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CASE REPORT

Opioid-sparing multimodal analgesia with bilateral bi-level erector spinae plane blocks in scoliosis surgery: a case report of two patients

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Abstract

Purpose Postoperative pain following scoliosis correction surgery is severe and usually requires prolonged intravenous opioid therapy. Regional anesthesia options are limited and include intrathecal opioid and epidural analgesia; however, they remain little used because of side effects and inconsistent efficacy. We describe a novel multimodal anesthetic regimen incorporating bilateral bi-level erector spinae plane (ESP) blocks together with a combination of several evidence-based intraoperative opioid-sparing analgesic strategies.

Methods Two healthy young adult patients with idiopathic scoliosis underwent posterior spinal fusion involving 12 vertebral levels (T2–L1 and T3–L2). Bilateral single-injection ESP blocks were performed at two levels (T4 and T10) prior to incision. Intraoperatively, patients received intravenous dexamethasone and infusions of dexmedetomidine and ketamine for multimodal analgesia. Remifentanil was omitted from the total intravenous anesthetic regimen to avoid opioid-induced hyperalgesia.

Results Both patients had minimal pain on emergence. They transitioned successfully to oral analgesia on the first postoperative day, with modest opioid requirements, no side effects, and low pain scores throughout their hospital stay.

Conclusion Bilateral bi-level ESP blocks are a simple method of providing pre-emptive regional analgesia in extensive multilevel spine surgery. Integration of ESP blocks into a multimodal regimen that employs other opioid-sparing strategies may have additive, and potentially synergistic, benefits in improving postoperative analgesia and reducing opioid requirements.

Keywords Scoliosis · Regional anesthesia · Erector spinae plane block · Postoperative pain · Multimodal analgesia

Introduction

Posterior spinal fusion for scoliosis correction is extremely painful and usually requires prolonged and significant opioid use for adequate perioperative analgesia [1, 2]. Regional anesthesia is an important component of multimodal analgesia but the options are limited. Intrathecal or epidural opioid injection and epidural local anesthetic infusion are reported but little used because of logistical complexity, side effects, and inconsistent analgesic efficacy [3–6]. The erector spinae plane (ESP) block was originally described for thoracoabdominal analgesia by anesthetizing ventral rami of spinal nerves [7, 8]. However, it also effectively blocks the dorsal rami innervating the back (Fig. 1) [9–12]. In this report, we describe a unique anesthetic regimen for opioid-sparing analgesia after posterior spinal fusion spanning 12 vertebral segments. This incorporates (1) bilateral ESP blocks performed at two levels (T4 and T10) and (2) a combination of intraoperative pharmacologic adjuncts previously shown to improve analgesic outcomes in spine surgery when used in isolation [13–16]. The benefits of this comprehensive multimodal approach are illustrated in two healthy young patients undergoing idiopathic scoliosis correction. Written informed consent was obtained from both patients for inclusion in this report.

