



Unilateral Right-Sided Ultrasound-Guided Erector Spinae Plane Block for Post-Laparoscopic Cholecystectomy Analgesia: A Randomized Control Trial

Poupak Rahimzadeh ¹, Seyed Hamid Reza Faiz ², Sajede Salehi ¹, Farnad Imani ¹, Ariel L. Mueller ³ and A. Sassan Sabouri ^{3,*}

¹Pain Research Center, Department of Anesthesiology and Pain Medicine, Iran University of Medical Sciences, Tehran, Iran

²Minimally Invasive Surgery Research Center, Department of Anesthesiology and Pain Medicine, Iran University of Medical Sciences, Tehran, Iran

³Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA

* Corresponding author: Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA.
Email: asabouri@mgh.harvard.edu

Received 2022 October 01; Revised 2022 November 26; Accepted 2022 November 28.

Abstract

Background: Post-laparoscopic cholecystectomy (LC) pain control is still an issue postoperatively.

Objectives: We investigated the effectiveness of the unilateral right-side ultrasound-guided erector spinae plane block (ESPB) on post-LC pain intensity and opioid consumption.

Methods: This is a parallel-arm randomized control trial on 62 adult patients with an American Society of Anesthesiologists (ASA) physical status ≤ 2 who underwent LC. The patients were randomized into 2 groups (the block group [BG] and the control group [CG]; $n = 31$ per group). BG received a single-shot right-sided T7 ESPB with 20 mL of 0.2% ropivacaine at arrival time in the post-anesthesia care unit (PACU). CG received no regional anesthesia. Both groups received patient-controlled intravenous fentanyl and rescue meperidine for analgesia. The primary outcome was the pain intensity determined using a Numerical Rating Scale (NRS) in the first 24 hours after surgery. Secondary outcomes included total fentanyl and meperidine consumption within 24 hours.

Results: Median pain scores were significantly higher in CG at rest and with coughing up to 12 hours after surgery compared with BG. Pain scores were higher in CG with a cough at 24 hours compared with BG (median 1 [interquartile range (IQR) 1, 2] vs. 1 [1, 0]; $P = 0.0005$). Total fentanyl consumption and meperidine consumption within 24 hours were significantly lower in BG compared with CG (median 60 μg [IQR 60, 90] vs 250 μg [90, 300]; $P < 0.0001$ and median 20 μg [IQR 10, 20] vs 25 [20, 25]; $P = 0.002$, respectively).

Conclusions: A single-shot, right-sided, unilateral ESPB decreases post-LC opioid consumption and pain.

Keywords: Ultrasound-guided, Erector Spinae Plane Block, Laparoscopic Cholecystectomy, Postoperative Pain

1. Background

Although most cholecystectomies are performed using a laparoscopic technique, post-laparoscopic cholecystectomy (LC) pain control is still an issue (1-3). Unlike other laparoscopic procedures, pain after LC can be moderate or even severe for patients and may require opioid treatment (4). Pain after LC alone is the second reason for 30-day hospital readmission after surgical complications (5). Early pain is a prevalent complaint after LC and is often responsible for an overnight stay on the day of admission in 26 - 41% of patients (6-8). Post-LC visceral pain is an independent risk factor for chronic, unexplained pain (9).

Post-LC pain is multifactorial; thus, multimodal analgesia has been suggested for its treatment (1, 10). Visceral pain has been the primary source of postoperative pain in

LC, especially in the first 24 hours (4, 11). The primary source of this pain is believed to be the visceral surgical manipulations during surgery, including clamping the cystic duct and cystic artery and resectioning the gall bladder. Coughing can trigger this pain and increases its intensity (12-15). Somatic or parietal pain in LC is less intense than visceral pain due to the small abdominal incisions (often 1 to 4 cm) of the trocar site and the limited damage to the abdominal wall (16). With more attention to regional anesthesia as part of multimodal analgesia (17), different techniques have been used for post-LC pain control, such as paravertebral block (18-20), rectus sheath block (21), transversus abdominis plane block (22-24), intercostal nerve block (25), subcostal transversus abdominal plane block (STAP) (26), thoracic epidural (27, 28), and erector spinae plane block

(ESPB). Bilateral ESPB has received significant attention as a regional technique for post-LC analgesia. Bilateral ESPB has been compared to STAP with similar or superior analgesia after LC (29-31). Case reports (4, 32, 33) and randomized control trials (34-38) have shown the efficacy of bilateral ESPB for pain control after LC, though the effects of unilateral ESPB have not yet been studied.

The recent finding of abdominal visceral pain control of ESPB (38-40) and bilateral sensory block effects of single unilateral injection by Schwartzmann et al. (41) and Tullgar et al. (42) has raised the question of whether unilateral ESPB can be used for postoperative pain control after LC.

2. Objectives

This study aimed to compare the right-sided unilateral ultrasound-guided ESPB with patients using intravenous narcotic analgesia on the post-LC analgesia consumption and pain in a single-center randomized controlled trial. It was hypothesized that adding right-sided unilateral ESPB after LC would reduce the intensity of pain and opioid consumption and increases the patients' satisfaction with pain control.

3. Methods

The Institutional Ethics Committee of Iran University of Medical Sciences approved the study protocol (code: IR.IUMS.FMD.REC.1397.287). Written informed consent was obtained from all subjects. The study was registered on the Iranian Registry of Clinical Trials website (code: IRCT20120814010599N25).

3.1. Eligibility Criteria

This prospective, single-center, single-blinded parallel arm randomized controlled clinical trial was performed on patients who were candidates for elective LC and referred to a quaternary university-based hospital in Tehran, Iran, between 5 February and 10 October 2020. Patients were included if they were between 20 and 65 years of age with an American Society of Anesthesiologists (ASA) physical status of I or II who were planning to undergo an LC. Patients were excluded if they were undergoing an emergency cholecystectomy, had a body mass index greater than 35 kg/m², had a history of opioid dependence/tolerance, had an allergy to ropivacaine, and had liver or renal disease or coagulopathy. Patients were further excluded intraoperatively if the surgery was converted to an open cholecystectomy or if another problem occurred intraoperatively (eg, uncontrolled intraoperative bleeding).

3.2. Randomization and Blinding

Eligible patients were randomly assigned to 2 groups (the block group [BG] and the control group [CG]). The randomization was generated by an independent statistician at the clinical research development center using a simple random sequence with permuted blocks (<http://www.randomization.com>) of size 4 in a 1:1 allocation. Each patient's assignment was sealed in an opaque, sequentially numbered envelope. The envelope was opened

in the post-anesthesia care unit (PACU) by either of the 2 regional anesthesia study staff members (PH or SHRF) to administer the block (or control). Separately, all individuals assessing outcomes were blinded to group assignment.

