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Comparison of the efficacy of erector spinae plane block according to the difference in bupivacaine concentrations for analgesia after laparoscopic cholecystectomy: a retrospective study

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Background: Laparoscopic cholecystectomy (LC) is a noninvasive surgery, but postoperative pain is a major problem. Studies have indicated that erector spinae plane block (ESPB) has an analgesic effect after LC. We aimed to compare the efficacy of different ESPB anesthetic concentrations in pain control in patients with LC.

Methods: This retrospective study included patients aged 20 to 75 years scheduled for LC with the American Society of Anesthesiologists physical status classification I or II. ESPB was administered using 0.375% bupivacaine in group 1 and 0.25% in group 2. Both groups received general anesthesia. Postoperative tramadol consumption and pain scores were compared and intraoperative and postoperative fentanyl requirements in the postanesthesia care unit (PACU) were measured.

Results: Eighty-five patients were included in this analysis. Tramadol consumption in the first 12 hours, second 12 hours, and total 24 hours was similar between groups ($p>0.05$). The differences between postoperative numeric rating scale (NRS) scores at rest did not differ significantly. The postoperative NRS scores upon bodily movement were not statistically different between the two groups, except at 12 hours. The mean intraoperative and postoperative fentanyl requirements in the PACU were similar. The difference in the requirement for rescue analgesics was not statistically significant ($p=0.788$).

Conclusion: Ultrasound-guided ESPB performed with different bupivacaine concentrations was effective in both groups for LC analgesia, with similar opioid consumption. A lower concentration of local anesthetic can be helpful for the safety of regional anesthesia and is recommended for the analgesic effect of ESPB in LC.

Keywords: Analgesia; Erector spinae plane block; Laparoscopic cholecystectomy; Postoperative pain; Ultrasound

Introduction

Although laparoscopic cholecystectomy (LC) is noninvasive, pain in the immediate postoperative period is one of the most common patient concerns [1,2]. Patients undergoing LC may experience somatic pain originating from port-entry wounds and visceral pain

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caused by gallbladder resection, abdominal insufflation, and peritoneal distention and damage [3]. The multimodal analgesic approach is a balanced and effective method for perioperative pain management and is important for regional anesthesia [4]. Multimodal treatments include regional anesthesia, regional analgesia, and analgesic medications for postoperative pain relief [5]. Regional anesthesia during surgery reduces the use of systemic medications, including opioids, for postoperative pain [6]. Regional anesthesia for postoperative pain in LC includes epidural, paravertebral, and fascial plane blocks [3,7-14]. However, epidural and paravertebral blocks have the potential risk of complications such as hematoma, pneumothorax, and epidural abscess [15]. Fascial plane blocks, such as the transversus abdominis plane (TAP) block, rectus sheath block, and erector spinae plane block (ESPB), can reduce postoperative pain during abdominal surgeries [3,9-14]. Sympathetic block, hypotension, and epidural hematoma in patients with coagulopathy can be avoided using fascial plane blocks instead of epidural blocks [16].

ESPB is a peri-paravertebral fascial plane block that has been demonstrated to be an effective regional anesthetic intervention for analgesia following various types of surgery. ESPB is a safe and easy-to-perform fascial plane block. Several studies have demonstrated the analgesic effect of ESPB on post-cholecystectomy pain [3,9-14]. Despite a growing number of publications related to ESPB, the appropriate dose of local anesthetics for ESPB in LC remains unclear. In the present study, we compared the efficacy of ESPB using the same volume of different bupivacaine concentrations for postoperative analgesia in patients with LC.

Methods

Ethical statements: This study was approved by the Institutional Review Board (IRB) of St. Vincent's Hospital (IRB No: VC22RISI0096). Due to the retrospective nature of the study, informed consent was waived. All procedures involving human participants were performed according to the ethical standards of the institutional and/or national research committee and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

1. Patients

The medical records of patients who underwent LC and ESPB with different doses of bupivacaine for postoperative analgesia between March 2019 and May 2020 were retrospectively analyzed. The inclusion criteria were patients 20 to 75 years of age who underwent LC and had American Society of Anesthesiologists physical status classification I or II. The exclusion criteria were as follows: patients with cognitive impairment, allergies to anesthetic agents, coagulation disorders, renal failure, hepatic failure, chronic opioid intoxication, and body mass index of > 35 kg/m^2.

