complication following spinal surgery.[5]

Postoperative constipation in this context may be primarily associated with iatrogenic nerve root irritation or injury during surgical manipulation. The lumbosacral nerve roots are integral to the defecation centers that innervate the pelvic organs.[6] Consequently, damage to these neural structures may impair colonic peristalsis and the rectal defecation reflex, culminating in delayed bowel motility. Intraoperative neurophysiological monitoring (IONM) has been proven to objectively evaluate neural pathway integrity in real time during spinal surgery. It provides early warnings of potential neural injury, allowing surgeons to promptly adjust their maneuvers and mitigate iatrogenic nerve damage.[7,8]

To date, however, no studies have investigated the efficacy of IONM in protecting the nerves

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governing bowel function during UBE lumbar surgery or its impact on the incidence of postoperative constipation. By providing real-time neurophysiological feedback, IONM theoretically enables surgeons to perform more refined maneuvers, thereby avoiding aggressive manipulation of the lumbosacral nerve roots and subsequently decreasing the risk of postoperative constipation.

AIM This study aimed to evaluate whether the application of IONM, anal sphincter free-running electromyography (frEMG), and the bulbocavernosus reflex (BCR) effectively reduced the incidence of postoperative constipation in patients undergoing UBE lumbar surgery.

MATERIALS AND METHODS **Patient selection and study design** This retrospective cohort study included 153 consecutive patients diagnosed with lumbar degenerative diseases, who underwent UBE lumbar surgery at the Xicheng Branch of Beijing Friendship Hospital in Beijing between January and December 2024.

The inclusion criteria were as follows: 1) confirmed diagnosis of lumbar degenerative disease, including lumbar spinal stenosis, lumbar disc herniation, or lumbar degenerative spondylolisthesis without instability; 2) clinical manifestations of lower back pain, leg pain, and intermittent claudication; 3) complete radiological data (X-ray, computed tomography, and magnetic resonance imaging) demonstrating concordance between clinical symptoms, neurological signs, and imaging findings; and 4) scheduling for UBE lumbar surgery.

The exclusion criteria comprised: 1) preoperative Visual Analog Scale (VAS) score for lower back pain of 5 points or higher; 2) a history of constipation prior to surgery; 3) cranial bone defects; 4) absolute contraindications to neuromonitoring, such as a history of epilepsy, intracranial hypertension, or cardiac pacemaker implantation; 5) incomplete clinical data; and 6) lack of informed consent.

Anesthetic management and surgical technique All procedures were performed under general anesthesia. Induction was achieved via intravenous injection of sufentanil (4–5 μg/kg), propofol (2–3 mg/kg), and rocuronium (2–3 mg/kg). Anesthesia was maintained with a continuous intravenous infusion of remifentanil (0.05–0.5 μg/kg/min) and propofol (3–9 mg/kg/h). No additional muscle relaxants were administered following endotracheal intubation to ensure the reliability of IONM.

The patients were positioned prone on a radiolucent operative frame with the abdomen free from compression, and the target intervertebral space aligned perpendicular to the floor. Two transverse incisions were meticulously planned to establish 2 portals: a working portal incision of approximately 10 mm and a viewing portal incision of approximately 5 mm, separated by a distance of 30 mm. Following the deep fascia incision, sequential dilation was performed. A spinal endoscope and a semitubular retractor were subsequently introduced into the viewing and working portals, respectively. Continuous saline irrigation was established, and the surrounding soft tissue was debrided using a radiofrequency probe to adequately expose the relevant anatomical landmarks. Under high-definition endoscopic visualization, targeted laminotomy and flavectomy were performed, utilizing osteotomes, high-speed burrs, and Kerrison rongeurs. This facilitated optimal expansion of the spinal canal and complete exposure of the compressed nerve roots and dural sac. Depending on the specific pathology, comprehensive spinal canal decompression or targeted discectomy was carried out.

Intraoperative neurophysiological monitoring protocol A multimodal IONM system (NIM-ECLIPSE, Medtronic, Minneapolis, Minnesota, United States) was utilized for continuous neurological surveillance. For BCR monitoring, stimulating electrodes were placed on the dorsal nerve of the penis or the clitoris / labia majora. Recording needle electrodes were inserted into the bilateral external anal sphincters. The BCR stimulation protocol consisted of a train of 4 biphasic pulses, with a pulse duration of 600 μs, an interstimulus interval of 3 ms, with intensity ranging from 30 to 50 mA. Both isolated and continuous frEMG activities in the bilateral anal sphincters, alongside BCR amplitude, were continuously recorded.

