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Original study

Ultrasound-Guided Erector Rhomboid Intercostal and Subserratus Plane Block (RISS) for perioperative analgesia in patients undergoing thoracotomy: a prospective randomized controlled study

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Abstract

Background: **The surgery of open thoracotomy often causes severe pain. The pain following thoracotomy affects respiration and rehabilitation.**
Objectives: **was to test ultrasound-guided rhomboid intercostal and subserratus plane (RISS) block for preoperative analgesia in open thoracotomy patients.**
Design: **a prospective randomized controlled study.**
Setting: **Tanta University Hospitals. Methods: 60 ASA I-III patients aged 18-60 and of any gender scheduled for elective unilateral open thoracotomy were randomly divided into two groups. The RISS group had a 10 ml ultrasound-guided bupivacaine 0.25% injection in the rhomboid intercostal region on the same side. Additionally, they received a 20 ml subserratus plane injection of 1:200 000 epinephrine. Control group received only general anesthesia. The initial 24-hour postoperative VAS score was the main outcome measure. Fentanyl during surgery, total morphine provided in 24 hours after surgery, and initial morphine dose were secondary outcomes.**
Results: **The RISS block group had significantly lower Visual Analog Scale scores in the first 12 hours after surgery (P < 0.001). The control group consumed more fentanyl (73.5 [35.75 – 88.5] µg) during surgery compared to the RISS block group (0.0 [0.0 – 34] µg) (P = 0.001). RISS block group morphine consumption was significantly lower than control group (21.0 [18.0–24.25] mg) over a 24-hour period (P = 0.001). The RISS group took longer to get the initial morphine dose than the control group (P < 0.001, 95% CI (605.0-855.0)).**
Conclusion: **Open thoracotomy patients who got an ultrasound-guided regional intercostal subcostal block had lower VAS scores for 12 hours after surgery.**
Pan African Clinical Trials Registry: **(PACTR202008534389448)**

Keywords: **Anesthesia, postoperative pain, thoracotomy.**

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The study protocol obtained permission from Tanta University Hospital Ethics Committee (33044/04/19, Prof. Dr. Mona EL-Gohary). Written informed consent was obtained from all participants in the trial. The trial's enrollment period was from October 2020 to November 2022.
Pan African Clinical Trials Registry: PACTR202008534389448.

Introduction

Open thoracotomy is commonly considered to be one of the most agonizing surgical operations. Pain following thoracotomy greatly impedes patient recovery and postoperative respiration[1,2]. The pain experienced after a thoracotomy can originate from various factors, including the surgical incision, injury to the ribs and intercostal nerves, manipulation of the pleura and lung tissue, and the placement of a drainage tube[3].

Various analgesic strategies have been proposed for managing post-thoracotomy pain. The available choices include systemic opioids, epidural analgesia, paravertebral and intercostal nerve blocks. Furthermore, intrapleural analgesia, cryoanalgesia, and transcutaneous electrical nerve stimulation (TENS) have been suggested as potential alternatives[3]. Additionally, the use of systemic or epidural patient-controlled analgesia (PCA) has been extensively utilized[1].

Interfacial chest wall plane blocks have shown promising results as alternatives to neuroaxial blocks4. The serratus anterior plane block has demonstrated efficacy in pain management following thoracotomy and thoracoscopic operations, as well as in delivering analgesia for rib fractures[5]. The erector spinae plane block has been utilized to treat acute postoperative and posttraumatic pain, as well as persistent neuropathic pain[6,7].

The RISS block illustrates the notion of interconnection among the fascial planes of the chest wall. During the study, it was noticed that the injectate dispersed towards the lateral cutaneous branches of the T4 - T9 intercostal nerves in deceased persons. As demonstrated by a series of case studies, this led to pain-relieving effects in the T5 - T8 region[8].

The proposition we provide is that the utilization of ultrasound-guided regional intercostal nerve block (RISS) can proficiently mitigate pain in patients having thoracotomy.

The aim of this study is to evaluate the pain-relieving effects of ultrasound-guided RISS block during the entire perioperative period in patients undergoing open thoracotomy.

Methods

The study was conducted in accordance with the Declaration of Helsinki, 2013. The study protocol obtained permission from the Hospital Ethics Committee (33044/04/19, Prof. Dr. Mona EL-Gohary) and was registered in the Clinical Trials Registry (PACTR202008534389448). Every participant willingly and knowingly gave their consent in writing. The study comprised a cohort of sixty patients, aged between 18 and 60 years, of any gender, who had ASA I-III classification and were undergoing elective unilateral open thoracotomy. The trial's enrollment period was from October 2020 to November 2022.