2. Anesthesia

Electrocardiography, peripheral oxygen saturation, noninvasive blood pressure, and bispectral index monitoring (BIS) were performed immediately after each patient entered the operating room (OR). Intravenous propofol (2–3 mg/kg), fentanyl (1 μg/kg), and rocuronium bromide (0.6 mg/kg) were administered for anesthesia. General anesthesia was induced with a mixture of 60% air and 4% to 6% desflurane in oxygen. The desflurane concentration was maintained at a BIS value of 40 to 60.

3. Block procedures

After obtaining written informed consent for the procedure, the patients in both groups were placed in a sitting position before general anesthesia. In the first group (group 1), a high-frequency linear ultrasound probe (Philips Ultrasound, Bothwell, WA, USA) was placed longitudinally at the level of the T7 spinous process by the anesthesiologist. The T7 transverse process and erector spinae muscle were confirmed. An 80-mm 21-gauge block needle (Tuohy Needle, Taechang, Gongju, Korea) was inserted using an in-plane approach at an angle of 30° to 40° in the cranial-to-caudal direction using an aseptic procedure. The needle was advanced until the tip contacted the T7 transverse process. Twenty milliliters of 0.375% bupivacaine solution was injected deep into the erector spinae muscle by the anesthesiologist. The same procedure was performed with 20-mL 0.375% bupivacaine on the opposite side. In the second group (group 2), the ESPB procedure was performed as described above with 20-mL 0.25% bupivacaine solution. The same procedure was repeated with 20-mL 0.25% bupivacaine solution on the contralateral side. After the block procedure, the patients were placed in the supine position.

4. Postoperative analgesia

At the end of surgery, the patients were provided with a patient-controlled analgesia (PCA) device for postoperative pain control. The patients received a 10-mg bolus of tramadol with a lockout time of 20 minutes without basal injection by the PCA device. Numeric rating scale (NRS) scores were recorded at 15 minutes and 1, 2, 6, 12, and 24 hours postoperatively. The patients received intravenous tramadol (50 mg) as a rescue analgesic when their NRS score was ≥ 4.

5. Outcome measures

Total tramadol consumption 24 hours postoperatively, intraoperative fentanyl requirements in the OR, postoperative fentanyl requirements in the postanesthesia care unit (PACU), NRS scores at each time point (0.5, 1, 2, 6, and 12 hours), and total rescue analgesic consumption in the first 24 hours postoperatively were included as outcome measures. Surgery time was defined as the time from the beginning of surgery to skin-suture closure. The patients were monitored for procedure-related complications such as pneumothorax, infection, hematoma, and nerve injury. We also monitored postoperative nausea and vomiting (PONV) and shoulder pain during the first 24 hours postoperatively.

6. Statistical analysis

Statistical analyses were conducted using IBM SPSS ver. 26.0 (IBM Corp., Armonk, NY, USA). Quantitative data are expressed as mean ± standard deviation and median (range), whereas qualitative data are expressed as counts (percentages). Data normality was assessed using the Shapiro-Wilk test. The Mann-Whitney U test or independent *t*-test was used to compare continuous variables in the outcomes between the groups. Categorical variables were analyzed using the chi-square test or Fisher exact test, as appropriate. A *p*-value of < 0.05 was deemed significant for all comparisons between the groups.

Results

We identified 95 patients who underwent ESPB for pain control after LC. The medical records of six patients were insufficient, and PCA was discontinued in four patients (Fig. 1). Eighty-five patients were included in this retrospective analysis. The demographic data of the patients are presented in Table 1. There were no significant differences in age, sex, ASA score, or other demographic characteristics such as height and weight between the groups. The duration of surgery was 42.35 ± 6.76 minutes in group 1 and 42.18 ± 7.21 minutes in group 2 ($p = 0.784$).