3.3. Standards of Care

Patients in both groups were anesthetized per the research protocol in accordance with the institutional standards of care, including intravenous antibiotic prophylaxis according to the hospital's protocol, in which 2 µg/kg of fentanyl and 0.12 mg/kg of midazolam were used as premedication. All patients were monitored by ASA standard monitoring and bispectral index (BIS). Anesthesia was induced using 2 mg/kg of propofol and 0.2 mg/kg of cisatracurium. Total intravenous anesthesia was used, including 100 - 150 µg/kg/min of propofol, 2 mg of cisatracurium (as needed), and 50 mcg of fentanyl every 30 minutes (as needed). End-tidal carbon dioxide was kept between 30 to 35 mm Hg, and BIS was maintained between 40 and 60. Four surgical trocar entry points (measuring between 1 and 5 cm) were used: one at the umbilicus and three in the right upper abdominal quadrant. Also, 4 mg of ondansetron and 1 g of acetaminophen were given in the last 20 minutes intravenously. After evacuating the pneumoperitoneum, cisatracurium was reversed by intravenous neostigmine (0.04 - 0.07 mg/kg) and atropine (7 µg/kg), and the patient was extubated. In both groups, standardized monitoring was applied on arrival at PACU. In addition, patient-controlled intravenous analgesia (PCIA) containing 6 µg/mL of fentanyl with a continuous infusion of 2 mL/h and bolus bottom (2 mL every 15 minutes, as needed) was started for each patient upon arrival to the PACU. At such a low dose, the half-life of fentanyl is very short; therefore, the continuous infusion looks safe, even in narcotic naïve patients. However, the patient did have an option of PCIA of another 12 mcg fentanyl every 15 minutes (lock-out interval) PRN to treat the pain. This makes the maximum dose of 50 µ per hour, which is very routine for PACU pain control, even in narcotic naïve patients.

3.4. Study Interventions

ESPB (43) was performed upon arrival to the PACU for patients in BG by 2 experienced regional anesthesiologists (PR, SHRF). For the ESPB, the patient is positioned on the left lateral with the right side up. The spinous process of the seventh thoracic vertebra (at the level of the lower border of the scapula) was marked. After sterilization, using a high linear frequency (5 - 13 MHz) ultrasound probe (Fujifilm Sonosite S-Nerve, Bothell, WA, USA), the right-sided seventh transverse process (TP) was recognized. Then a 22-gauge 90 mm disposable spinal needle was inserted and arrived at the tip of the seventh TP. A total of 20 mL of 0.2% ropivacaine was injected with increments of 5 mL with negative aspiration each time. The accurate site of the injection point was controlled by detaching the erector spinae muscles from the TP. The success of the ESPB was confirmed by obtaining ultrasound images of the cranio-caudal spread and subsequent multi-dermatomal thermal changes to the cold stimulus that the patient perceived on the right-sided dorsolateral aspect of the mid-thorax.

3.5. Outcomes Assessment

The primary outcome of interest was patient-reported pain intensity using a Numerical Rating Scale (NRS) during rest and voluntary deep coughing. This score resulted in a value from 0 (no pain) to 10 (severe pain) and was assessed by a blinded outcome assessor at 7 different times, including on arrival to the PACU (time 0), as well as at 20 minutes and 2, 4, 6, 12, and 24 hours after admission to the PACU. For each patient with NRS greater than 3, 20 mg of intravenous meperidine was prescribed as rescue analgesia every 3 to 4 hours during the postoperative period for 24 hours, as needed. Meperidine was chosen as a rescue drug because meperidine produces less spasm in the sphincter of Oddi than other opioids due to its atropine-like effects; therefore, meperidine is an appropriate choice for the treatment of biliary tree and pancreatic pain.

The same blinded outcome assessor evaluated the patient's satisfaction with their pain control at each interval and the end of 24 hours using a 5-point satisfaction score (0, weak; 1, moderate; 2, good; 3, very good; 4, excellent) as an exploratory endpoint. Other secondary outcomes included the total opioid consumption used during the first 24 hours after surgery (in mg).

3.6. Sample Size Determination

The sample size determination was based on the previous studies on the effect of the ESPB on post-LC analgesia (36). The study was powered to detect a difference of 2 points in pain with an SD of 0.93 points, assuming a 2-tailed alpha of 0.05 and power of 0.80, which required a sample

size of 62 patients (31 patients in each group). Considering the possibility of a 10% drop, a total of 68 patients were considered for the study.

3.7. Statistical Analysis

Descriptive statistics were reported as mean $\pm$ SD or medians (interquartile ranges [IQR]) for numeric variables based on the data distribution. Normality was assessed using the Shapiro-Wilk test and confirmed by a visual inspection of the data.

Categorical variables were summarized using frequencies and percentages. Univariate analyses were performed using 2 independent sample *t*-tests for normally distributed data, Wilcoxon rank sum tests for non-parametric continuous variables, and chi-square and Fisher exact tests for testing associations of categorical variables. To evaluate pain scores over time between groups, separate generalized linear models (with Gaussian distribution and identity link function) were constructed for pain scores at rest and with coughing. In each model, the patients' study number was included as a random intercept to account for the repeated nature of data collection. Models were constructed with a fixed effect for group assignment and time of pain score collection (20 minutes and 2, 4, 6, 12, or 24 hours); models were conditional on the baseline pain score. The results of these models are presented as mean differences and their associated 95% CI. All statistical analyses were performed using SPSS version 21 (SPSS Inc, Chicago, Ill, USA) and SAS version 9.4 (SAS Institute Inc, Cary, NC). Two-sided *P*-values of less than 0.05 were considered statistically significant for all analyses.

4. Results

Sixty-eight patients undergoing elective LC were enrolled in the study. Six patients were excluded from the study because they converted to open surgery and vessel injury intraoperatively. Thus, a total of 62 patients were randomized postoperatively and included in the analysis of this study (Figure 1). Age, body mass index, ASA status, intraoperative fentanyl usage, and operation time were not statistically different between the 2 groups (Table 1).

4.1. Pain Scores

Pain scores both at rest and during a cough at the time of arrival in the PACU were not statistically different between the 2 groups. Patients in BG had lower pain scores both at rest (mean difference -1.54 points; 95% CI, -1.78 to -1.29; *P* < 0.0001) and during coughing (mean difference -1.51 points; 95% CI, -1.74 to -1.29; *P* < 0.0001) compared with CG. A statistically significant interaction was