The exclusion criteria included patient refusal, a body mass index (BMI) above 35 kg/m^2, any contraindication to regional anesthetic such as coagulopathy or infection at the puncture site, and pregnancy. The study excluded patients with allergies to local anesthetics, a history of substance abuse, or those who were regularly using opioids.

At the preoperative appointment, every patient received a detailed explanation of the study protocol, the Visual Analog Scale (VAS) used for pain evaluation, and the proper use of the PCA device.

The participants were allocated at random to two groups, with each group including 30 individuals. The randomization technique was conducted using a computer-generated sequence that was concealed within sealed opaque envelopes.

The control group (C) comprised people who exclusively received general anesthesia.

The RISS group had a 10 ml injection of bupivacaine 0.25% for the rhomboid intercostal and subserratus plane (RISS) blocks. Located at the same side of the body, specifically at the intersection of the rhomboid and intercostal muscles. In addition, a subserratus plane injection was administered using 20 ml of bupivacaine 0.25% with epinephrine (1:200 000). Before the surgery, the patients received premedication in the form of oral midazolam 0.1 mg/kg, which was given 60 minutes before to the procedure.

Each individual underwent a standardized protocol for administering general anesthesia. After employing several monitoring methods including 5 lead ECG, pulse oximetry, non-invasive and invasive blood pressure, and capnography, general anesthesia was induced using fentanyl at a dosage of 1 μg/kg, propofol at a dosage of 2-2.5 mg/kg, and cisatracurium at a dosage of 0.15 mg/kg. Anesthesia was maintained by administering isoflurane at concentrations between 1.2% and 1.5%, in addition to a mixture of oxygen and air, after inserting a double lumen endobronchial tube into the trachea. The administration of cisatracurium was done in increments of 0.03 mg/kg to sustain muscular relaxation. The mechanical ventilation parameters were modified to ensure that the end-tidal carbon dioxide levels remained within the range of 35 to 40 mmHg.

After administering general anesthesia, the anesthesiologist left the operating room in both

groups. Within group II, a distinct anesthesiologist, possessing specialized knowledge in regional anesthesia and not participating in the present investigation, either administered the RISS blocks or performed skin preparation and ultrasound scanning of the block site in patients allocated to the control group.

If there was an increase in hemodynamics (heart rate or mean arterial pressure) of more than 20% from the original values during the procedure, it was considered inadequate pain management and treated by administering 0.5 μg/kg intravenously. Fentanyl. The quantity of fentanyl administered during the surgical procedure was recorded.

After the procedure was finished, the reversal of neuromuscular blockade was performed by administering neostigmine (0.05 mg/kg) and atropine (0.02 mg/kg). After the removal of the endotracheal tube, patients were then transferred to the Post-Anesthesia Care Unit (PACU). Each patient was administered intravenous paracetamol at a dose of 1 gram every 6 hours, along with ketorolac at a dose of 30 milligrams every 6 hours, beginning immediately upon admission to the PACU.

While the patient was waking up, an anesthesiologist who was not aware of the assigned group started giving intravenous morphine titration 9 to the patients who experienced discomfort while resting, had a Visual Analog Scale (VAS) score of 40 or higher, or requested additional pain relief. Intravenous morphine was administered in 3 mg doses at 5-minute intervals. No maximum restriction was specified to the titration dose[9].

The titration of morphine dosage was halted if the Ramsay sedation score surpassed 210, or if notable adverse effects linked to morphine were detected, such as respiratory depression (defined as SpO_2 dropping below 95% and/or a respiratory rate below 12 breaths per minute despite receiving 3 liters per minute of oxygen), vomiting, an allergic reaction, or severe pruritus[9].

The timestamp of the initial morphine delivery was recorded. Following the titration process, patients were provided with instructions to initiate the use of the PCA device. The gadget was programmed to deliver a solitary dosage of 1 milligram, with a lockout period of 7 minutes.

The Visual Analog Scale (VAS) was evaluated upon the patient's arrival to the Post-Anesthesia Care Unit (PACU), and subsequently at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, 8 hours, 12 hours, 18 hours, and 24 hours following the surgery. Every occurrence of adverse events, such as hypotension, nausea, vomiting, or problems related to nerve blocks, was recorded.

