

Spread patterns and effectiveness for surgery after ultrasound-guided rectus sheath block in adult day-case patients scheduled for umbilical hernia repair

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Abstract

Background and Aims: We conducted a prospective study to examine the local anesthetic (LA) spread and the effectiveness for surgical anesthesia of ultrasound (US)-guided rectus sheath block (RSB) in adult patients undergoing umbilical hernia repair.

Material and Methods: Thirty patients received at T-10 level a bilateral US-guided injection of 20 mL levobupivacaine 0.375% + epinephrine 5 µg/mL behind the rectus muscle to detach it from its sheath. Anesthetic spread into the rectus sheath was evaluated ultrasonographically at T-9 and T-11 levels and scored from 0 to 4. The RSB was defined effective for surgical anesthesia if it was able to guarantee an anesthetic level sufficient for surgery without any mepivacaine supplementation.

Results: Overall, the block was effective for surgical anesthesia in 53.3% of patients (95% confidence interval, ±17.8). In the remaining patients, anesthesia supplementation was needed at cutaneous incision, whereas manipulation of the muscle and fascial planes was painless. No patients required general anesthesia. LA spreads as advocated (to T-9 and to T-11 bilaterally = spread score 4) in 8/30 patients (26.6%); in these cases, the block was 75% effective for surgery. The anesthetic spread was most negatively influenced by increased body mass index. Postoperative analgesia was excellent in 97% of patients.

Conclusion: Use of RSB as an anesthetic management of umbilical herniorrhaphy is recommended only with anesthetic supplementation at the incision site.

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

Introduction

With the introduction of fast-track surgery protocols and the ongoing shift toward day-case surgery, transversus abdominis plane, ilioinguinal-iliohypogastric, and rectus sheath block (RSB) have all regained popularity for abdominal surgery.^[1] RSB is an example of this evolution. First described by Schleich in 1899,^[2] the aim of the technique is to deposit the local anesthetic (LA) in the virtual space between the posterior wall of the rectus abdominis muscle and its sheath. An anesthetic injected into this space is

assumed to spread freely cephalad and caudal and to block the terminal branches of the intercostal nerves before they leave the rectus sheath. Since the extensive origin of the nerves innervating the abdominal wall pose significant problems in terms of block success and LA consumption, a limited operative surgery field involving fewer intercostals nerves (i.e., T9-T11) was found to be more amenable to this technique, and starting from the late 1990s this block was tested mainly in children having periumbilical surgery.^[3-5] The advent of ultrasound (US)-guidance has helped to increase the feasibility and clinical applications for truncal block, allowing easier identification of the target anatomy structures and accurate visualization of the needle and LA spread,^[6,7] reopening the way for clinical application, study and refinement of RSB.^[8-13] The anesthetic spread in the space behind the rectus abdominis muscle is the premise for an effective RSB, though strong evidence is lacking, and no studies to date have examined the potential role of RSB as an anesthetic management in umbilical herniorrhaphy.

We conducted a prospective study to test the effectiveness for surgical anesthesia of US-guided RSB in adult patients undergoing umbilical hernia repair.

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Material and Methods

The study was conducted as a prospective nonblinded trial after approval by our Hospital Ethics Committee. Informed written consent was obtained from 30 patients (American Society of Anesthesiology classification I-III; age range, 18-80 years) scheduled for day-case primary, small and medium size (defect width ≤ 4 cm) umbilical hernia repair.^[14] Exclusion criteria were noncooperative patients, known allergy to LA agents, history of bleeding or seizure disorders, and previous abdominal surgery.