The pain scores for each group are shown in Table 2. The NRS scores at rest were not significantly different at each postoperative time point between the two groups. The postoperative NRS scores upon movement were similar between the groups at 15 minutes, 1 hour, 2 hours, 6 hours, and 24 hours, but were significantly different at 12 hours. Specifically, the postoperative NRS score at 12 hours was 2 in group 1 and 3 in group 2 ($p = 0.035$). However, the median NRS score remained < 3 for the first 24 hours after surgery.

Table 3 shows the total analgesic use during the first 24 hours postoperatively. Although fentanyl consumption in the OR and PACU was greater in group 2 than in group 1, the difference was not significant ($p = 0.291$ and $p = 0.841$, respectively). Tramadol consumption in the first 12 hours, second 12 hours, and total 24 hours did not differ significantly between the groups ($p > 0.05$).

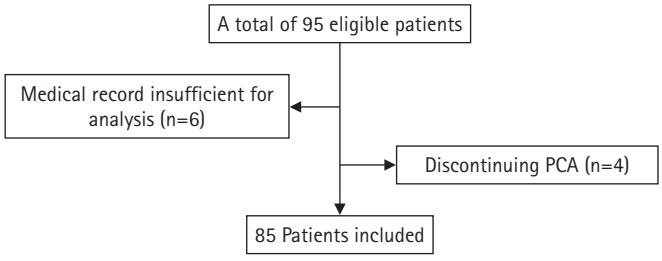

Fig. 1. Flow diagram describing patient selection. PCA, patient-controlled analgesia.

Table 1. Descriptive variables of groups

Variable	Group 1	Group 2	*p*-value
No. of patients	40	45	
Sex, male:female	15:25	19:26	0.825
ASA PS classification I/II	17/23	20/25	>0.999
Age (yr)	51.58 ± 14.16	51.36 ± 14.13	0.943
Height (cm)	163.30 ± 7.94	162.56 ± 9.33	0.819
Weight (kg)	65.22 ± 12.04	66.74 ± 17.47	0.764
Surgical duration (min)	42.35 ± 6.76	42.18 ± 7.21	0.784

Values are presented as number or mean ± standard deviation.
Group 1, 0.375% bupivacaine group; group 2, 0.25% bupivacaine group.
ASA, American Society of Anesthesiologists; PS, physical status.

Table 2. Average NRS scores at rest and upon movement/coughing during the first 24 hours after surgery

Time after operation	NRS score		*p*-value
	Group 1	Group 2	
At rest			
15 min	2 (1–2)	2 (2–2)	0.210
1 hr	2 (2–2)	2 (2–2)	0.410
2 hr	2 (2–2)	2 (2–3)	0.056
6 hr	2 (2–2)	2 (2–3)	0.135
12 hr	2 (2–3)	2 (2–3)	0.132
24 hr	2 (1–2)	2 (1–2)	0.496
On movement			
15 min	2 (2–3)	2 (2–3)	0.305
1 hr	2 (2–3)	2 (2–3)	0.395
2 hr	2 (2–3)	2 (2–3)	0.427
6 hr	2 (2–3)	3 (2–3)	0.054
12 hr	2 (2–3)	3 (2–3)	0.035
24 hr	2 (1–2)	2 (2–3)	0.090

Values are presented as median (interquartile range).
Group 1, 0.375% bupivacaine group; group 2, 0.25% bupivacaine group.
NRS, numeric rating scale.

