Original Article

High-volume, multilevel local anesthetics–Epinephrine infiltration in kyphoscoliosis surgery: Intra and postoperative analgesia

Alaa Mazy, Mohamed Serry[1], Mohamed Kassem[2]

Anesthesia and Surgical Intensive Care, [1]Orthopedic Surgery and [2]Neurosurgery, Faculty of Medicine, Mansoura University, Egypt

Abstract

Background and Aims: Local anesthetic (LA) infiltration is one of the analgesic techniques employed during scoliosis correction surgery. However, its efficacy is controversial. In the present study for optimizing analgesia using the infiltration technique, we proposed two modifications; first is the preemptive use of high volume infiltration, second is applying three anatomical multilevel infiltrations involving the sensory, motor, and sympathetic innervations consecutively.

Material and Methods: This prospective study involved 48 patients randomized into two groups. After general anesthesia (GA), the infiltration group (I) received bupivacaine 0.5% 2 mg/kg, lidocaine 5 mg/kg, and epinephrine 5 mcg/mL of the total volume (100 mL per 10 cm of the wound length) as a preemptive infiltration at three levels; subcutaneous, intramuscular, and the deep neural paravertebral levels, timed before skin incision, muscular dissection, and instrumentation consecutively. The control group (C) received normal saline in the same manner. Data were compared by Mann-Whitney, Chi-square, and *t*-test as suitable.

Results: Intraoperatively, the LA infiltration reduced fentanyl, atracurium, isoflurane, nitroglycerine, and propofol consumption. Postoperatively, there was a 41% reduction in morphine consumption, longer time to the first analgesic request, lower VAS, early ambulation, and hospital discharge with high-patient satisfaction.

Conclusion: The preemptive, high-volume, multilevel infiltration provided a significant intra and postoperative analgesia in scoliosis surgery.

Keywords: Analgesia, autonomic, bupivacaine, epinephrine, infiltration, pain, paraspinal muscles, scoliosis, spine, tumescent

Introduction

The correction of scoliosis deformities is usually associated with severe pain.[1] Pain is augmented by the peripheral and central sensitization that associates the extensive nature of this surgery.[2] Preemptive, multimodal analgesia is the basis of optimal pain management.[3] Local anesthetics (LA) infiltration is a crucial component of multimodal analgesia.[4]

The most frequently used loco-regional analgesic techniques in spine surgery, namely, intrathecal, epidural, and caudal morphine, wound catheter, or local infiltrations techniques that may be initiated before, during, or after the surgery.[5]

LA infiltration was first applied about 40 years ago in lumbar spine surgery.[6] It was evaluated as a reliable technique for pain relief.[7] However, data revealed inconclusive efficacy.[8] This conflict may arise from the differences in the techniques and drugs. There are three levels of infiltration such as

Address for correspondence: Prof. Alaa Mazy,
Department of Anesthesia and Surgical Intensive Care, Faculty of Medicine, Mansoura University, Egypt.
E-mail: alaa_mazy@yahoo.com

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subcutaneous,[9] muscular,[7] and perineural.[10] Its timing is either pre-incision[11] or postsurgery.[12] In general, the preemptive and deep infiltration techniques offer better analgesia when compared with postsurgical and superficial forms.[13] Different drugs including LA, epinephrine, and adjuvants can be given as a single injection or continuous infusion.[14] Doses and volumes are usually small (10 to 40 mL).[7,15]

Our proposal is that the preemptive sensory, motor, and sympathetic blockade using enough volume of LA, at three anatomical levels consecutively, may provide optimal analgesia for scoliosis surgery.

Material and Methods

This prospective randomized double-blind study was conducted on kyphoscoliosis patients subjected to posterior spinal fusion from 11/2016 to 11/2017, in the age group of 8–18 years, ASA II status, after obtaining approval from the institutional review board (ID: R/17/02/85) and clinical trial registry (ID: PACTR201703002123104).

The exclusion criteria involved patient's or parent's refusal, surgical site infection, amide LA hypersensitivity, severe cardiac, hepatic, respiratory, renal or cognitive impairment, and intensive care admission.

All patients were assessed for history, investigations, and were clinically examined. The consent forms were duly signed by parents after the explanation of the technique, pain scoring, and possible wake-up test.