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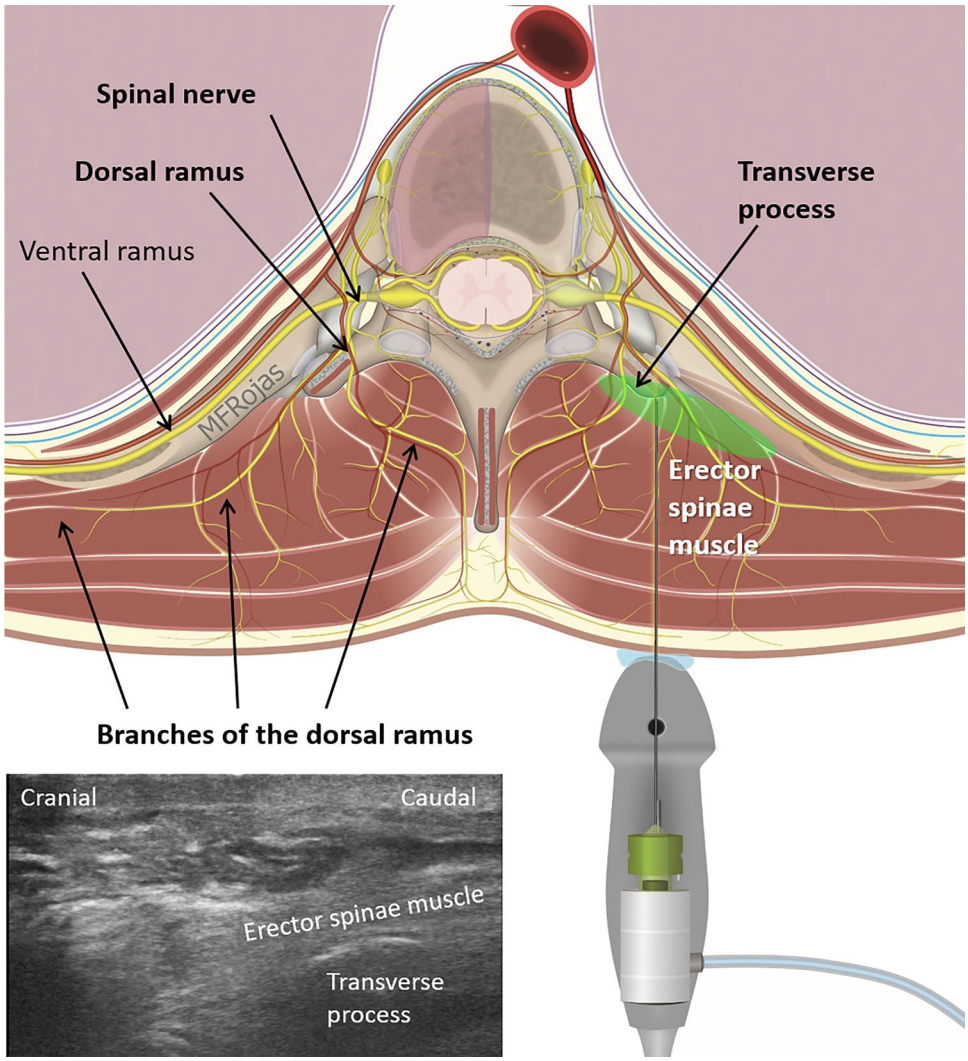

Fig. 1 The erector spinae plane block is performed by injection of local anesthetic into the musculofascial plane between the deep aspect of the erector spinae muscle and the transverse processes. This local anesthetic (green oval) spreads to effectively anesthetize the branches of the dorsal rami of the spinal nerves that travel through this plane. Image adapted and used with permission from Maria Fernanda Rojas Gomez

Case description

Perioperative anesthetic regimen

Prior to induction of general anesthesia, bilateral ESP blocks were performed at T4 and T10 vertebral levels by an experienced regional anesthesiologist. These levels were chosen by dividing the extent of the planned incision into two and injecting at the approximate midpoint of each half (Fig. 2). In each ESP block, a 22-gauge needle was inserted in-plane to a linear-array ultrasound transducer placed in a longitudinal orientation over the tip of the transverse processes. The needle was directed in a caudal-to-cranial direction at T4 and a cranial-to-caudal direction at T10. Entry into the musculofascial plane between transverse process and erector spinae muscle was confirmed by hydrolocation with 1–2 mL of 5% dextrose, following which 15–20 mL of 0.25% bupivacaine with epinephrine 5 mcg/mL was injected (Fig. 3). The volume administered was calculated so as not to exceed a total bupivacaine dose of 3 mg/kg.

