Randomized Non-controlled Trial

Use of Bilateral Rectus Sheath Blocks in Open Umbilical Hernia Repair

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Background: In recent years, the rectus sheath block (RSB) has become increasingly prevalent in laparoscopic surgery. However, there is currently no definitive research on its use in the open repair of umbilical hernias with cirrhotic ascites.

Objective: In this study, we assessed the safety and clinical efficacy of ultrasound-guided (US-guided) bilateral RSBs in open umbilical hernia repair for patients diagnosed with cirrhotic ascites.

Study Design: Seventy-two patients diagnosed with umbilical hernias that presented with cirrhotic ascites and who were admitted to our hospital were randomly divided into 2 groups. These categories were labeled the RSB group (Group R) and the local infiltration group (Group L); we used US-guided RSBs in Group R and local infiltration in Group L.

Setting: The clinical outcomes of the patients in each group were compared to one another. Heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were recorded at various time points in both groups.

Methods: Measurements of the patients' outcomes were taken before anesthesia (T0), at the beginning of surgery (T1), at the time of the separation of the hernia sac (T2), at the end of surgery (T3), 6 hours postoperatively (T4), and 24 hours postoperatively (T5). On the Visual Analog Scale (VAS), pain scores at rest (T1-T3) and during activity (T4-T5) were recorded, as were the incidence of perioperative remedial analgesia and adverse effects.

Results: Compared to T0, both groups' HR was significantly higher at T1-T3 ($P < 0.05$). The SBP and DBP were also significantly higher ($P < 0.05$). At T1-T3, the HR of Group R was significantly slower than that of Group L ($P < 0.05$), and at T4-T5, the VAS score for activity in Group R was significantly lower than that of Group L ($P < 0.05$). Group R had a significantly lower incidence of intraoperative remedial analgesia and postoperative nausea and vomiting than did Group L ($P < 0.05$). Neither group required postoperative remedial analgesia, and no patient experienced adverse reactions during the perioperative period.

Limitations: This study has limitations in its sample size, lack of blood ammonia levels, and absence of data on patient satisfaction, necessitating future studies to address these issues.

Conclusion: US-guided RSBs are an efficient method of anesthesia for open umbilical hernia repair in patients diagnosed with cirrhosis. This technique not only provides precise anesthesia and appropriate analgesia but also results in a low incidence of postoperative nausea and vomiting.

Key words: Rectus abdominis sheath block, ultrasound-guided, umbilical hernia

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An umbilical hernia is a primary defect located in the center of the umbilical ring, which is situated in the median line. Umbilical hernias account for approximately 6% to 14% of all laparoceles in adults (1) and are one of the most common complications in patients diagnosed with cirrhosis, with a prevalence of up to 20% (2). Increases in intra-abdominal pressure and abdominal wall tension may

occur in cirrhosis patients who experience recurrent episodes of ascites. In addition, malnutrition in patients with advanced cirrhosis often leads to the deterioration of the abdominal wall fascia and connective tissues. Together, these factors contribute to the increased incidence of umbilical hernias. Cirrhotic ascites can cause several complications in patients with umbilical hernias, including incarceration and hernia sac rupture. Therefore, patients diagnosed with cirrhotic ascites and umbilical hernias require immediate surgical treatment.

Objectives

In recent years, the rectus sheath block (RSB) technique has become increasingly prevalent in laparoscopic surgery. However, there is currently no definitive research on its use in the open repair of umbilical hernias with cirrhotic ascites. The aim of this study is to evaluate the efficacy and safety of ultrasound (US)-guided RSBs in open umbilical hernia repair in patients diagnosed with cirrhotic ascites. The findings of this study can be used as a guide for clinical application.

Study Design

General Data

We enrolled 72 patients with liver cirrhosis, ascites, and umbilical hernias who were admitted to our hospital from November 2021 to July 2023. Inclusion criteria were as follows: 1) Patients had to be 18 years or older with umbilical hernias and cirrhotic ascites; 2) The patients had no serious cardiac, pulmonary, or renal dysfunction; 3) Patients were admitted based on routine outpatient visits and no incarceration involvement. The following criteria were grounds for exclusion: 1) Patients were minors; 2) Patients had severe cardiac, pulmonary, or renal dysfunction; 3) Patients had advanced hepatic malignant tumors; 4) Patients had incarcerated umbilical hernias, skin infections at the puncture sites, or extra-abdominal leakage on emergency admission.