Outcome parameters The train-of-four response was routinely monitored to verify the complete metabolism of muscle relaxants prior to initiating frEMG and BCR recordings. The evaluated parameters included sex, age, body mass index, surgical procedure type, operative levels, operative time, intraoperative blood loss, intraoperative fluid volume, rates of postoperative nausea and vomiting, postoperative constipation (defined strictly as an absence of bowel movement for 3 consecutive days postoperatively),[9] time to first postoperative ambulation, length of hospital stay, pre- and postoperative fall scores, pre- and postoperative VAS scores, and perioperative opioid consumption. These variables were systematically compared between the 2 groups.

Statistical analysis Statistical analyses were performed using SPSS software (IBM Corp., Armonk, New York, United States). Continuous variables were presented as mean (SD) or median with interquartile ranges (IQRs), and analyzed utilizing the *t* test or the Mann–Whitney test, depending on data distribution. Categorical variables were expressed as frequencies and percentages, and were evaluated using the χ^2 test. A *P* value below 0.05 was considered significant.

Ethics This study was conducted in strict accordance with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of Beijing Friendship Hospital, Capital Medical University

TABLE 1 Demographic characteristics of the study population

Variable		IONM group (n = 50)	Non-IONM group (n = 103)	*P* value
Sex	Men	21 (42)	52 (50.5)	0.32
	Women	29 (58)	51 (49.5)	
Age, y		61.6 (14)	61.3 (12.4)	0.87
BMI, kg/m^2		25.8 (4.6)	27.1 (4.9)	0.12
Number of operative levels	1	47 (94)	99 (96.1)	0.86
	2	3 (6)	4 (3.9)	
Surgical procedure	Decompression	15 (30)	26 (25.2)	0.2
	Discectomy	23 (46)	62 (60.2)	
	ULBD	12 (24)	15 (14.6)	

Data are presented as mean (SD) or number (percentage).

Abbreviations: BMI, body mass index; IONM, intraoperative neurophysiological monitoring; ULBD, unilateral laminotomy for bilateral decompression

TABLE 2 Postoperative outcomes

Variable		IONM group (n = 50)	Non-IONM group (n = 103)	*P* value
Operative time, min[a]		119.9 (54.6)	116.5 (50)	0.71
Intraoperative blood loss, ml		44.4 (16.2)	39.8 (17.7)	0.11
Intraoperative fluid volume, ml		1157.2 (405.8)	1141.3 (364.8)	0.81
Postoperative nausea and vomiting		11 (22)	13 (12.6)	0.14
Postoperative constipation		24 (48)	67 (65.1)	0.04
No bowel movement within 2 d postoperatively		32 (64)	83 (80.6)	0.03
Time to first postoperative ambulation, h		10.4 (5)	10.2 (4.6)	0.79
Length of hospital stay, d		5 (4–5.3)	5 (4–5)	0.78
Leg pain VAS score, points	Preoperatively	5.9 (1.2)	5.9 (1)	0.42
	24 postoperatively	1.9 (0.3)	2.1 (0.2)	0.002
Fall score, points	On admission	33.5 (22.3)	33.8 (18.7)	0.91
	Postoperatively	40.2 (16.8)	39.3 (11.3)	0.74
Opioid consumption, n (%)	Preoperatively	2 (4)	5 (4.9)	>0.99
	Postoperatively	3 (6)	4 (3.9)	0.86
Intraoperative medication	Remifentanil, mg	1.9 (1–2)	2 (1–2)	0.3
	Sufentanil, μg	30.5 (8.2)	31.7 (10.2)	0.44

Data are presented as mean (SD) or median (interquartile range) unless indicated otherwise.

a Interval from anesthesia induction to skin closure

Abbreviations: VAS, Visual Analog Scale; others, see **TABLE 1**

(BFHHZS20250029). Informed consent was obtained from all participants.

