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ORIGINAL RESEARCH

Impact of Erector Spinae Plane Blocks on Pain Management and Postoperative Outcomes in Patients with Chronic Pain Undergoing Spine Fusion Surgery: A Retrospective Cohort Study

Krizia Amoroso[1,2], James A Beckman[1], Jiaqi Zhu[3], Erika Chiapparelli[2], Ali E Guven[2], Jennifer Shue[2], Andrew A Sama[2], Federico P Girardi[2], Frank P Cammisa[2], Alexander P Hughes[2], Ellen M Soffin[1]

[1]Department of Anesthesiology, Critical Care and Pain Management, Hospital for Special Surgery, New York, NY, USA; [2]Orthopedic Surgery, Spine Care Institute, Hospital for Special Surgery, New York, NY, USA; [3]Biostatistics Core, Hospital for Special Surgery, New York, NY, USA

Correspondence: Ellen M Soffin, Department of Anesthesiology, Critical Care and Pain Management, Hospital for Special Surgery, 535 East 70th Street, New York, NY, 10021, USA, Email soffine@hss.edu

Purpose: To evaluate the impact of bilateral ultrasound-guided erector spinae plane blocks (ESPBs) on pain and opioid-related outcomes in a surgical population with chronic pain.

Methods: A retrospective, observational cohort study. Clinical data were extracted from the electronic medical records of patients who underwent lumbar fusion (February 2018 – July 2020). Eligible patients had a confirmed history/diagnosis of chronic pain starting >3 months before surgery and received either bilateral ESPBs or no ESPBs. Patients were matched on demographic variables (sex, age, race, BMI, ASA Classification, and preoperative opioid use) in a 1:1 ratio. The primary outcome was median opioid consumption (morphine equivalent dose, MED) 24 hours post-surgery (hydromorphone iv-PCA and oral). Secondary outcomes included Numeric Rating Scale (NRS) pain scores, opioid consumption up to 48 hours post-surgery, and hospital length of stay (LOS). Group differences were analyzed using bivariable and multivariable regression.

Results: Of 72 patients, 36 received ultrasound-guided ESPBs and 36 did not. Baseline demographics showed no significant differences. On bivariable analysis, ESPBs were associated with significantly lower 24-hour opioid consumption (79 mg MED vs 116 mg MED, p=0.024) and shorter LOS (82 hours, 95% CI 51–106 vs 126 hours, 95% CI 101–167, p<0.001). No significant differences in NRS pain scores were found up to 48 hours post-surgery. Multivariable analysis confirmed significant reductions in 24-hour opioid consumption (−44, 95% CI −1.06 - −87.55, p=0.044), IV-PCA use (−22, 95% CI −1.59 - −56.77, p=0.038), and LOS (−38, 95% CI −10.074 - −66.22, p=0.008) in the ESPB group without differences in NRS pain scores.

Conclusion: ESPBs were associated with statistically and clinically significant reductions in 24-hour opioid consumption and LOS, without differences in NRS pain scores after spinal fusion in a chronic pain surgical cohort. Given these effects, patients with chronic pain may disproportionately benefit from ESPBs for spine surgery.

Keywords: chronic pain, erector spinae plane block, spine surgery, lumbar, thoracolumbar, outcomes

Introduction

Chronic pain and opioid tolerance are frequently reported in patients presenting for spine surgery.[1,2] Both are known to influence the clinical course, outcomes and length of hospital stay after spine surgery. Chronic pain, by its nature, leads to altered pain perception and often results in opioid tolerance due to prolonged use of analgesic medications. Patients with chronic pain often experience increased pain intensity and greater difficulty managing postoperative pain, making their care more complex and requiring multimodal pain management strategies. These patients are more likely to experience heightened central sensitization, which makes traditional pain relief methods, such as opioids, less effective.

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Despite (or potentially because of) these effects, patients with chronic pain and opioid tolerance are frequently excluded from studies of acute pain interventions in the perioperative period. For example, a recent systematic review synthesizing the benefits of bilateral erector spinae plane blocks (ESPB) in lumbar spine surgery specifically excluded studies from analysis if they had included patients "…with a history of chronic pain and opioid dependence".[3] Excluding patients with opioid tolerance and chronic pain from the underlying trials and from the systematic reviews compromises our ability to generalize the potential benefits of acute pain interventions to this surgical population. Further, we risk compromising the care of patients who may be the most at-risk of poorly controlled post-operative pain and opioid-related harms.

