

Effect of ultrasound-guided transversus abdominis plane block with rectus sheath block on patients undergoing laparoscopy-assisted radical resection of rectal cancer: a randomized, double-blind, placebo-controlled trial

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Research article

Keywords: ultrasound, transversus abdominis plane, rectus sheath, sufentanil, rectal cancer

Posted Date: September 28th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-72105/v1>

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Version of Record: A version of this preprint was published on March 24th, 2021. See the published version at <https://doi.org/10.1186/s12871-021-01295-9>.

Abstract

Background

Many patients complain of pain following laparoscopic surgery. Clinicians have used ultrasound-guided posterior transversus abdominis plane block (TAPB) and rectus sheath block (RSB) for multimodal analgesia after surgery. We investigated the analgesic effects of US-guided posterior TAPB with RSB on postoperative pain following laparoscopy-assisted radical resection of early-stage rectal cancer.

Methods

Seventy-eight adults scheduled for laparoscopy-assisted radical resection of rectal cancer were enrolled in this double-blind placebo-controlled trial. Patients were randomized into 3 groups: the TR Group underwent US-guided bilateral posterior TAPB (40 mL 0.33% ropivacaine) with RSB (20 mL 0.33% ropivacaine); the T Group underwent US-guided bilateral posterior TAPB alone; and the Control Group received saline alone. All patients also had access to patient-controlled intravenous analgesia (PCIA) with sufentanil. The primary outcome was postoperative sufentanil consumption at 0–24, 24–48, and 48–72 h. The secondary outcomes were postoperative pain intensity and functional activity score at rest and while coughing for the same three time periods, intraoperative medication dosage, use of rescue analgesia, recovery parameters, and adverse effects.

Results

The three groups had no significant differences in baseline demographic and perioperative data, use of intraoperative medications, recovery parameters, and adverse effects. The TR group had significantly lower postoperative use of PCIA and rescue analgesic than in the other two groups ($P < 0.05$), but the Control Group and T Group had no significant differences in these outcomes.

Conclusions

Postoperative US-guided posterior TAPB with RSB reduced postoperative opioid use in patients following laparoscopy-assisted radical resection of rectal cancer.

Trial registration

The trial was registered with chictr.org (ChiCTR2000029326) on January 25, 2020.

Background

Colorectal cancer is one of the most common tumors and is a leading cause of cancer-related deaths worldwide [1]. Because of the increasing incidence of rectal cancer and the improved rates of recovery after surgery, laparoscopy-assisted radical resection of early-stage rectal cancer has become more common [2]. Although laparoscopy reduces the size of the operative incision, many patients complain of

postoperative pain. Opioid analgesia is traditionally provided following a laparoscopic abdominal operation [3]. However, adverse effects from opioid analgesia (postoperative nausea and vomiting [PONV]), may increase the duration of the hospital stay and reduce patient satisfaction [4].

There has been an increasing use of ultrasound (US) technologies, and US-guided peripheral nerve block has become a fundamental part of postoperative multimodal analgesia. US-guided posterior transversus abdominis plane block (TAPB) and US-guided rectus sheath block (RSB) have been used during abdominal surgeries, and previous studies indicated that they provide potent analgesic effects [5–7]. Currently, there is limited evidence in the literature to support the use of US-guided posterior TAPB combined with RSB.

The aim of this study is to evaluate the efficacy of US-guided posterior TAPB with or without RSB in postoperative pain management for patients following laparoscopy-assisted radical resection of rectal cancer.

Methods

Patients

This randomized, double-blinded, placebo-controlled trial was performed following approval of the ethics committee of the Liaocheng People's Hospital. The trial was registered with [chictr.org](http://www.chictr.org) before enrollment of the first participant (Trial registration: ChiCTR, ChiCTR2000029326. Registered 25 January 2020, <http://www.chictr.org.cn>), and written informed consent was obtained from all patients prior to enrollment. All findings are reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

All enrolled patients were scheduled to undergo laparoscopic radical resection (Dixon operation) following diagnosis of clinical stage I or II rectal cancer at the Liaocheng People's Hospital between January 2020 and June 2020. The inclusion criteria were age between 35 and 70 years, ability to understand and use the pain assessment method, and physical status of I to III according to the American Society of Anesthesiologists (ASA). The exclusion criteria were history of allergy to local anesthetics, history of opioid abuse, history of treatment for another cancer, refusal to use patient-controlled analgesia (PCA), need for resection of another organ(s) in addition to the rectum, history of previous abdominal surgery, and preoperative intestinal obstruction requiring emergency surgery.