Consent was obtained from the patients and their families, who signed the appropriate forms prior to surgery. We used the random number table method to divide the patients into 2 groups: the RSB group (Group R, n = 36 cases) and the local infiltration anesthesia group (Group L, n = 36 cases). The preoperative American Society of Anesthesiologists (ASA) classifications of the 2 groups were Class II and III. Group R consisted of 15 males and 21 females ranging in age from 28 to 88 years, with a mean age of 67.56 years. Group L consisted of 14 men and 22 women between the ages of 25 and 92, with a mean age of 60.91 years. Comparing the general information about the 2 groups revealed no statistically significant difference ($P > 0.05$).

Setting

Prior to surgery, relevant perioperative interventions were performed on all patients. These interventions included preoperative evaluation of the ascites's volume and depth as well as patients' bed rest, dietary management, oral diuretics, correction of hypoproteinemia, and enhancement of coagulation. When necessary, hepatoprotective medications and abdominal punctures for the release of ascites were administered. Cephalosporin antibiotics were used during the preoperative period.

All surgeries were elective open surgeries performed by the same group of surgeons. During surgery, the anterior rectus sheath was repaired in a tension-free manner.

Anesthesia Method

None of the patients received preoperative medication. The patients' vital signs were routinely monitored, and peripheral venous access was established after their information was confirmed and they were admitted to the operating room. All nerve blocks were administered with a 40 mL volume of 0.25% bupivacaine hydrochloride + epinephrine hydrochloride (1:100,000). Patients in Group R received US-guided RSB anesthesia. After the surgeons observed the intact rectus muscle, a high-frequency US probe was placed transversely at the umbilicus and inserted at this level. With the in-plane needle insertion technique, the needle was inserted at a 45° angle at a depth of one to 2 cm. The needle was inserted from the outside and moved inward through the outer side of the rectus muscle. It passed through the skin, the subcutaneous tissues, the anterior sheath of the rectus muscle, and finally the rectus muscle itself. After surgeons confirmed that no blood was being withdrawn, 2 mL of a local anesthetic was injected into the middle and outer thirds of the rectus muscle once the needle had reached that depth. US examination revealed that the local anesthetic caused the rectus muscle to separate but that this separation was limited to the muscle sheath. The local anesthetic was then applied downward, causing the peritoneum to descend into the abdominal cavity. This result demonstrated that the puncture was successful. Twenty mL of the remaining local anesthetic was then injected on each side (Fig. 1). Anesthesiologists with expert knowledge

in US-guided nerve puncture conducted the entire US-guided nerve block procedure. Twenty minutes after the surgeons completed the nerve block, the block range was determined, and surgery began when the block range met the surgical requirements. If the block range was insufficient, the nerve block was deemed unsuccessful. In such cases, general anesthesia was administered intravenously, and the patient was excluded from the study. After the surgery began, if the patient had a VAS score > 4 and was unable to cooperate with the procedure or exhibited an intolerable pulling reaction, a remedial analgesia of 0.1 μg/Kg of sufentanil was administered intravenously. Those who were still unable to tolerate the procedure after one administration of remedial analgesia were switched to intravenous general anesthesia, which was also recorded as a failure of the nerve block and resulted in the patients' automatic withdrawal from the study. Group L was administered local anesthetics through layer-by-layer incision infiltration. On a layer-by-layer basis, the skin, subcutaneous tissues, and anterior peritoneal space were anesthetized with 0.25% bupivacaine hydrochloride and (1:100,000) epinephrine hydrochloride. The total dose administered did not exceed 40 mL. Postoperative observation was conducted to assess the patients' pain levels. As remedial analgesia, 50 mg of flurbiprofen axetil injection was administered to patients with a VAS score > 4 and self-reported intolerance.

Methods

Each patient's heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were recorded at various time points in both groups: prior to anesthesia (T0), at the beginning of surgery (T1), when the hernia sac was separated (T2), at the end of surgery (T3), 6 hours postoperatively (T4), and 24 hours postoperatively (T5). VAS scores at rest during T1-T3 and during activity at T4-T5 were recorded. During the perioperative period, the use of analgesic medications and the occurrence of adverse reactions were also recorded. These reactions included failure of the nerve block, nausea and vomiting, blood pressure changes exceeding 30% of the baseline value, complications related to nerve block puncture (such as nerve injury and peritoneal perforation), and local anesthetic toxicity.

