

# The Analgesic Efficiency of Ultrasound-Guided Rectus Sheath Analgesia Compared with Low Thoracic Epidural Analgesia After Elective Abdominal Surgery with a Midline Incision: A Prospective Randomized Controlled Trial

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## Abstract

**Background:** Ultrasound-guided rectus sheath blockade has been described to provide analgesia for midline abdominal incisions. We aimed to compare thoracic epidural analgesia (TEA) and rectus sheath analgesia (RSA) with respect to safety and efficacy.

**Methods:** Sixty patients who underwent elective laparotomies through a midline incision were assigned randomly to receive either continuous TEA (TEA group, n = 31) or intermittent RSA (RSA group, n = 29). The number of patients who required analgesia, the time to first request analgesia, the interval and the cumulative morphine doses consumption during 72 hours postoperatively, and pain intensity using visual analog score (VAS) at rest and upon coughing were reported in addition to any side effects related to both techniques or administered drugs.

**Results:** While 17 (54.84 %) patients were in the TEA group, 25 (86.21%) patients in the RSA group required analgesia postoperatively, P = 0.008. Cumulative morphine consumed during the early 72 hours postoperatively median (interquartile range) = 33 mg (27 - 39 mg), 95% confidence interval (28.63 - 37.37 mg) for the TEA group. While in the RSA group, it was 51 mg (45 - 57 mg), 95% CI (47.4 - 54.6 mg), P < 0.001. The time for the first request of morphine was 256.77 ± 73.45 minutes in the TEA group versus 208.82 ± 64.65 min in the RSA group, P = 0.031. VAS at rest and cough were comparable in both groups at all time points of assessment, P > 0.05. The time to the ambulation was significantly shorter in the RSA group (38.47 ± 12.34 hours) as compared to the TEA group (45.89 ± 8.72 hours), P = 0.009. Sedation scores were significantly higher in the RSA group, only at 12 hours and 24 hours postoperatively than in TEA group, with P = 0.041 and 0.013, respectively. The incidence of other morphine-related side effects, time to pass flatus, and patients satisfaction scores were comparable between both groups.

**Conclusions:** Continuous TEA had better opioid sparing effects markedly during the early 72 hours postoperatively than that of intermittent RSA with catheters inserted under real-time ultrasound guidance, both had comparable safety perspectives, and RSA had the advantage of early ambulation. RSA could be used as an effective alternative when TEA could not be employed in patients undergoing laparotomies with an extended midline incision, especially after the first postoperative day.

**Keywords:** Postoperative Analgesia, Rectus Sheath Analgesia, Midline Incision Abdominal Surgery, Thoracic Epidural Analgesia

## 1. Background

Laparotomies that necessitate a midline incisions were commonly accompanied by postoperative pain which derived mainly from abdominal wall incision (1).

Adequate postoperative pain control is crucial to mitigate stress response, postoperative insulin resistance, and to reduce the incidence of postoperative chronic pain. In addition, postoperative analgesia enhances early mobilization and consequently decreases the incidence of postoperative chest infection and deep venous thrombosis (2, 3).

Administration of multimodal analgesics could limit

the excessive use of systemic opioid analgesia, which had a high rate of postoperative side effects as sedation, respiratory depression, ileus, nausea, vomiting, constipation, urine retention, and itching (3-7). The thoracic epidural analgesia (TEA) is considered the standard analgesic modality for major laparotomies (2, 8). Nevertheless, TEA is not a technique without risks, although rare, it could be dangerous and devastating like hematoma formation, epidural abscess, neural damage, immobilization due to motor block, urine retention, sympathetic block, hypotension, and had 25% - 30% failure rate (9-12).

Rectus sheath analgesia (RSA) provides pain relief for

anterior abdominal wall structures superficial to the peritoneum. It is suitable for the procedures that required a midline incision as well as the procedures that necessitated lower abdominal transverse incisions (13). Local anesthetic instillation within the posterior rectus sheath bilaterally provides intense analgesia for the middle anterior wall from the xiphoid process to the symphysis pubis in adults (14) and in pediatric population (15, 16). Nonetheless, it devoid the ability to control visceral pain, which could be severe in the early 12 - 36 hours postoperatively (2, 17).

The use of real-time ultrasonography guidance for rectus sheath block may reduce risks of peritoneal puncture, bleeding, visceral injury, and facilitate correct needle position. Furthermore, ultrasound guidance enables accurate catheter placement, ensures satisfactory local anesthetics spread, and putatively increases the rate of success (18-21).

## 2. Objectives

The aim of this trial was to compare continuous TEA with US-guided RSA with catheter placement for a midline abdominal incisions in adults undergoing elective major upper abdominal surgery as regard safety and efficacy. We hypothesized that RSA could be an efficient surrogate analgesic modality to continuous TEA in procedures requiring a midline incision.

## 3. Methods

### 3.1. Trial Setting and Eligibility Criteria

After local ethical committee approval and patient's informed written consent, this prospective, observer-blinded, and randomized clinical trial was conducted on 60 patients whose ages ranged between 18 and 80 years. ASA physical status class I, II, and III patients who were prepared for elective upper abdominal surgery through a midline incision were included.

Patients with known hypersensitivity to local anesthetics, local infection at the site of block, uncontrolled hypertension, obese (BMI > 30 kg/m<sup>2</sup>), any cardiac, cerebrovascular, renal, hepatic or muscular disease, patients with coagulation disorders, and patients complaining of chronic pain were excluded from the study.

### 3.2. Randomization and Blinding

Patients were randomly assigned to receive either continuous TEA (TEA group, n = 31 patients) or bilateral RSA with catheter insertion (RSA group, n = 29 patients) with an

online randomization program that generated a list of random numbers. Patient randomization numbers were concealed in opaque envelopes that were opened by the study investigator. The investigators who were involved in obtaining data were blinded to study protocol and randomization for the period of data collection and analysis.

### 3.3. Interventions

#### 3.3.1. Preoperative Patients' Preparation

One day before surgery, all patients were interviewed to elucidate the visual analog scale (VAS) (where 0 = no pain and 10 = worst comprehensible pain) and routine investigations were fulfilled.

#### 3.3.2. Anesthesia Management

The patients were monitored with pulse oximeter, electrocardiogram, non-invasive arterial pressure, temperature probe, and capnography. An intravenous (IV) access was established and IV midazolam 0.01 - 0.02 mg/kg was given. An arterial line was inserted for blood gas analysis. Right internal jugular venous catheter was placed for central venous pressure (CVP) measurements. The fluid replacement strategy aimed to maintain CVP between 5 - 10 cm H<sub>2</sub>O with lactated Ringer's solution and packed red blood cells were given to keep hemoglobin level above 10 g/dL.

#### 3.3.3. Thoracic Epidural Analgesia

Before induction of anesthesia for patients allocated to TEA group, attending senior anesthetists who were not involved in the study inserted a 20 gauge epidural catheter (Perifix, B.Braun, Melsungen AG, Germany). The techniques were performed under aseptic precaution in the lateral position at T8 - T9 level. A midline approach with loss of resistance technique with saline was employed using an 18 gauge and an 80 mm Tuohy needle (Perifix, B.Braun, Melsungen AG, Germany). There were no drugs administered but test dose of 3 mL of Lidocaine 1% mixed with epinephrine 1: 200 000.