RESULTS **General characteristics** The cohort comprised 73 men (47.7%) and 80 women (52.3%) at a mean age of 61.4 (12.9) years (range, 19–88 y). The patients were categorized into 2 cohorts: the IONM group (n = 50) and the non-IONM group (n = 103). Baseline demographic characteristics were similar between the groups (**TABLE 1**), confirming their comparability.

Intraoperative anal sphincter surface electromyography In the IONM group, unilateral or bilateral frEMG activity in the anal sphincter was triggered in 26 patients (52%) during critical surgical steps, including spinal canal decompression, discectomy, or incidents of dural tear (**FIGURE 1A–1D**). Conversely, 24 patients (48%) exhibited no notable frEMG activity in the anal sphincter throughout the procedure (**FIGURE 1E**).

Intraoperative bulbocavernosus reflex monitoring Reliable baseline bilateral BCR waveforms were successfully obtained in 41 patients (82%). Among these, 9 participants (18%) exhibited a significant amplitude reduction immediately following the elicitation of anal sphincter frEMG activity (**FIGURE 1F** and **1G**), while the remaining 32 patients (64%) showed no obvious amplitude attenuation (**FIGURE 1H**). Notably, in all cases where transient reductions were observed, BCR amplitudes fully recovered to baseline levels prior to surgical closure.