Randomization and blinding

Two days before surgery, a computerized random number generator was used to assign equal numbers of eligible participants to one of the three groups. The TR Group received US-guided bilateral posterior TAPB with 40 mL of 0.33% ropivacaine and RSB with 20 mL of 0.33% ropivacaine; the T Group received US-guided bilateral posterior TAPB with 40 mL of 0.33% ropivacaine and RSB with 20 mL of 0.9% normal saline; the Control Group received US-guided bilateral posterior TAPB with 40 mL of 0.9% normal saline

and RSB with 20 mL of 0.9% normal saline. Patients in all groups also received postoperative patient controlled intravenous analgesia (PCIA) (see below for details). Randomized results were kept in a sealed envelope and relayed to an independent nurse anesthetist who prepared the drug or placebo on the morning of the operation. The remainder of the clinicians, the main anesthesiologist, and the anesthesiologist who administered the TAPB were all blinded to the group allocations.

General anesthesia and monitoring

All patients underwent regular fasting for 8 to 12 h without any preoperative medication. Before the induction of anesthesia, intravenous (IV) fluids were administered at a rate of 10 mL/kg/h, and the heart rate, continuous invasive arterial blood pressure, pulse oxygen saturation, bispectral index (BIS), and nasopharyngeal temperature were continuously monitored using a multifunction monitor (Philips IntelliVue MP50, Boeblingen, Germany). For all patients, anesthesia was induced with IV propofol (2.0 mg/kg), fentanyl (3 µg/kg), and cisatracurium (0.15 mg/kg), according to standard general anesthesia guidelines set by the institute. Tracheal intubation was performed after muscle relaxation. Anesthesia was maintained using inhalational sevoflurane and remifentanyl. To maintain a BIS value of 40 to 60 and a mean arterial pressure within 20% of the baseline value, sevoflurane and remifentanyl were continuously adjusted. Ephedrine was administered if the intraoperative blood pressure was more than 20% below the baseline, and atropine was administered if the heart rate was lower than 50 bpm. IV cisatracurium (0.03 mg/kg) was added hourly until the end of the operation.

Surgery

Laparoscopic incision and trocar insertion were performed by adopting the five hole method. The five incisions were: (i) on the supraumbilical site; (ii) 2 finger widths inside the right anterior superior iliac spine; (iii) 3 to 4 cm above the cross point of the right clavicular midline and the umbilicus intersection; (iv) at the mid-point of the line between the left anterior superior iliac spine and umbilicus; and (v) 2 finger widths above the symphysis pubis, which could be expanded to 5 or 6 cm for specimen removal (Fig. 1). The pneumoperitoneum was established with carbon dioxide, and pressure was 12 to 14 mmHg (1.36 to 1.58 kpa). The operation was performed according to the specifications and principles of laparoscopic and radical resection of rectal cancer (*i.e.* total mesorectal resection (TEM), thorough lymphadenectomy, and tumor eradication). The Dixon operation was used based on tumor location.

US-guided TAPB and RSB

After removal of the tracheal tube, TAPB was performed immediately by a qualified anesthesiologist using US guidance (SonoSite S-Nerve Ultrasound System) and a broadband (4 to 13 MHz) linear array ultrasound probe. For the posterior approach, the probe was placed transversely in the midaxillary line between the iliac crest and the costal margin [8]. Then, the probe was moved outward and the needle was inserted when the TAP was identified. When the tip of the needle was in the TAP, 2 mL of normal saline was injected to adjust its position. Then, 40 mL of 0.33% ropivacaine was administered to the TR Group and T Group, and 40 mL of 0.9% normal saline was administered to the Control Group (Fig. 2). Next, RSB

was performed on both sides of the linea alba under US-guidance [7]. For the RSB, the probe was placed transversely on the rectus abdominis and the needle was inserted using US guidance until the tip was in the plane between the rectus abdominis and the posterior sheath of the rectus abdominis [9]. Patients in the TR Group received 20 mL of 0.33% ropivacaine, and patients in the T Group and Control Group received 20 mL of 0.9% normal saline. The procedure was divided into 3 or 4 injection sites on the left and right sides of the surgical site (Fig. 3).

Postoperative care

Sufentanil was used for PCIA, which was initiated in the post-anesthesia care unit (PACU). The PCIA regimen consisted of 300 mL of 0.8 µg/mL sufentanil, with a bolus dose of 2 mL, a lockout time of 5 min with no background infusion, and a 4-h maximum limit of 30 mL (24 µg). The aim of PCIA was to control pain intensity based on a numerical rating scale (NRS) at rest of 4 or less. The NRS is an objective pain intensity assessment tool that has a scale of 0 to 10, in which 0 indicates no pain and 10 indicates the worst pain possible. Any patient whose NRS value at rest was above 4 was given a loading dose of 4 mL (3.2 µg) sufentanil, and had a 4 h maximum limit of 40 mL. For patients with insufficient analgesia or sufentanil intolerance, additional rescue analgesia was given (30 mg IV ketorolac).