Following block completion, general anesthesia was induced and maintained using intravenous (IV) infusions of propofol 80–130 mcg/kg/min, dexmedetomidine 0.2–0.4 mcg/kg/min, and ketamine 0.5 mg/kg/h (Table 1), titrated to achieve hemodynamic stability and adequate anesthetic depth (Entropy™ (GE Healthcare, Helsinki, Finland) values between 45 and 65). Dexmedetomidine and ketamine infusions were stopped at the commencement of wound closure. Local anesthetic infiltration of the wound was not performed. Somatosensory and motor evoked potential monitoring was routine in all cases.

Postoperative analgesia consisted of oral acetaminophen 1 g 6-hourly, and IV patient-controlled analgesia (PCA) with hydromorphone (bolus 0.2–0.4 mg, lockout interval

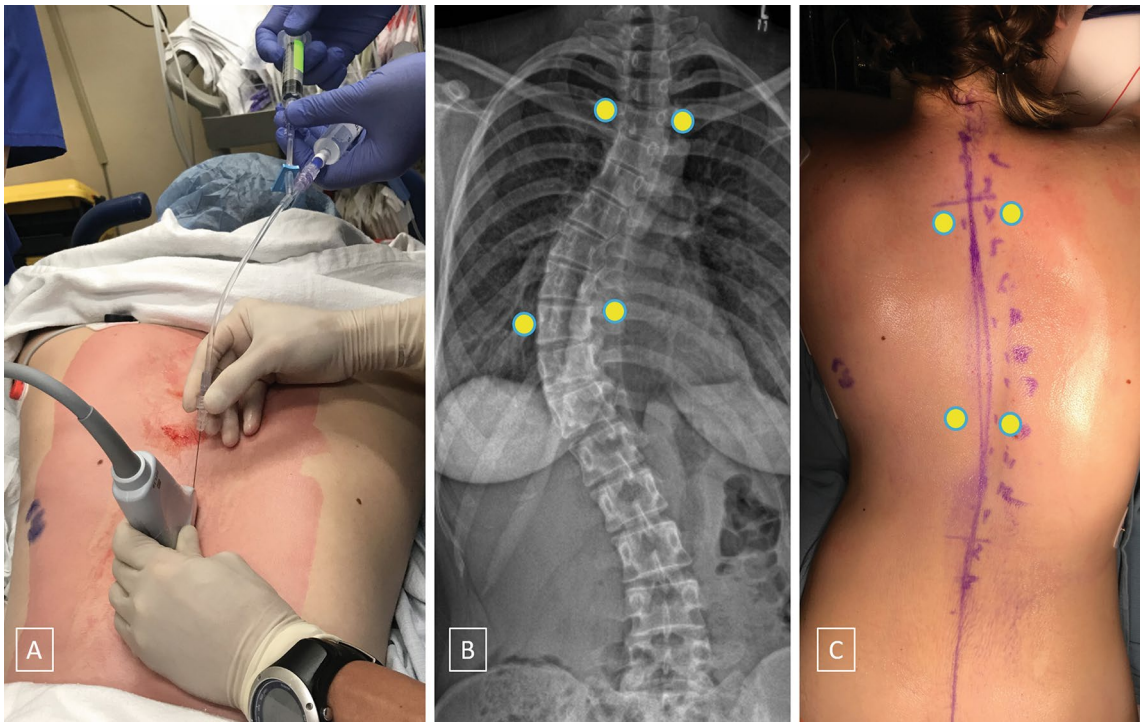

Fig. 2 Preoperative performance of erector spinae plane (ESP) blocks in the second patient of the series (panel A). Bilateral injections at T4 and T10 transverse processes (circles) (panel B) were performed to cover the planned incision (panel C)