Statistical Analysis

The statistical analysis was conducted using the SPSS 23.0 software package. Normal distribution measurements were expressed as mean ± SD ($\bar{x} \pm S$). The 2-independent-sample t-test was used for inter-group comparison, and a repeated measures ANOVA was used for intra-group comparison. Numerical data were expressed as absolute numbers and percentages (%), and comparisons were made between the groups using the chi-squared test. $P < 0.05$ was considered statistically significant.

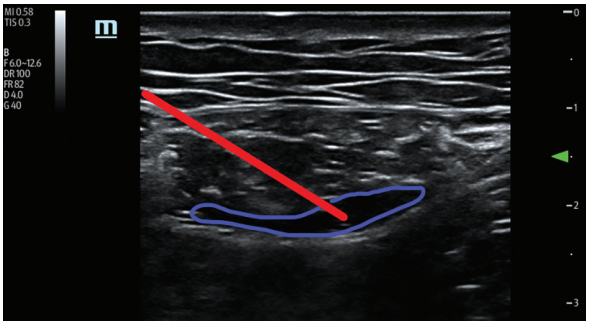

Fig. 1. *The red straight line represents the nerve-stimulating needle, while the blue curve represents the local anesthetic diffusion component.*

Results

There were no statistically significant differences between the 2 groups in terms of age, gender, ASA classification, or duration of surgery (Table 1).

The HR was significantly slower in both groups at T1-T3 than at T0 ($P < 0.05$). In addition, both the SBP and DBP were reduced significantly ($P < 0.05$). At T1-T3, the HR was significantly lower in Group R than in Group L ($P < 0.05$), and the SBP and DBP were also significantly lower than in Group L ($P < 0.05$). The differences in the HR, SBP, and DBP between the 2 groups at T0 and T4~T5 were not statistically significant (Table 2).

At T1-T3, the VAS scores at rest were significantly lower in Group R than in Group L ($P < 0.05$). In addition, VAS scores recorded when patients walked on level ground were significantly lower in Group R at T4-T5 than in Group L ($P < 0.05$) (Table 3).

In Group R, the incidence of intraoperative remedial analgesia was significantly lower than in Group L ($P < 0.05$). In addition, nausea and vomiting were significantly lower in Group L ($P < 0.05$) (Table 4). No postoperative analgesia was required in either group, and there were no adverse reactions such as a > 30% increase or decrease in blood pressure from the baseline, complications from the nerve block puncture (e.g., nerve injury or peritoneal perforation), or toxicity from local anesthetics during the perioperative period.

Cirrhotic ascites is associated with an increase in

intra-abdominal pressure and a decline in systemic nutritional status. This affliction can weaken the abdominal wall, thereby increasing susceptibility to umbilical hernias. Ascites is not only a cause of umbilical hernias but also the key factor contributing to postoperative recurrence. Cirrhosis with umbilical hernias is associated with increased incarcerated strangulation, which has a 10% incidence and a mortality rate of up to 15%, making it the most severe complication (3). Patients diagnosed with cirrhosis are susceptible to abnormal immune regulation, and research suggests that general anesthesia can impact the immune organs and tissues as well as their immune function (4). This complication can potentially worsen postoperative infections and hinder postoperative recovery. Juo et al (5) conducted a retrospective analysis of case data from 536 patients with cirrhotic abdominal wall hernia who underwent laparoscopic repair. They discovered that when ascites was present, the laparoscopic technique increased patients' mortality rate and incidences of systemic complications and unplanned secondary surgery. In addition, the results of another study demonstrated that the laparoscopic technique increased the risk of cardiopulmonary complications and prolonged the operative time (6). In our study, patients with cirrhosis underwent umbilical hernia repair using either local or RSB anesthesia.