On arrival in the anesthesia room, peripheral intravenous access was established, and an infusion of Ringer's acetate was started. Routine monitoring included electrocardiography, noninvasive blood pressure, and pulse oximetry. No premedication was administered. Before block placement, the lateral borders of the rectus muscles (linea semilunaris) were identified sonographically (SonoSite M-turbo and L38/10-5 linear array probe; SonoSite Inc., Bothell, WA) and marked with two vertical lines. The intersection between linea semilunaris and costal margin was labeled as a T-8 dermatome level.^[15] A horizontal line joining the linea semilunaris on either side of the rectus abdominis at the umbilical level was drawn and labeled as a T-10 dermatome level. Each linea semilunaris midpoint between T-8 and the T-10 dermatome was joined by a horizontal line which was labeled as the T-9 dermatome. Another horizontal line joining each linea semilunaris was traced below the umbilicus at the same distance between T-9 and T-10; this line was labeled as the T-11 dermatome [Figure 1]. The rectus muscle width (distance between the linea semilunaris and the linea alba at T-10) was measured and multiplied by the distance between T-9 and T-11; this abdominal surface was considered similar, by extension, to the surface area of the underlying rectus sheath that would

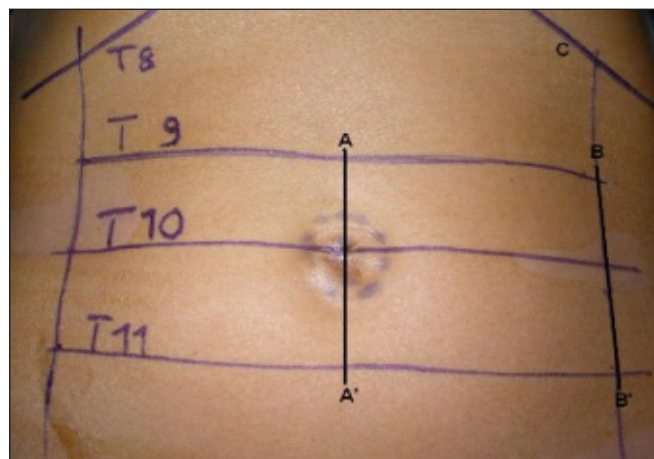


Figure 1: Dermatome lines. A-A' = Linea alba, B-B' = Linea semilunaris, C = Costal margin

be filled with the anesthetic. These data were recorded for further investigations.

The abdominal skin was disinfected with a 2% chlorhexidine solution, and the transducer was equipped with a sterile plastic cover and gel. The rectus muscle was visualized with the US probe held in transversus orientation at the T-10 level. The posterior rectus muscle sheath and the fascia transversalis were identified as twin hyperechoic lines; rectus muscle thickness and posterior sheath depth (midway from each border) were measured with the built-in caliper of the US machine at the T-10 level [Figure 2]. A 20G Tuohy needle (Pajunk Geisingen Germany) connected to an infusion line was introduced in plane with the US probe in a medial to lateral direction at an angle of approximately 45° to the skin plane. No local anesthesia was performed [Figure 3]. Under real-time US guidance, the needle was gradually advanced posterior to the rectus muscle and above the underlying rectus sheath toward its lateral edge, approaching the rectus sheath with the blunt side of the bevel, lateral to the deep inferior epigastric artery to avoid damaging it with the needle. Following negative aspiration testing, a bolus of 1 mL of 20 mL levobupivacaine solution was slowly injected through the needle. The solution was prepared by mixing 10 mL of levobupivacaine 0.75% (Chirocaine™, AbbVie Italy) and 10 mL of saline solution, added with 0.1 mg epinephrine (final concentration levobupivacaine 3.75 mg/mL, epinephrine 5 μ g/mL).^[16] If intramuscular spread of the LA occurred, the needle was advanced until the rectus muscle was separated from the posterior rectus sheath by hydrodissection; the number of attempts to obtain correct hydrodissection was counted. At this point, the remaining anesthetic solution was deposited under US guidance [Figure 4]. The same procedure was repeated on the opposite side. All procedures were recorded as static and dynamic images. All blocks were performed by two investigators adequately skilled in the procedure.