#### 3.3.4. Standard General Anesthetic

Standard general anesthesia for both groups was induced with fentanyl 3 mcg/kg, propofol 1-3 mg/kg followed by rocuronium 0.6 mg/kg to facilitate endotracheal intubation. Anesthesia maintained with isoflurane 1.5 volume % and rocuronium 0.15 mg/kg as a maintenance dose every 30 minutes until completion of the procedure. Ventilation parameters were adjusted as follows: tidal volume (TV) = 5 - 8 mL/kg, positive end-expiratory pressure (PEEP) = 5 cm H<sub>2</sub>O, respiratory rate (RR) = 12/minute then it was adjusted to maintain end-tidal CO<sub>2</sub> between 35 - 40 mmHg, and fraction of inspired oxygen (FiO<sub>2</sub>) = 0.4 - 0.7.

### 3.3.5. Thoracic Epidural Catheter Activation

After completion of the surgical procedure, the thoracic epidural catheter was activated with 10 ml of bupivacaine 0.25% in increments over 10 minutes.

### 3.3.6. Rectus Sheath Analgesia

For the patients allocated to RSA group, US-guided rectus sheath block with catheters insertion was performed bilaterally by other attending senior anesthetists, who did not participate in the study. The techniques were performed with complete aseptic precaution by using ultrasound machine (Logiq p5, GE corporate, general electric company®, USA) while the patient in the supine position after completion of the surgical procedure. The high frequency (11 MHz) linear array ultrasound probe enabled rectus muscle identification and allowed localization of the hyperechoic matching lines deep to it (posterior rectus sheath and fascia transversalis). The same type and size Tuohy needle was introduced in plane to the ultrasound probe below the costal margin at an angle of approximately 45 degrees to the skin. The needle tip proceeded to the desired position, posterior to the rectus muscle and above the underlying rectus sheath. Installation of a 20 ml bolus dose of 0.25% bupivacaine was done to dissect the posterior rectus sheath on each side, then the same type and size catheters were passed through the Tuohy needle and fixed to the skin, an 8 cm of the catheters were inserted into space on each side.

### 3.3.7. Postoperative Management

After anesthesia emergence, all patients were transferred to the post-anesthesia care unit (PACU) for 2 hours observation period. The patients were discharged from the PACU after fulfilling the discharge criteria based on the modified Aldrete score  $\geq 9$  (22).

As a part of standardized regular institutional postoperative pain control policy, Acetaminophen 1 gm every 6 hours by IV infusion and ketorolac 30 mg diluted in 100 mL normal saline through IV infusion over 20 minutes every 8 hours were administered as 2 components of multimodal anesthesia regimen for postoperative pain control.

Postoperative analgesia in the TEA group achieved with continuous infusion of a fixed rate of 5 mL/h of bupivacaine 0.25% for 72 hours started shortly after activation. The local anesthetic solution was equipped by a devoted nurse who did not participate in the trial by using the disposable ambulatory elastomeric accufuser® infusion pump (Accufuser, code C0050XL, CairoMed, Cairo, Egypt) with a total volume of 550 mL, fixed infusion rate of a 5 mL/h, and usable for 110 hours. Postoperative analgesia in the RSA group was achieved with an intermittent injection of 20 mL of bupivacaine 0.25% on each side every 6 hours

till 72 hours. The local anesthetic solutions were prepared by another devoted nurse who did not contribute in the study.

A postoperative rescue analgesia with intravenous morphine per a titration protocol (3 mg morphine sulfate IV as a bolus dose that could be repeated every 5 minutes with a maximum dose of 15 mg per 4 hours or 45 mg per 24 hours) was employed if visual analog pain scale (VAS)  $\geq 4$ . The morphine titration protocol was suspended with Oxygen saturation  $< 95\%$ ; respiratory rate  $< 10$  / min; the development of sedation (Ramsay sedation scale  $>2$ ); development of acute adverse effects (allergy, marked itching, excessive vomiting, and hypotension with systolic blood pressure  $\leq 20\%$  of baseline values); or attaining adequate level of analgesia.

### 3.4. Outcomes

The primary outcome measure was the cumulative 72 hours morphine consumption. Secondary objectives were to compare numbers of patients required postoperative analgesia, to compare the duration of analgesia based on time to first request of morphine analgesia, and to compare the quality of analgesia based on VAS at rest and upon coughing at 1, 6, 12, 24, 48, and 72 hours, postoperatively. Incidences of complications related to both techniques and morphine-related side effects (ileus; nausea; vomiting; pruritus; and excessive sedation) were reported. Ileus was defined as recent nausea and vomiting, abdominal distention, and abdominal discomfort with loss of bowel sounds. Sedation was assessed at 2, 6, 12, 24, 48, and 72 hours postoperatively on a 5-point sedation Ramsay's score (23) (5, aroused only by shaking; 4, asleep, difficulty responding to verbal commands; 3, mostly sleeping but easily aroused; 2, drowsy or dozing intermittently; 1, awake). Over-sedation is defined as having a sedation score  $\geq 4$  combined with a respiratory rate  $< 8$  breaths per minute. Patients with over-sedation were transferred to the intensive care unit for close monitoring and observation, and patients with nausea and vomiting were treated by Ondansetron 0.15 mg/kg intravenously over 15 minutes. Other secondary outcome measures included the duration of surgery, time elapsed for ambulation, time for returning of regular bowel habits and passing flatus, and patients satisfaction with postoperative analgesia after 72 hours postoperatively according to a satisfaction score (poor = 0; fair = 1; good = 2; excellent = 3).

### 3.5. Statistical Analysis

Continuous data with normal distribution were presented as the mean  $\pm$  standard deviation (SD) and were compared for significance by using unpaired student t-test. Continuous data with skewness and kurtosis as well

as ordinal data were presented as median (interquartile range [IQR] and range) and compared for significance by using the Mann-Whitney U test. The Kolmogorov-Smirnov test was implemented to check the normality of continuous data distribution ( $P \leq 0.05$ ). Qualitative data were presented as numbers (percentages) and were analyzed by using the Chi-square test or Fisher exact test as appropriate. Statistical analysis was performed using the statistical package for the social sciences (SPSS) version 16 (SPSS Inc., Chicago, IL, USA).  $P \leq 0.05$  was considered statistically significant.

### 3.6. Sample Size Calculation

T-test was used to detect the sample size based on a pilot study (8 participants in TEA arm and 9 participants in RSA arm) with estimation of cumulative morphine consumption at 72 hours (the primary outcome). The mean cumulative morphine consumption at 72 hours was 47.86 mg in the RSA group and was 32.55 mg in the TEA group. The clinical effect size  $d$  calculated to be 0.753 with a mean difference of cumulative morphine consumption at 72 hours between both groups = 15.31 mg and pooled SD = 20.34 mg. Assuming the power = 80% and the two-sided  $\alpha$  error = 0.05, a sample size of 29 participants per group were found adequate to detect a 30% difference between the 2 groups. Recruitment of 35 patients per group was done to account for possible data loss. Sample size calculation has been done by using the G\*Power software version 3.1.7 (institute of experimental psychology, Heinrich Heine university, Dusseldorf, Germany).