Table 1. *Comparison of the general conditions of patients in the 2 groups.*

Group	Group R	Group L	*P* value
Number of cases	36	36	
Age (years)	67.6 ± 15.5	60.9 ± 15.2	0.68
Gender (male/female)	15/21	14/22	0.81
ASA classification II/III (cases)	17/19	24/12	0.96
Duration of surgery (min)	72.1 ± 27.3	66.9 ± 23.3	0.39

The rectus muscle is located on both sides of the midline of the anterior abdominal wall and surrounded by the rectus sheath. Between the internal oblique muscle and transversus muscle, the T7-T11 intercostal nerve and the anterior cutaneous branch of the subcostal nerve run obliquely inward. In the anterior abdominal wall, they also pass between the rectus muscle and posterior rectus muscle sheath and through the rectus muscle and anterior rectus muscle sheath. These nerves provide innervation to the skin, muscles, and peritoneal wall layer in the corresponding region (7). It is possible to block the nerves' terminal branches in the corresponding areas by injecting a local anesthetic into the potential space between the rectus muscle and the posterior rectus sheath. The local anesthetic can then diffuse cephalad and caudad along the posterior rectus sheath, providing analgesia to the skin, muscles, and peritoneum of the incision in the median anterior abdominal wall.

A study by Manassero et al (8) confirmed that the RSB can be used as an independent anesthesia technique for umbilical hernia repair. They used 20 mL of 0.375% levobupivacaine + 0.1 mL of epinephrine on each side. The results revealed that 55.3% of the patients achieved a perfect anesthetic effect with the RSB alone, while the remaining patients required additional local anesthesia at the incision site to complete the procedure. Not all the patients required general anesthesia. To ensure the safety of the low-concentration bupivacaine RSB in patients diagnosed with cirrhotic ascites, a lower concentration of bupivacaine was chosen for this study.

Studies have demonstrated that compared to wound infiltration, RSBs may provide superior pain relief and a reduced need for opioids during the immediate postoperative period in children undergoing umbilical hernia repair. A study by Relland et al

Table 2. *Comparison of HR, SBP, and DBP between the 2 groups at various time points ($\bar{x} \pm S$).*

Items	HR (n/min)		SBP (mmHg)		DBP (mmHg)	
Group	Group R	Group L	Group R	Group L	Group R	Group L
Number of cases	36	36	36	36	36	36
T0	76.0 ± 10.3	76.7 ± 10.4	153.2 ± 20.8	145.3 ± 22.8	77.6 ± 10.7	79.4 ± 10.4
T1	67.22 ± 10.0[a]	71.95 ± 9.8[a]	124.8 ± 19.6[a]	134.9 ± 20.8[a]	69.0 ± 9.5[a]	74.2 ± 9.4[a]
T2	67.2 ± 8.4[a]	71.5 ± 9.7[a]	126.6 ± 21.1[a]	134.5 ± 19.9[a]	69.4 ± 10.4[a]	74.5 ± 9.8[a]
T3	66.7 ± 9.5[a]	71.4 ± 9.3[a]	123.5 ± 20.3[a]	133.8 ± 21.0[a]	70.1 ± 10.0[a]	74.8 ± 9.0[a]
T4	74.9 ± 11.1[b]	76.9 ± 12.0[b]	146.0 ± 21.9[b]	140.1 ± 19.6[b]	77.3 ± 12.4[b]	77.0 ± 10.1[b]
T5	74.2 ± 9.9[b]	75.2 ± 10.8[b]	149.5 ± 20.9[b]	144.7 ± 19.7[b]	78.1 ± 11.2[b]	77.6 ± 15.1[b]

Note: Compared with T0, [a]$P < 0.05$; compared with T0, [b]$P > 0.05$.

revealed that the RSB could be used as an alternative for sacral block anesthesia in daytime umbilical hernia surgery on children (9). The RSB can be administered at lower doses, thereby preventing systemic toxicity and facilitating early postoperative mobility. In addition, RSBs reduce urinary retention and may lead to shorter hospitalization duration. Flack et al (10) demonstrated that US-guided RSB was more effective than wound infiltration in repairing children's umbilical hernias. The peak plasma concentration of 0.25% bupivacaine at a dosage of 1 mg/kg during the RSB was higher than that of wound infiltration and occurred later. These differences meant an increased duration of postoperative analgesia, an enhanced analgesic effect, a reduced amount of postoperative pain, and a decreased dosage of opioids and their related side effects.

Laparoscopic-guided RSBs were discovered to be possible by injecting local anesthetics into the posterior rectus sheath using direct laparoscopic visualization (11-13). This type of anesthesia is administered by a surgeon and does not require US technology. In addition, the risk of intestinal injury associated with blind US-guided RSB is avoided. In contrast to previous research, Kinjo et al (13) found that an RSB done with direct laparoscopic visualization did not significantly reduce pain scores during postoperative rest and coughing.