In parallel, effective pain management for all patients undergoing spine surgery remains challenging, often requiring a multidisciplinary, multimodal approach to care. Recent advances in multimodal analgesic regimens for lumbar spine surgery have suggested the benefits for regional analgesic techniques within enhanced recovery after surgery (ERAS) pathways.[4,5] Of all published strategies, the most attention has been directed towards characterizing the effects of bilateral ultrasound-guided ESPBs on recovery and pain- and opioid related outcomes. This body of evidence suggests ESPBs are safe, improve early postoperative pain control, and reduce opioid consumption and -related side effects after spine surgery.[6,7] However, these benefits have been poorly characterized in patients with chronic pain and opioid tolerance undergoing spine surgery.

Accordingly, this retrospective, single-center study aimed to evaluate the impact of bilateral ultrasound-guided ESPBs on opioid consumption, opioid-containing intravenous patient-controlled analgesia (IV-PCA) use, pain scores and hospital length of stay (LOS) in a population of patients with established chronic pain presenting for posterior lumbar spinal fusion. We hypothesized that ESPB would significantly reduce opioid consumption and pain scores. We found opioid-sparing benefits of ESPBs up to 24 hours after surgery and reductions in LOS, that were not accompanied by differences in pain scores. Given the magnitude of effects, we speculate that this population may disproportionately benefit from receiving regional analgesia, compared to patients without chronic pain.

Methods

Study Design and Patients

This is a single-center observational, retrospective cohort study. The study was performed in accordance with the ethical standards of the Declaration of Helsinki (1964) and its subsequent amendments, under exempt status granted by the Institutional Review Board at Hospital for Special Surgery (HSS-IRB# 2020–1877). Written patient consent was waived due to the anonymous, retrospective nature of the data collection. The study population comprised consecutive patients undergoing single or multilevel posterior lumbar spinal fusion surgery at our institution between February 2018 and July 2020. Patients with a documented history of chronic pain, and who received either pre-incisional bilateral ultrasound guided ESPBs or no ESPBs were eligible for inclusion in the analysis. Patients who did or did not receive ESPBs were grouped and matched 1:1 based on sex, age, race, BMI, ASA Classification and preoperative opioid use. Exclusion criteria were patients <18 years old, emergency surgery, or surgery performed for trauma, infection, or neoplasm.

Variables and Data Collection

Demographic variables, surgical characteristics, and outcomes were extracted through manual search of the EMR. Data collected included patient age, gender, race, American Society of Anesthesiologists (ASA) classification, body mass index (BMI), smoking status, history of depression, history of anxiety, preoperative numeric rating scale (NRS) pain scores (0–10 where 0=no pain and 10=worst imaginable pain), preoperative opioid prescribing (yes/no), and baseline opioid dose in morphine equivalent dose (MED).

Operative and anesthetic variables included pre-incision bilateral ultrasound guided ESPBs or no ESPB, number of operative levels, operative time (from surgical incision to closure of the wound), intraoperative ketamine, methadone, fentanyl, and/or hydromorphone use (yes/no). Hospitalization data included post-anesthesia care unit (PACU) NRS pain scores, postoperative NRS pain scores at 24 and 48 hours, opioid consumption at PACU, 24 and 48 hours, opioid-IV PCA use at 24 and 48 hours, total opioid-IV PCA dose, PACU LOS, nursing floor LOS, total LOS, and discharge opioid prescribing.

Definitions

Chronic pain was defined as pain lasting longer than three months, leading to functional and/or psychological impairment (consistent with the definition provided by the International Association for the Study of Pain).[8] Opioid tolerance was defined as opioid use on most days for more than 3 months.[9] Patients with chronic pain and opioid tolerance were identified from the electronic medical record (EMR) based on available information (including documentation in the medical history, medication history, and clinical notes following preoperative review/evaluation by a member of the HSS Perioperative Pain Service).[10] Opioid consumption was defined as the total MED of all opioid medications administered during inpatient hospitalization, including oral and IV PCA use. Post-discharge opioid prescribing was defined as the total MED of opioids prescribed at discharge.