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Table 3. Intraoperative and postoperative analgesic requirements

Variable	Group 1	Group 2	*p*-value
Average fentanyl use (μg)			
Operative room	91.25 ± 45.13	93.78 ± 31.50	0.291
Recovery room	34.38 ± 39.50	36.11 ± 40.08	0.841
Tramadol PCA (mg)			
First 12 hr	62.38 ± 13.40	63.11 ± 11.93	0.600
Second 12 hr	68.63 ± 20.19	70.22 ± 14.77	0.399
Full 24 hr	130.88 ± 26.33	133.22 ± 19.83	0.470
Rescue analgesic requirements (mg)			
First 12 hr	17.50 ± 26.68	17.78 ± 28.52	0.944
Second 12 hr	12.50 ± 21.18	14.44 ± 25.83	0.928
Full 24 hr	30.00 ± 41.68	32.22 ± 51.57	0.788

Values are presented as mean ± standard deviation.
Group 1, 0.375% bupivacaine group; group 2, 0.25% bupivacaine group.
First 12 hr, 0–12 hr; second 12 hr, 12–24 hr; full 24 hr, 0–24 hr.
PCA, patient-controlled analgesia.

Table 4. Incidences of shoulder pain, nausea, and vomiting

Variable	Group 1	Group 2	*p*-value
Shoulder pain			> 0.999
Yes	4 (10.0)	5 (11.1)	
No	36 (90.0)	40 (88.9)	
Nausea			0.813
Yes	11 (27.5)	14 (31.1)	
No	29 (72.5)	31 (68.9)	
Vomiting			0.679
Yes	2 (5.0)	4 (8.9)	
No	38 (95.0)	41 (91.1)	

Values are presented as number (%).
Group 1, 0.375% bupivacaine group; group 2, 0.25% bupivacaine group.

The average tramadol consumption (mg) in the first 24 hours was 130.88 ± 26.33 mg for group 1 and 133.22 ± 19.83 mg for group 2 ($p = 0.470$). The requirement for rescue analgesics in the ward was 32.22 ± 51.5 mg in group 2 and 30.00 ± 41.68 in group 1 at 24 hours postoperatively; the difference was not significant ($p = 0.788$).

Postoperative right shoulder pain was reported in four patients in group 1 and five patients in group 2 (Table 4). The frequency of PONV was comparable between the groups. No block-related complications, such as infection, bleeding, or pleural puncture, were reported in either group. No opioid-related side effects, such as pruritus, respiratory depression, and urinary retention, were reported in either group.

Discussion

To the best of our knowledge, the present study is the first to compare the efficacy of ESPB using two concentrations of bupivacaine (0.25% and 0.375%) in patients undergoing LC with respect to postoperative pain scores, dose of rescue analgesics required in the postoperative period, and total tramadol consumption at 24 hours postoperatively.

Tramadol consumption was similar at both lower and higher concentrations of bupivacaine. The intraoperative fentanyl requirements and rescue analgesics after surgery were comparable between the two groups. The NRS scores of group 1 were similar to those of group 2 at rest. The NRS scores during movement were similar in both groups, except at 12 hours. The NRS score at 12 hours during movement was 2 in group 1 and 3 in group 2; however, both scores are considered clinically analgesic. In our study, ultrasound-guided ESPB with two concentrations of bupivacaine (0.25% and 0.375%) was effective for managing postoperative pain after LC.

Pain following LC includes both somatic and visceral components, and multimodal analgesic methods have been used to reduce postoperative pain. A previous study demonstrated that the development of chronic pain in LC is related to early visceral pain [17]. Several analgesic approaches, such as regional anesthesia, regional analgesia, and analgesic medications, can reduce the risk of chronic pain development and are recommended during the perioperative period [5]. Multimodal therapy has been widely used for postoperative analgesia to decrease opioid-related side effects [18]. Regional anesthetic techniques such as epidural block, paravertebral block, TAP block, quadratus lumborum block, and ESPB have been developed for analgesia after LC [3,7-14].

Since 2016, ESPB has been used for pain control in various surgeries. Several studies have examined the use of ESPB for pain control in LC. A systematic review and meta-analysis conducted by Daghmouri et al. [19] showed that bilateral ultrasound-guided ESPB could be an effective treatment to reduce opioid consumption and the time to the first use of rescue analgesia. However, the concentration and volume of local anesthetics used to perform ESPB differ among reports [9-14]. There is no consensus on the use of anesthetics. The optimum volume and concentration of local anesthetic agents for ESPB remain unclear.