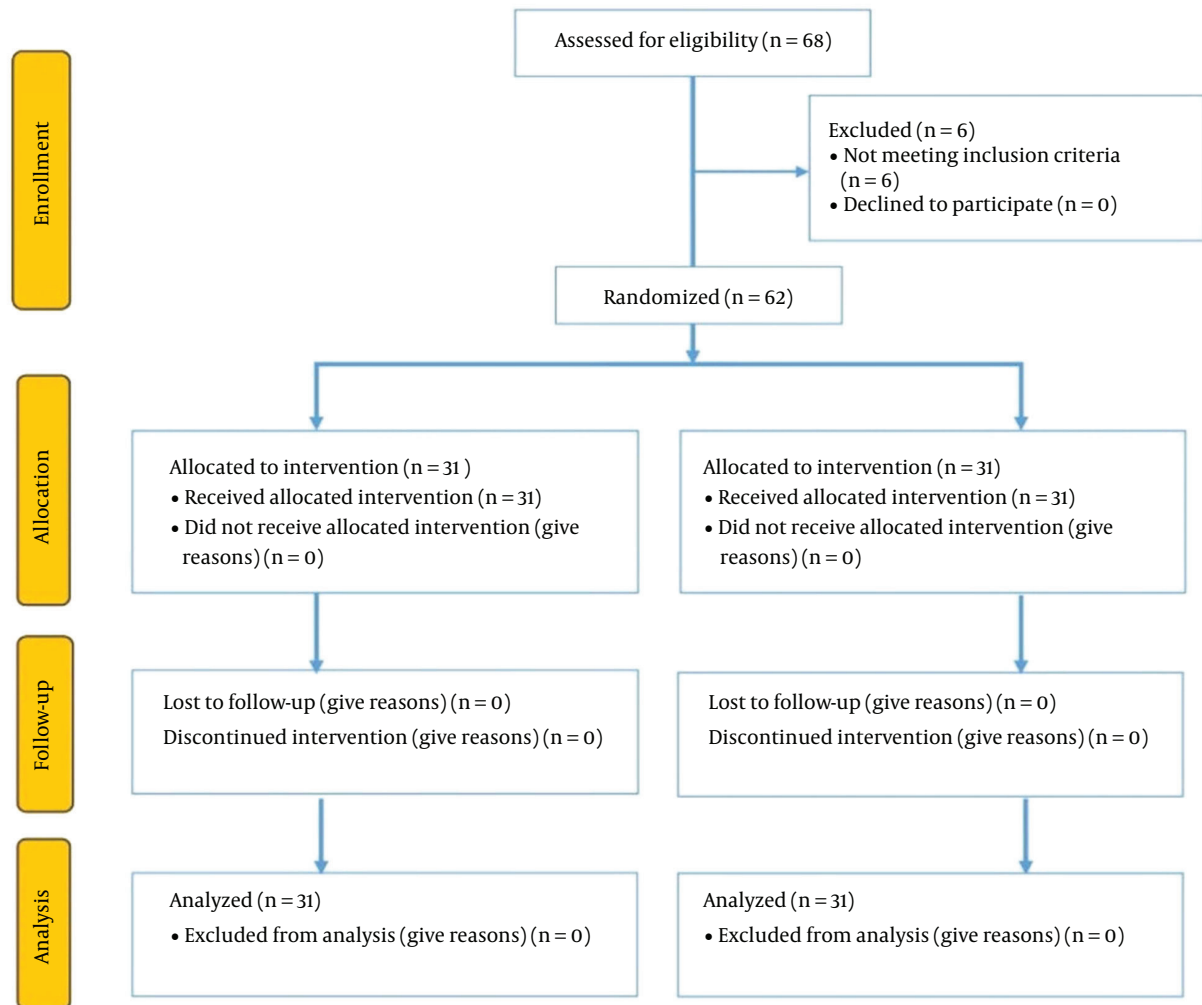


Figure 1. Consolidated Standards of Reporting Trials. Six patients were excluded from the study after converting to open surgery. A total of 62 patients were included in the analysis of this study, including 31 in each study arm. No subjects were lost to follow-up.

observed, such that this association varied by time ($P < 0.0001$ for at rest and with cough models; [Figure 2](#)). Specifically, differences were observed up to 12 hours postoperatively. That is, in the first 12 hours after arrival to the PACU, a difference in median (IQR) NRS pain scores was observed at rest (BG 1 [0, 1] vs CG 1 [1, 2]) and with coughing (BG 1 [1, 2] vs CG 2 [2, 3]) in BG vs CG, respectively (both $P < 0.0001$). At 24 hours, pain intensity with cough was slightly higher in CG (median 1 [IQR 1, 2] vs 1 [1, 0]; $P = 0.0005$) than in BG; however, no statistically significant difference was observed at rest (BG 0 [0, 0] vs CG 0 [0, 1]; $P = 0.12$). In BG, 71.0% of patients had NRS pain scores less than 4 at 20 minutes after surgery, and by 6 hours, 87.1% of patients in BG had pain scores below 2. In CG, no patients (0%) had NRS pain scores

less than 4 at 20 minutes after surgery, and only 1 patient (3.2%) had a pain score below 2 at the 6-hour time point.

4.2. Opioid Consumption and Other Secondary Outcomes

At 24 hours, the total opioid (fentanyl) consumption was significantly reduced in BG than in CG (median 60 μg [IQR 60, 90] vs 250 μg [90, 300]; $P < 0.0001$; [Table 2](#)). Overall, 77.4% of patients in BG consumed less than 100 μg of fentanyl, while 78.0% of patients in CG required more than 100 μg of fentanyl. Of note, no patient in BG required more than 300 μg of fentanyl. In contrast, 22.6% of patients in CG required PCIA to be recharged because they required more than 300 μg of fentanyl in the first 24 hours postoperatively. Further, the time to first analgesia request was

Table 1. Patient and Surgical Characteristics ^a

	Block Group (n = 31)	Control Group (n = 31)	P-Value
Patient characteristics			
Age, y	45.6 ± 12.4	40.9 ± 9.5	0.10
Sex (female)	25 (80.65)	26 (83.87)	0.74
Weight, kg	70 (67, 76)	70 (60, 80)	0.48
Height, cm	162 (160, 169)	160 (158, 165)	0.12
Body mass index, kg/m ²	26.3 (25.4, 27.8)	25.4 (24.0, 30.5)	0.78
ASA physical status I (%)	22 (70.97)	22 (70.97)	> 0.99
Surgical characteristics			
Operation time, min	115 (80, 140)	120 (80, 120)	0.67

Abbreviation: ASA, American Society of Anesthesiologists.

^a Data are reported as mean ± SD, median (interquartile range) or n (%) depending on the variable type and distribution.

significantly faster in CG than in BG (median 10 minutes [IQR 10, 20] vs 80 [55, 110]; $P = 0.0002$; [Figure 3](#)). The mean meperidine dose administered as rescue analgesia in the first 24 hours after surgery was also significantly lower in BG than in CG (median 20 [IQR 10, 20] vs 25 [20, 25]; $P = 0.002$).

After PACU arrival, differences in patient satisfaction were observed 24 hours postoperatively. Patients in BG reported higher overall satisfaction with their pain control, reporting median scores of “very good” compared with CG. The median satisfaction score in BG was 3 (IQR 3, 4) compared to 3 (IQR 3, 3) in CG ($P = 0.0002$). In BG, 83.9% of patients achieved “good” satisfaction (score of 2 or higher) at 20 minutes, whereas no one in CG achieved this metric within the first 20 minutes of PACU arrival. By 6 hours, 96.8% of patients in BG achieved “good” or better satisfaction (6.5% excellent, 80.7% very good, and 9.7% good), whereas only 67.7% of the CG achieved “good” satisfaction (3.2% very good and 64.5% good).

4.3. Safety and Adverse Events

Only 1 patient (3.2%) in BG and 3 in CG (9.7%) suffered from nausea, of which 2 patients in CG needed treatment. Two patients (1 in each group) experienced shoulder pain. No vomiting was recorded. However, all patients reported comfort throughout the procedure and did not experience any side effects determined to be directly related to the ESPB.

5. Discussion

This study suggests that ESPB is an effective analgesic strategy that is easy to perform, especially in the outpatient setting ([44-47](#)).