Anesthetic Care

All patients undergoing lumbar fusion receive standardized perioperative care as part of an ERAS pathway. In brief, the pathway includes general anesthesia (GA) with endotracheal intubation and a total intravenous anesthetic-based regimen. Patients also receive perioperative comprehensive multimodal analgesia (MMA), including ketorolac (15 mg every 8 h up to 3 doses), acetaminophen (1000 mg every 8 h), and opioids on an as-needed basis (tramadol 50 mg every 4 h, or oxycodone 5–10 mg every 4 h, according to pain scores), as well as PONV prophylaxis (intraoperative dexamethasone 4–8 mg and ondansetron 4 mg) and postoperative pain management with hydromorphone IV-PCA as needed.[4]

Erector Spinae Plane Blocks

The decision to administer bilateral ultrasound-guided ESPBs is at the discretion of the anesthetic-surgical care teams. When performed, bilateral ultrasound guided ESPBs are provided to patients in the prone position after the induction of GA, prior to surgical incision. ESPBs are typically performed using a C60 curved array ultrasound probe to visualize the tips of the transverse processes at the relevant spinal level. A 20-Ga 4-inch Ultraplex needle is then inserted in-plane and advanced cranially to caudally until positioned under the erector spinae plane. Local anesthetic (0.25–0.375% bupivacaine, depending on patient weight) is injected bilaterally at the tips of the transverse processes.[6]

Outcomes

The primary outcome was total opioid consumption during the first 24 hours after surgery. Total opioid consumption included both oral and intravenous (clinician-administered and hydromorphone-IV-PCA) opioids used during PACU and nursing floor phases of care.

Secondary outcomes included differences in NRS pain scores (by phase of care: PACU, nursing floor, 24 and 48 hours after surgery), total inpatient opioid consumption (oral and iv), IV-PCA use and dose, LOS, and the quantity of opioid prescribed at discharge from the hospital.

Statistical Analysis

The normality of continuous variables was assessed using the Shapiro–Wilk test. Due to non-normal distribution, median and interquartile range (IQR) were used to summarize continuous variables. For discrete variables, count and percentage were calculated. The Kruskal–Wallis test was employed to compare continuous variables between two groups. Fisher's exact test or the Chi-square test was used to compare categorical variables between groups, depending on cell sizes. Multivariable linear regression, adjusting for age, sex, BMI, and number of levels fused, was conducted to evaluate the relationship between ESPB and NRS pain score, opioid consumption, and LOS. Statistical significance was defined as $p < 0.05$. The statistical analysis was performed using R-Studio version 2023.09.1.[11]

Results

A total of 72 patients with a documented history of chronic pain undergoing posterior single or multilevel spinal fusion surgery met the inclusion criteria for this analysis. Of these, 36 (50%) received ultrasound guided ESPBs, and 36 (50%) did not.

Patient Demographics and Baseline Characteristics

The demographic characteristics and perioperative clinical data for the entire study cohort are summarized in Table 1. There were no statistically significant differences between the groups in baseline demographics. The cohort exhibited a balanced distribution of sex (44% male, 56% female, p=0.155), had comparable median ages (64.0 years; 55.0–68.25, p=0.8) and BMI scores (28.25 kg/m^2; 24.65–32.57, p=0.766). Most patients were Caucasian (85%, p=0.182), and there were no significant differences in ASA status, smoking status, or preoperative opioid use.

Surgical Characteristics

Significant differences were observed in surgical duration and the number of spinal levels fused. Patients in the ESPB group had fewer levels fused (2; 1–2 vs 2; 2–7, p=0.001) and shorter duration of surgery (181; 132–248 vs 237; 195–310 minutes, p=0.01). There were no significant differences in intraoperative ketamine, methadone, or hydromorphone use. However, intraoperative fentanyl use was significantly higher in the no-ESPB group (78% vs 97%, p=0.028; Table 2).

Primary Outcome

On simple comparisons, total opioid consumption in the first 24 hours after surgery was statistically significantly lower in the ESPB group (79 mg MED; 43–122 vs 116 mg MED; 77–161, p=0.024) (Table 3). Total opioid dosage administered via IV-PCA in the first 24 hours was also significantly lower (24mg MED; 12–38 vs 36 mg MED; 25–52, p=0.011) in the ESPB group.

Table 1 Patient Demographics

Variable	ESPB	No ESPB	Total	p value
Patients (%)	36 (50%)	36 (50%)	72 (100%)	
Sex, males (%)	19 (53%)	13 (36%)	32 (44%)	0.155
Age, median (IQR)	64 (54.750–69.250)	64 (56.500–68)	64 (55–68.250)	0.800
Race, Caucasian (%)	28 (78%)	33 (92%)	61 (85%)	0.182
BMI, median (IQR)	29 (25.475–32.850)	27.800 (23.800–31.125)	28.250 (24.650–32.575)	0.766
ASA				0.778
1	1 (3%)	0 (0%)	1 (1%)	
2	28 (78%)	27 (75%)	55 (76%)	
3	7 (19%)	9 (25%)	16 (22%)	
4	0 (0%)	0 (0%)	0 (0%)	
Current Smoking (%)	4 (11%)	4 (11%)	8 (11%)	0.999
Depression (%)	9 (25%)	11 (31%)	20 (28%)	0.599
Anxiety	13 (36%)	11 (31%)	24 (33%)	0.617
Preop Opioid Use	31 (86%)	31 (86%)	62 (86%)	1
Baseline Opioid Dose (MED/day), median (IQR)	20 (5–45)	23 (10–60)	20 (8–60)	0.667