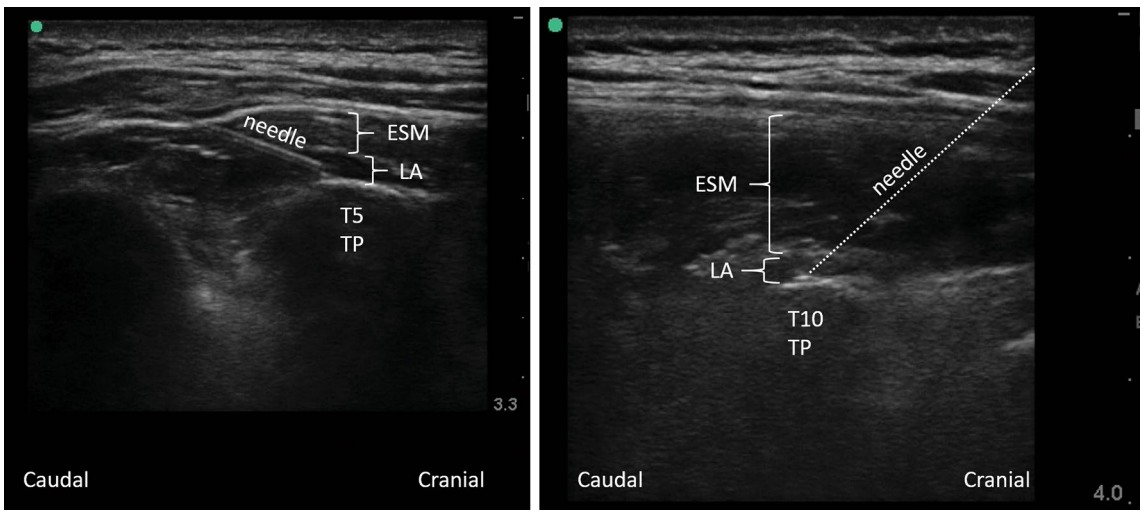

Fig. 3 Ultrasound images of injection at the transverse processes (TP) of T5 and T10 vertebrae in the second patient. Note that the erector spinae muscle (ESM) is significantly thicker and the TP deeper at the T10 level. The needle has to be advanced at a steeper trajectory and is less visible as a result (indicated by dotted line). Nevertheless, local anesthetic (LA) spread is clearly visible as a hypoechoic layer that lifts the ESM off the TP

5 min, no background infusion). Patients were assessed daily by the acute pain service team and IV-PCA was converted to oral opioid therapy when deemed appropriate.

Case 1

A 22-year-old man presented for T2–L1 scoliosis correction and instrumented fusion (Fig. 4a, b). IV midazolam 2 mg was administered for sedation and the ESP blocks

Table 1 Summary of clinical details, opioid consumption, and pain scores

	Case 1	Case 2
Age (years)/gender	22/male	21/female
Weight (kg)	57.0	55.6
Height (cm)	166	172
Surgery	T2–L1 posterior fusion with posterior column osteotomies at T7–8, T8–9, T9–10, T10–11	T3–L2 posterior fusion with posterior column osteotomies at T8–9, T9–10, T10–11
Bilateral ESP blocks at T4 and T10	4 × 20 mL 0.25% bupivacaine + epinephrine 5 mcg/mL	4 × 15 mL 0.25% bupivacaine + epinephrine 5 mcg/mL
Intraoperative medications and analgesic adjuncts	Prior to incision: IV dexamethasone 8 mg + IV hydromorphone 1 mg IV dexmedetomidine loading dose 0.5 mcg/kg, infusion 0.2–0.4 mcg/kg/min IV ketamine loading dose 0.5 mg/kg, infusion 0.5 mg/kg/h IV propofol 80–100 mcg/kg/min Prior to emergence: IV ketorolac 30 mg + IV fentanyl 100 mcg	Prior to incision: PO acetaminophen 1 g + PO celebrex 200 mg + IV dexamethasone 10 mg IV dexmedetomidine loading dose 0.5 mcg/kg, infusion 0.2 mcg/kg/min IV ketamine loading dose 0.5 mg/kg, infusion 0.5 mg/kg/h IV propofol 100–120 mcg/kg/min Prior to emergence: No medications
Opioid consumption (IV hydromorphone milligram equivalents)		
Intraoperative	2.5	0
PACU	0	1
0–24 h	4.4	4.8
24–48 h	3.4	2.0
48–72 h	4.4	4.4
72–96 h	3.2	2.2
96 h +	1.6	NA
Average pain scores at rest/movement (numerical rating scale, 0 = no pain, 10 = worst pain)		
PACU	0/0	0/1
0–24 h	2/2	3/5
24–48 h	2/2	3/8
48–72 h	6/6	5/8
72–96 h	4/6	NA*