The results of this study are consistent with prior data and support the efficacy of ESPB for visceral pain control. For instance, in a case series, Chin et al. showed that ESPB could effectively block the visceral pain associated with bariatric surgeries ([40](#)); Also, other studies on the effect of ESPB on post-LC ([4, 32-37](#)) proved the fact that most of the source of the post-LC pain has a visceral origin ([12](#)). However, all studies on ESPB for post-LC analgesia have used a bilateral approach ([4, 32-37](#)). To the best of our knowledge, this is the first report of the proven efficacy of unilateral ESPB for post-LC pain control in a content of a randomized control trial with a larger sample size.

The mechanism of somatic and visceral analgesia of ESPB has been a central focus of research in this field. There are multiple human cadaveric studies with considerable discrepancies among the results ([48](#)). The number of cadaveric investigations of the spread of stained local anesthetic to neural foramina, paravertebral, and/or epidural space ([49-51](#)) is almost equal to those which failed to show that ([52-54](#)). Although ESPB has been performed unilaterally in these cadaveric studies, spread to the contralateral side of injection has not been reported. Meanwhile, a growing body of evidence supports or rejects if the truncal fascia plan block, including ESPB, can be used as a regional anesthesia modality to control visceral pain ([55](#)).

A case report of 3D computed tomography scan images on patients with T5 ESPB demonstrated the spread of the contrast to costotransverse foramen at the level of the T6-T0. Thus, costotransverse foramen could be the possible gate of the reach of local anesthetics during ESPB to more ventral neural structures ([56](#)). Using magnetic resonance imaging of the spine and injection of the 30 mL of the mixture of local anesthetic and gadolinium contrast at T10, Schwartzmann et al. showed circumferential T5 to T12 epidural and paravertebral spread through the left T5 to

Table 2. Study Outcomes and Postoperative Data ^a

	Block Group (n = 31)	Control Group (n = 31)	P-Value
24-Hour opioid consumption, mg	60 (60, 90)	250 (90, 300)	< 0.0001
Time to first request, min	80 (55, 110)	10 (10, 20)	0.0002
24-Hour meperidine dose, mg	20 (10, 20)	25 (20, 25)	0.002
Pain scores at rest			
PACU arrival (time 0)	6 (6, 6)	6 (6, 6)	0.82
20 min	3 (3, 4)	6 (6, 6)	< 0.0001
2 h	2 (2, 2)	5 (4, 5)	< 0.0001
4 h	2 (1, 2)	4 (3, 4)	< 0.0001
6 h	1 (1, 1)	2 (2, 3)	< 0.0001
12 h	1 (0, 1)	1 (1, 2)	< 0.0001
24 h	0 (0, 0)	0 (0, 1)	0.12
Pain scores during cough			
PACU arrival (time 0)	7 (7, 7)	7 (7, 7)	0.54
20 min	5 (4, 5)	6 (6, 7)	< 0.0001
2 h	4 (3, 4)	6 (5, 6)	< 0.0001
4 h	3 (2, 3)	5 (4, 5)	< 0.0001
6 h	2 (2, 2)	4 (3, 4)	< 0.0001
12 h	1 (1, 2)	2 (2, 3)	< 0.0001
24 h	1 (0, 1)	1 (1, 2)	0.0005
Satisfaction scores			
PACU arrival (time 0)	0 (0, 0)	0 (0, 0)	0.17
20 min	2 (2, 2)	0 (0, 0)	< 0.0001
2 h	2 (2, 3)	1 (1, 1)	< 0.0001
4 h	3 (2, 3)	1 (1, 1)	< 0.0001
6 h	3 (3, 3)	2 (1, 2)	< 0.0001
12 h	3 (3, 3)	2 (2, 3)	< 0.0001
24 h	3 (3, 4)	3 (3, 3)	0.0002

Abbreviation: PACU, post-anesthesia care unit.

^a Data are reported as mean $\pm$ SD, median (interquartile range) or n (%) depending on the variable type and distribution.

T12 intervertebral foramina after a T10 left-sided ESPB (41). This finding may explain the bilateral sensory changes that Tulgar et al. mentioned (42). These results, along with studies on the spread to ventral rami of the intercostal nerves in the paravertebral space (14), rami communicants, and sympathetic chain (57), may explain the visceral pathway blockade (at the intervertebral foramen where the greater and lesser splanchnic nerves merge) and the bilateral multiple spinal segmental blockades through the circumferential epidural spread.

Mechanisms of the bilateral sensory changes after a unilateral single injection of ESPB are also most likely related to the spread to the epidural space and the contralat-

eral sensory block.

However, a possible alternative explanation for this observation might be the contralateral passage through the interspinous ligament as observed with the retrolaminar block (58), especially if the injection is closer to the lamina than the tip of the TP.

Many postulating factors that can result in a bilateral spread after unilateral block include the volume and concentration of the local anesthetics, injection closer to the lamina (resulting in retrolaminar spread), and the structural variations of the patient's erector spinae muscles and fascia planes. In addition, the type of surgery and patient positioning may contribute to the spread to the con-