Data Collection

Sufentanil-based PCIA was used in all groups with the same regimen for 72 h after surgery. The cumulative PCA usage during three time period after the operation (0 to 24 h, 24 to 48 h, and 48 to 72 h) was the primary outcome, and was recorded by a blinded member of the acute pain service (APS) team. The secondary outcomes were postoperative pain intensity on the NRS and functional activity score (FAS) at rest and during coughing after 24, 48, and 72 h [10]. The FAS is a subjective pain intensity assessment tool that uses grades A, B, and C. Grade A indicates that functional activity is not limited by pain; grade B indicates that functional activity is moderately limited because of pain; and grade C indicates that functional activity is severely limited because of pain. Use of intraoperative medications and rescue analgesia were recorded. In addition, the time to first flatus, defecation, oral intake, and discharge were recorded. All adverse effects possibly due to sufentanil, such as nausea, vomiting, pruritus, respiratory depression, and dizziness, were recorded.

Statistical Analysis

The sample size was based on the initial pilot data, in which the means ± standard deviations of sufentanil use during the 24 h period after surgery were recorded. (Control Group: 84 ± 47 µg, T Group: 80 ± 37 µg, TR Group: 41 ± 16 µg). Based on a power of 95% and a significance level of 5%, 20 patients per group were necessary. Assuming a 30% dropout rate, a minimum of 26 patients per group were enrolled.

Statistical analysis was performed using SPSS 16.0 (SPSS Inc. Chicago, IL). The Kolmogorov-Smirnov test was used to assess the distributions of variables, and homogeneity of variance was determined using Levene's test. Data with normal distributions are presented as means and standard deviations and

data with non-normal distributions are presented as medians and interquartile ranges. Categorical data are presented as number (n) and percentage (%). Non-parametric tests were used to compare data with non-normal distributions; the Kruskal-Wallis H method was used for overall comparisons, and the Mann-Whitney U method was used to compare differences between groups. Categorical variables were analyzed using the χ^2 test or Fisher's exact test. *P* values below .05 were considered significant.

Results

Our assessments indicated that 97 patients were eligible for enrollment (Fig. 4) Seventeen patients were excluded and 2 patients were lost to follow-up. We therefore analyzed data of the remaining 78 patients. The 3 groups had no significant differences in demographic parameters, operation conditions, and fluid and anesthetic administration ($P > 0.05$, Table 1 and Table 2). In addition, none of the patients required a change of analgesic.

Table 1
Demographic and perioperative characteristics of the three groups

Variable	Group C (n = 26)	Group T (n = 26)	Group TR (n = 26)	<i>P</i>
Age (years)	60.6 ± 8.2	61.5 ± 8.2	61.5 ± 8.1	0.899
Male/Female (n)	13/13	16/10	18/8	0.362
BMI (kg/m ²)	23.6 ± 2.2	23.4 ± 2.0	23.9 ± 2.6	0.697
ASA I/II/III (n)	1/21/4	1/18/7	0/19/7	0.691
Clinical Stage I/II (n)	14/12	10/16	13/13	0.513
Blood loss (mL)	108.0 ± 65.4	131.9 ± 30.1	131.5 ± 26.6	0.092
Urine (mL)	398.0 ± 226.5	301.9 ± 197.7	380.8 ± 183.9	0.199
Surgery duration (min)	174.6 ± 50.2	195.2 ± 46.0	181.7 ± 42.7	0.275
Fluid infusion (mL)	1465.4 ± 386.7	1511.5 ± 436.3	1536.5 ± 437.6	0.833
Variables presented as mean ± SD or number of patients (n)				
ASA American Society of Anesthesiology, BMI body mass index				

Table 2
Use of intraoperative medications in the three groups

Variable	Group C (n = 26)	Group T (n = 26)	Group TR (n = 26)	P
Propofol (mg)	120.0 ± 21.9	119.6 ± 17.5	128.3 ± 18.3	0.197
Fentanyl (mg)	0.27 ± 0.08	0.29 ± 0.08	0.29 ± 0.09	0.765
Cisatracurium (mg)	20.1 ± 3.7	21.0 ± 3.2	19.8 ± 3.3	0.412
Remifentanil (mg)	0.38 ± 0.13	0.46 ± 0.12	0.42 ± 0.10	0.065
Sevoflurane (%)	2.47 ± 0.37	2.44 ± 0.37	2.32 ± 0.40	0.336
Atropine (mg)	2(7.7%)	3(11.5%)	4(15.4%)	0.690
Ephedrine (mg)	5(19.2%)	3(11.5%)	2(7.7%)	0.448
Variables presented as mean ± SD or number of patients n (%)				