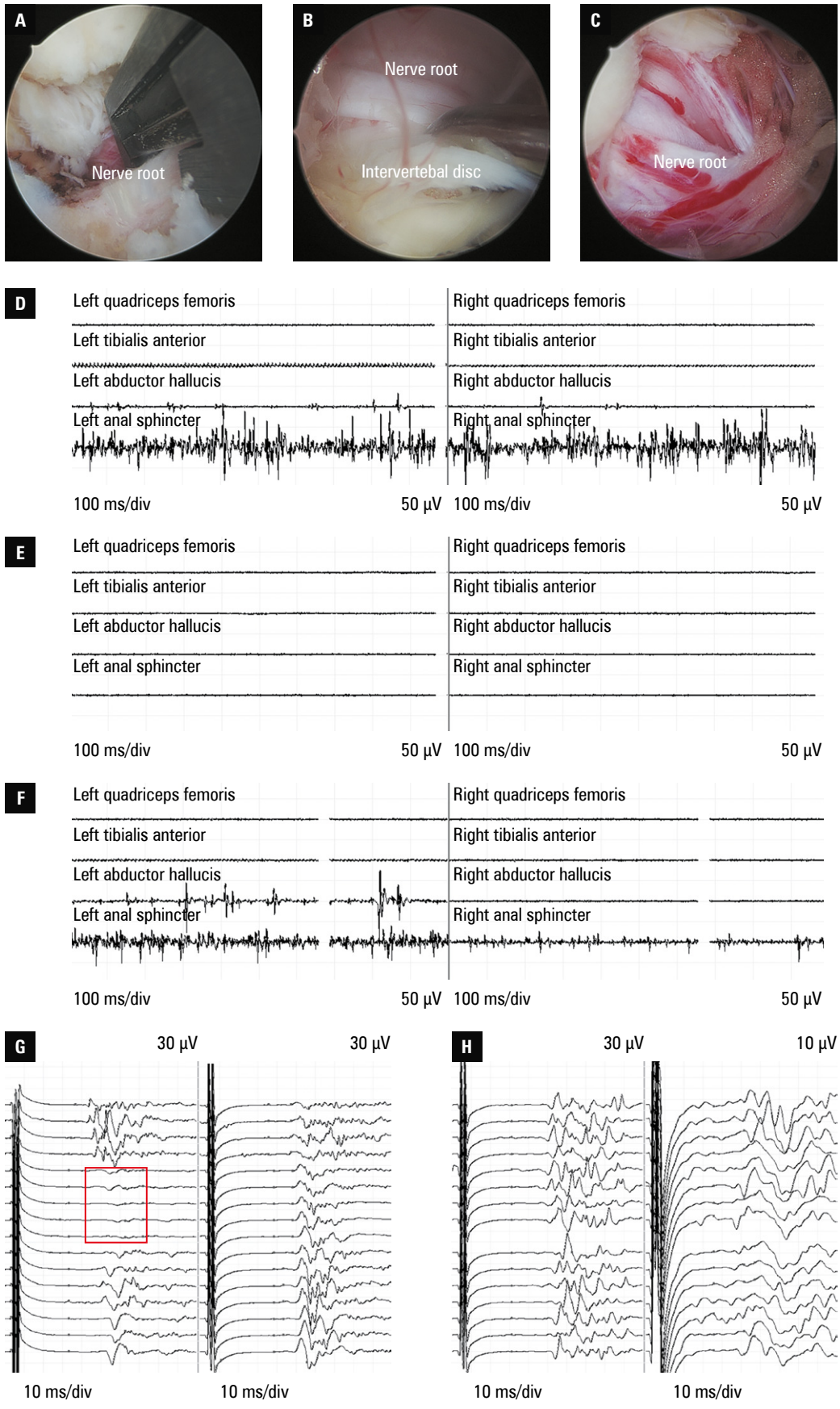

FIGURE 1 Intraoperative neurophysiological monitoring signal changes during unilateral biportal endoscopic lumbar surgery; **A** – left-side approach, decompression of the left L5/S1 nerve root; **B** – L5/S1 disc exploration; **C** – dural tear during decompression; **D** – surgical manipulation inducing bilateral anal sphincter free-running electromyography (frEMG) activity; **E** – no frEMG activity in the anal sphincter; **F** – left-sided L5/S1 nerve root decompression inducing bilateral anal sphincter frEMG activity, with higher amplitude on the left side; **G** – transient decrease in the left bulbocavernosus reflex (BCR) amplitude (red square) following left anal sphincter frEMG activity; **H** – no change in BCR amplitude throughout the procedure

Postoperative patient outcomes In the IONM group, 24 patients (48%) developed postoperative constipation, as compared with 67 individuals (65.1%) in the non-IONM group (P = 0.04; TABLE 2). Furthermore, the number of patients with no bowel movement within the first 2 postoperative days was 32 (64%) in the IONM group vs 83 patients (80.6%) in the control cohort (P = 0.03; TABLE 2). Mean (SD) leg pain VAS score at 24 hours postoperatively was 1.9 (0.3) in the IONM group and 2.1 (0.2) in the non-IONM group (P = 0.002; TABLE 2).

No significant differences were observed between the 2 cohorts in terms of overall operative time, intraoperative blood loss, intraoperative fluid volume, incidence of postoperative nausea and vomiting, time to first postoperative ambulation, length of hospital stay, perioperative fall risk scores, preoperative VAS scores, or perioperative opioid consumption (TABLE 2).

DISCUSSION In our previous study, we found that dural tear was a common complication following UBE surgery[10]; however, its incidence of 2.5% was much lower than that of postoperative constipation. The reported incidence of constipation following thoracolumbar spine surgery ranges from approximately 44.4% to 62.4%,[11,12] a complication frequently associated with intraoperative neural irritation. Existing literature has established that IONM offers real-time feedback regarding the integrity of neural pathways. While somatosensory evoked potentials and motor evoked potentials are standard modalities for preserving lower limb sensory and motor functions, frEMG of the anal sphincter provides immediate, actionable feedback when the cauda equina is mechanically stimulated during decompression or disc exploration. This modality issues timely alerts to the surgical team, thereby minimizing the risk of irreversible nerve injury. Furthermore, the BCR—elicited via stimulation of the dorsal nerve of the penis or clitoris to record the resultant electromyographic response from the anal sphincter—has been historically utilized during tethered cord release and spinal oncology surgeries to prognosticate urinary function.[13,14] However, there is limited research investigating the impact of IONM on postoperative bowel function, particularly in the context of UBE lumbar surgery. Thus, the synergistic application of anal sphincter frEMG and the BCR for intraoperative neuroprotection during UBE procedures carries substantial clinical significance.

Defecation is a complex physiological process requiring a coordinated action of the anal sphincter, pelvic viscera, and both the peripheral and central nervous systems.[15] Intestinal dysfunction is intrinsically linked to neural compromise affecting pelvic splanchnic innervation. The lumbar nerve roots provide sympathetic innervation to the colon and anorectum, transmitting visceral afferent signals and mediating inhibitory pathways.[16] Concurrently, the sacral nerve roots supply parasympathetic and sensorimotor innervation to the rectum, anal canal, and pelvic floor musculature.[17] Consequently, frEMG activity recorded from the anal sphincter during decompression and discectomy serves as a direct neurophysiological proxy for the surgical irritation of these delicate lumbosacral neural elements.