After the application of the standard monitoring, general anesthesia (GA) was induced by fentanyl 1 mcg/kg, propofol 2 mg/kg, and atracurium 0.5 mg/kg followed by endotracheal intubation. Maintenance of anesthesia was achieved using isoflurane in a 40% oxygen in air and atracurium increments. Tranexamic acid (Kapron ampules® Amoun Pharmaceutical Co. 100 mg/mL) injection at 15 mg/kg intravenously (iv).

The hypertensive and tachycardic episodes were considered when the mean arterial blood pressure (MBP) or heart rate (HR) increases more than 25% of the basal value. It was managed by increasing isoflurane concentration up to 2% and increments of 0.5 mcg/kg fentanyl. Hypertension was controlled by nitroglycerine 0.5–10 mcg/kg/min to a target MBP 55–65 mmHg during dissection. For resistant hypertension and tachycardia add 50 mg increments of propofol, 1 mg propranolol. Hypotension (MBP < 55 mmHg) was managed by discontinuation of nitroglycerine, reducing isoflurane concentration, preload compensation, and ephedrine 6 mg increments. Intraoperative doses of these drugs were further recorded.

The local infiltration cocktail is prepared blindly by an anesthetist not involved in the study as 2 mg/kg plain bupivacaine 0.5%, 5 mg/kg lidocaine, and epinephrine 5 mcg/mL of the total volume. Normal saline was added to a total volume of 100 mL per 10 cm of the wound length. The patients were randomly allocated into two groups using a closed envelop method:

The infiltration group (I): $n = 24$. After GA, marking and measuring the wound length in cm was carried out and the patients received the infiltration in the following sequence:

- Subcutaneous (SC): performed before skin incision in volume 30–40 mL per 10 cm of the wound length by the anesthetist or surgeon.
- Muscular: after the exposure of the thoracolumbar fascia, the intramuscular infiltration in the paramedian plane is performed by the surgeon through the muscle thickness to reach vertebral lamina, using 20 mL per 10 cm of the wound length bilaterally.
- Deep neural paravertebral: after exposure of transverse processes, 5 mL of the same cocktail is injected bilaterally, 1 cm deep to the surface of each corresponding transverse process,[16] after negative blood aspiration, before or after screws fixation.

The control group (C): $n = 24$. Infiltration with the blindly prepared normal saline in the same volume and infiltration technique.

Postoperatively, all patients received a multimodal regimen including 15 mg/kg acetaminophen/6 h orally, 0.5 mg/kg ketorolac iv every 8 h (ketolac ® Amriya, Alexandria, 30 mg/2 mL ampules) and 0.03 mg/kg morphine increments as a rescue analgesic if pain score is ≥4. The total morphine consumption during the first 24 h was the primary outcome. The secondary outcomes were the intraoperative drug consumption, the opioid request episodes, the time to the first analgesic request, the hemodynamics, the time to successful ambulation, hospital stay, and patient satisfaction regards analgesia after 24 h by a score (0–10), where 10 is the best.

Statistically, a preliminary study involved 10 patients considering the postoperative opioid consumption as a primary outcome produced a mean of 9 versus 12 mg, and SD value of 3.2 and 2.9 for the infiltration and control groups respectively. Using the priori G-power analysis, version 3.01 (Franz Faul, Christian-Albrechts-Universität Kiel, Germany), a power of 95% was targeted with a type I error of 0.05 that yielded a total sample size of 46 patients. A total number of 48 patients were enrolled to compensate for the expected drop out of 5% of cases (24 per group).

Data were analyzed by SPSS software version 16 (SPSS, Inc., Chicago, IL, USA). Data were tested for normality using the Shapiro-Wilk statistics. The Mann-Whitney U statistic was applied for nonparametric and Chi-square test for ordinal variables. The parametric data were compared using a *t*-test and displayed as mean and standard deviation. The nonparametric data are displayed in median and range or number and percentage. The significant level is P value ≤0.05.

Results

In this study, 52 patients were included [Figure 1], three were excluded due to postoperative intensive care admission for respiratory care post thoracoplasty. One female (8 years) patient showed postoperative hypoxia (SaO_2 <90% on air) in the recovery room, her diagnosis was bilateral pneumothorax as confirmed by X-ray which was relieved by intercostal tubes that were removed after 2 days. The actual cause was still unclear whether related to paravertebral injection or pleural injury during near rib dissection.

The demographic data were not different between the groups [Table 1].

Intraoperatively; fentanyl, nitroglycerine, propofol, and atracurium drug consumption were lower in I group than C group. Also, the tachycardic episodes and isoflurane utilized concentration was significantly lower in the infiltration group [Table 2 and Figure 2].