The TR Group used significantly less postoperative sufentanil than the Control Group and Group T at 0 to 24 h ($37.5 \pm 17.38 \mu\text{g}$ vs. $80.0 \pm 46.13 \mu\text{g}$ vs. 74.8 ± 51.10 , $P < 0.01$), 24 to 48 h ($29.0 \pm 24.28 \mu\text{g}$ vs. $56.3 \pm 31.31 \mu\text{g}$ vs. 57.6 ± 32.86 , $P < 0.01$), and 48 to 72 h ($19.4 \pm 15.84 \mu\text{g}$ vs. $47.6 \pm 35.41 \mu\text{g}$ vs. 42.0 ± 26.24 , $P < 0.01$) (Fig. 5). The Control Group and T Group had no significant difference in use of postoperative sufentanil ($P > 0.05$, Fig. 5).

The postoperative NRS pain scores at rest and during coughing were low in all groups at 24 h, 48 h, and 72 h, and there were no significant differences among the three groups ($P > 0.05$, Fig. 6). The postoperative FASs were also favorable in all groups at 24 h, 48 h, and 72 h, and there were no significant differences ($P > 0.05$, Table 3).

Table 3
Postoperative functional activity scores in the three groups (n)

FAS	Variable	Group C (n = 26) C/B/A	Group T (n = 26) C/B/A	Group TR (n = 26) C/B/A	P
	24 h	0/4/22	0/2/24	0/3/23	0.686
	48 h	0/2/24	0/1/25	0/0/26	0.353
	72 h	0/1/25	0/0/26	0/0/26	0.363
Variables presented as number of patients (n)					
FAS Functional Activity Score (A, not limited [functional activity not limited because of pain]; B, mild to moderate limitation [functional activity mildly to moderately limited because of pain]; C, severely restricted [functional activity severely limited because of pain])					

The TR Group required less rescue analgesia than the Control Group and the T Group ($P < 0.05$, Table 4), but there were no significant differences between the Control Group and the T Group ($P > 0.05$, Table 4). The three groups had no significant differences in any of the measured recovery parameters ($P > 0.05$, Table 5) and no differences in the incidences of sufentanil-associated adverse effects ($P > 0.05$, Table 6). None of the patients experienced respiratory depression ($P > 0.05$, Table 6).

Table 4
Use of rescue analgesia in the three groups

Variable	Group C (n = 26)	Group T (n = 26)	Group TR (n = 26)	P
Rescue analgesic	11(42.3%)	8(30.8%)	2(7.7%)*	0.016
Variables presented as number of patients n (%)				
* $p < 0.05$ versus Group T or Group C				

Table 5
Recovery parameters in the three groups

Variable	Group C (n = 26)	Group T (n = 26)	Group TR (n = 26)	P
Time to first flatus (h)	63.4 ± 8.71	64.6 ± 7.80	65.6 ± 6.35	0.604
Time to first solid food (h)	81.5 ± 7.64	82.9 ± 6.80	84.5 ± 6.83	0.283
Time to first feces (h)	132.3 ± 13.16	133.1 ± 14.73	126.5 ± 13.82	0.192
Postoperative ileus	1 (3.8%)	1 (3.8%)	2 (7.7%)	0.768
Duration of postoperative hospital stay (days)	6.5 ± 1.01	6.7 ± 0.96	6.8 ± 1.08	0.590
Variables presented as mean ± SD or number of patients n (%)				

Table 6
Adverse effects in the three groups

Variable	Group C (n = 26)	Group T (n = 26)	Group TR (n = 26)	P
Nausea	5(19.2%)	4(15.4%)	6(23.1%)	0.781
Vomiting	2(7.7%)	1(3.8%)	2(7.7%)	0.808
Puritus	2(7.7%)	1(3.8%)	0(0%)	0.353
Respiratory depression	0	0	0	1.000
Dizziness	3(11.5%)	1(3.8%)	1(3.8%)	0.425
Variables presented as number of patients n (%)				

Discussion

This study demonstrated that patients who received laparoscopy-assisted radical resection of early-stage rectal cancer had significantly reduced use of postoperative PCIA and rescue analgesia when they received US-guided posterior TAPB with RSB rather than US-guided posterior TAPB alone or saline alone.

Laparoscopic surgery has become the preferred approach for treatment of early-stage rectal cancer [11, 12], because it requires minimal incision, and is associated with a low postoperative pain score, minimal scarring, reduced incidence of postoperative incision hernia, and shorter hospital stay [13]. Nevertheless, abdominal incision pain is still the main factor affecting recovery of these patients [14]. The adverse effects of insufficient postoperative pain management include delayed wound healing, development of chronic pain, decreased immunity, and postoperative cognitive dysfunction [15–17]. Therefore, adequate postoperative analgesia is essential to promote the recovery of these patients [18, 19]. There is evidence that perioperative multimodal analgesia reduces opioid consumption and the incidence of postoperative nausea and vomiting, and also allows patients to get out of bed sooner after surgery [3]. Several recent studies, in agreement with our results, have demonstrated that PCIA combined with US-guided peripheral nerve block provides effective pain management after abdominal operations [20–22].