BCR waveform inherently comprises 2 distinct components: R1 and R2. R1 denotes an oligosynaptic response with an onset latency of approximately 30–50 ms, whereas R2 represents a subsequent polysynaptic response that is notoriously susceptible to intraoperative anesthetic suppression.[18,19] Accordingly, a sustained reduction greater than 50% in the R1 amplitude from baseline is typically established as the critical threshold for issuing an intraoperative BCR alarm.[14] Previous oncological spine studies have demonstrated that the complete loss of BCR amplitude during lumbosacral tumor resection correlates strongly with postoperative urinary dysfunction.[20]

In the current study, intraoperative frEMG activity of the anal sphincter was elicited in 52% of the patients in the IONM group, likely reflecting necessary surgical traction and manipulation. In 18% of these individuals, a transient decline in BCR amplitude was observed subsequent to the frEMG burst. Following a brief cessation of manipulation, BCR amplitude consistently rebounded to baseline once frEMG reverted to a quiescent state. Crucially, no permanent loss of the BCR was recorded, which clinically corresponded with the absence of severe, new-onset postoperative urinary retention in this cohort.

The incidence of postoperative constipation was lower in the IONM group (48%) than the non-IONM cohort (65.1%). This protective effect was further evidenced by the marked disparity in the proportion of patients experiencing delayed bowel movements beyond 2 days (64% vs 80.6%). Consistent with our preliminary findings,[6] the postoperative leg pain VAS scores were also significantly lower in the monitored group. These parallel outcomes strongly suggest that postoperative constipation is, at least in part, mechanically linked to intraoperative neural irritation. By guiding surgeons to temper aggressive neural mobilization, IONM concurrently mitigates postoperative radicular pain and bowel motility dysfunction.

It is well documented that opioid analgesics can profoundly delay intestinal transit time, inducing rectal hyposensitivity and functional defecatory disorders.[21-23] However, in our analysis, there were no significant discrepancies in perioperative opioid consumption between the 2 cohorts, effectively eliminating narcotic-induced bowel dysfunction as a confounding variable.

Limitations Several limitations of this study should be acknowledged. First, as a retrospective cohort study, patient allocation to the IONM or non-IONM group was not randomized, which may introduce selection bias. Although

we compared baseline demographic and clinical characteristics of the 2 groups and found no significant differences, we cannot exclude the influence of unmeasured confounding factors. These include, but are not limited to, individual surgeon operative habits and variations in technical proficiency across different stages of the learning curve. Such factors could have potentially affected the incidence of postoperative constipation and other outcomes. Therefore, our findings should be interpreted with caution. Second, the study lacked a longitudinal assessment of long-term postoperative alterations in anal sphincter muscle strength or chronic bowel habits. Third, the definition of postoperative constipation used in this study—absence of bowel movement for 3 consecutive days—is a relatively broad clinical criterion. While commonly employed in perioperative studies, it does not distinguish between neurogenic bowel dysfunction caused by lumbosacral nerve root irritation and delayed intestinal motility secondary to anesthetic or opioid analgesics. Although we found no significant difference in perioperative opioid consumption between the 2 groups, we cannot entirely exclude the contribution of anesthetics or other medications to delayed defecation. Future studies should incorporate validated constipation assessment tools to provide a more nuanced evaluation of postoperative bowel function. Finally, future prospective randomized controlled trials with extended follow-up are warranted to confirm the potential protective role of IONM in reducing postoperative constipation after UBE surgery.

CONCLUSIONS The integrated application of anal sphincter frEMG and BCR provides invaluable, real-time neurophysiological feedback during UBE lumbar surgery. This modality enables surgeons to minimize aggressive mechanical manipulation of critical neural elements, a surgical refinement that appears to be significantly associated with a reduced incidence of postoperative constipation.

ARTICLE INFORMATION

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CONFLICT OF INTEREST None declared.

AI STATEMENT Artificial intelligence was not used in the preparation of this manuscript.

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JOURNAL INFORMATION

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