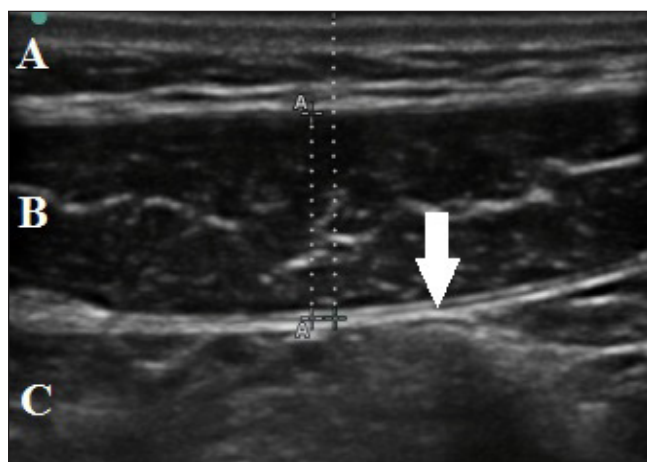


Figure 2: Ultrasound visualization of rectus muscle in transversus orientation at the T-10 level. A = Subcutaneous, B = Muscle, C = Bowel, arrow = Posterior rectus sheath and the fascia transversalis

Five minutes after block placement, anesthetic spread at the T-9 and T-11 dermatome levels was sonographically assessed bilaterally and scored as: 0 = no spread, 1 = detectable spread. A composite spread score from 0 to 4 was obtained for each patient. Twenty minutes after block placement, the patient entered the operating theatre. Oxygen 40% was delivered via a ventimask. Due to traction-related pain and discomfort on deep structures (hernial sac and omentum are not innervated by intercostals nerves), an intravenous infusion of remifentanyl 0.03 $\mu\text{g}/\text{kg}/\text{min}$ was started 5 min before placing the incision to maintain a level of 4-5 points of conscious sedation based on the Observer's assessment of alertness/sedation scale.^[17,18] As per protocol, inadequate anesthesia occurring during surgery was supplemented with local injection of 1% mepivacaine; if this did not alleviate the pain sensation, general anesthesia was planned.

Umbilical hernia repair was performed through a short horizontal, over-umbilical incision; the hernia sac was freed by gentle sharp dissection, opened, and excised. A simple suture (defect ≤ 1 cm) or an endoperitoneal polypropylene mesh was used to close the defect. No vacuum drains were inserted. Postoperative pain was recorded hourly using a numerical rating scale 0-10 both at rest and coughing; patients with a pain score ≥ 3 received intravenous paracetamol 1000 mg. Patients were eligible for discharge once hemodynamically stable, the pain score at rest and coughing was $< 3/10$, and were able to walk and drink freely.

The primary outcome of this work was the effectiveness of RSB for surgical anesthesia, defined as it produced anesthesia sufficient for surgery without the need for mepivacaine supplementation. The secondary outcome was the anesthetic spread pattern into the rectus sheath and its correlation with anthropometric data.



Figure 3: Tuohy needle introduction

Normally distributed data were tested using D'Agostino's distribution. Correlation between anesthetic spread, anthropometric, and block characteristic data were assessed by Pearson's analysis. In this analysis, it was assumed that the population distributions were identical to the sample distributions. Normally distributed data are expressed as means \pm standard deviation; nonnormally distributed data are expressed as the median and inter-quartile range (IRQ). Statistical analysis was performed using GraphPad Prism for Windows, version 5.00 (GraphPad Software, La Jolla, California, USA).

Results

The data from 30 patients (60 RSBs) were analyzed. Table 1 presents patient demographics and block characteristics. The block was effective for surgical anesthesia in 16/30 patients (53.3%) (95% confidence interval 95% \pm 17.8). In the remaining patients, anesthesia supplementation was needed at cutaneous incision, whereas manipulation of the muscle and fascial planes did not cause discomfort. No patients required general anesthesia.