## 4. Results

Eighty patients were enrolled in the study. Data from 60 patients, 31 from TEA group and 29 from RSA group, were included in the final analysis (Figure 1). The 2 groups were comparable on age, sex, weight, height, BMI, duration of surgery, and types of surgical procedures,  $P > 0.05$  (Table 1). Seventeen patients (54.84%) in the TEA group received morphine with 95% confidence interval (CI) (37.32% - 72.36%), compared with 25 patients (86.21%) in the RSA group with 95% CI (81.78% - 90.64%),  $P = 0.008$  (Table 2).

The time for the first request for morphine was significantly longer in the TEA group ( $256.77 \pm 73.45$  minutes) with 95% CI (219.01 - 294.53 minutes) than in the RSA group ( $208.82 \pm 64.65$  minutes) with 95% CI (182.14 - 235.5 minutes),  $P = 0.031$  (Table 2). The cumulative postoperative morphine consumption during 72 hours (the primary outcome) was significantly lower in the TEA group [a median of 33 mg, IQR (27 - 39 mg), and range (15 - 54 mg) with 95% CI (28.63 - 37.37 mg)], in comparison with the RSA group, [a median of 51 mg, IQR (45 - 57 mg), and range (36 - 63 mg) with

95%CI (47.4 - 54.6 mg)],  $P < 0.001$  (Table 2). The cumulative postoperative morphine consumption during the early 24 hours was significantly lower in the TEA group [a median of 18 mg, IQR (15 - 18 mg), and range (9 - 27 mg) with 95% CI (16.91 - 19.09 mg)], in comparison with the RSA group [a median of 33 mg, IQR (30 - 36 mg), and range (24 - 39 mg) with 95%CI (31.2 - 34.8 mg)],  $P < 0.001$  (Table 2). The titration doses of morphine consumption were significantly lower in TEA group than those of RSA group at the intervals during the initial 24 hours postoperatively,  $P < 0.05$  (Table 2). The doses of morphine consumption at day 2 and day 3 postoperatively were comparable between both groups,  $P = 0.41$  and  $0.53$ , respectively (Table 2). The VAS at rest and upon coughing were similar between both groups at 1, 6, 12, 24, 48, and 72 hours postoperatively,  $P > 0.05$  (Figure 2 and Figure 3). The time to ambulation was significantly longer in the TEA group than in the RSA group ( $45.89 \pm 8.72$  hour versus  $38.47 \pm 12.34$  hour respectively),  $P = 0.009$  (Table 3). There were no reported complications related to both techniques (hematoma formation, abscess, neural damage, and visceral perforation). The morphine-related side effects (ileus, nausea, vomiting, and pruritus), time elapsed to pass flatus, and patients' satisfaction for postoperative analgesia were comparable between both groups,  $P > 0.05$  (Table 3). Postoperative sedation scores were comparable between both groups at all time points of assessments except at 12 hours and at 24 hours. There was a significant increase in sedation scores in the RSA group as compared to the TEA group [a median (IQR) = 3 (2, 3) and 3 (2, 3) for the RSA group versus 2 (2, 3) and 2 (2, 2) for the TEA group at 12 hours and 24 hours respectively],  $P = 0.041$  and  $0.013$  at 12 hours and 24 hours respectively (Table 4).

## 5. Discussion

This study revealed that in an elective upper abdominal surgery with a midline incision, both TEA and RSA provided satisfactory control of postoperative pain with practically insignificant postoperative complications. However, TEA had a better opioid sparing effect than RSA, as showed by lesser postoperative cumulative morphine consumption during the early 72 hours. The better opioid sparing effects in the TEA group attributed mainly to the significant reduction of cumulative morphine consumption during the first postoperative day as the interval morphine consumption during the second and third postoperative days were comparable between both groups (Table 2). Despite the comparable effects of both techniques on the pain assessment at rest and upon coughing at all time points (Figures 2 and 3), the TEA group had smaller number of patients who needed opioid rescue therapy and had a prolonged analgesic effect in those who required opioid