The HR and MBP significantly increased during skin incision in the C group but not in I group [Figure 3]. Also, in I group, the MBP was high in relation to the C group with infrequent surgeon complaints.

Postoperatively, I group showed lower total opioid consumption than C group (41% difference between the means of the 2 groups), and less opioid episodes, pain score, ambulation time, hospital stay, with higher patient satisfaction score [Table 3 and Figure 4].

Discussion

The LA infiltration in this study provided significant intra and postoperative analgesia. Many studies displayed effective analgesia following LA infiltration in spine surgery.[9,15,17,18] However, other studies denied these analgesic benefits.[14,15,19] Though, the results are inconclusive.[8] To overcome the controversy we must control the pain sources. Four sources of pain instigate the analgesic challenges in scoliosis surgery; the long cutaneous incisions, the extensive muscular stripping, multilevel vertebral instrumentations, and the neural tractions.[3]

The back innervation has two supplies, namely, somatic and sympathetic:

- The first is segmental somatic from the dorsal rami of spinal nerves along the medial, intermediate, and lateral branches to the dorsal compartment including the skin, muscles, ligaments, and joints.[20]
- The second is the usually overlooked visceral sympathetic innervation. It arises from the sympathetic trunk and the splanchnic nerve through dorsal transverse and superficial oblique rami communicants, and the sinu-vertebral nerves.[21] The sympathetic innervation covers the posterior longitudinal and ventral ligaments, the ventral surface of the dura, the intervertebral discs, vertebral bodies, and epidural vessels.[22] The vertebral bodies are supplied by somatic and sympathetic nerves .[23,24]

According to the anatomical rationale, the infiltration in this study was directed at three levels:

- The first is subcutaneous (SC) infiltration to provide a sensory block of the skin. In our patients, there was no rise of HR or MBP on skin incision in the infiltration group.

Table 1: Demographic and operative data

	Group C	Group I	P
Age (years)	13.8±3.5	14.9±2.1	0.214
Female/male *n* (%)	16/8 (67/33%)	17/7 (71/29%)	0.755
BMI (kg/m²)	27.4±5.7	24.7±3.8	0.076
Operative duration (h)	5:19±1:2*	4:02±1:1	0.001
Fused levels (number)	12.4±1.3	12.8±1.6	0.378
Infiltration volume (mL)	431±46	428±60	0.830

**Significant difference between the groups. Data are in mean±SD or number and percent. BMI=Body mass index. n=24*

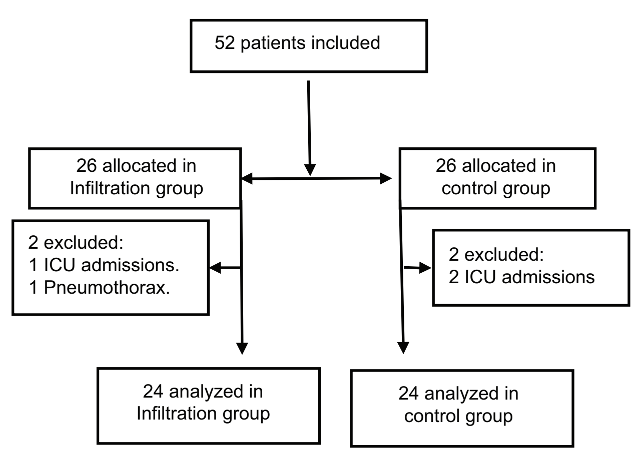

Figure 1: The study flowchart

Table 2: Intraoperative anesthetic requirements

Intraoperative	Group C	Group I	P
Nitroglycerine (mL)	5 (0-12)*	0 (0-4)	0.001
Fentanyl (mcg)	50 (0-200)*	25 (0-60)	0.001
Propofol (mg)	50 (0-100)*	0 (0-50)	0.001
Atracurium (mg)	20 (0-55)*	7.5 (0-40)	0.043
Ephedrine (mg)	0 (0-18)	0 (0-18)	0.714
Propranolol *n* (%)	4 (16.7%)	1 (4.2%)	0.156
Tachycardic episodes	2 (1-5)*	1 (0-3)	0.001
Hypertensive episodes	1.5 (0-3)	1 (0-3)	0.194