Tulgar et al. [11] evaluated bilateral ultrasound-guided ESPB for postoperative analgesia in patients with LC. Twenty milliliters of 0.375% bupivacaine was injected. The procedure was repeated on the contralateral side. Altıparmak et al. [9] performed ultrasound-guided ESPB versus oblique subcostal TAP block for postoperative analgesia in LC using 20-mL 0.375% bupivacaine. The same procedure was repeated with 20-mL 0.375% bupivacaine on the contralateral side. Cesur et al. [12] compared bilateral and uni-

lateral ESPB for postoperative analgesia in patients with LC. Twenty milliliters of 0.25% bupivacaine was injected on the right side in the unilateral group and bilaterally in the bilateral group. Postoperative analgesia after LC was more effective in bilateral ESPB than in unilateral ESPB [12]. Vrsajkov et al. [13] reported that ESPB reduces pain after LC. Bilateral ESPB was performed with 20 mL of 0.25% levobupivacaine plus 2 mg of dexamethasone per side. Aygun et al. [10] performed bilateral ESPB or bilateral quadratus lumborum block and used a local anesthetic mixture consisting of 30-mL 0.5% bupivacaine, 10-mL 2% lidocaine, and 20-mL normal saline, with half of the mixture administered to each side. Ozdemir et al. [14] compared ESPB and subcostal TAP blocks for postoperative analgesia after LC. A local anesthetic mixture (10-mL 0.25% bupivacaine and 10-mL 2% prilocaine) was administered into the target space. The same procedure was repeated on the contralateral side.

Several studies have indicated that different local anesthetics at various concentrations and doses are effective for postoperative analgesia following LC [9-14]; however, no trials have been conducted to compare the efficacy of ESPB using different concentrations of these agents in LC. The allowable dose of bupivacaine is 150 to 175 mg [20]. We determined the comparative doses of bupivacaine as 20 mL of 0.375% and 0.25% because side effects can occur with systemic absorption. The dose of local anesthetic should be chosen by carefully weighing the risks and benefits of analgesia and associated side effects. Although regional anesthesia is safer than general anesthesia, overdosage and toxicity of local anesthetics are associated with severe mortality and morbidity, occurring in approximately 1 in 1,000 patients [21]. Local anesthetic systemic toxicity (LAST) can occur when local anesthetics are administered, and is related to the serum concentration of the drug absorbed into the circulation [20]. This serum concentration is affected by the dose, site, and method of drug administration. Ultrasound has been reported to decrease the risk of LAST by 60% to 65% compared with peripheral nervous stimulation alone [22]. However, LAST continued to occur even with ultrasound, and ultrasound guidance did not affect the risk of LAST due to the systemic absorption of local agents. Advances in regional anesthesia, such as the advent of high-volume fascial plane blocks, have contributed to the continued risk of LAST [23,24]. Fascial plane blocks require large-volume (> 20 mL) injections of local anesthetics into the fascial plane between muscles. Since muscles usually have abundant vascular supply, there is a significant risk of LAST due to systemic absorption of local agents [25,26]. Toju et al. [26] demonstrated that administration of ropivacaine at 3 mg/kg for subcostal TAP block rapidly increased the plasma concentration of the anesthetic during the first 2 hours after the block. The peak plasma concentration nearly reached the threshold of systemic toxicity. Other factors, such as the patient's age and condition, including renal dysfunction, liver dysfunction, heart failure, and pregnancy, should be considered prior to regional anesthesia. Old age and renal, hepatic, and cardiac dysfunction reduce the clearance of local anesthetics from the body [6]. The metabolism and excretion of local anesthetics are important determinants of serum drug concentrations [20]. The decrease in clearance of local anesthetics associated with renal, liver, and heart diseases is the most important reason for dose reduction during repeated or continuous anesthetic administration. In hepatic or renal dysfunction, clearance is reduced with the retention of local anesthetics and certain metabolites in the body [20]. Older people have reduced organ function. Therefore, lower concentrations of regional anesthetics should be cautiously selected for older individuals. Doses should be modified according to age- and disease-related effects on the pharmacodynamics and pharmacokinetics of local anesthetics. Limiting the drug dose may contribute to a lower risk of LAST [27]. Lower concentrations and doses of local anesthetics should also be used if epinephrine is omitted [28].