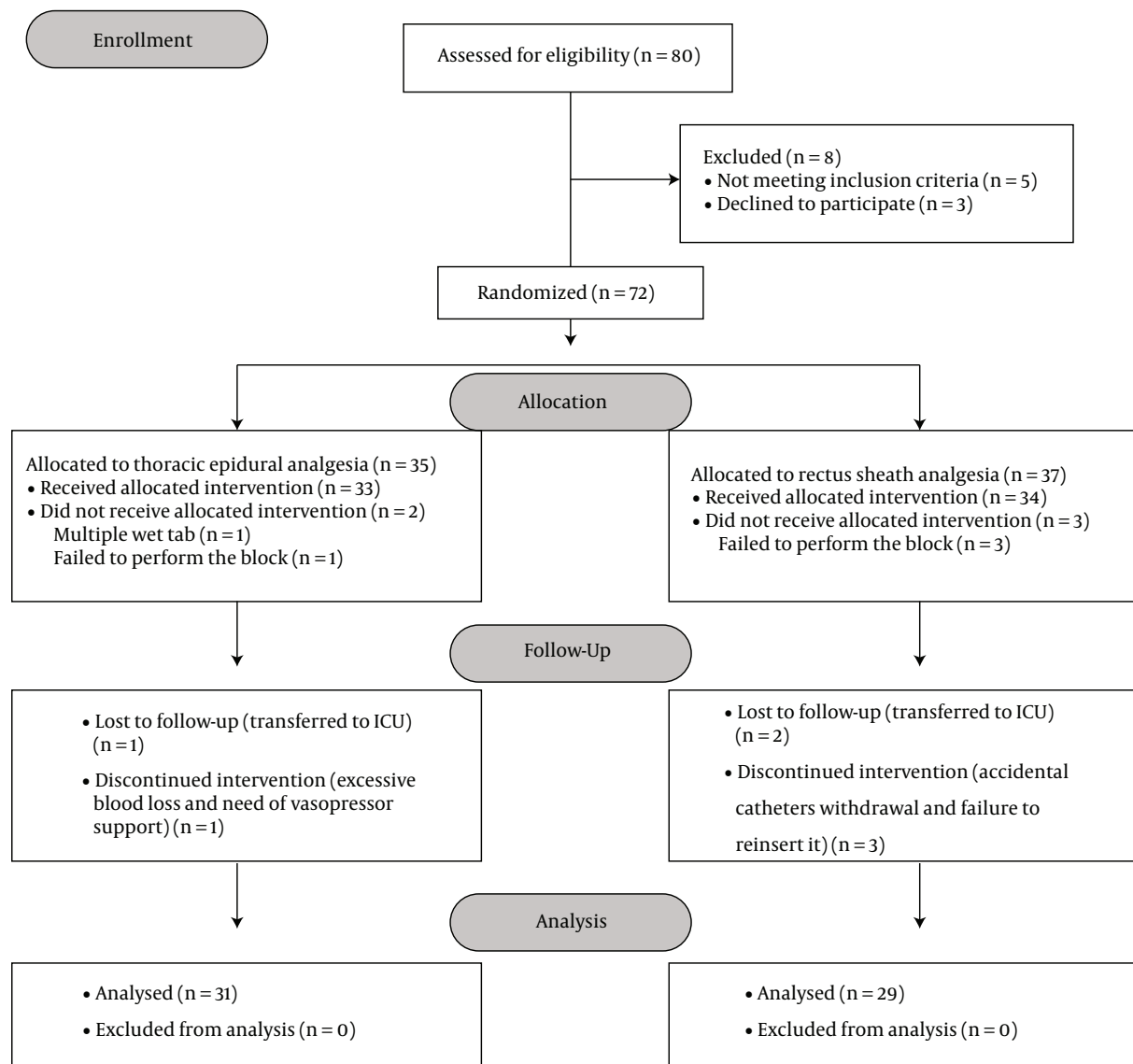


Figure 1. CONSORT Flow Diagram

analgesia as signified by statistically significant prolonged time for rescue analgesia (Table 2). There were higher sedation scores in the RSA group only at 12 hours and 24 hours postoperatively with a significant statistical difference in comparison to the TEA group, reflecting the increased morphine consumption in the RSA group in the early 24 hours postoperatively (Table 4). The single advantage of RSA on TEA was in significantly shorter time for ambulation. Otherwise, there was an insignificant difference between both groups on other morphine-related side effects, the return of regular bowel habits, and patient's satisfaction score for postoperative analgesia (Table 3).

In the same context, Bashandy and their colleagues concluded that RSA decreased pain scores and opioid consumptions in adult patients who underwent radical cancer resection necessitating an extensive midline incision at PACU and during the subsequent postoperative 2 days significantly (24). Gurnaney and their colleagues found a significant statistical difference in perioperative opioid doses administration between RSA group and the local anesthetic infiltration group in pediatric patients who underwent umbilical hernia repair (16). The findings of Gurnaney et al. were confirmed by the work of Kim and colleagues, who compared 2 groups of adult patients who un-

**Table 1.** Demographic Characteristic and Types of Surgery<sup>a</sup>

	TEA (n = 31)	RSA (n = 29)	P Value
Age	48.36 ± 11.73	47.53 ± 9.43	0.76
Weight	79.39 ± 9.47	79.06 ± 7.52	0.88
Height	169.03 ± 7.26	168.56 ± 7.30	0.8
Body mass index (kg/m <sup>2</sup> )	27.7 ± 1.05	28.01 ± 1.52	0.36
Gender (Male: Female)	21:10	23:6	0.3
ASA (I: II: III)	7: 20: 4	3: 24: 2	0.2
Duration of surgery (min.)	225.51 ± 65.8	245.21 ± 71.44	0.27
<b>Types of surgery</b>			
Biliary	11 (35.48%)	9 (31.03%)	0.71
Partial gastrectomy	8 (25.81%)	12 (41.38%)	0.20
Small intestinal	9 (29.03%)	6 (20.69%)	0.46
Splenectomy	1 (3.23%)	2 (6.90%)	0.51
Pancreatic	2 (6.45%)	0 (0%)	0.16

Abbreviations: RSA, Rectus sheath analgesia; TEA, Thoracic epidural analgesia.

<sup>a</sup>Age, weight, height, body mass index, and duration of surgery presented as mean ± SD. Gender, ASA status presented as numbers, and type of surgery presented as numbers (percentages). \* P ≤ 0.05.

**Table 2.** Postoperative Morphine Consumption<sup>a</sup>

	TEA (n = 31)	RSA (n = 29)	P Value
Need for morphine n (%)	17 (54.84%)	25 (86.21%)	0.008 <sup>b</sup>
Time to first dose of morphine (min)	256.77 ± 73.45	208.82 ± 64.65	0.031 <sup>b</sup>
Morphine consumption at PACU 0 - 2 hours postoperatively (mg)	6 (4.5, 6)	9 (6, 12)	< 0.001 <sup>b</sup>
Morphine consumption at 2 - 6 hours (mg)	6 (5.25, 6.75)	6 (6, 9)	0.002 <sup>b</sup>
Morphine consumption at 6 - 12 hours (mg)	6 (6, 9)	9 (6, 9)	0.043 <sup>b</sup>
Morphine consumption at 12 - 24 hours (mg)	6 (3, 6)	6 (6, 9)	0.006 <sup>b</sup>
Cumulative morphine consumption during 24 hours postoperatively (mg)	18 (15, 18)	33 (30, 36)	< 0.001 <sup>b</sup>
Morphine consumption at 48 hours (mg)	9 (9, 12)	12 (9, 15)	0.41
Morphine consumption at 72 hours (mg)	9 (6, 9)	9 (6, 9)	0.53
Cumulative morphine consumption during 72 hours postoperatively (mg) (primary outcome)	33 (27, 39)	51 (45, 57)	< 0.001 <sup>b</sup>

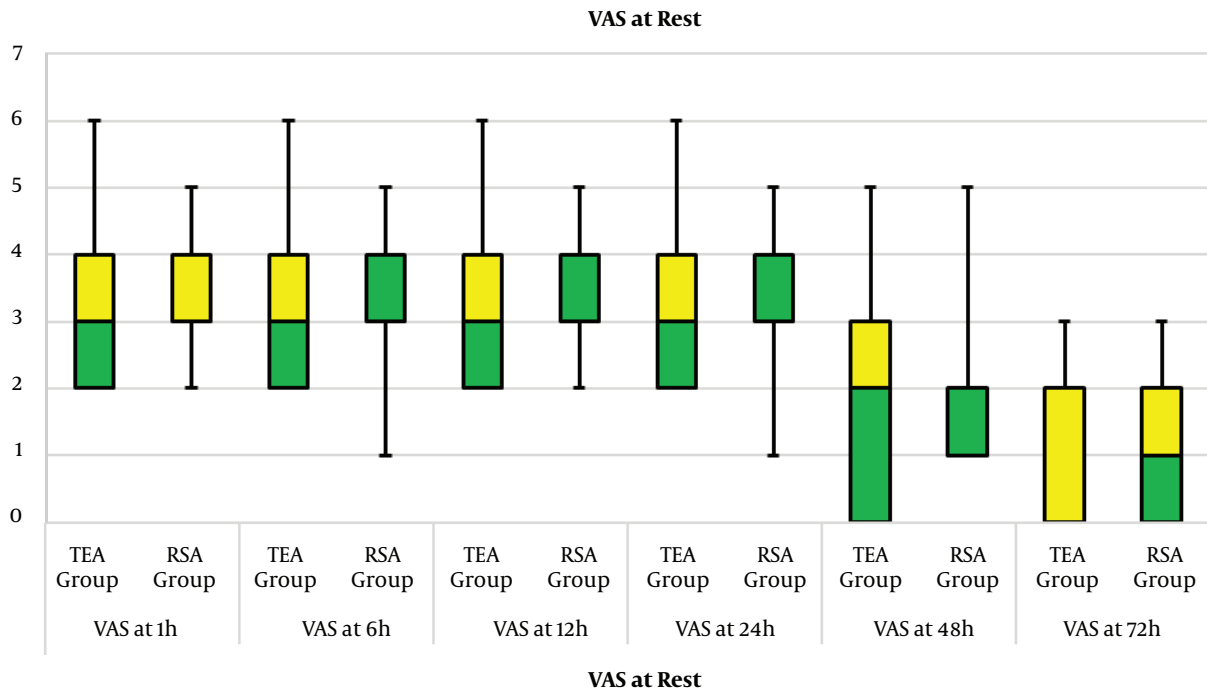
Abbreviations: RSA, Rectus sheath analgesia; TEA, Thoracic epidural analgesia.