The primary metric of interest was the initial Visual Analog Scale (VAS) score recorded within the first 24 hours following the surgical procedure. The secondary outcomes comprised the quantity of fentanyl delivered during the surgical procedure, the cumulative amount of morphine taken within the initial 24 hours post-surgery (including both morphine titration and morphine PCA ingestion), and the duration until the initial morphine dosage was administered. An impartial investigator, who had no knowledge of the participants' assignment to different study groups, undertook the evaluation of all research parameters.

The patients in the RISS group were examined using a linear ultrasound probe (6-12 MHz - SonoSite Edge, Bothell, Washington, USA) positioned in the sagittal plane at the T5-6 level. The probe was positioned approximately 1 to 2 cm inward from the medial scapular line while the patient was lying on their side. After locating the trapezius, rhomboid major, and intercostal muscles, a 22-gauge needle was inserted into the area between the rhomboid major and intercostal muscles. The needle was moved in a downward and outward motion, starting from a higher and more central position. An injection of a 10 ml solution containing bupivacaine at a concentration of 0.25% and epinephrine at a ratio of 1:200,000 was delivered. Afterwards, the probe was directed downwards and laterally to examine the gap between the serratus anterior and external intercostal muscles in order to give the sub-serratus block. An additional 20 mL of bupivacaine (0.25%) was then administered, as illustrated in Figure 1, 2[11].

We calculated our sample size according to a pilot study based on our primary outcome which is the reportable 24 hours VAS. The sample size was obtained using the G* Power 3 analytical tool created by Heinrich-Heine-Universitat ¨ Düsseldorf in Germany. The sample size estimate was derived based on the visual analog scale score measured 24 hours post-surgery. Based on the results of our pilot study, which included 10 patients in each group, the mean (standard deviation) postoperative visual analog scale (VAS) score was 39.5 (22.8) for the control group and 19.8 (17.9) for the RISS block group. In order to identify this distinction, it was imperative to have a sample size of 24 patients in each group, with an alpha error rate of 0.05 and a research power of 90%. To reduce the frequency of dropout cases, we opted to recruit 30 patients for each group. The sample size was obtained using a 2-sample independent t test (2-sided) of the visual analog scale score.

The statistical analysis was performed using SPSS 16, a software created by SPSS Inc. in