IV intravenous, *NA* not available, *PACU* postanesthetic care unit, *PO* oral

*Pain scores not available during this period, but pain was documented in nursing notes as "well-controlled"

performed in the sitting position. General anesthesia was induced with IV fentanyl 150mcg, lidocaine 100 mg, propofol 150 mg, and rocuronium 50 mg. IV dexamethasone 8 mg and hydromorphone 1 mg were administered prior to incision (Table 1). Surgery lasted 5 h and was uneventful with estimated blood loss (EBL) of 1195 mL. Additional intraoperative analgesics included IV ketorolac 30 mg and fentanyl 100mcg administered at completion of wound closure. The patient was extubated awake 105 min after cessation of dexmedetomidine and ketamine and reported no pain in his back. He required no analgesics in the PACU and was able to lift both legs and roll over on his side for wound inspection without discomfort. The first PCA demand occurred 1 h after extubation, and the IV-PCA was discontinued on the morning of postoperative day (POD) 1, with the patient having used IV hydromorphone 4.4 mg over the preceding 15 h. He did not experience any opioid-related side effects. Analgesia was provided by oral acetaminophen 1 g 6-hourly and hydromorphone 2–4 mg 2-hourly as needed until hospital discharge on POD5. Opioid consumption and pain scores are summarized in Table 1.

Case 2

A 21-year-old woman presented for T3–L2 scoliosis correction and instrumented fusion (Fig. 4c, d). Oral acetaminophen 1 g and celebrex 200 mg was administered upon hospital admission. IV midazolam 2 mg was administered for sedation and the ESP blocks performed in the prone position. General anesthesia was induced with IV midazolam 2 mg, propofol 300 mg, lidocaine 100 mg, and rocuronium 40 mg. IV dexamethasone 10 mg was administered prior to incision. Surgery lasted four hours and was uneventful with EBL 1900 mL. No additional intraoperative analgesics were administered. The patient was extubated awake 50 min after cessation of dexmedetomidine and ketamine and reported