<sup>a</sup>Data presented as numbers (percentages), mean ± SD, and median (IQR).

<sup>b</sup>P ≤ 0.05.

derwent robotic cholecystectomies. They found that the RSA group had better pain scores, lower doses of opioid requirements, and higher satisfaction scores (17). The finding of Kamei and colleagues did not differ so much when they used RSA in a group of patients who underwent single incision laparoscopic cholecystectomies; they emphasized that analgesia could have lasted for 6 hours postoperatively (25). Manasserto and colleagues reported that ultrasound guided rectus sheath block can achieve complete

sensory block when used as a sole anesthetic for umbilical hernia repair in 53.3% of patients. Furthermore, it can provide adequate postoperative analgesia in 97% of patients in their trial that aimed at detection of the local anesthetic spread and the effectiveness for surgical anesthesia of RSA (26). Unlike the previously mentioned trials (16, 17, 24-26), we used extended duration RSA for postoperative 72 hours through catheter embedded in rectus sheath bilaterally after completion of surgeries. There is lack of sufficiently de-

**Figure 2.** Postoperative VAS at Rest

TEA, Thoracic epidural analgesia; RSA, Rectus sheath analgesia; VAS, Visual analog score. Median values represented by a transverse line between the yellow boxes above and the green boxes below otherwise it is the upper border of the green boxes or the lower border of the yellow boxes, the 25th percentiles represented by the green boxes, the 75th percentiles represented by the yellow boxes, and the error bars refer to minimum and maximum values.

**Table 3.** Morphine Related Side Effects, Time to Passing Flatus, Time to Ambulation, and Patient Satisfaction Score<sup>a</sup>

	TEA (n = 31)	RSA (n = 29)	P Value
<b>Ileus</b>	4 (13%)	9 (31%)	0.08
<b>Nausea</b>	5 (16%)	7 (24%)	0.43
<b>Vomiting</b>	1 (3.23%)	3 (10.34%)	0.27
<b>Pruritus</b>	4 (12.9%)	8 (27.59%)	0.15
<b>Time to passing flatus (h)</b>	61.12 ± 9.37	57.54 ± 11.20	0.18
<b>Time to ambulation (h)</b>	45.89 ± 8.72	38.47 ± 12.34	0.009 <sup>b</sup>
<b>Patient satisfaction score</b>	2 (2 - 3)	2 (1 - 3)	0.08

Abbreviations: RSA, Rectus sheath analgesia; TEA, Thoracic epidural analgesia.

<sup>a</sup>Categorical data presented as numbers (percentages), Numerical data presented as mean ± SD, and ordinal data presented as median (interquartile range).

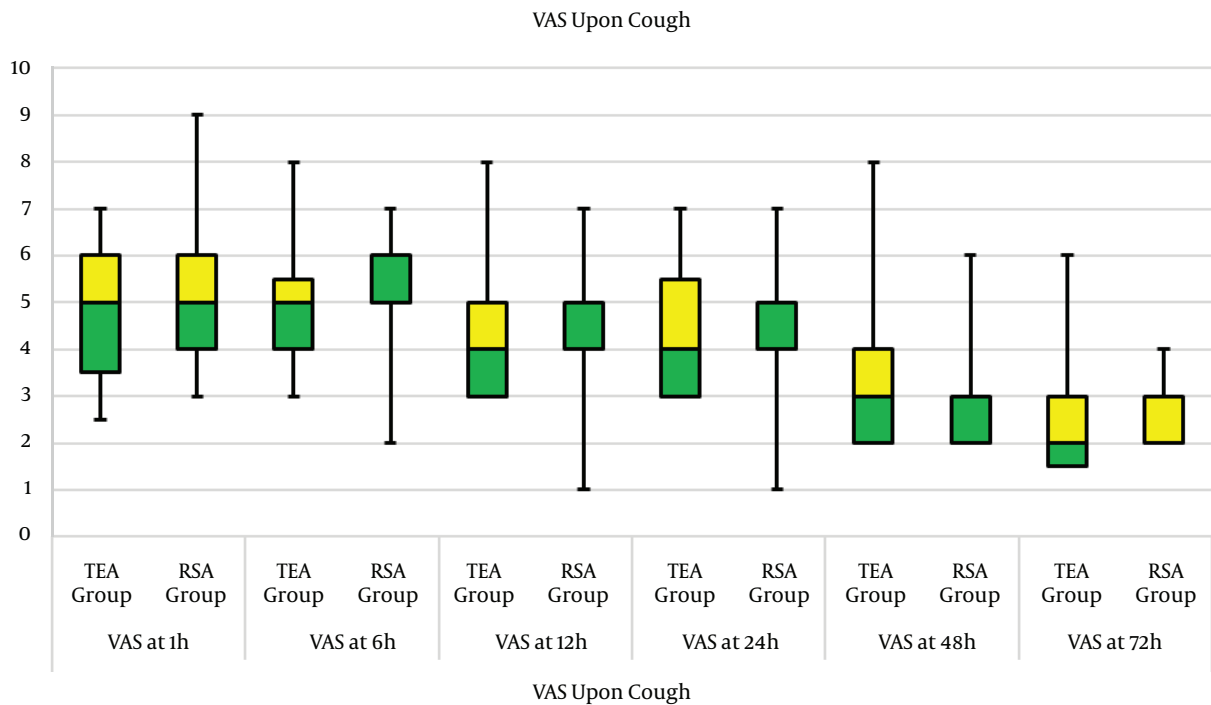
<sup>b</sup>P ≤ 0.05.

signed prospective randomized controlled trials that compare the opioid sparing properties of extended time RSA against placebo or TEA (27). Furthermore, the work of Parsons et al. supported our trial findings. They retrospectively compared between lumbar epidural and bilateral ultrasound-guided rectus sheath block in patients who underwent radical cystectomies (28). Contradictory to our results, Godden et al., reviewed 120 patients underwent open

colorectal cancer surgery retrospectively, comparing thoracic epidural analgesia with rectus sheath analgesia via bilateral rectus sheath catheters and found no significant difference in the opioid sparing effect of TEA over RSA. The use of more diluted bupivacaine concentration (0.125 %) for TEA could be the cause of dissimilarity to our results (29).