In the literature, most studies did not indicate significant complications after ESPB in LC [19]. A case of pneumothorax after ESPB has been previously reported [29]. An alternative approach using a transverse view of the vertebra and an in-plane lateral-to-medial approach can reduce pneumothorax during ESPB at low thoracic level [30]. ESPB has been used for only several years. Thus, with the increased use of ultrasound-guided ESPB, more complications will occur.

With an increase in the concentration of local anesthetics in the systemic circulation, various signs and symptoms of effects on the cardiovascular and central nervous systems can occur. The immediate management of LAST includes general safety and resuscitation. Early lipid emulsion therapy, prompt seizure management, and supportive cardiovascular pharmacotherapy are necessary [27].

In this study, 0.25% bupivacaine was found to have a clinical effect on postoperative pain. Similarly, several studies have also performed ESPB using 20 mL of 0.25% bupivacaine and obtained effective postoperative analgesia after LC [12,13]. Low concentrations of local anesthetics may have a more positive effect than high concentrations. Bilateral ESPB following LC provides more effective analgesia than unilateral ESPB [12] but requires more volume due to the two sides of treatment, which can cause systemic toxicity. Therefore, the use of lower concentrations of local anesthetics can reduce the risk of systemic toxicity and potential complications of local anesthetics [31]. Furthermore, body weight is important for local anesthetic concentrations. If the body weight of a patient

receiving ESPB is low, the risk of toxicity increases [20]. The minimum dose of a local anesthetic agent with maximal effect can increase the safety of regional anesthesia [20].

PONV is one of the most common and painful postoperative adverse effects. The main risk factors for PONV are a history of motion sickness or PONV, postoperative opioids, female sex, and non-smoking status [32]. The use of regional analgesia usually reduces the need for systemic medications such as opioids [6]. In the present study, the incidence of PONV was comparable between groups.

In our study, the incidence of postoperative shoulder pain was similar between groups. However, the mechanisms underlying shoulder pain after LC remain unclear. Shoulder pain occurs because of irritation of the diaphragm and referred pain from the phrenic nerve [33]. Postoperative shoulder pain may increase with high-pressure pneumoperitoneum and has been shown to be reduced by removal of the remaining gas [34]. Cesur et al. [12] reported that bilateral ESPB decreased shoulder pain postoperatively compared to unilateral ESPB.

This study has some limitations. First, we performed block intervention while the patient was conscious before intubation for general anesthesia. Thus, we did not check the sensory dermatome of the block or risk of block failure. However, we performed ESPB to observe how the drug spreads to the erector spinae plane at the proper target area using ultrasound in real time. Second, we compared the effects of ESPB using different concentrations of local anesthetics within the first 24 hours after surgery. We were unable to study the long-term effects of each block on the chronic phase of cholecystectomy pain. Furthermore, this study did not include control or sham groups, and the placebo effect was unclear.

Ultrasound-guided ESPB using different concentrations of bupivacaine provided clinical analgesic effects and led to similar opioid consumption in both groups. A lower concentration of local anesthetic may reduce the risk of local anesthetic toxicity and can be recommended for safe postoperative analgesia during ESPB following LC.

Notes

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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Author contributions

Conceptualization: SC, JDJ; Data curation, Investigation: SC; Formal analysis, Supervision: JDJ; Methodology: YJP; Writing-original draft: YJP; Writing-review & editing: EY.

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