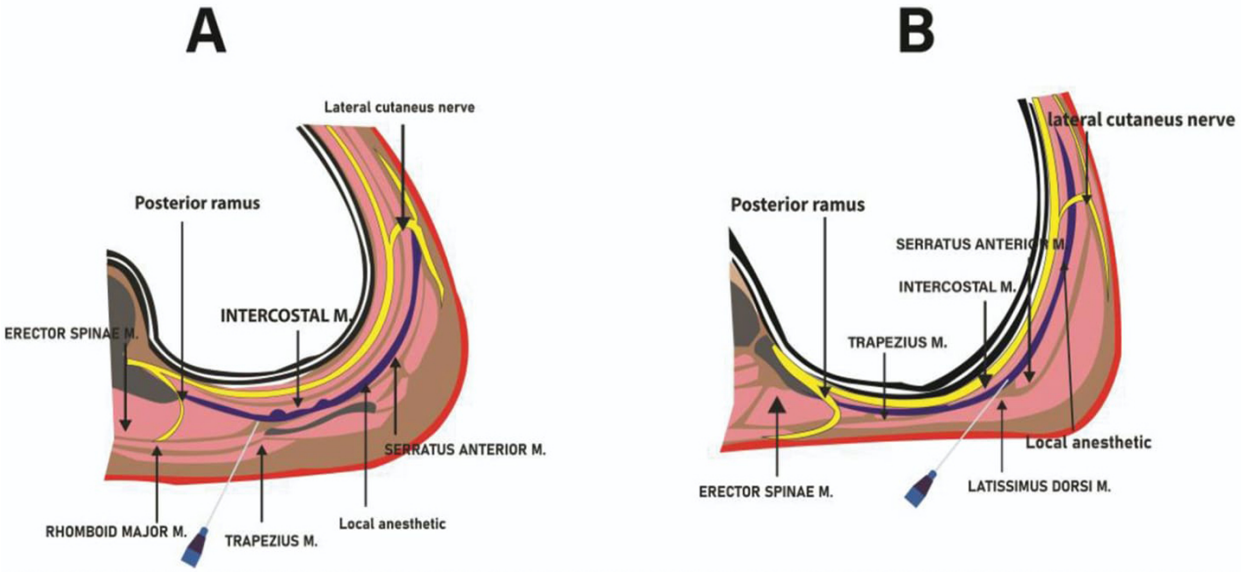

Fig. 1 — Anatomical illustration of the Rhomboid Intercostal and subserratus plane (RISS) block. **A: The Rhomboid intercostal block**: Schematic illustration at the level of T5-6 demonstrating needle position and injectate spread during rhomboid intercostel injection. **B: The sub-serratus block**: Schematic illustrationof the sub-serratus block: performance at the level of T7-8 demonstrating the surrounding muscle layers and local anesthetic spread.

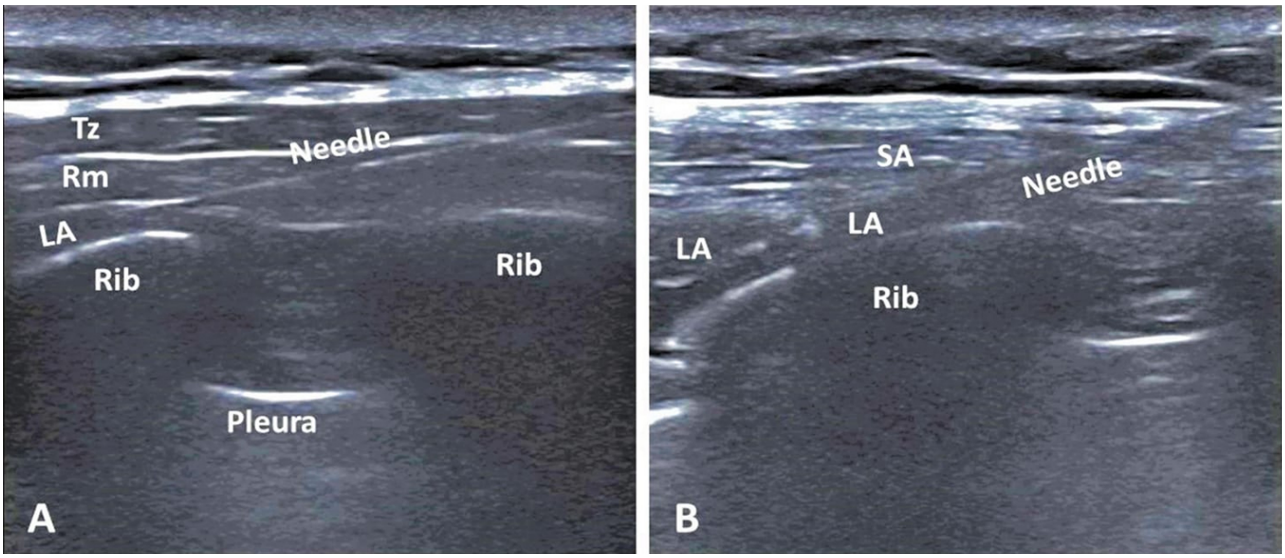

Fig. 2 — Ultrasound-guided demonstartion of the Rhomboid Intercostal and subserratus plane (RISS) block. A: The Rhomboid intercostal block: Tz: trapezius muscle, Rm: rhomboid major muscle, LA local anesthetic. Needle is visualised with LA deposited in the plane between the rhomboid major ans intercostal muscles. B: The sub-serratus block: SA: serratus anteroir miscle, LA: local anesthetic. Needle is visualised with LA deposited in the tissue plane between the serrantus anterior and external intercostal muscles.

Chicago, IL, USA. To confirm the assumption of normality, the Shapiro-Wilk test and visual inspection of histograms were employed. The quantitative data, which followed a normal distribution, were presented as the mean (standard deviation) and analyzed using an independent sample t-test. The parameters that exhibited non-normal distribution were represented by the median with interquartile range and compared between the groups using the Mann-Whitney test. The categorical data were presented as the count or proportion of patients and were evaluated using either the Chi-square test or the Fisher exact test, depending on the specific situation. A significance level of $p < 0.05$ was employed. The hypothesis testing was performed using a two-tailed technique.

Results

Seventy-four patients were assessed to ascertain their eligibility. Six patients did not meet our inclusion criteria. Eight patients refused to participate. A cohort of sixty patients was enlisted, observed, and assessed following the flowchart illustrated in Figure 3. The demographic characteristics and duration of the surgical procedure were comparable, as indicated in Table I. The time to perform the RISS block which was 16.9±2.5 minute.