Rafi et al. first described postoperative TAPB as a peripheral nerve block in 2001 [23]. Because of improvements in US technologies, anesthesiologist now commonly use US-guided TAPB for perioperative pain management [6, 24]. The transverse abdominal plane, which is between the internal oblique and the transverse abdominal muscles, has a nerve that passes through and innervates the anterior abdominal wall. Local anesthetics injected in this plane can produce an anesthetic effect (a TAP block), and the use of US during this procedure increases effectiveness and safety. Previous research demonstrated that US-guided TAPB reduced postoperative pain after laparoscopic colorectal surgery [6, 25]. There are two major approaches used for TAP: a lateral approach and the more conventional posterior approach. In the latter approach (which we used), the US probe is placed between the costal margin and the iliac crest at the axillary midline, and then scanned backward until the transverse abdominal muscle moved into the aponeurosis. The local anesthetic is then injected into the TAP near the aponeurosis, and a wider spread of local anesthetic could provide sufficient analgesia. Previous research demonstrated that the drug spreads to the paravertebral space and creates a paravertebral block that relieves visceral pain during lower abdominal surgery [5, 26].

Some studies showed that the analgesic effect of US-guided posterior TAPB was better than other approaches, including the subcostal or lateral approaches. Faiz et al. demonstrated that US-guided posterior TAPB was more effective than lateral TAPB for pain management after cesarean section [27]. Yoshiyama et al. showed that patients receiving posterior TAPB had lower pain scores than those receiving lateral TAPB after gynecologic surgery [5]. Another study reported that posterior TAPB appeared to produce more prolonged analgesia than lateral TAPB following transverse lower abdominal incision [28]. Our findings for rectal cancer are consistent these previous findings.

On the contrary, some studies demonstrated that subcostal TAPB may be superior to posterior TAPB following laparoscopic cholecystectomy [8, 29]. Ari et al. reported that subcostal-posterior TAP block and subcostal TAP block alone provided equivalent analgesia following laparoscopic sleeve gastrectomy [30]. Studies of pain management following laparoscopic colorectal cancer surgery have reported contradictory results [31, 32]. There may be several reasons for these contradictory results. First, laparoscopy-assisted radical resection of rectal cancer requires two incisions above the umbilicus, and there may be variations among patients in the pain arising from these incisions. There is evidence that the cephalad dermatome levels achieved by posterior TAP is at T₁₀, which is more suitable for analgesia of the incision below the umbilicus [8, 33]. Furthermore, there is a lack of uniform standards regarding the doses of local anesthetics used during US-guided TAPB.

For upper abdominal incisions, US-guided RSB might be a better alternative for injecting local anesthetics into the posterior rectus sheath [34]. The ventral branch of the T₇-T₁₂ intercostal nerve can be blocked, thus anesthetizing the anterior wall of the abdomen from the xiphoid process to the pubic symphysis [35]. There is evidence that RSB blocks the anterior branch of T₉-T₁₁, and provides a better analgesic effect for incision around the umbilicus [36]. RSB could be performed alongside posterior TAPB to block higher dermatomes in the abdominal wall, up to T₆ [37]. There is also evidence that TAPB reduces the use of fentanyl by 20%, and that RSB combined with TAPB reduces the use of fentanyl by more than 60% in patients with cirrhosis undergoing liver resection [22].

No previous studies have examined the analgesic effect of US-guided TAPB with RSB in laparoscopy-assisted radical resection of rectal cancer. This study compared the analgesic effects of US-guided posterior TAPB with or without RSB on pain intensity in patients receiving laparoscopic surgery for rectal cancer and postoperative PCIA. In particular, we compared patients who received three different analgesia protocols: The Control Group received PCIA alone, the T Group received US-guided posterior TAP and PCIA, and the TR Group received US-guided PTAP with RSB and PCIA. Our results indicated that postoperative sufentanil use was significantly reduced in the TR group compared with the other two groups during all three time postoperative periods (0 to 24 h, 24 to 48 h, and 48 to 72 h; $p < 0.05$), and that there was no significant differences between the Control Group and the T Group in postoperative sufentanil use. The TR Group also had significantly lower use of rescue analgesia than the other two groups ($p < 0.05$). However, all three groups had similar pain intensity scores and FAS, and were similar in other secondary outcome measures. It should be emphasized that the patients in all three groups received PCIA to maintain a postoperative NRS pain score of 4 or below. Based on our results, we believe that US-guided posterior TAPB with RSB should be considered for postoperative pain management in patients undergoing laparoscopy-assisted radical resection of rectal cancer.