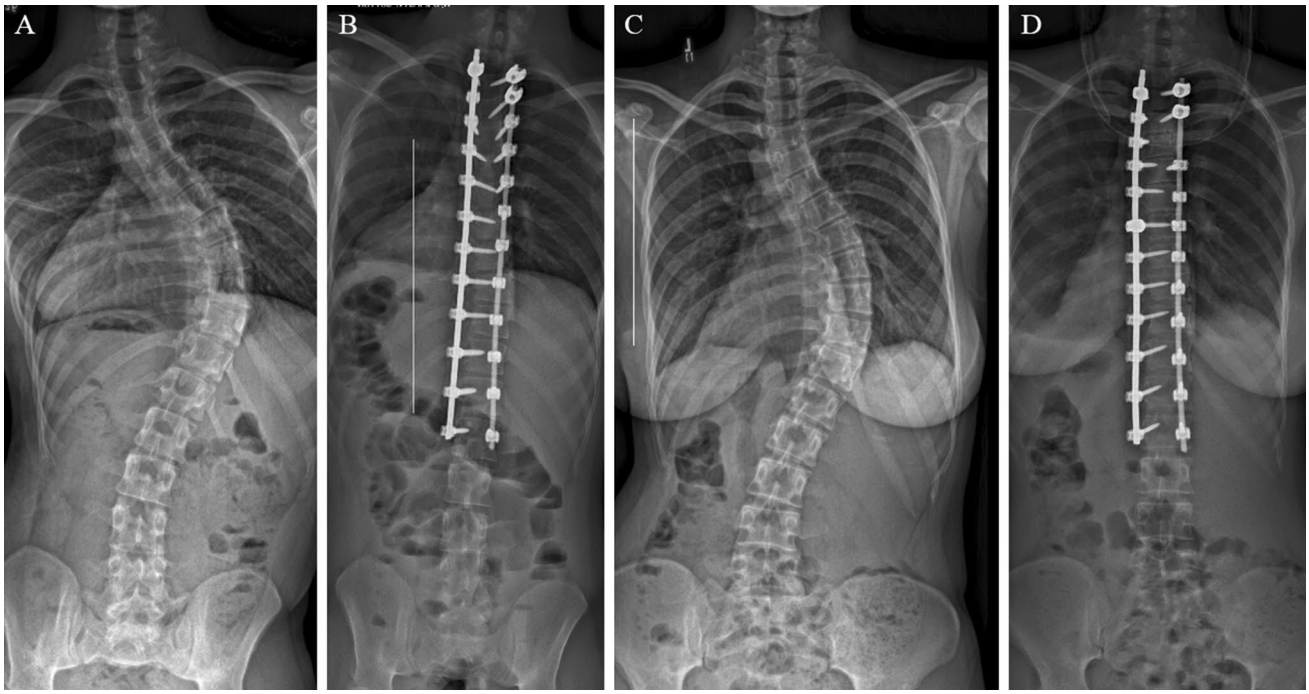

Fig. 4 Preoperative and postoperative anterior–posterior X-rays of the spine in the first (panels A and B) and second (panels C and D) patients

mild pain, for which she received IV hydromorphone 1 mg in PACU. Shortly thereafter, she reported no pain in the back and was able to perform straight-leg raises without discomfort. No further analgesics were administered in PACU and her first PCA demand was initiated 2 h after extubation. The IV-PCA was discontinued on the morning of POD1, with the patient having used IV hydromorphone 4.8 mg over the preceding 18 h. She did not experience any opioid-related side effects. Analgesia was provided by oral acetaminophen 1 g 6-hourly and hydromorphone 2–4 mg 2-hourly as needed until hospital discharge on POD4. Opioid consumption and pain scores are summarized in Table 1.

Discussion

Most patients undergoing posterior spinal fusion for scoliosis correction require IV-PCA opioid for 36 h or more and report moderate-to-severe pain over the first several postoperative days [1, 2]. This brief report suggests that the application of ESP blocks, combined with intraoperative use of multiple non-opioid analgesic modalities, can significantly improve the pain trajectory and reduce opioid consumption.

Intrathecal or epidural opioid injection and surgically-inserted epidural catheters are alternative regional anesthesia strategies; however, they have several significant limitations. The analgesic duration of intrathecal opioid is dose-dependent, limited to 12–24 h, and must be weighed against side effects of pruritus, nausea and vomiting, sedation, and respiratory depression [3, 4]. Epidural opioid is associated with similar adverse effects and may be less effective [4]. Epidural analgesia with local anesthetic infusion is resource-intensive, and concerns include adverse effects of epidural opioids, hypotension, and leg weakness. Analgesia is often incomplete and significant benefits are only seen if two catheters are placed [5, 6]; this is likely due to the extent of surgery and surgical disruption of the epidural space. Local anesthetic wound infiltration at closure is a simple and commonly used option; however, a recent meta-analysis found that the analgesic benefit was modest and not evident beyond the first few postoperative hours [17].