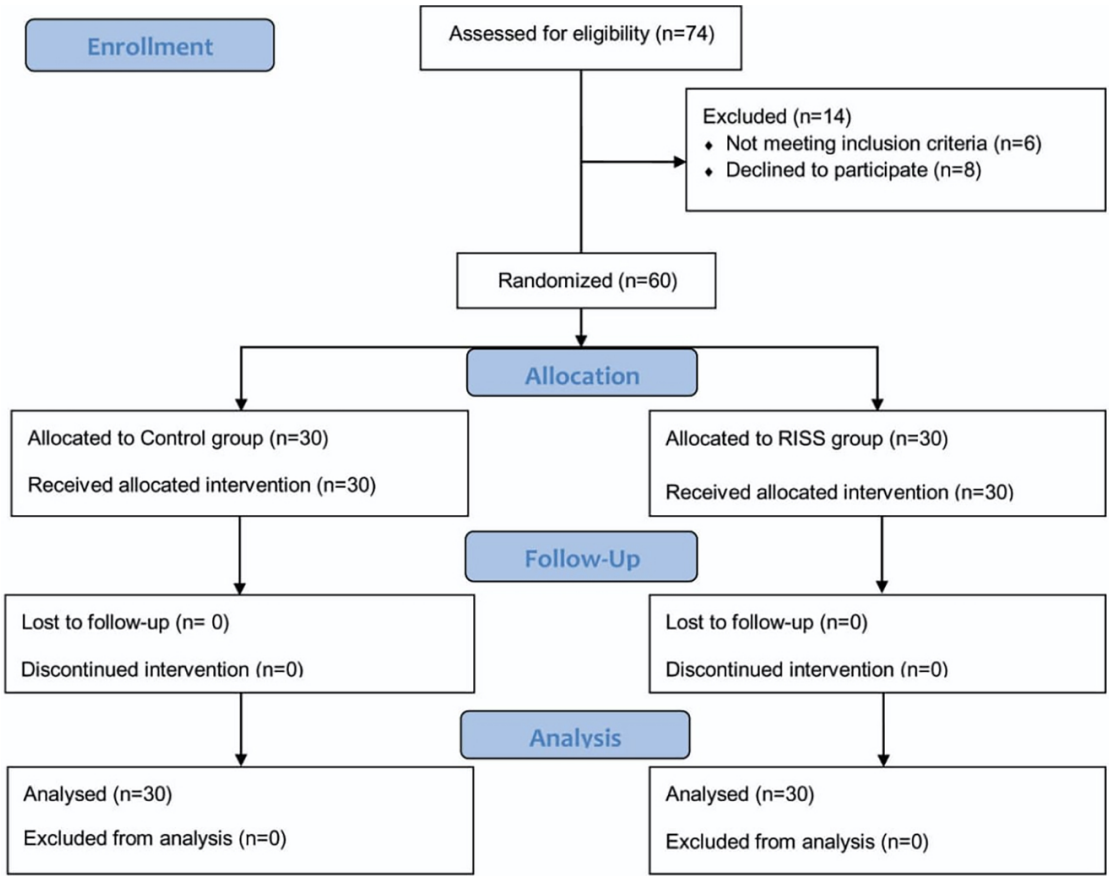

Fig. 3 — CONSORT flow diagram of participants through each stage of the randomised trial.

Table I. — Comparison of demographic data between the two studied groups.

	Control group (n= 30)	RISS group (n= 30)	P value
Age (years)	47.73 (5.95)	49.57 (5.81)	0.232
Sex (M/F)	24/6	22/8	0.761
Weight (kg)	81.2 (12.0)	77.00 (10.2)	0.149
Duration of surgery (min)	172.7 (22.4)	167.7 (27.6)	0.441
Type of surgery			
Decortication	18	14	
Lobectomy	8	11	0.581
pneumonectomy	4	5	

RISS: Rhomboid intercostal and subserratus plane; Data presented as mean (SD) or patient number. *P<0.05 denotes statistical significance.