Abbreviations: BMI, Body Mass Index; ASA, American Society of Anesthesiologists, IQR, Interquartile Range.

Table 2 Anesthetic & Surgical Characteristics

Variable	ESPB	No ESPB	Total	p value
N° Levels Fused, median (IQR)	2 (1–2)	2 (2–7)	2 (2–3)	**< 0.001**
Surgical Duration min, median (IQR)	181 (132–248)	237 (195–310)	215 (148–297)	**0.010**
Intraop Ketamine (%)	34 (94%)	29 (81%)	63 (88%)	0.151
Intraop Methadone (%)	7 (19%)	14 (39%)	21 (29%)	0.070
Intraop Fentanyl (%)	28 (78%)	35 (97%)	63 (88%)	**0.028**
Intraop Hydromorphone (%)	26 (72%)	22 (61%)	48 (67%)	0.317

Note: Bold values indicate statistical significance (p<0.05).
Abbreviation: IQR, Interquartile Range.

Table 3 Unadjusted Primary and Secondary Outcomes

Variable	ESPB	No ESPB	Total	p value
Opioid Consumption PACU, median (IQR)	30 (15–51)	23 (14–38)	24 (15–40)	0.278
Opioid Consumption 24h, median (IQR)	79 (43–122)	116 (77–161)	100 (61–138)	**0.024**
Opioid Consumption 48h, median (IQR)	44 (0–120)	96 (47–163)	85 (13–128)	**0.010**
Opioid Consumption Total, median (IQR)	175 (82–315)	258 (172–371)	213 (102–352)	**0.026**
IV-PCA Use (%)	27 (75%)	36 (100%)	63 (88%)	**0.002**
IV-PCA 24h, median (IQR)	24 (12–38)	36 (25–52)	28 (21–48)	**0.011**
IV-PCA 48h, median (IQR)	26 (12–41)	26 (11–66)	26 (12–56)	0.651
IV-PCA Total, median (IQR)	24 (12–64)	50 (33–84)	40 (24–78)	**0.007**
NRS Pain Score PACU, median (IQR)	6 (5–7)	6 (4–8)	6 (4–8)	0.994
NRS Pain Score 24h, median (IQR)	5 (3–6)	5 (4–6)	5 (4–6)	0.364
NRS Pain Score 48h, median (IQR)	5 (4–7)	6 (4–7)	6 (4–7)	0.507
LOS PACU h, median (IQR)	5 (4–13)	6 (3–12)	6 (4–13)	0.616
LOS Nursing Floor h, median (IQR)	16 (10–20)	99 (83–151)	33 (16–97)	**< 0.001**
LOS Total h, median (IQR)	82 (51–106)	126 (101–167)	104 (79–151)	**< 0.001**

Note: Bold values indicate statistical significance (p<0.05).
Abbreviations: PACU, Post-Anesthesia Care Unit; IV-PCA, Intravenous Patient Controlled Anesthesia; NRS, Numerical Rating Scale; LOS, Length of Stay.

In multivariable linear regression analysis, there was a significant reduction in 24-hour opioid consumption (−44, 95% CI −1.06 - −87.55, p=0.044) and a statistically significant decrease in IV-PCA use (−29, 95% CI −1.59 - −56.77, p=0.038), based on an overall reduction of 44 mg MED within the first 24 hours post-surgery (Table 4).