The ESP block, on the other hand, has few adverse effects and provides effective analgesia by blocking the dorsal rami of spinal nerves as they course through the musculofascial plane where local anesthetic is deposited [9–12]. Physical spread over at least 4–6 vertebral levels in the erector spinae plane from a single injection of 20 mL [7, 8, 10, 11, 18] makes coverage of the entire surgical incision in scoliosis surgery feasible with two injections per side. The risk of local anesthetic systemic toxicity is minimized by the addition of epinephrine and by observing recommended maximum bupivacaine dose limits. Unlike surgical wound infiltration, ESP blocks can also be performed prior to incision, which minimizes intraoperative opioid requirements, pain "windup" and central sensitization [19], and contributes to preventive analgesia [20]. Although physical evidence of

epidural and paravertebral spread of local anesthetic has been described with the ESP block [18, 21], there was no interference with evoked potential monitoring which is consistent with other reports [9]. Similarly, hypotension related to local anesthetic-induced sympathectomy has never been reported [22]. The most likely explanation is that the actual mass of local anesthetic reaching the epidural space is insufficient to produce a clinically-detectable effect; nevertheless, this should be a consideration in cases at high risk of intraoperative neurological compromise. We performed the ESP blocks in a dedicated block room primarily to maximize operating room efficiency; however they may also be performed after anesthetic induction and prone positioning. This adds little risk to the procedure, and may be more acceptable in young or highly anxious patients. One caveat to this approach is that there may be insufficient time for complete block onset with the long-acting local anesthetics (bupivacaine or ropivacaine) before surgical incision. In this case, the addition of lidocaine to the local anesthetic mixture may help to speed onset [23].

Preoperative performance mandates the use of single-injection blocks instead of a continuous technique. We elected not to surgically place catheters at wound closure due to uncertainty regarding the adequacy of cranial–caudal spread in the now-disrupted tissue plane, and to minimize the complexity of the postoperative analgesic regimen. Studies in other patient populations indicate that a single-injection ESP block provides effective analgesia for at least 8–12 h [22, 24]. We addressed this limitation of fixed analgesic duration by concomitant use of an intraoperative multimodal regimen incorporating agents that have been individually shown to reduce postoperative pain scores and opioid requirements for up to 48 h. Employing pre-emptive multimodal analgesia has been shown to significantly contribute to improved analgesia in spine surgery [25, 26]; however, the combination of dexamethasone, dexmedetomidine, and ketamine has not previously been reported.

Intravenous dexmedetomidine [27] and dexamethasone [28] both prolong the duration of local anesthetic effect, and they may even be synergistic in this regard [29]. In addition, each drug has a systemic analgesic effect, reducing postoperative pain scores and opioid consumption for 24–48 h [30, 31]. In the case of dexmedetomidine, this is attributed to central effects at alpha-2 receptors in the dorsal horn, as well as anti-inflammatory effects which reduce the stress response to surgery and peripheral sensitization [19, 32]. Further benefit may be gained by substituting it for remifentanil, which has been implicated in exacerbating postoperative pain via opioid-induced hyperalgesia [33]. A reduction in pain scores and opioid requirements for up to 48 h following major spine surgery was observed when dexmedetomidine was used instead of remifentanil [15, 16]. Finally, subanesthetic doses of intraoperative ketamine also reduce postoperative opioid consumption without significant side effects [16, 34], with an analgesic benefit lasting up to 48 h [14]. The higher postoperative opioid consumption and pain scores in our patients in the 48–72-h period compared to the 24–48-h period may reflect offset of these analgesic benefits but also increased physical activity.

In summary, this case report serves as proof of concept for a novel multimodal opioid-sparing analgesic strategy for scoliosis correction surgery. ESP blocks are relatively simple and safe compared to other regional anesthetic techniques in spine surgery, and the multimodal combination of intraoperative pharmacological adjuncts offers additive, and potentially synergistic, benefits. Further research, including randomized controlled trials, is warranted to confirm these preliminary observations, and to investigate whether the strategy will provide similar opioid-sparing analgesia in other types of spine surgery.

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Compliance with ethical standards

Conflicts of interest The authors declare no conflicts of interest.

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