The Visual Analog Scale (VAS) scores were significantly reduced in the RISS group upon admission to the Post-Anesthesia Care Unit (PACU) and remained lower than those in the control group for the initial 12 hours following the surgery ($P < 0.001$). The Visual Analog Scale (VAS) scores at 18 and24 hours post-surgery showed no significant difference ($P = 0.525$ and 0.087 respectively) Figure 4. The RISS group consisted of 11 patients who required intraoperative fentanyl, whereas the control group comprised 26 patients who needed it ($P < 0.001$). The RISS group had a significantly decreased median [IQR] of intraoperative fentanyl consumption (0 [0 – 34] µg) in comparison to the control group (73.5 [35.75 – 88.50] µg); $P < 0.001$, with a 95% confidence interval of [35.00-76.01], Table II.

No detrimental consequences that required the cessation of morphine titration were seen. The RISS group had significantly lower median values for titration (3.0 mg with an interquartile range of 3.0-6.0 mg) and first 24h PCA morphine consumption (5.5 mg with an interquartile range of 4.0-7.0 mg) compared to the control group (7.5 mg with an interquartile range of 6.0-9.0 mg and 14.0 mg with an interquartile range of [10.75-

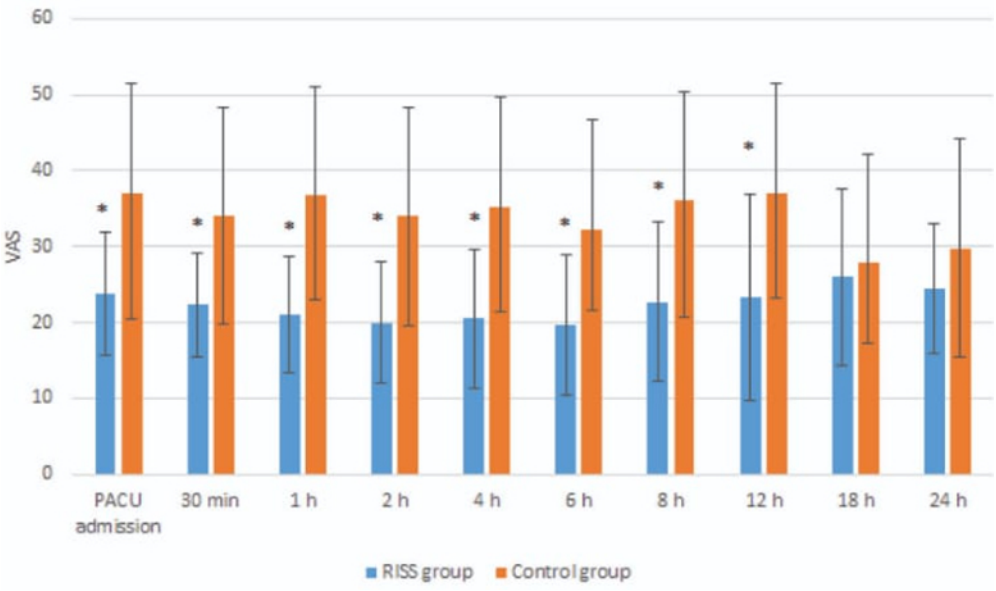

Fig. 4 — Visual Analogue Scale of pain in the studied groups.

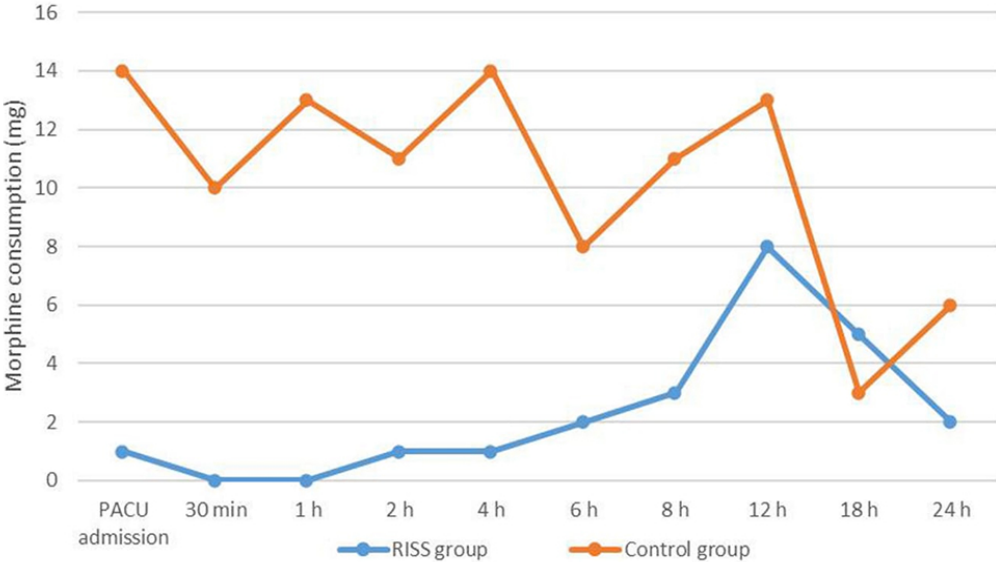

Fig. 5 — Postoperative morphine consumption.