Spread of the LA was contemporaneously bilateral to T-9 and T-11 (echographic spread score = 4) in eight patients (26.6%) [Table 1]; in these cases, the block was 75% effective for surgery. The anesthetic spread score correlated negatively with abdominal surface ($r = -0.7117$), body mass index (BMI) ($r = -0.7228$) and the number of attempts to obtain correct hydrodissection of the rectus muscle away from the posterior rectus sheath ($r = -0.4930$). No correlations were found between the anesthetic spread score and the rectus muscle deepness and thickness. Correct hydrodissection was attained at the first attempt in 32% of patients (median 2.0 [IRQ 2.0]).

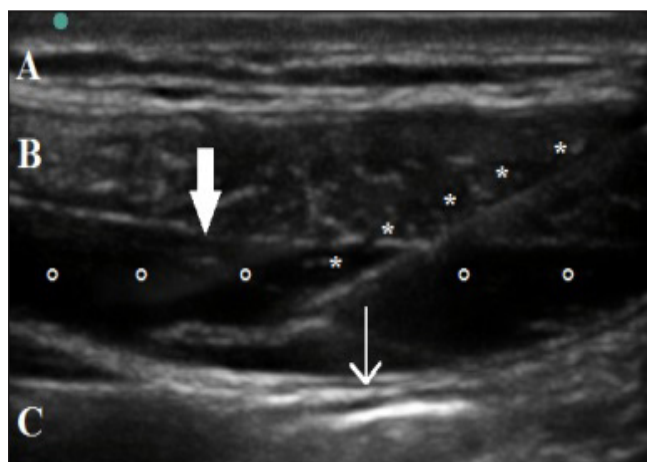


Figure 4: Local anesthetic (LA) injection. A = Subcutaneous, B = Muscle rectus, C = Bowel, * = Needle, ° = LA, thin arrow = Rectus sheath and the fascia transversalis, large arrow = Posterior wall of the rectus

Table 1: Demographics and block characteristics

Age (years)	54 (21-80)
Height (cm)	170 (152-190)
Weight (kg)	78 (50-118)
BMI*	27 (18-39)
Number of males (%)	18 (60.0)
Surgery time (min)	20 (11-40)
Rectus sheath depth (mm)	26 (12-40)
Number of patients with spread score 4/3/2/1/0	8/4/11/4/3
Rectus muscle thickness (mm)	10 (6-16)
Abdominal surface (cm ²)	84 (42-169)

Continuous data are presented as means (range), categorical data as numbers,

*Body mass index

Postoperative analgesia was excellent both at rest and coughing; only one patient required a single rescue dose of paracetamol. Neither intraperitoneal injection of LA nor abdominal wall hematoma was observed. No adverse effects of LA were observed. All patients were discharged home at about 6.00 pm on the day of surgery. No complications were referred at the first postdischarge ambulatory control visit 3 days later.

Discussion

We have attempted to examine the feasibility of US-guided RSB as a unique anesthetic technique in adult patients undergoing elective umbilical hernia repair. When performed at the T-10 level with 20 mL of levobupivacaine 0.375% each side, the block was effective for surgical anesthesia in 53% of the patients.

Umbilical hernia repair is one such surgical procedure in which RSB may be contemplated; however, to our knowledge, only two cases reported its use as the sole anesthetic technique in a high-risk patient to avoid the complications of both general and spinal anesthesia.^[19,20] The purpose of the block is to give anesthesia to the rectus muscle and overlying skin around the umbilicus by bilaterally blocking the terminal branches of the T9-T11 intercostal nerves which, in theory, need bilateral spread of LA to T-9 and T-11 levels (spread score = 4). In the present study, 20 mL of anesthetic Solution was transversely injected to the long axis of the rectus at the umbilicus level and the spread occurred bilaterally to T-9 and T-11 (echographic spread score = 4) in only 26.6% of patients. As the rectus sheath is a virtual container, its filling by a fixed dose of fluid was found inversely proportional to its size (the greater the abdominal surface, the lower the spread score; $r = -0.7117$) so, while performing RSB the volume of the anesthetic agent should be adjusted to the patient's BMI, taking into account the maximum dosage permitted.^[21] Further, as correct hydrodissection of the rectus muscle away from the posterior rectus sheath was successful at the first attempt in only 32% of patients, we noted that each failed attempt in obtaining correct hydrodissection of the rectus muscle