Bupivacaine is a commonly used long-acting amide local anesthetic in umbilical hernia repair. However, its use can lead to severe cardiotoxicity, especially when administered intravascularly. In contrast, when the posterior rectus sheath is operated on using direct US visualization, fewer blood vessels are present, reducing the risk of local anesthetic cardiotoxicity (14). Rosenberg et al (15) recommend a maximum dose of 2 mg/kg of bupivacaine. Maximos et al have demonstrated that when bupivacaine is administered in erector spinae plane and intercostal plane blocks, the blood concentration of 2 mg/kg is significantly lower than the concentration that causes central nervous system or cardiac toxicity (16). Epinephrine slows the absorption of anesthetic drugs, thereby prolonging anesthesia and enhancing analgesia. Studies have confirmed that high doses of epinephrine reduce blood levels of bupivacaine (17). The blocked nerves are peripheral sensory nerves. Thus, the local anesthetic used in this study was 0.25% bupivacaine with epinephrine hydrochloride 1:100,000.

Based on the results of this study, most of the patients who received wound infiltration alone experienced moderate intraoperative pain, necessitating the administration of additional analgesics to complete the procedure. Notably, the use of supplemental analgesics may also increase the incidence of nausea and vomiting. The RSB procedure is more comprehensive, resulting in minimal or mild intraoperative pain. Most patients do not require additional pain relief, and nausea and vomiting are significantly reduced. However, the operation is still painful when performed with deep block traction, possibly because the greater omentum is not innervated by the intercostal nerves. Insufficient local anesthetic distribution caused by intramuscular injection may be to blame for subpar anesthesia. Alternatively, the problem may be because the intercostal nerve does not pass between the rectus muscle and posterior rectus sheath but rather between the rectus muscle and anterior rectus sheath (18). Due to the rectus muscle's involvement in coughing, the RSB significantly reduced pain during coughing and other such postoperative activities. This result is especially advantageous for elderly patients who tend to actively cough up sputum. Since RSB anesthesia was administered using visualization, no instances of local anesthetic toxicity occurred, and no adverse effects associated with bupivacaine, such as headaches, nausea, vomiting, urinary retention, or cardiotoxicity, were recorded.

Table 3. *Comparison of VAS scores at various time points between the 2 patient groups (scores, $\bar{x} \pm S$).*

Group		Group R	Group L	*P* value
Number of cases		**36**	**36**	
Rest	T1	2.9 ± 1.1	4.3 ± 1.0	0.00
	T2	2.2 ± 1.1	2.6 ± 0.6	0.003
	T3	1.4 ± 0.5	2.4 ± 0.6	0.00
Active	T4	1.2 ± 0.4	1.6 ± 0.5	0.00
	T5	0.4 ± 0.0	1.1 ± 0.3	0.00

Table 4. *A comparison of the occurrence of perioperative remedial analgesia, nausea, and vomiting between the 2 groups [case (%)].*

Group	Group R	Group L	*P* value
Number of cases	**36**	**36**	
Remedial analgesia	8 (22.2%)	30 (83.3%)	0.00
Nausea and vomiting	3 (8.3%)	10 (33.3%)	0.01

Limitations

This study has several limitations. First, we used a randomized clinical trial design, but the sample size was limited, leading to inadequate representation of

the actual clinical significance of the difference in VAS scores between the 2 patient groups. Second, blood ammonia levels were not measured, so we were unable to determine the presence of hepatic encephalopathy and its impact on VAS scores. Third, we did not collect data on patient satisfaction, such as the procedure's impact on quality of life and long-term prognosis after surgery. Future studies must address these limitations to validate the scenarios outlined above.

Conclusion

In conclusion, the US-guided bilateral RSB is an effective anesthesia technique for open umbilical hernia repair in patients diagnosed with cirrhotic ascites. The RSB is associated with a low incidence of nausea and vomiting and provides superior postoperative analgesia. This method provides a superior approach to anesthesia for open umbilical hernia repair in patients with cirrhotic ascites.