This study had some limitations that should be considered. First, we did not study the effect of the duration of analgesia provided by the peripheral nerve block. Previous studies showed that the analgesia duration from a single-shot TAPB lasts for 24 to 48 h, but it is possible that our use of two nerve blocks and the poor vascularization of the TAP and RS prolonged the duration of analgesia. Second, all nerve blocks were performed by the same anesthesiologist. Although this approach reduced variability, it limits

our ability to generalize our findings to other anesthesiologist. Third, the study indicated that TAPB with RSB afforded better analgesic effect than TAPB or placebo, although we did not compare the analgesic effect of RSB and TAPB. Further research on this topic is necessary. Finally, this was a single center study, so our results cannot be generalized to other medical centers.

Conclusions

In conclusion, we found that postoperative US-guided posterior TAPB with RSB significantly reduced postoperative opioid use by patients following laparoscopy-assisted radical resection of rectal cancer. Further studies are required to determine the duration of analgesia provided by this procedure.

Abbreviations

PONV: postoperative nausea and vomiting; US:ultrasound; TAPB:transversus abdominis plane block; RSB:rectus sheath block; ASA:American Society of Anesthesiologists; PCA:patient-controlled analgesia; PCIA:patient controlled intravenous analgesia; IV:intravenous; BIS:bispectral index; TEM:total mesorectal resection; CONSORT:Consolidated Standards of Reporting Trials; PACU:post-anesthesia care unit; NRS:numerical rating scale; APS:acute pain service; FAS:functional activity score

Declarations

Availability of data and materials

The raw data of the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethical approval was obtained from the institutional ethical committee of Liaocheng People's Hospital (No. 2019016). Written informed consents were obtained from participants before inclusion.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

No funding.

Authors' contributions

ML, YXY and XJG conceived and designed the trial. ML and XX collected the data. CGR analyzed the data. ML, YXY and XJG wrote this paper. All authors have readed and approved the manuscript.

Acknowledgements

Not applicable.

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Figures



Figure 1

Laparoscopic incision and trocar insertion using the five hole method.