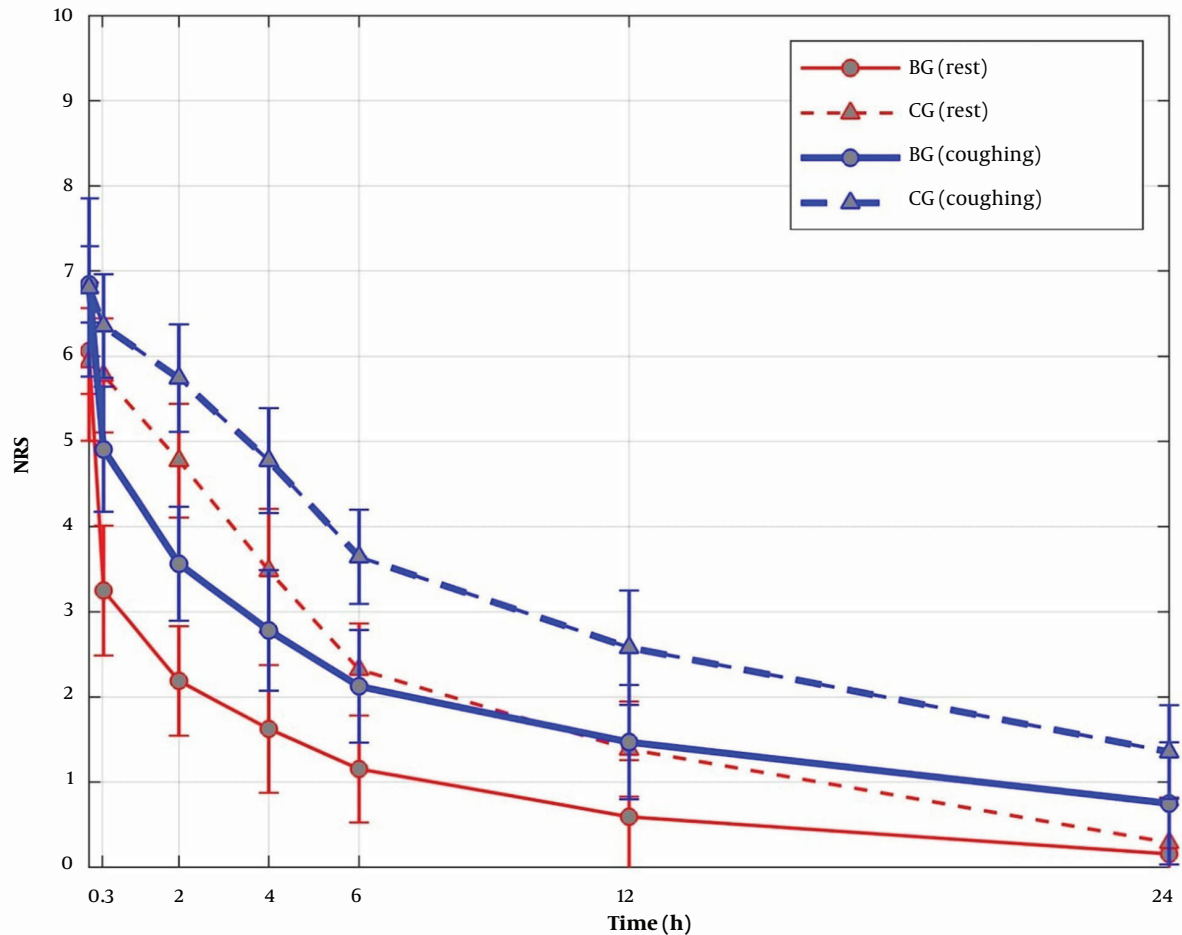


Figure 2. Pain scores from arrival to the post-anesthesia care unit (time0) to 24 hours post-surgery in the block group and control group. The pain was assessed using a Numerical Rating Scale.

tralateral side. More anatomical and radiological studies may thus be needed to explain the bilateral sensorial block caused by unilateral ESPB.

It is essential to emphasize that innervation of the intra-abdominal viscera is complex and involves bilateral sympathetic and parasympathetic nervous systems. Innervation of the gallbladder and liver involves celiac ganglion, superior mesenteric ganglion, prevertebral, and paravertebral ganglia using greater and lesser splanchnic nerves, as well as white rami communicants to the dorsal root ganglion and the spinal cord. A blockade on this pathway is the key to providing visceral analgesia for a successful ESPB, either unilateral or bilateral. More studies on live subjects may reveal the site of action of ESPB on the visceral track (59, 60). In this study, we were able to leverage ropivacaine use with lower cardiotoxicity. It should be noted that performing unilateral ESPB will reduce the time of the block,

reduce the total amount of local anesthetic dosage and the risk of toxicity, and have a similar analgesic efficacy as bilateral ESPB for post-LC pain control. Postoperative analgesia at rest and during cough extended up to 24 hours, which may indicate the duration of ESPB in this group of patients.

However, more studies are needed to fully elucidate this result.

Our study has its limitations. This research study occurred at a single center with a small sample size. Though we found a difference, it is possible that this may not be generalizable to other hospital settings or institutions. This research was also single-blinded, and patients in CG did not get a sham block. Therefore, patients in BG might report less pain because of the awareness of ESPB. However, the difference in narcotic usage, either as PCIA or rescue meperidine, was so significant, indicating that blinding alone may not explain this difference. Performing a

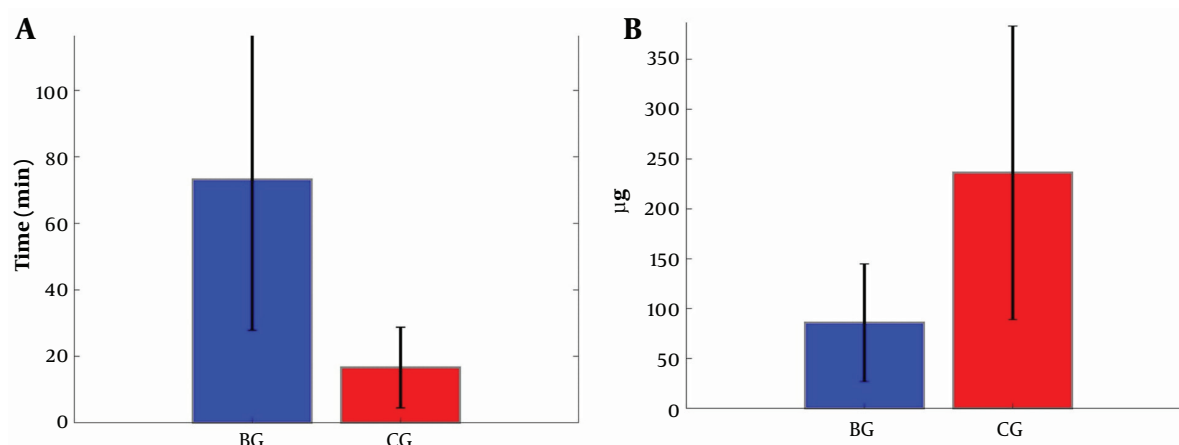


Figure 3. Postoperative opioid consumption. (A) Time to first analgesia (meperidine) was significantly lower in the block group than in the control group ($P = 0.0002$). (B) The fentanyl dose consumption in the first 24 hours postoperatively was statistically higher in the control group ($P < 0.0001$) than in the block group. Abbreviations: BG, block group; CG, control group.

double-blinded cross-over randomized control trial may overcome some of these limitations. Our pain measurements were limited to the first 24 hours post-PACU. It is possible that some shoulder pain associated with LC may have been missed, as it is more prominent after 24 hours. The long-term effect of having or not having ESPB in LC was not considered in this study. Non-steroidal anti-inflammatory drugs were not part of the multimodal analgesia in this study, as it was not a standard of care in that facility. Of note, however, if we had applied a conservative post hoc test (eg, Bonferroni adjustment with $\alpha = 0.05/14$ [7 assessments of pain at rest and 7 with cough] = 0.004), our associations would retain significance; therefore, we believe that these interpretations are robust. Finally, we did not assess the impact of the unilateral ESPB on gastrointestinal function, discharge, or overall cost of care. More studies are needed to confirm these outcomes. A preoperative block might also reduce or eliminate intraoperative narcotic usage, another indicator of a successful block.

5.1. Conclusions

Performing right-sided unilateral ESPB at the level of T7 is effective pain management for post-LC. It reduces acute postoperative pain and the need for narcotic analgesia and may improve patient satisfaction.

5.2. What Is Known

- Post-LC pain is multifactorial; thus, multimodal analgesia has been suggested for its treatment.
- Visceral pain has been the primary source of postoperative pain in LC, especially in the first 24 hours.

5.3. What Is New

- Performing right-sided unilateral ESPB at the level of T7 is effective pain management for post-LC.
- Right-sided unilateral ESPB at the level of T7 reduces the acute postoperative pain and the need for narcotic analgesia and may improve patient satisfaction.

Acknowledgments

We thank all the patients and investigators who participated in this study and other members of the research team and referral centers for their efforts. The authors also wish to thank Rasool Akram Medical Complex Clinical Research Development Center (RCRDC) for its editorial assistance.

Footnotes

Authors' Contribution: PR, SHRF, and SS substantially contributed to the conception of the design of the manuscript. FI, ALM, and ASS contributed to the acquisition, analysis, and interpretation of the data. ALM, PR, and SHRF revised the manuscript critically. All authors have participated in drafting the manuscript. All authors read and approved the final version of the manuscript.

Clinical Trial Registration Code: The study was registered on the Iranian Registry of Clinical Trials website (code: IRCT20120814010599N25).