We preferred to use bupivacaine 0.25% in the TEA group

**Figure 3.** Postoperative VAS Upon Cough



TEA, Thoracic epidural analgesia; RSA, Rectus sheath analgesia; VAS, Visual analog score. Median values represented by a transverse line between the yellow boxes above and the green boxes below otherwise it is the upper border of the green boxes or the lower border of the yellow boxes, the 25th percentiles represented by the green boxes, the 75th percentiles represented by the yellow boxes, and the error bars refer to minimum and maximum values.

**Table 4.** Postoperative Sedation Score<sup>a</sup>

	TEA (n = 31)	RSA (n = 29)	P Value
Sedation score on admission at PACU	2 (2, 3)	3 (2, 3)	0.856
Sedation score at two hours	2 (2, 3)	2 (2, 3)	0.287
Sedation score at six hours	2 (2, 3)	2 (2, 3)	0.755
Sedation score at 12 hours	2 (2, 3)	3 (2, 3)	0.041 <sup>c</sup>
Sedation score at 24 hours	2 (2, 2)	3 (2, 3)	0.013 <sup>c</sup>
Sedation score at 48 hours	1 (1, 2)	2 (1, 2)	0.351
Sedation score at 72 hours	1 (1, 2)	2 (1, 2)	0.124

Abbreviations: RSA, Rectus sheath analgesia; TEA, Thoracic epidural analgesia.

<sup>a</sup>Ordinal data presented as median (interquartile range).

<sup>c</sup>P ≤ 0.05.

as there is a growing body of evidence that supported the view that the total dose administered hourly is the principal factor that determined the analgesic quality and the occurrence of side effects during continuous thoracic epidural analgesia (30-35). We believed that the delivered concentration or the volume has a modest role on sensory block, motor block, and adverse events incidences. Fur-

thermore, the elastomeric pumps with higher flow rates (8 - 10 mL/h) were not accessible in our medical center. The lack of adjuvant opioid on bupivacaine encouraged us to not use the more diluted 0.125% or 0.0625% bupivacaine concentrations. Dernerde and colleagues used a small volume large concentration 0.5% and 0.75% levobupivacaine in postoperative thoracic epidural analgesia



efficiently with satisfactory safety profile (31). They have used a dose of 15 mg/h safely, meanwhile our patients received 12.5 mg/h in TEA group without reporting major related side effects.

Acetaminophen and ketorolac were prescribed as parts of the regular local institutional policy for postoperative pain management. Both drugs are integral parts of multimodal analgesia regimen, which necessitated administration of multiple analgesic drugs with different modes of action (3).

Numerous multimodal analgesia practices have been established to provide appropriate postoperative pain control for laparotomies done through a midline incision targeting at limiting the perioperative use of morphine, thus decreasing its related side effects, postoperative morbidity, and hospital stay (36). The use of ultrasound-guided techniques on a broad scale a decade ago guaranteed efficacy and safety of those techniques and became a substantial element of modern anesthesia practice that improved postoperative pain control and decreased the dependence on postoperative systemic opioid administration (6, 37). These facts called for a continuous arguable issue, that if the thoracic epidural analgesia is still considered the gold standard anesthetic management of postoperative pain control after major abdominal procedures as assumed for decades ago by a lot of field practitioner (38)? Our data supported that the TEA may be the most robust method to control postoperative pain after major laparotomies, however, it lacks the advantage with concerns related to patients' safety perspective. Although we have not reported any complications pertained to the TEA technique, this trial was not powered primarily to detect rates of the TEA procedure complications. In addition, there are medical conditions where TEA could not, or contraindicated to be used as hemodynamic instability, excessive blood loss, systemic sepsis, or coagulopathy while RSA could be used with an acceptable level of effectiveness and supposedly better safety profile (24, 39-41).

The ability of TEA to alleviate both visceral and somatic components of postoperative pain is the most plausible cause of better opioid-sparing effects of TEA than RSA. Visceral pain mitigation is a pivotal constituent in multimodal analgesia regimens. This fact was emphasized by the work of Smith and their colleagues who found that the benefits of RSA were eminent in diagnostic laparoscopy than laparoscopic sterilization because women undergoing sterilization experienced a deep pelvic visceral pain (42).

Our study has many limitations. First, a continuous infusion was not considered in the RSA group. Otherwise, intermittent 6 hours' interval injection was used, meanwhile an uninterrupted epidural infusion used for the TEA

group. Second, we used single blinding in the PACU and during the observation time points in the consecutive 72 hours for IV morphine titration, because the TEA group patients received a comprehensible epidural infusion elastomeric pump. Third, we did not appraise the level of the sensory block in RSA group patients after catheters insertion. Fourth, exclusion of the patients with ASA physical status classes > III and BMI  $\geq 30$  kg/m<sup>2</sup> could limit the external validity and the generalizability of the current findings in this trial. Fifth, we did not use patients controlled analgesia (PCA) techniques in this trial due to limited resources, as an alternative we used a titration method to supplement morphine according to pain score assessments. Sixth, we have not reported the time needed by the practitioners to perform each procedure. Finally, adding adjuvants to bupivacaine may prolong the duration and intensify the block of RSA that can be verified in future studies.

### 5.1. Conclusion

Continuous thoracic epidural analgesia had better opioid sparing effects than that of intermittent rectus sheath analgesia with catheters inserted under real-time ultrasound guidance during the early 72 hours postoperatively, both had comparable safety perspectives, and RSA had the advantage of early ambulation. RSA could be used as an effective alternative when TEA contraindicated or could not be used in patients undergoing laparotomies with an extended midline incision especially after the first postoperative day.

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### Footnotes

**Authors' Contribution:** Hany Mahmoud Yassin initially comprehended of the study design, actively conducted the study, helped in data collection and analysis, performed the statistical analysis, edited and wrote the final manuscript'; Ahmed Tohamy Abd Elmoneim helped in study design, conducting the study in the operating room

and was actively involved in data collection, and editing the manuscript; Hatem El Moutaz actively gathered, analyzed the data, and share in the manuscript editing.