References

1. Shankar DA, Itani KMF, O'Brien WJ, Sanchez VM. Factors associated with long-term outcomes of umbilical hernia repair. *JAMA Surg* 2017; 152:461-466.
2. Coelho JC, Claus CM, Campos AC, Costa MA, Blum C. Umbilical hernia in patients with liver cirrhosis: A surgical challenge. *World J Gastrointest Surg* 2016; 8:476-482.
3. Yu BC, Chung M, Lee G. The repair of umbilical hernia in cirrhotic patients: 18 consecutive case series in a single institute. *Ann Surg Treat Res* 2015; 89:87-91.
4. Yin GP, Hu WJ, Zhang WF, Wang J, Zhong YL. Influence of anesthesia on immune function in patients with liver cirrhosis. *Jiangsu Medicine* 2013; 39:1284-1286. https://kns.cnki.net/kcms2/article/abstract?v=oslmGXurZ-pDowILREJQqFk3tzwBMT_XX8PfmKE3ckrKQV4agCeLVGkiRRMzSX_2ciR9mK3Ja6TqzvBGB3hJ-nhBSXgnd5Qpidcg5ia7Nv53rS58xd23RFBL75VH2kEvRP5m7m8j7Rs=&uniplatform=NZKPT&language=CHS.
5. Juo YY, Skancke M, Holzmacher J, Amdur RL, Lin PP, Vaziri K. Laparoscopic versus open ventral hernia repair in patients with chronic liver disease. *Surg Endosc* 2017; 31:769-777.
6. Cassie S, Okrainec A, Saleh F, Quereshy FS, Jackson TD. Laparoscopic versus open elective repair of primary umbilical hernias: Short-term outcomes from the American College of Surgeons National Surgery Quality Improvement Program. *Surg Endosc* 2014; 28:741-746.
7. Çalışkan B, Metin Ç, Şen Ö. Ultrasound-guided rectus sheath block as the single anaesthetic technique for umbilical hernia repair: A report of 3 cases. *Turk J Anaesthesiol Reanim* 2022; 50:151-154.
8. Manassero A, Bossolasco M, Meineri M, Ugues S, Liarou C, Bertolaccini L. Spread patterns and effectiveness for surgery after ultrasound-guided rectus sheath block in adult day-case patients scheduled for umbilical hernia repair. *J Anaesthesiol Clin Pharmacol* 2015; 31:349-353.
9. Relland LM, Tobias JD, Martin D, et al. Ultrasound-guided rectus sheath block, caudal analgesia, or surgical site infiltration for pediatric umbilical herniorrhaphy: A prospective, double-blinded, randomized comparison of three regional anesthetic techniques. *J Pain Res* 2017; 10:2629-2634.
10. Flack SH, Martin LD, Walker BJ, et al. Ultrasound-guided rectus sheath block or wound infiltration in children: A randomized blinded study of analgesia and bupivacaine absorption. *Paediatr Anaesth* 2014; 24:968-973.
11. Miyazaki D, Shichinohe T, Ebihara Y, et al. Laparoscopic-assisted rectus sheath block as a novel technique is effective and safe: A randomized controlled trial. *Surg Laparosc Endosc Percutan Tech* 2017; 27:19-23.
12. Landmann A, Visoiu M, Malek MM. Development of a novel technique for bilateral rectus sheath nerve blocks under laparoscopic-guidance. *J Pediatr Surg* 2017; 52:966-969.
13. Kinjo Y, Kurita T, Fujino Y, Kawasaki T, Yoshino K, Hachisuga T. Evaluation of laparoscopic-guided rectus sheath block in gynecologic laparoscopy: A prospective, double-blind randomized trial. *Int J Surg* 2019; 62:47-53.
14. Foley PL, Ulery BD, Kan HM, et al. A chitosan thermogel for delivery of ropivacaine in regional musculoskeletal anesthesia. *Biomaterials* 2013; 34:2539-2346.
15. Rosenberg PH, Veering BT, Urmey WF. Maximum recommended doses of local anesthetics: A multifactorial concept. *Reg Anesth Pain Med* 2004; 29:564-575.
16. Maximos S, Vaillancourt-Jean É, Mouksassi S, et al. Peak plasma concentration of total and free bupivacaine after erector spinae plane and pectointercostal fascial plane blocks. *Can J Anaesth* 2022; 69:1151-1159.
17. Gin T, Chan K, Kan AF, Gregory MA, Wong YC, Oh TE. Effect of adrenaline on venous plasma concentrations of bupivacaine after interpleural administration. *Br J Anaesth* 1990; 64:662-666.
18. Courreges P, Poddevin F, Lecoutre D. Para-umbilical block: A new concept for regional anaesthesia in children. *Paediatr Anaesth* 1997; 7:211-214.