Secondary Outcomes

On simple comparisons, there were no significant differences in median NRS pain scores in the PACU between the groups (6; 5–7 vs 6; 4–8, p=0.994) or nursing floor for the first 24 hours (5; 3–6 vs 5; 4–6, p=0.364). After adjustment, NRS pain scores in the PACU and at 24 hours postoperatively remained non-significant (p=0.865 and p=0.455, respectively). (Table 4) Opioid consumption at 48 hours was significantly lower in the ESPB group compared to the no ESPB group on simple comparisons (44 mg MED; 0–120 vs 96 mg MED; 47–163, p=0.01), but not after adjustment

Table 4 Multivariable Linear Regression for Primary and Secondary Outcomes

Outcome	Estimate	CI	p value
Opioid Consumption PACU	8	23.180 - −6.257	0.255
Opioid Consumption 24h	**−44**	−1.069 - −87.552	**0.044**
Opioid Consumption 48h	−51	3.687 - −104.900	0.067
Opioid Consumption Total	−86	11.195 - −184.155	0.081
NRS Pain Score PACU	0	1.231 - −1.037	0.865
NRS Pain Score 24h	0	0.475 - −1.049	0.455
NRS Pain Score 48h	0	1.006 - −0.972	0.972
IV-PCA 24h	**−29**	−1.599 - −56.776	**0.038**
IV-PCA 48h	−16	26.942 - −59.796	0.443
IV-PCA Total	**−57**	−16.399 - −97.588	**0.006**
LOS PACU h	1	3.710 - −2.506	0.700
LOS Nursing Floor h	**−101**	−80.376 - −121.183	**1.14E-14**
LOS Total h	**−38**	−10.074 - −66.216	**0.008**
Opioid Dose at Discharge	−29	12.056 - −69.906	0.159

Note: Bold values indicate statistical significance (p<0.05).
Abbreviations: PACU, Post-Anesthesia Care Unit; IV-PCA, Intravenous Patient Controlled Anesthesia; NRS, Numerical Rating Scale; LOS, Length of Stay.

(−51, 95% CI 3.687 - −104.9, p=0.067). Total opioid consumption was significantly lower in the ESPB group in the unadjusted analysis (175 mg MED; 82–315 vs 258 mg MED; 172–371, p=0.026), but not after adjustment (−87, 95% CI 11.195 - −184.155, p=0.081) (Table 3 and Table 4).

While IV-PCA use at 48 hours did not show statistical significance on univariable or multivariable analyses (p=0.65 and p=0.44, respectively), we observed a markedly lower total opioid dosage administered via IV-PCA in the ESPB group in both unadjusted (24 mg MED; 12–64 vs 50 mg MED; 33–84, p=0.007) and adjusted (−57, 95% CI −16.399 - −97.588, p=0.006) analyses. NRS pain scores at 48 hours did not differ significantly between groups in either unadjusted (5; 4–7 vs 6; 4–7, p=0.507) or adjusted (0, 95% CI 1.006 - −0.972, p=0.972) models (Table 3 and Table 4).

Total LOS was significantly shorter in the ESPB group in both unadjusted (82; 51–106 vs 126; 101–167 hours, p<0.001) and adjusted analysis (−38, 95% CI −10.074 - −66.216, p=0.008), with a significant, 38-hour decrease associated with ESPBs. Although no significant differences were observed in PACU LOS, LOS on the nursing floor was significantly shorter for the ESPB group in both unadjusted (16; 10–20 vs 99; 83–151 hours, p<0.001) and adjusted analysis (−101, 95% CI −80.376 - −121.183, p=1.14E-14) (Table 3 and Table 4).

Discussion

In this retrospective cohort study of 72 patients with a history of chronic pain, we assessed the impact of ESPB on postoperative outcomes following posterior lumbar spinal fusion. ESPB was associated with large, clinically and statistically significant reductions in 24-hour opioid consumption. Hydromorphone-IV-PCA use and LOS were also reduced among patients who received ESPBs, without significantly affecting NRS pain scores during any phase of care. These findings align with existing literature highlighting the potential benefits of ESPBs in spine surgery cohorts. Additionally, these results extend the body of evidence to support bilateral ESPBs in specific populations of spine surgery

patients. Indeed, to our knowledge, this study represents the first evaluation of ESPBs in a restricted cohort of patients with chronic pain.

Chronic pain, defined as pain persisting beyond normal tissue healing time (>3 months), presents a substantial global health burden, characterized by significant suffering and disability.[8] Complex peripheral and central sensitization processes occur in nociceptors, dorsal root ganglia, the spinal cord, and cerebral cognitive and emotional centers. These processes involve the upregulation of receptors and signaling molecules implicated in pain perception, and alterations in nerve fiber responsiveness and neurotransmitter release, leading to lowered pain thresholds and increased sensitivity to pain stimuli.[12,13]