Conflict of Interests: Professors FI, PR and SHRF are members of Board of Trustees of the journal and they have no

financial interests related to this study. The other authors have no conflict of interest to declare.

Data Reproducibility: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: The Institutional Ethics Committee of Iran University of Medical Sciences approved the study protocol (code: IR.IUMS.FMD.REC.1397.287).

Funding/Support: The authors did not receive any funding support for this study.

Informed Consent: Written informed consent was obtained from all subjects.

References

- Barazanchi AWH, MacFater WS, Rahiri JL, Tutone S, Hill AG, Joshi GP, et al. Evidence-based management of pain after laparoscopic cholecystectomy: a PROSPECT review update. *Br J Anaesth*. 2018;**121**(4):787-803. [PubMed ID: 30236241]. <https://doi.org/10.1016/j.bja.2018.06.023>.
- Wills VL, Hunt DR. Pain after laparoscopic cholecystectomy. *Br J Surg*. 2000;**87**(3):273-84. [PubMed ID: 10718794]. <https://doi.org/10.1046/j.1365-2168.2000.01374.x>.
- Bisgaard T, Kehlet H, Rosenberg J. Pain and convalescence after laparoscopic cholecystectomy. *Eur J Surg*. 2001;**167**(2):84-96. [PubMed ID: 11266262]. <https://doi.org/10.1080/110241501750070510>.
- Hannig KE, Jessen C, Soni UK, Borghlum J, Bendtsen TF. Erector Spinae Plane Block for Elective Laparoscopic Cholecystectomy in the Ambulatory Surgical Setting. *Case Rep Anesthesiol*. 2018;**2018**:1-6. [PubMed ID: 29805812]. [PubMed Central ID: PMC5899876]. <https://doi.org/10.1155/2018/5492527>.
- Rosero EB, Joshi GP. Hospital readmission after ambulatory laparoscopic cholecystectomy: incidence and predictors. *J Surg Res*. 2017;**219**:108-15. [PubMed ID: 29078868]. <https://doi.org/10.1016/j.jss.2017.05.071>.
- Callesen T, Klarskov B, Mogensen TS, Kehlet H. [Outpatient Laparoscopic Cholecystectomy: Feasibility and Recovery]. *Ugeskr Laeg*. 1998;**160**(14):2095-100. Danish.
- Fiorillo MA, Davidson PG, Fiorillo M, D'Anna JJ, Sithian N, Silich RJ. 149 ambulatory laparoscopic cholecystectomies. *Surg Endosc*. 1996;**10**(1):52-6. [PubMed ID: 8711607]. <https://doi.org/10.1007/s004649910013>.
- Tuckey JP, Morris GN, Peden CJ, Tate JJ. Feasibility of day case laparoscopic cholecystectomy in unselected patients. *Anaesthesia*. 1996;**51**(10):965-8. [PubMed ID: 8984874]. <https://doi.org/10.1111/j.1365-2044.1996.tb14967.x>.
- Blichfeldt-Eckhardt MR, Ording H, Andersen C, Licht PB, Toft P. Early visceral pain predicts chronic pain after laparoscopic cholecystectomy. *Pain*. 2014;**155**(11):2400-7. [PubMed ID: 25250720]. <https://doi.org/10.1016/j.pain.2014.09.019>.
- Bisgaard T. Analgesic treatment after laparoscopic cholecystectomy: a critical assessment of the evidence. *Anesthesiology*. 2006;**104**(4):835-46. [PubMed ID: 16571981]. <https://doi.org/10.1097/00000542-200604000-00030>.
- Singla S, Mittal G, Mittal RK, Raghav. Pain management after laparoscopic cholecystectomy-a randomized prospective trial of low pressure and standard pressure pneumoperitoneum. *J Clin Diagn Res*. 2014;**8**(2):92-4. [PubMed ID: 24701492]. [PubMed Central ID: PMC3972609]. <https://doi.org/10.7860/JCDR/2014/7782.4017>.
- Joris J, Thiry E, Paris P, Weerts J, Lamy M. Pain after laparoscopic cholecystectomy: characteristics and effect of intraperitoneal bupivacaine. *Anesth Analg*. 1995;**81**(2):379-84. [PubMed ID: 7618731]. <https://doi.org/10.1097/00000539-199508000-00029>.
- Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia*. 2017;**72**(4):452-60. [PubMed ID: 28188621]. <https://doi.org/10.1111/anae.13814>.
- Ueshima H, Hiroshi O. Retracted: Spread of local anesthetic solution in the erector spinae plane block. *J Clin Anesth*. 2018;**45**:23. [PubMed ID: 29258057]. <https://doi.org/10.1016/j.jclinane.2017.12.007>.
- Mitra S, Khandelwal P, Roberts K, Kumar S, Vadivelu N. Pain relief in laparoscopic cholecystectomy-a review of the current options. *Pain Pract*. 2012;**12**(6):485-96. [PubMed ID: 22008277]. <https://doi.org/10.1111/j.1533-2500.2011.00513.x>.
- Wang Q, Huang L, Zeng W, Chen L, Zhao X. Assessment of Port-Specific Pain After Gynecological Laparoscopy: A Prospective Cohort Clinical Trial. *J Laparoendosc Adv Surg Tech A*. 2017;**27**(6):597-604. [PubMed ID: 27935740]. <https://doi.org/10.1089/lap.2016.0340>.
- Chou R, Gordon DB, de Leon-Casasola OA, Rosenberg JM, Bickler S, Brennan T, et al. Management of Postoperative Pain: A Clinical Practice Guideline From the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. *J Pain*. 2016;**17**(2):131-57. [PubMed ID: 26827847]. <https://doi.org/10.1016/j.jpain.2015.12.008>.
- Visoiu M, Cassara A, Yang CI. Bilateral Paravertebral Blockade (T7-10) Versus Incisional Local Anesthetic Administration for Pediatric Laparoscopic Cholecystectomy: A Prospective, Randomized Clinical Study. *Anesth Analg*. 2015;**120**(5):1106-13. [PubMed ID: 25427288]. <https://doi.org/10.1213/ANE.0000000000000545>.
- Agarwal A, Batra RK, Chhabra A, Subramaniam R, Misra MC. The evaluation of efficacy and safety of paravertebral block for perioperative analgesia in patients undergoing laparoscopic cholecystectomy. *Saudi J Anaesth*. 2012;**6**(4):344-9. [PubMed ID: 23493523]. [PubMed Central ID: PMC3591552]. <https://doi.org/10.4103/1658-354X.105860>.
- Naja MZ, Ziade MF, Lonnqvist PA. General anaesthesia combined with bilateral paravertebral blockade (T5-6) vs. general anaesthesia for laparoscopic cholecystectomy: a prospective, randomized clinical trial. *Eur J Anaesthesiol*. 2004;**21**(6):489-95. [PubMed ID: 15248630]. <https://doi.org/10.1017/s026502150400612x>.
- Jeong HW, Kim CS, Choi KT, Jeong SM, Kim DH, Lee JH. Preoperative versus Postoperative Rectus Sheath Block for Acute Postoperative Pain Relief after Laparoscopic Cholecystectomy: A Randomized Controlled Study. *J Clin Med*. 2019;**8**(7). [PubMed ID: 31336767]. [PubMed Central ID: PMC6679218]. <https://doi.org/10.3390/jcm8071018>.
- El-Dawlaty AA, Turkistani A, Kettner SC, Machata AM, Delvi MB, Thallaj A, et al. Ultrasound-guided transversus abdominis plane block: description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy. *Br J Anaesth*. 2009;**102**(6):763-7. [PubMed ID: 19376789]. <https://doi.org/10.1093/bja/aep067>.
- Ra YS, Kim CH, Lee GY, Han JI. The analgesic effect of the ultrasound-guided transverse abdominis plane block after laparoscopic cholecystectomy. *Korean J Anesthesiol*. 2010;**58**(4):362-8. [PubMed ID: 20508793]. [PubMed Central ID: PMC2876857]. <https://doi.org/10.4097/kjae.2010.58.4.362>.
- Petersen PL, Stjernholm P, Kristiansen VB, Torup H, Hansen EG, Mitchell AU, et al. The beneficial effect of transversus abdominis plane block after laparoscopic cholecystectomy in day-case surgery: a randomized clinical trial. *Anesth Analg*. 2012;**115**(3):527-33. [PubMed ID: 22763903]. <https://doi.org/10.1213/ANE.0b013e318261f16e>.
- Fernandez Martin MT, Lopez Alvarez S, Mozo Herrera G, Platero Burgos JJ. [Ultrasound-guided cutaneous intercostal branches nerves block: A good analgesic alternative for gallbladder open surgery]. *Rev Esp Anesthesiol Reanim*. 2015;**62**(10):580-4. [PubMed ID: 25896736]. <https://doi.org/10.1016/j.redar.2015.02.011>.