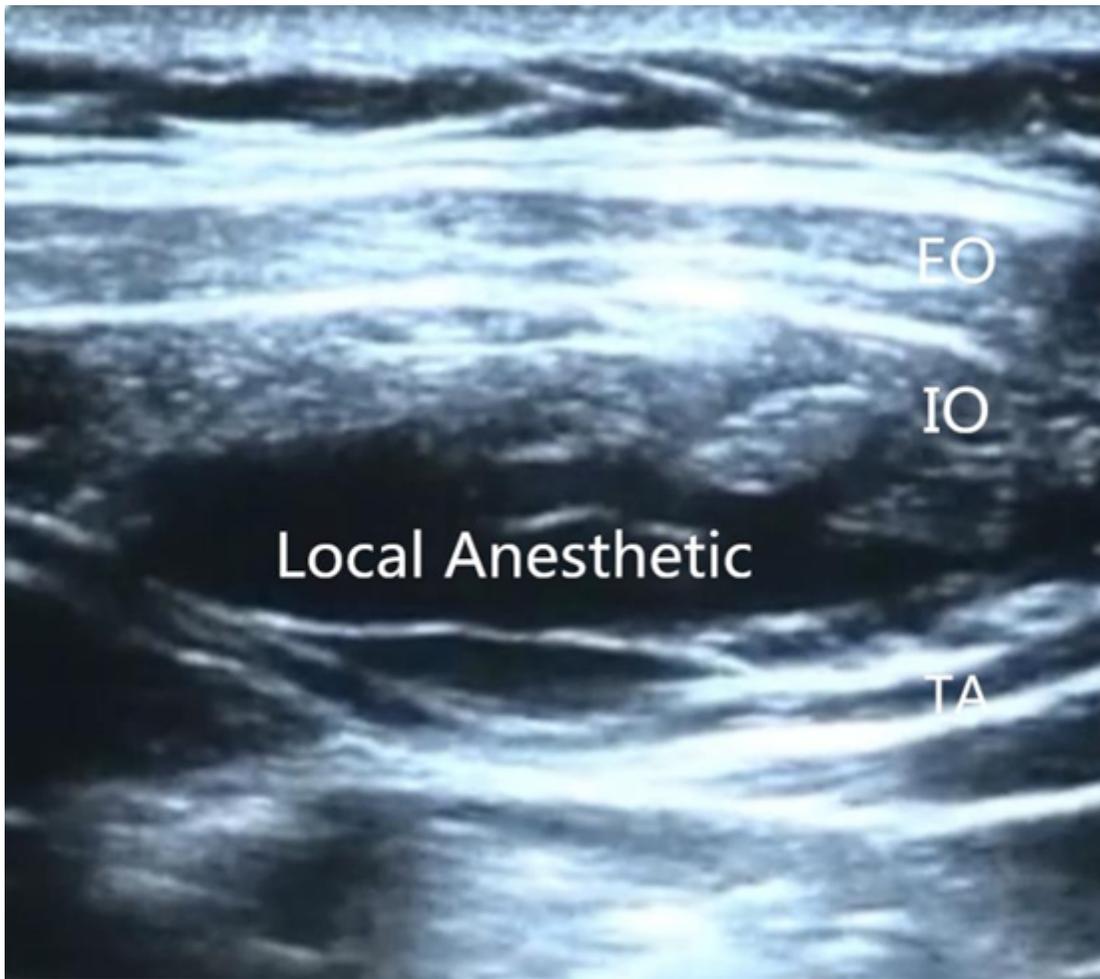


Figure 2

TAP block



Figure 3

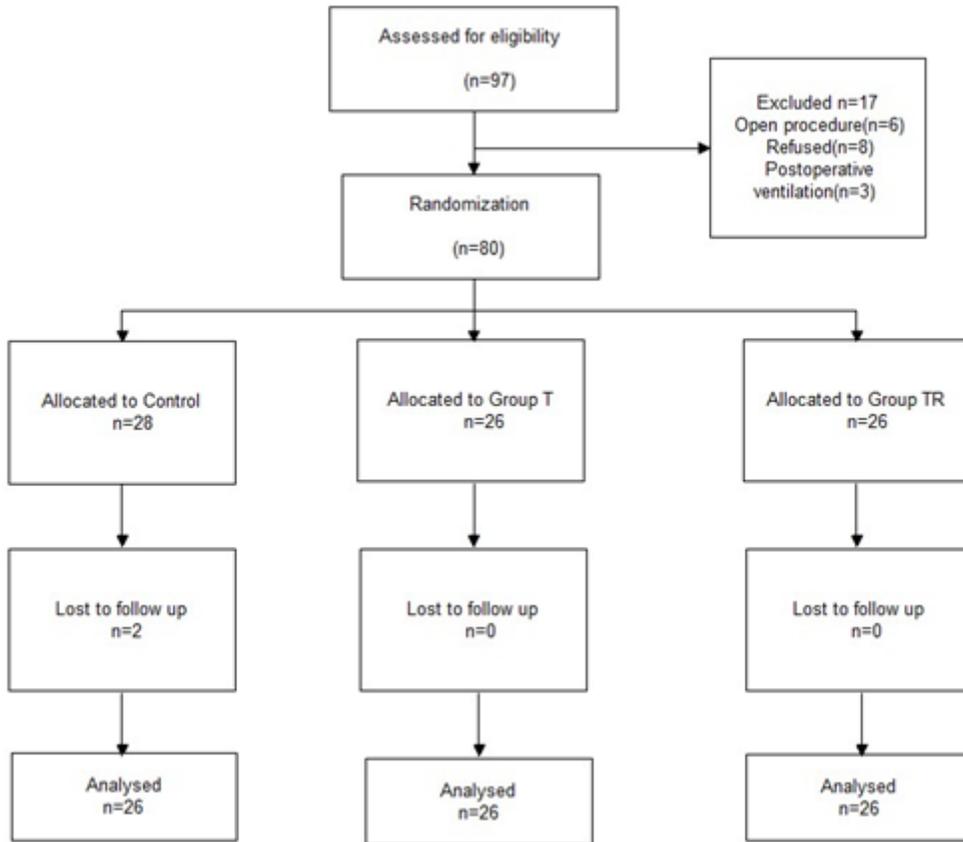


Figure 4

Disposition of eligible patients with stage I/II rectal cancer

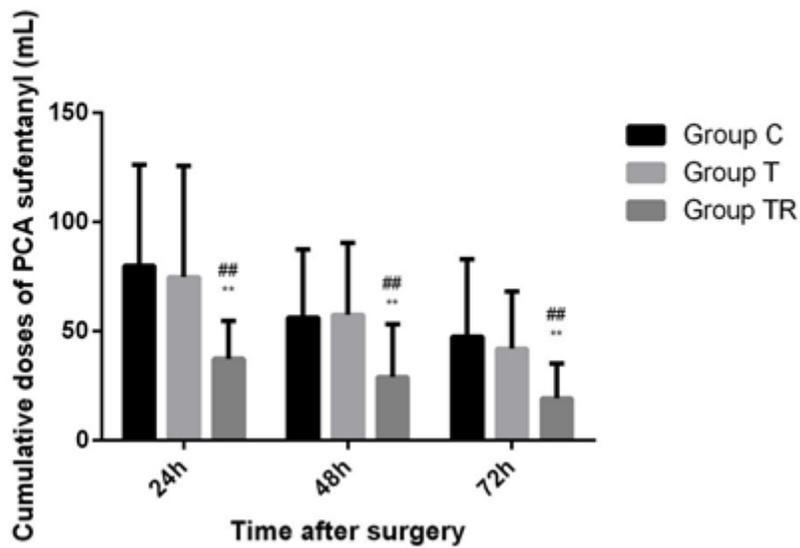


Figure 5

Postoperative sufentanil use in the three groups. **P< .01 vs. Control Group, ##P< .01 versus. T Group