from its posterior sheath inevitably resulted in a certain amount of LA being injected intramuscularly, thus, reducing the LA volume availability for spreading resulting in a poor spread pattern ($r = -0.4930$). To minimize this factor, correct needle position should be tested by injecting a glucose solution. Interestingly, no correlation was found between the number of attempts to obtain correct hydrodissection and the depth of the posterior rectus sheath. Dolan *et al.*^[7] reported a higher success rate of LA placement into the rectus sheath at the time of the first injection under US guidance by trainee anesthesiologists, but differently from our study as these injections were not performed between the rectus wall and its posterior sheath. However, even when the LA spreads as advocated (spread score = 4), the block was effective for surgery in not more than 75% of the patients. This stems from the difficulty of blocking the cutaneous branches of the thoracoabdominal nerves, whereas good anesthesia was achieved in the muscular and fascial planes in 100% of the patients.

Precise details regarding the course and distribution of the thoracolumbar nerves are lacking, and the literature describing these nerves has been contradictory. From a study by Courreges *et al.*,^[4] it would seem that in up to 30% of the population the cutaneous branch of the intercostal nerves is formed before the rectus sheath and so does not pierce the posterior wall of the rectus sheath but instead runs anterior to the rectus muscle in the subcutaneous tissue. To capture these aberrant anterior cutaneous branches, the author placed two injections of anesthetic bilaterally at the umbilicus level: One just under the anterior rectus sheath and one in the subcutaneous plane. de Jose Maria *et al.*,^[9] in an attempt to minimize the importance of such anatomical variations, performed the block between the aponeurosis of the internal oblique and transversus muscles before the 10th intercostal nerves enter the rectus sheath. In contrast, Mori *et al.*^[22] and Yap *et al.*^[23] noted that all intercostal nerves from T-8 to T-11 pierce the rectus sheath at its lateral margin and run posterior to the rectus muscle for about 5 cm before entering the muscle (occasionally entering it at its lateral border). In keeping with this anatomical study, as recently described by Gurnaney *et al.*,^[10] we placed the injection of LA behind the rectus muscle, with the needle oriented in a medial to lateral direction, in an attempt to deposit the LA near the lateral border of the rectus sheath, as close as possible to the nerves before they enter the rectus muscle. Our results may either corroborate Courreges' findings^[4] or simply represent a limit of the procedure. Taken together, greater division and subdivision of the thoracoabdominal nerve origins, extensive communications between these branches, higher anatomical variation in their approach to the posterior surface of the rectus abdominis, and two-sided variability in the same patient set the stage for difficulty in achieving a full block of their cutaneous branches.

This study has several limitations. First, the assessment of the anesthetic spread was performed only 5 min after block

placement, hence we do not know how it progressed; second, the spread was scored categorically without grading for intermediate levels; third, we did not assess the spread over the T-9 and T-11 dermatome. Considering all these limitations the anesthetic spread might have been underestimated.

Conclusion

Our findings show that US-guided RSB is a safe technique. When performed at the T-10 level with the aim to achieve surgical anesthesia in adult patients undergoing umbilical hernia repair, the advocated LA spread is difficult to manage, and the resulting cutaneous block is not easy to obtain. In contrast, postoperative analgesia was excellent. Higher BMI, with increased abdominal surface area, was found to be a factor that most negatively influenced LA spread so, it may be improved by adjusting the volume of the anesthetic agent to the patient's anthropometric data and/or modifying the technique (i.e., changing the direction of the injection by placing the needle in the long axis of the muscle instead of the short axis or performing two injections on each side over and under the umbilicus). Further comparative studies are needed to confirm these hypotheses. Because, achieving full cutaneous sensory block is the main challenge of the procedure, we recommend LA supplementation at the incision site before starting surgery.

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