Effective postoperative analgesia is crucial for all patients undergoing posterior lumbar surgery. Available evidence supports effective analgesia to facilitate recovery after spine surgery, reduce LOS, and lower the risk of conversion from acute-to-chronic pain.[14,15] Multimodal analgesia, including ultrasound guided ESPBs, has become a key strategy for enhancing postoperative recovery and reducing opioid consumption after lumbar spinal surgery.[16] Although the exact mechanism of action remains unclear, available evidence suggests that the local anesthetic spreads to the dorsal root ganglia and dorsal rami of the spinal nerves.[17]

Multiple systematic reviews with meta-analysis demonstrate analgesic and opioid-sparing effects of ESPBs performed for lumbar spine surgery.[3,18–20] However, the informing RCTs and the meta-analyses themselves tend to either exclude, do not report, or include mixed cohorts of patients with and without chronic pain and opioid tolerance. There are several implications associated with this heterogeneity: First, studies of ESPBs conducted in surgical cohorts without chronic pain hampers our ability to generalize the results to chronic pain populations.[21] Second, including mixed cohorts (ie, chronic pain and pain-naive patients) may underestimate the effects of ESPBs on "spine surgery" outcomes. Finally, as suggested by the present results, studying ESPBs in a population-specific fashion may reveal unique (or even disproportionate) benefits among various surgical cohorts.

The latter is supported by our present findings that ESPBs reduced median opioid consumption by 44 mg MED at 24 hours after surgery. This finding is in contrast to previously published data from our group showing that the median opioid sparing capacity of patients who received ESPBs was approximately 15 mg MED at 24 hours, in a non-chronic pain lumbar fusion cohort.[6] This disproportionate reduction in opioid consumption also exceeds the minimum clinically important difference established in previous published research, albeit in a different surgical population,[22] as well as in other studies of ESPBs in spine surgery cohorts.[6,23,24] Reasons for these differences must remain speculative, but may be due to modulation of the central sensitization experienced by patients with chronic pain.

We also found a significant decrease in IV-PCA opioid use in the ESPB group during the first 24 hours, although this disappeared at the 48-hour mark. An unexpected finding in our study, consistent with prior reports, was that the lower opioid consumption over the first 24 hours in the ESPB group was not associated with differences in pain scores at any phase of care.[6,24] This suggests that while ESPBs reduce opioid use, they may not adequately address all pain sources after lumbar fusion. An alternative explanation is that the MMA provided may mask additional benefits of ESPBs. Further investigation into the duration and comprehensive efficacy of ESPBs is needed, especially considering our study's retrospective design, which limited our ability to measure block duration or efficacy directly.

Patients receiving ESPB had a clinically important shorter LOS, primarily driven by duration of admission on the nursing floor. The contribution of ESPBs to LOS after spine surgery has been inconsistently reported, with most studies suggesting that ESPBs reduce LOS but to a variable degree.[25,26] For example, a recent retrospective analysis of various lumbar procedures reported a statistically significant 5-hour reduction in overall LOS with ESPB.[6] Conversely, there are others that have not found any significant differences regarding this outcome.[24,27] The reduction of 38 hours found here represents a significant potential for cost-savings for individual hospitals and healthcare systems, particularly as the demand for spine surgery continues to rise.

In summary, our findings not only support the use of ESPB for opioid reduction in lumbar fusion surgery but also emphasize its distinct efficacy in chronic pain populations. Future research should directly compare ESPB's effects across chronic and non-chronic pain cohorts to better understand its full potential in spine surgery.

Strengths and Limitations

Our study benefits from strict definitions of chronic pain and opioid tolerance, together with a simple matching design. These aspects improve the strength of the associations described here. The study suffers from several limitations inherent to the retrospective nature of the design. These include the potential for confounding and selection bias, and variability in block performance due to different anesthesiologists performing the procedure, and/or the choice to perform or not perform ESPBs made by individual anesthesiologist-surgeon-patient teams. Further, the relatively small cohort size limits our statistical power. Finally, the study was conducted at an academic orthopedic surgery specialty hospital, which may restrict generalizability to other settings.

Conclusions

In this cohort of patients with chronic pain undergoing spinal fusion, ESPB provided both clinically and statistically significant reductions in opioid consumption and hospital length of stay. The results suggest the potential for disproportionate benefits of ESPBs for patients with chronic pain, compared to mixed populations, or populations without chronic pain. Given the relative paucity of studies focused on patient-specific populations, together with the rising demand for spine surgery, these results suggest several avenues for future research. Chief among these is to confirm and extend these results in larger cohorts and directly compare outcomes in a patient-specific fashion.

Data Sharing Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Disclosure

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