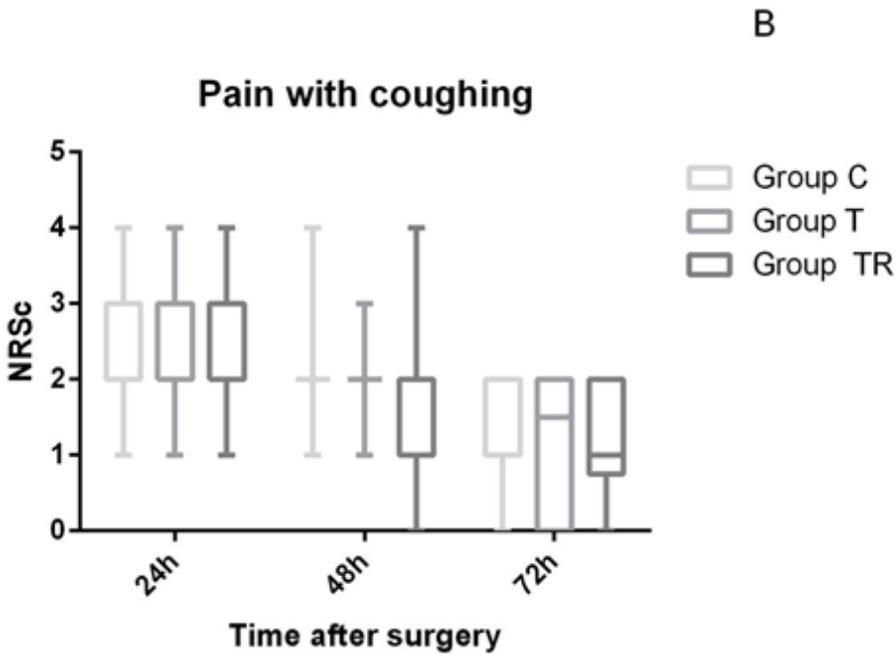
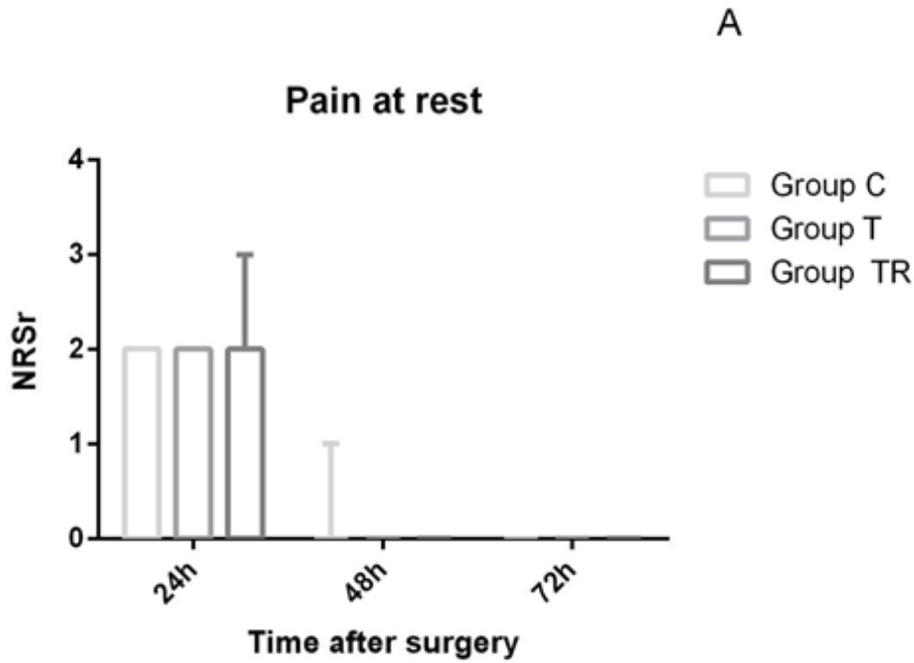


Figure 6

A: Postoperative pain scores at rest in the three groups (NRS = numerical rating scale). B: Postoperative pain scores with coughing in the three groups

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