15.0 mg] respectively) (P <0.001, 95% confidence interval [3.00-6.00] and [6.00-9.00] respectively). Regarding PCA morphine consumption in the first 12 postoperative hours, the RISS group had a significantly lower median morphine consumption (2 mg, interquartile range: 1.0 – 3.0 mg) compared to the control group (11 mg, interquartile range: 9 – 12 mg) (p < 0.001, 95% confidence interval [8.00-10.00]), Table II, Figure 5. The RISS group had a significantly lower median cumulative morphine intake in the first 12 hours after surgery (6 mg, interquartile range: 4.75 – 7.25 mg) compared to the control group (18.5 mg, interquartile range: 15.0 – 22 mg) (p < 0.001, 95% confidence interval [10.00-14.00]), Table II. The RISS group had a significantly lower median cumulative morphine intake in the first 24 hours after surgery (9.5 mg, interquartile range: 7.75 – 11.25 mg) compared to the control group (21.0 mg, interquartile range: 18.0 – 24.25 mg) (p < 0.001, 95% confidence interval [9.00-13.00]), Table II.

The RISS group exhibited a significantly longer median [IQR] time to administer the first morphine dose (720 [413.8-972.5] min) in comparison to the control group (30 [4.75-48.75] min), with a p-value of less than 0.001 and a 95% confidence interval of [605.0-855.0], Table II. The mean duration of the RISS block was 12.17 hours, with a standard deviation of 3.31 hours. No significant concerns were identified in either group. Among the patients in the control group, four individuals encountered intraoperative hypotension. In contrast, three patients in the RISS group experienced the same condition. The statistical analysis revealed that the difference between the two groups was not significant (P > 0.99). Postoperative nausea and

Table II. — Comparison of perioperative analgesic consumption between the two studied groups.

	Control group (n= 30)	RISS group (n= 30)	Median difference/ relative risk	P value	95% CI
Patients who required intraoperative fentanyl	26 (86.67%)	11 (36.67%)	2.36	<0.001*	1.45-3.86
Intraoperative fentanyl consumption (µg)	73.5 [35.75-88.50]	0 [0-34]	50	<o.oo1*	35.0-76.0
Morphine titration consumption (mg)	7.5 [6.0-9.0]	3.0 [3.0-6.0]	3.0	0.001 *	3.0- 6.0
12 h PCA morphine Consumption (mg)	11.0 [9 – 12]	2 [1.0 – 3.0]	9	< 0.001*	8.00 -10.00
24 h PCA morphine consumption (mg)	14.0 [10.75 – 15]	5.5 [4.0 – 7.0]	8	< 0.001 *	6.00-9.00
Cumulative 12 h morphine consumption	18.5 [15 – 22]	6 [4.75 – 7.25]	12	0.001*>	10.00 -14.00
Cumulative 24 h morphine consumption (mg)	21 [18–24.25]	9.5 [7.75– 11.25]	11	< 0.001 *	9.00-13.00
Time to 1st morphine dose (min)	30.0 [4.75 – 48.75]	720 [413.8 – 972.5]	690	< 0.001 *	605.0- 855.0
RISS: Rhomboid intercostal and subserratus plane; Data presented as patient number (%) or median [IQR]; CI; confidence interval for median difference or relative risk. *P<0.05 denotes statistical significance.					

vomiting occurred in 5 patients in the control group, but only 3 patients in the RISS group had similar symptoms (P = 0.707). No complications related to nerve blocks were detected in any of the patients, Table III. The RISS group had significantly higher patient satisfaction levels compared to the control group (P = 0.004), Table III.

Discussion

The pain scores of patients who underwent open thoracotomy were reduced during the initial 24 hours following surgery when the RISS block was conducted with the assistance of ultrasound guidance, as determined by the Visual Analog Scale (VAS). Moreover, the utilization of RISS block was associated with reduced consumption of pain medication during the perioperative phase and a prolonged interval before the delivery of the initial postoperative morphine dose.