**Conflict of Interest:** The authors declare that there is no conflict of interest.

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## References

- Rozen WM, Tran TM, Ashton MW, Barrington MJ, Ivanusic JJ, Taylor GI. Refining the course of the thoracolumbar nerves: a new understanding of the innervation of the anterior abdominal wall. *Clin Anat*. 2008;**21**(4):325–33. doi: [10.1002/ca.20621](https://doi.org/10.1002/ca.20621). [PubMed: [18428988](https://pubmed.ncbi.nlm.nih.gov/18428988/)].
- Wilkinson KM, Krige A, Brearley SG, Lane S, Scott M, Gordon AC, et al. Thoracic Epidural analgesia versus Rectus Sheath Catheters for open midline incisions in major abdominal surgery within an enhanced recovery programme (TERSC): study protocol for a randomised controlled trial. *Trials*. 2014;**15**:400. doi: [10.1186/1745-6215-15-400](https://doi.org/10.1186/1745-6215-15-400). [PubMed: [25336055](https://pubmed.ncbi.nlm.nih.gov/25336055/)].
- Imani F. Postoperative pain management. 1. Anesthesiol pain Med; 2011.
- Block BM, Liu SS, Rowlingson AJ, Cowan AR, Cowan JA, Wu CL. Efficacy of postoperative epidural analgesia: a meta-analysis. *JAMA*. 2003;**290**(18):2455–63. doi: [10.1001/jama.290.18.2455](https://doi.org/10.1001/jama.290.18.2455). [PubMed: [14612482](https://pubmed.ncbi.nlm.nih.gov/14612482/)].
- Imani F, Faiz HR, Sedaghat M, Hajiashrafi M. Effects of adding ketamine to fentanyl plus acetaminophen on postoperative pain by patient controlled analgesia in abdominal surgery. *Anesth Pain Med*. 2014;**4**(1):12162. doi: [10.5812/aapm.12162](https://doi.org/10.5812/aapm.12162). [PubMed: [24660145](https://pubmed.ncbi.nlm.nih.gov/24660145/)].
- Gharaei H, Imani F, Almasi F, Solimani M. The effect of ultrasound-guided tap on pain management after total abdominal hysterectomy. *Korean J Pain*. 2013;**26**(4):374–8. doi: [10.3344/kjp.2013.26.4.374](https://doi.org/10.3344/kjp.2013.26.4.374). [PubMed: [24156004](https://pubmed.ncbi.nlm.nih.gov/24156004/)].
- Karbasy SH, Derakhshan P. Effects of opium addiction on level of sensory block in spinal anesthesia with bupivacaine for lower abdomen and limb surgery: a case-control study. *Anesth Pain Med*. 2014;**4**(5):21571. doi: [10.5812/aapm.21571](https://doi.org/10.5812/aapm.21571). [PubMed: [25798378](https://pubmed.ncbi.nlm.nih.gov/25798378/)].
- Clarke H, Chandya T, Srinivas C, Ladak S, Okubo N, Mitsakakis N, et al. Epidural analgesia provides better pain management after live liver donation: a retrospective study. *Liver Transpl*. 2011;**17**(3):315–23. doi: [10.1002/lt.22221](https://doi.org/10.1002/lt.22221). [PubMed: [21384514](https://pubmed.ncbi.nlm.nih.gov/21384514/)].
- Horlocker TT, McGregor DG, Matsushige DK, Schroeder DR, Besse JA. A retrospective review of 4767 consecutive spinal anesthetics: central nervous system complications. Perioperative Outcomes Group. *Anesth Analg*. 1997;**84**(3):578–84. [PubMed: [9052305](https://pubmed.ncbi.nlm.nih.gov/9052305/)].
- Wheatley RG, Schug SA, Watson D. Safety and efficacy of postoperative epidural analgesia. *Br J Anaesth*. 2001;**87**(1):47–61. [PubMed: [11460813](https://pubmed.ncbi.nlm.nih.gov/11460813/)].
- Mogensen T, Hjortso NC, Bigler D, Lund C, Kehlet H. Unpredictability of regression of analgesia during the continuous postoperative extradural infusion of bupivacaine. *Br J Anaesth*. 1988;**60**(5):515–9. [PubMed: [3377927](https://pubmed.ncbi.nlm.nih.gov/3377927/)].
- Hermanides J, Hollmann MW, Stevens MF, Lirk P. Failed epidural: causes and management. *Br J Anaesth*. 2012;**109**(2):144–54. doi: [10.1093/bja/aes214](https://doi.org/10.1093/bja/aes214). [PubMed: [22735301](https://pubmed.ncbi.nlm.nih.gov/22735301/)].
- Cuneyitoglu S, Turkkan M, Biricik E, Ozcengiz D. Ultrasound-Guided Rectus Sheath Block in Gynaecological Surgery with Pfannenstiel Incision. *Turk J Anaesthesiol Reanim*. 2015;**43**(5):318–22. doi: [10.5152/TJAR.2015.79037](https://doi.org/10.5152/TJAR.2015.79037). [PubMed: [27366521](https://pubmed.ncbi.nlm.nih.gov/27366521/)].
- Osaka Y, Kashiwagi M, Nagatsuka Y, Oosaku M, Hirose C. [Ultrasound-guided rectus sheath block for upper abdominal surgery]. *Masui*. 2010;**59**(8):1039–41. [PubMed: [20715537](https://pubmed.ncbi.nlm.nih.gov/20715537/)].
- Hamill JK, Liley A, Hill AG. Rectus sheath block for laparoscopic appendectomy: a randomized clinical trial. *ANZ J Surg*. 2015;**85**(12):951–6. doi: [10.1111/ans.12950](https://doi.org/10.1111/ans.12950). [PubMed: [25581711](https://pubmed.ncbi.nlm.nih.gov/25581711/)].
- Gurnaney HG, Maxwell LG, Kraemer FW, Goebel T, Nance ML, Ganesh A. Prospective randomized observer-blinded study comparing the analgesic efficacy of ultrasound-guided rectus sheath block and local anaesthetic infiltration for umbilical hernia repair. *Br J Anaesth*. 2011;**107**(5):790–5. doi: [10.1093/bja/aer263](https://doi.org/10.1093/bja/aer263). [PubMed: [21856778](https://pubmed.ncbi.nlm.nih.gov/21856778/)].
- Kim JS, Choi JB, Lee SY, Kim WH, Baek NH, Kim J, et al. Pain related to robotic cholecystectomy with lower abdominal ports: effect of the bilateral ultrasound-guided split injection technique of rectus sheath block in female patients: A prospective randomised trial. *Medicine (Baltimore)*. 2016;**95**(31):4445. doi: [10.1097/MD.0000000000004445](https://doi.org/10.1097/MD.0000000000004445). [PubMed: [27495072](https://pubmed.ncbi.nlm.nih.gov/27495072/)].
- Dolan J, Lucie P, Geary T, Smith M, Kenny GN. The rectus sheath block: accuracy of local anesthetic placement by trainee anesthesiologists using loss of resistance or ultrasound guidance. *Reg Anesth Pain Med*. 2009;**34**(3):247–50. doi: [10.1097/AAP.0b013e31819a3f67](https://doi.org/10.1097/AAP.0b013e31819a3f67). [PubMed: [19587624](https://pubmed.ncbi.nlm.nih.gov/19587624/)].
- Abrahams MS, Horn JL, Noles LM, Aziz MF. Evidence-based medicine: ultrasound guidance for truncal blocks. *Reg Anesth Pain Med*. 2010;**35**(2 Suppl):S36–42. doi: [10.1097/AAP.0b013e3181d32841](https://doi.org/10.1097/AAP.0b013e3181d32841). [PubMed: [20216023](https://pubmed.ncbi.nlm.nih.gov/20216023/)].
- Quek KH, Phua DS. Bilateral rectus sheath blocks as the single anaesthetic technique for an open infraumbilical hernia repair. *Singapore Med J*. 2014;**55**(3):39–41. [PubMed: [24664392](https://pubmed.ncbi.nlm.nih.gov/24664392/)].
- Abrahams M, Derby R, Horn JL. Update on Ultrasound for Truncal Blocks: A Review of the Evidence. *Reg Anesth Pain Med*. 2016;**41**(2):275–88. doi: [10.1097/AAP.0000000000000372](https://doi.org/10.1097/AAP.0000000000000372). [PubMed: [26866299](https://pubmed.ncbi.nlm.nih.gov/26866299/)].
- Aldrete JA. Modifications to the postanesthesia score for use in ambulatory surgery. *J Perianesth Nurs*. 1998;**13**(3):148–55. [PubMed: [9801540](https://pubmed.ncbi.nlm.nih.gov/9801540/)].
- Ramsay MA, Savege TM, Simpson BR, Goodwin R. Controlled sedation with alphaxalone-alphadolone. *Br Med J*. 1974;**2**(5920):656–9. [PubMed: [4835444](https://pubmed.ncbi.nlm.nih.gov/4835444/)].
- Bashandy GM, Elkholy AH. Reducing postoperative opioid consumption by adding an ultrasound-guided rectus sheath block to multimodal analgesia for abdominal cancer surgery with midline incision. *Anesth Pain Med*. 2014;**4**(3):18263. doi: [10.5812/aapm.18263](https://doi.org/10.5812/aapm.18263). [PubMed: [25289373](https://pubmed.ncbi.nlm.nih.gov/25289373/)].
- Kamei H, Ishibashi N, Nakayama G, Hamada N, Ogata Y, Akagi Y. Ultrasound-guided rectus sheath block for single-incision laparoscopic cholecystectomy. *Asian J Endosc Surg*. 2015;**8**(2):148–52. doi: [10.1111/ases.12178](https://doi.org/10.1111/ases.12178). [PubMed: [25720303](https://pubmed.ncbi.nlm.nih.gov/25720303/)].
- 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**(3):349–53. doi: [10.4103/0970-9185.161671](https://doi.org/10.4103/0970-9185.161671). [PubMed: [26330714](https://pubmed.ncbi.nlm.nih.gov/26330714/)].
- Bakshi S, Mapari A, Paliwal R. Ultrasound-guided rectus sheath catheters: A feasible and effective, opioid-sparing, post-operative pain management technique: A case series. *Indian J Anaesth*. 2015;**59**(2):118–20. doi: [10.4103/0019-5049.151376](https://doi.org/10.4103/0019-5049.151376). [PubMed: [25788745](https://pubmed.ncbi.nlm.nih.gov/25788745/)].
- Parsons B, Aning J, Daugherty MMJ. The use of rectus sheath catheters as an analgesic technique for patients undergoing radical cystectomy. *Br J Med Surg Urol*. 2011;**4**:24–30.
- Godden AR, Marshall MJ, Grice AS, Daniels IR. Ultrasonography guided rectus sheath catheters versus epidural analgesia for open colorectal cancer surgery in a single centre. *Ann R Coll Surg Engl*. 2013;**95**(8):591–4. doi: [10.1308/003588413X13629960049270](https://doi.org/10.1308/003588413X13629960049270). [PubMed: [24165343](https://pubmed.ncbi.nlm.nih.gov/24165343/)].
- Dermedde M, Stadler M, Bardiau F, Boogaerts JG. Continuous epidural infusion of large concentration/small volume versus small concentration/large volume of levobupivacaine for postoperative analgesia. *Anesth Analg*. 2003;**96**(3):796–801. [PubMed: [12598265](https://pubmed.ncbi.nlm.nih.gov/12598265/)] table of contents.