**significant difference between the groups. P≤0.05, Data are in median (range), or number (percent)*

Table 3: Data of postoperative analgesia

	Group C	Group I	P
Total morphine consumption in 24 h (mg)	13.20±1.8*	7.75±2.9	0.002
Number of opioid episodes in 24 h	7 (5-8)*	3 (1-7)	0.001
Time to the first request for analgesia (h)	0.35±0.2	2.55±1.3*	0.001
Patient satisfaction score (0-10)	5.4±0.5	6.6±0.8*	0.006
Time to ambulation (h)	26.5±9.1*	13.9±5.8	0.001
Hospital stay (days)	2.98±0.7*	2.40±0.5	0.002

**Significant difference between the groups. P≤0.05, data are in mean±SD, or median (range)*

- The second is the muscular infiltration against reflex muscle spasm.[18] The deep paramedian infiltration may diffuse to the branches of the dorsal rami.[20] In addition, deep muscular infiltration over the laminae implicates the laminar approach proved to spread to the paravertebral spaces.[25]

In this study, we cannot confirm the motor blockade of the paraspinal muscles and the LA spread was not delineated. As an indirect indicator for analgesia at this level, the anesthetic requirements were significantly less in the group I with almost no need for vasodilators to reduce the MBP with favorable hemodynamics.

- The third is the deep neural injection at the paravertebral space, intended not only to block the posterior rami providing sensory and motor supply but also the ventral rami and the sympathetic rami communicants to block the visceral supply and interrupt the efferent sympathetic small myelinated β fibers that exit with the spinal nerves and later synapse in the sympathetic trunk.[26] At this level, we applied the same principles of the paravertebral block but it was easy after exposure of transverse processes. Nevertheless, the sympathetic blockade could not be evaluated which may be considered as a limitation.

The deficient sympathetic blockade and the use of the small volume of LA may explain the previous inconsistent analgesia involved; subcutaneous,[18] muscular,[15] or both

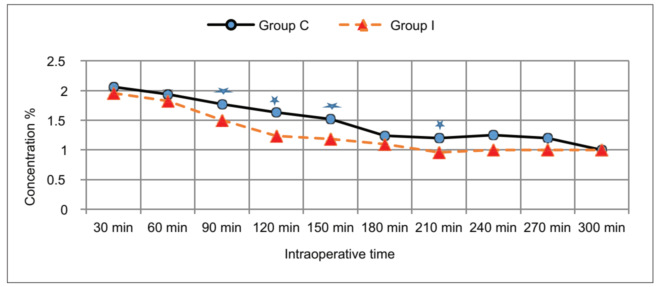

Figure 2: Intraoperative mean isoflurane concentrations in percent. ★ = significant $P \leq 0.05$

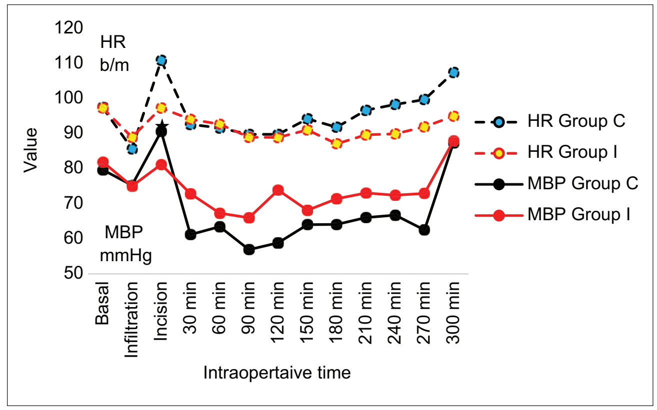

Figure 3: Intraoperative mean heart rate (HR) and mean arterial blood pressure (MBP) changes. ★ = significant P ≤ 0.05

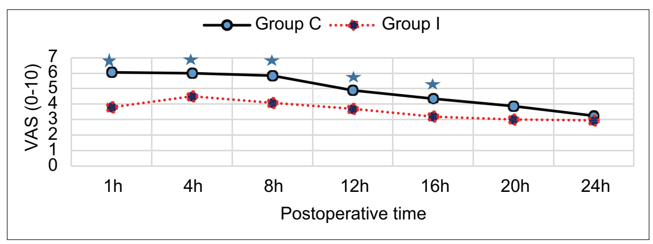

Figure 4: Postoperative visual analog scores (VAS) for 24 h. ★ = significant $P \leq 0.05$

levels.[27] Similarly, the thoracolumbar interfascial plane block confirmed to spread to the dorsal rami only,[28]thereby not targeting the sympathetic blockade at the ventral rami and rami communicants.