26. Chen CK, Tan PC, Phui VE, Teo SC. A comparison of analgesic efficacy between oblique subcostal transversus abdominis plane block and intravenous morphine for laparoscopic cholecystectomy. A prospective randomized controlled trial. *Korean J Anesthesiol.* 2013;**64**(6):511-6. [PubMed ID: 23814651]. [PubMed Central ID: PMC3695248]. <https://doi.org/10.4097/kjae.2013.64.6.511>.
27. Erol DD, Yilmaz S, Polat C, Arıkan Y. Efficacy of thoracic epidural analgesia for laparoscopic cholecystectomy. *Adv Ther.* 2008;**25**(1):45-52. [PubMed ID: 18227981]. <https://doi.org/10.1007/s12325-008-0005-2>.
28. Luchetti M, Palomba R, Sica G, Massa G, Tufano R. Effectiveness and safety of combined epidural and general anesthesia for laparoscopic cholecystectomy. *Reg Anesth.* 1996;**21**(5):465-9. [PubMed ID: 8896010].
29. Altıparmak B, Korkmaz Tokar M, Uysal AI, Kusu Y, Gumus Demirebilek S. Ultrasound-guided erector spinae plane block versus oblique subcostal transversus abdominis plane block for postoperative analgesia of adult patients undergoing laparoscopic cholecystectomy: Randomized, controlled trial. *J Clin Anesth.* 2019;**57**:31-6. [PubMed ID: 30851501]. <https://doi.org/10.1016/j.jclinane.2019.03.012>.
30. Tulgar S, Kapaklı MS, Kose HC, Senturk O, Selvi O, Serifsoy TE, et al. Evaluation of Ultrasound-Guided Erector Spinae Plane Block and Oblique Subcostal Transversus Abdominis Plane Block in Laparoscopic Cholecystectomy: Randomized, Controlled, Prospective Study. *Anesth Essays Res.* 2019;**13**(1):50-6. [PubMed ID: 31031480]. [PubMed Central ID: PMC6444941]. https://doi.org/10.4103/aer.AER_194_18.
31. Ibrahim M. Erector Spinae Plane Block in Laparoscopic Cholecystectomy, Is There a Difference? A Randomized Controlled Trial. *Anesth Essays Res.* 2020;**14**(1):119-26. [PubMed ID: 32843804]. [PubMed Central ID: PMC7428093]. https://doi.org/10.4103/aer.AER_144_19.
32. Baran O, Kir B, Şahin A, Arar C. Erector spinae plane block in laparoscopic cholecystectomy: a case report. *Ain Shams J Anesthesiol.* 2020;**12**(1):1-4. <https://doi.org/10.1186/s42077-020-0053-7>.
33. Petsas D, Pogiatzi V, Galatidis T, Drogouti M, Sofianou I, Michail A, et al. Erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: a case report. *J Pain Res.* 2018;**11**:1983-90. [PubMed ID: 30288093]. [PubMed Central ID: PMC6163005]. <https://doi.org/10.2147/JPR.S164489>.
34. Altıparmak B, Tokar MK, Uysal AI, Kusu Y, Demirebilek SG. [Efficacy of ultrasound-guided erector spinae plane block for analgesia after laparoscopic cholecystectomy: a randomized controlled trial]. *Braz J Anesthesiol.* 2019;**69**(6):561-8. [PubMed ID: 31822353]. [PubMed Central ID: PMC9621114]. <https://doi.org/10.1016/j.bjan.2019.09.001>.
35. Aksu C, Gurkan Y. Ultrasound-guided bilateral erector spinae plane block could provide effective postoperative analgesia in laparoscopic cholecystectomy in paediatric patients. *Anaesth Crit Care Pain Med.* 2019;**38**(1):87-8. [PubMed ID: 29630940]. <https://doi.org/10.1016/j.jaccpm.2018.03.008>.
36. Tulgar S, Kapaklı MS, Senturk O, Selvi O, Serifsoy TE, Ozer Z. Evaluation of ultrasound-guided erector spinae plane block for postoperative analgesia in laparoscopic cholecystectomy: A prospective, randomized, controlled clinical trial. *J Clin Anesth.* 2018;**49**:101-6. [PubMed ID: 29913392]. <https://doi.org/10.1016/j.jclinane.2018.06.019>.
37. Peker K, Akcaboy ZN, Aydin G, Gencay I, Sahin AT, Kocak YF, et al. The Effect of Erector Spinae Plane Block on Laparoscopic Cholecystectomy Anesthesia: Analysis of Opioid Consumption, Sevoflurane Consumption, and Cost. *J Laparoendosc Adv Surg Tech A.* 2020;**30**(7):725-9. [PubMed ID: 32023174]. <https://doi.org/10.1089/lap.2019.0809>.
38. Kwon HM, Kim DH, Jeong SM, Choi KT, Park S, Kwon HJ, et al. Does Erector Spinae Plane Block Have a Visceral Analgesic Effect?: A Randomized Controlled Trial. *Sci Rep.* 2020;**10**(1):8389. [PubMed ID: 32439926]. [PubMed Central ID: PMC7249264]. <https://doi.org/10.1038/s41598-020-65172-0>.
39. Aydin T, Balaban O, Demir L. Ultrasound-guided erector spinae plane block for pain management in pancreatic cancer: A case report. *Agri.* 2019;**31**(4):218-9. [PubMed ID: 31741341]. <https://doi.org/10.14744/agri.2019.09815>.
40. Chin KJ, Malhas L, Perlas A. The Erector Spinae Plane Block Provides Visceral Abdominal Analgesia in Bariatric Surgery: A Report of 3 Cases. *Reg Anesth Pain Med.* 2017;**42**(3):372-6. [PubMed ID: 28272292]. <https://doi.org/10.1097/AAP.0000000000000581>.
41. Schwartzmann A, Peng P, Maciel MA, Forero M. Mechanism of the erector spinae plane block: insights from a magnetic resonance imaging study. *Can J Anaesth.* 2018;**65**(10):1165-6. [PubMed ID: 30076575]. <https://doi.org/10.1007/s12630-018-1187-y>.
42. Tulgar S, Selvi O, Ahiskalioglu A, Ozer Z. Can unilateral erector spinae plane block result in bilateral sensory blockade? *Can J Anaesth.* 2019;**66**(8):1001-2. [PubMed ID: 31114943]. <https://doi.org/10.1007/s12630-019-01402-y>.
43. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The Erector Spinae Plane Block: A Novel Analgesic Technique in Thoracic Neuropathic Pain. *Reg Anesth Pain Med.* 2016;**41**(5):621-7. [PubMed ID: 27501016]. <https://doi.org/10.1097/AAP.0000000000000451>.
44. Kendall MC, Alves L, Traill LL, De Oliveira GS. The effect of ultrasound-guided erector spinae plane block on postsurgical pain: a meta-analysis of randomized controlled trials. *BMC Anesthesiol.* 2020;**20**(1):99. [PubMed ID: 32357842]. [PubMed Central ID: PMC7195766]. <https://doi.org/10.1186/s12871-020-01016-8>.
45. De Cassai A, Bonvicini D, Correale C, Sandei L, Tulgar S, Tonetti T. Erector spinae plane block: a systematic qualitative review. *Minerva Anesthesiol.* 2019;**85**(3):308-19. [PubMed ID: 30621377]. <https://doi.org/10.23736/S0375-9393.18.13341-4>.
46. Kot P, Rodriguez P, Granell M, Cano B, Rovira L, Morales J, et al. The erector spinae plane block: a narrative review. *Korean J Anesthesiol.* 2019;**72**(3):209-20. [PubMed ID: 30886130]. [PubMed Central ID: PMC6547235]. <https://doi.org/10.4097/kja.d.19.00012>.
47. Cai Q, Liu GQ, Huang LS, Yang ZX, Gao ML, Jing R, et al. Effects of erector spinae plane block on postoperative pain and side-effects in adult patients underwent surgery: A systematic review and meta-analysis of randomized controlled trials. *Int J Surg.* 2020;**80**:107-16. [PubMed ID: 32461196]. <https://doi.org/10.1016/j.ijsu.2020.05.038>.
48. Dautzenberg KHW, Zegers MJ, Bleeker CP, Tan E, Vissers KCP, van Geffen GJ, et al. Unpredictable Injectate Spread of the Erector Spinae Plane Block in Human Cadavers. *Anesth Analg.* 2019;**129**(5):e163-6. [PubMed ID: 31107261]. <https://doi.org/10.1213/ANE.00000000000004187>.
49. Yang HM, Choi YJ, Kwon HJ, O J, Cho TH, Kim SH. Comparison of injectate spread and nerve involvement between retrolaminar and erector spinae plane blocks in the thoracic region: a cadaveric study. *Anaesthesia.* 2018;**73**(10):1244-50. [PubMed ID: 30113699]. <https://doi.org/10.1111/anae.14408>.
50. Adhikary SD, Bernard S, Lopez H, Chin KJ. Erector Spinae Plane Block Versus Retrolaminar Block: A Magnetic Resonance Imaging and Anatomical Study. *Reg Anesth Pain Med.* 2018;**43**(7):756-62. [PubMed ID: 29794943]. <https://doi.org/10.1097/AAP.0000000000000798>.
51. Vidal E, Gimenez H, Forero M, Fajardo M. Erector spinae plane block: A cadaver study to determine its mechanism of action. *Rev Esp Anesthesiol Reanim (Engl Ed).* 2018;**65**(9):514-9. [PubMed ID: 30166123]. <https://doi.org/10.1016/j.redar.2018.07.004>.
52. Ivanusic J, Konishi Y, Barrington MJ. A Cadaveric Study Investigating the Mechanism of Action of Erector Spinae Blockade. *Reg Anesth Pain Med.* 2018;**43**(6):567-71. [PubMed ID: 29746445]. <https://doi.org/10.1097/AAP.0000000000000789>.
53. Aponte A, Sala-Blanch X, Prats-Galino A, Masdeu J, Moreno LA, Sermeus LA. Anatomical evaluation of the extent of spread in the erector spinae plane block: a cadaveric study. *Can J Anaesth.* 2019;**66**(8):886-93. [PubMed ID: 31119551]. <https://doi.org/10.1007/s12630-019-01399-4>.
54. Govender S, Mohr D, Bosenberg A, Van Schoor AN. A cadaveric study of the erector spinae plane block in a neonatal sample. *Reg Anesth Pain Med.* 2020;**45**(5):386-8. [PubMed ID: 32047107]. <https://doi.org/10.1136/rapm-2019-100985>.
55. Helander EM, Webb MP, Kendrick J, Montet T, Kaye AJ, Cornett EM, et al. PECS, serratus plane, erector spinae, and paravertebral blocks: A