The interconnections between the planes located behind the erector spinae, rhomboid, serratus anterior muscles, latissimus dorsi, and upper section of the external oblique muscle have been documented[8,12]. The substance injected in the RISS block diffuses within the rhomboid and intercostal muscles, and subsequently penetrates beneath the scapula and serratus anterior muscle. It specifically affects the lateral cutaneous branches of the ventral rami of the thoracic intercostal nerves. Subsequently, the injected substance diffuses towards the center of the erector spinae tissue plane and extends towards the surface of the thoracic transverse processes. The dorsal rami of the thoracic intercostal nerves originate from the spaces between the tips of the neighboring T3 to T9 transverse processes. Hence, the RISS block possesses the capability to provide analgesia for procedures affecting the chest wall and upper abdomen8.

The RISS block technique has been utilized in several surgical operations, such as lung transplants[13], back surgeries[14], thoracotomies[15], breast reconstruction16, and modified radical mastectomy with axillary clearing[17], as demonstrated by numerous research. These investigations consistently demonstrate that RISS block is highly

Table III. — Demonstration of patient satisfaction and perioperative complications in the two studied groups.

		Control group (n= 30)	RISS group (n= 30)	P value
Satisfaction	Satisfied	14 (46.7%)	26 (86.7%)	0.004
	Fair	13 (43.3%)	3 (10%)	
	Dissatisfied	3 (10%)	1 (3.3%)	
Complications	Nausea and vomiting	5 (16.7%)	3 (10%)	0.707
	Hypotension	4 (13.3%)	3 (10%)	> 0.99
RISS: Rhomboid intercostal and subserratus plane; Data presented as patient number (%). *P<0.05 denotes statistical significance.				

effective in providing analgesia from the T2 to T9 levels.

Postoperative pain following thoracic procedures can be attributed to intercostal neuralgia, pleural stimulation resulting from the presence of a drainage tube, vigorous coughing, the surgical incision, and nerve injury[11]. Longo et al.[18] found that the RISS block effectively relieved pain in non-intubated patients having video-assisted thoracoscopic surgery (VATS) at 1 and 4 hours post-surgery, eliminating the need for additional pain medication. Deng et al.[11] conducted a study comparing the analgesic effectiveness of ultrasound-guided rhomboid intercostal block (RIB) and RISS block following VATS. The findings obtained were comparable to the ones documented by Longo et al.[18] The researchers determined that the RISS block yielded superior pain relief over the initial 24-hour period following surgery, while also reducing the requirement for sufentanil. Altıparmak et al.[19] performed ultrasound-guided rib interscalene block (RIB) on two patients having thoracoscopic surgery. They noted a T3 and T10 sensory blockade and determined that no supplementary analgesics were necessary during the initial 12-hour postoperative period. We injected 10 ml of bupivacaine 0.25% for the rhomboid intercostal injection, and 20 ml of bupivacaine 0.25% with 1:200,000 epinephrine for the subserratus plane injection. In their work, Betul Kozanhan et al.[20] discovered that administering a 40 ml dose of bupivacaine (0.25%) was a secure and efficient method for performing a RISS block. In their research, Ferdinando Longo et al.[21] discovered that the use of 35 ml of 0.375% ropivacaine in RISS block was both secure and efficient in delivering adequate pain alleviation. In their research, Wei Deng et al.[22] found that the administration of 40 ml of 0.375% ropivacaine resulted in safe and efficient pain alleviation for chest wall block.

Although there is a dearth of recorded adverse consequences linked to RISS block in the literature, there is a possibility of problems such as pneumothorax, hematoma, or infection. Local anesthetic toxicity may occur[23]. However, our study did not encounter any challenges related to nerve blocks.

The extent of our investigation is limited by the relatively small size of our sample. In addition, we chose not to assess the dermatomal distribution of sensory block in the RISS block group to maintain the integrity of the study's double-blinded design.

To summarize, the utilization of ultrasound-guided RISS block led to reduced postoperative pain scores within the first 12 hours following surgery in patients undergoing open thoracotomy. Furthermore, it resulted in decreased utilization of analgesic drugs in the perioperative phase and a prolonged interval before the initial administration of postoperative morphine was necessary.

Conflict of interest: none to be declared.
Data availability: The data associated with paper are not publicly available but are available from the corresponding author on reasonable request.

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