Ross *et al.*, in a retrospective study, showed no difference in opioid consumption while using catheters in positions lacking the sympathetic block; the morphine consumption for near implant catheters (16 mg), in the paraspinal muscle (37 mg), and for the subfascial and SC together (18 mg).[29]

In spine surgery, the deep neural blocks are already applied using neuraxial,[30] and the neural sheath block which is promising, as 41% of patients required no analgesia till discharge.[31] However, surgical exposure is required, so it may be suitable for discectomy. Likewise, the epidural and intrathecal administration are effective for analgesia in scoliosis surgery,[30] but the evidence mostly limits its implication to postoperative analgesia, Practically, there is a high rate of epidural failure.[32] Adding LA is usually delayed until an assessment of neurologic function, and some surgeons refuse the placement of catheters in or nearby the surgical field.

In this study, the mean total morphine consumption in 24 h was 41% less in I group than the C group (7.75 vs. 13.2 mg). From a meta-analysis, the mean opioid consumption following intramuscular infiltration ranged from 13–37 mg while in the control from 17–50 mg with a total significant reduction of -9.7 mg in the infiltration group.[17] Yörükoglu *et al*., found similar equivalent requirements of opioids in the control group (13.1 mg morphine) while the intrathecal morphine group required equivalent (10.5 mg) that accounts for a 20% difference from the control. In the epidural group, the consumption was (11.3 mg) with a 14% difference. The infiltration group used equivalent (12.1 mg) accounts for only 7% difference,[33] while the difference in this study was 41%. However, they used the infusion catheter above the thoracolumbar fascia (SC) at the end of the procedure. A possible catheter failure or the nonadequate LA volume spread through the large incision were suggestive of the causes of failure of analgesia.[19]

In spite of the three levels blockade in this study, VAS was 2.4–4.9 with no zero pain score. We may explain that by the low concentration of LA, possible uneven distribution of the infiltration, or the inability to access all the sympathetic fibers, and the single-dose injection. Nevertheless, the bilateral laparoscopic sectioning of the lumber L_1, $_2$ rami communicants relieved the back pain in 22% of patients only with 30–50% reduction of pain suggesting that the sympathetic innervation has a complex collateral network.[34] However, the LA offers neural desensitization, hence effective against chronicity of pain,[14] and prevents hyperalgesia for at least 1 month.[35]

By comparison, epidural and intrathecal morphine for discectomy were more effective than infiltration but only up to 8 h. However, their infiltration was limited to 30 mL before wound closure at the SC level only. Meperidine was still required after intrathecal morphine (105 mg), epidural morphine (113 mg), infiltration bupivacaine (121 mg), and the control (131 mg).[33] The review of Benyahia *et al*., could not determine which of the three techniques; epidural, intrathecal morphine, and local infiltration is preferred.[5] Therefore, there may be no superiority of neuraxial techniques.

To provide adequate analgesia in the extensive spine surgery, high doses of intrathecal morphine (10–20 mcg/kg) are required.[36] So there are increased side effects including the risk of delayed respiratory depression, while many scoliosis patients may already have some respiratory compromise.[37]

In this study, the single injection is a limitation. However, the VAS was lower in I group for 16 h. The analgesia may be extended by the tumescent nature of our infiltration. Tumescence optimizes the local drug efficacy, prolongs its effect, and decreases its toxicity.[38] In addition, we may recommend a second dose infiltration before closure, also, adding adjuvants as dexmedetomidine or dexamethasone to extend the action.

The hemodynamic stability and absence of arrhythmia during infiltration may reflect the safety of this study technique. The plasma concentration of LA was not measured, that may be a limitation, however, the tumescent nature of infiltration may add safety.[38]

A limitation of this technique may be the liability for pneumothorax during the deep thoracic paravertebral injection that can be avoided by shallow injection below the surface of the transverse process, especially in slim patients.

In general, the benefits of LA infiltration comply with the opioid-free anesthesia and the enhanced recovery targets. The ambulation and hospital discharge were earlier in I group (2.4 days). While the time of discharge is often between 4 and 7 days, no difference was found with the epidural time of mobilization when compared with GA in discectomy patients.[39]

Conclusion

The preemptive high-volume multilevel infiltration provided significant intra and postoperative analgesia in scoliosis surgery.

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Conflicts of interest

There are no conflicts of interest.

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