31. Dervede M, Stadler M, Bardiau F, Boogaerts J. Comparison of different concentrations of levobupivacaine for post-operative epidural analgesia. *Acta Anaesthesiol Scand.* 2003;**47**(7):884-90. [PubMed: [12859311](#)].
32. Dervede M, Stadler M, Bardiau F, Boogaerts JG. Comparison of 2 concentrations of levobupivacaine in postoperative patient-controlled epidural analgesia. *J Clin Anesth.* 2005;**17**(7):531-6. doi: [10.1016/j.jclinane.2005.01.007](#). [PubMed: [16297753](#)].
33. Mendola C, Ferrante D, Oldani E, Cammarota G, Cecci G, Vaschetto R, et al. Thoracic epidural analgesia in post-thoracotomy patients: comparison of three different concentrations of levobupivacaine and sufentanil. *Br J Anaesth.* 2009;**102**(3):418-23. doi: [10.1093/bja/aeq004](#). [PubMed: [19189982](#)].
34. Li H, Wang B, Wang F, Xu Z, Zhou N, Wang X, et al. Effects of epidural analgesia with different concentrations of bupivacaine plus fentanyl on pain in patients undergoing thoracic surgery. *Int J Clin Exp Med.* 2015;**8**(8):14123-6. [PubMed: [26550381](#)].
35. Dervede M, Stadler M, Bardiau F, Seidel L, Boogaerts JG. Low vs. high concentration of levobupivacaine for post-operative epidural analgesia: influence of mode of delivery. *Acta Anaesthesiol Scand.* 2006;**50**(5):613-21. doi: [10.1111/j.1399-6576.2006.001004.x](#). [PubMed: [16643233](#)].
36. Feldheiser A, Aziz O, Baldini G, Cox BP, Fearon KC, Feldman LS, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 2: consensus statement for anaesthesia practice. *Acta Anaesthesiol Scand.* 2016;**60**(3):289-334. doi: [10.1111/aas.12651](#). [PubMed: [26514824](#)].
37. Wu Y, Liu F, Tang H, Wang Q, Chen L, Wu H, et al. The analgesic efficacy of subcostal transversus abdominis plane block compared with thoracic epidural analgesia and intravenous opioid analgesia after radical gastrectomy. *Anesth Analg.* 2013;**117**(2):507-13. doi: [10.1213/ANE.0b013e318297fcee](#). [PubMed: [23744953](#)].
38. Rawal N. Epidural technique for postoperative pain: gold standard no more?. *Reg Anesth Pain Med.* 2012;**37**(3):310-7. doi: [10.1097/AAP.0b013e31825735c6](#). [PubMed: [22531384](#)].
39. Crosbie EJ, Massiah NS, Achiampong JY, Dolling S, Slade RJ. The surgical rectus sheath block for post-operative analgesia: a modern approach to an established technique. *Eur J Obstet Gynecol Reprod Biol.* 2012;**160**(2):196-200. doi: [10.1016/j.ejogrb.2011.10.015](#). [PubMed: [22104479](#)].
40. Abdelsalam K, Mohamdin OW. Ultrasound-guided rectus sheath and transversus abdominis plane blocks for perioperative analgesia in upper abdominal surgery: A randomized controlled study. *Saudi J Anaesth.* 2016;**10**(1):25-8. doi: [10.4103/1658-354X.169470](#). [PubMed: [26955306](#)].
41. Christie IW, McCabe S. Major complications of epidural analgesia after surgery: results of a six-year survey. *Anaesthesia.* 2007;**62**(4):335-41. doi: [10.1111/j.1365-2044.2007.04992.x](#). [PubMed: [17381568](#)].
42. Smith BE, MacPherson GH, de Jonge M, Griffiths JM. Rectus sheath and mesosalpinx block for laparoscopic sterilization. *Anaesthesia.* 1991;**46**(10):875-7. [PubMed: [1835318](#)].