- comprehensive review. *Best Pract Res Clin Anaesthesiol.* 2019;**33**(4):573–81. [PubMed ID: 31791572]. <https://doi.org/10.1016/j.bpa.2019.07.003>.
56. Bang S, Chung K, Chung J, Yoo S, Baek S, Lee SM. The erector spinae plane block for effective analgesia after lung lobectomy: Three cases report. *Medicine (Baltimore).* 2019;**98**(29):e16262. [PubMed ID: 31335674]. [PubMed Central ID: PMC6708622]. <https://doi.org/10.1097/MD.00000000000016262>.
57. Sullivan TR, Kanda P, Gagne S, Costache I. Harlequin Syndrome Associated with Erector Spinae Plane Block. *Anesthesiology.* 2019;**131**(3):665. [PubMed ID: 31021847]. <https://doi.org/10.1097/ALN.0000000000002733>.
58. Sabouri AS, Crawford L, Bick SK, Nozari A, Anderson TA. Is a Retrolaminar Approach to the Thoracic Paravertebral Space Possible?: A Human Cadaveric Study. *Reg Anesth Pain Med.* 2018;**43**(8):864–8. [PubMed ID: 29923954]. <https://doi.org/10.1097/AAP.0000000000000828>.
59. Boezaart AP, Smith CR, Chembrovich S, Zaslavovich Y, Server A, Morgan G, et al. Visceral versus somatic pain: an educational review of anatomy and clinical implications. *Reg Anesth Pain Med.* 2021;**46**(7):629–36. [PubMed ID: 34145074]. <https://doi.org/10.1136/rapm-2020-102084>.
60. Urits I, Charipova K, Gress K, Laughlin P, Orhurhu V, Kaye AD, et al. Expanding Role of the Erector Spinae Plane Block for Postoperative and Chronic Pain Management. *Curr Pain Headache Rep.* 2019;**23**(10):71. [PubMed ID: 31372769]. <https://doi.org/10.1007/s11916-019-0812-y>.