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Effect of enhanced recovery after surgery on older patients undergoing transvaginal pelvic floor reconstruction surgery: a randomised controlled trial

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Abstract

Background Prospective trial evidence is lacking regarding the application of enhanced recovery after surgery (ERAS) in transvaginal pelvic floor reconstruction surgery among older patients. Our study aimed to investigate whether implementing the ERAS protocol could enhance post-operative recovery in this patient population.

Methods Older patients undergoing elective transvaginal pelvic floor reconstruction surgery were randomly assigned to either the ERAS group or the conventional group. The primary outcome was post-operative length of stay (LOS). The secondary outcomes encompassed other post-operative recovery metrics, post-operative pain within 30 days, the occurrence of complications, the peri-operative blood test and cognitive function.

Results A cohort of 100 patients was enrolled. Implementation of the ERAS protocol significantly reduced the duration of post-operative LOS (74.00 (69.00, 96.00) vs. 65.00 (59.00, 78.25) h, $P < 0.01$). Additionally, the ERAS protocol significantly reduced the duration of the first oral intake post-operatively (5.00 (2.50, 7.00) vs. 3.00 (2.00, 4.00) h, $P = 0.01$), and reduced rest and movement-related pain within 48 h post-operatively, effects that persisted through the 7-day follow-up period. It also shortened the duration of post-operative laryngeal mask airway support and promoted opioid-sparing. Moreover, the incidence and severity of post-operative nausea and vomiting (PONV) were significantly lower in the ERAS group compared to the conventional group at 12 h post-operatively.

Conclusions Implementation of the ERAS protocol can expedite post-operative recovery in older patients undergoing transvaginal pelvic floor reconstruction surgery, achieve opioid-sparing, alleviate pain post-operatively, and decrease the incidence of complications.

Trial registration This study was retrospectively registered with the Chinese Clinical Trial Registry (registration number: ChiCTR2400084608). The date of first registration was 21/05/2024.

Keywords Pelvic organ prolapse, Gynaecological surgery, Aged, Enhanced recovery after surgery, Length of stay, Pain, Postoperative nausea and vomiting

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Background

The concept of enhanced recovery after surgery (ERAS) was first introduced by a Danish anaesthetist Henrik Kehlet, with the aim of optimising peri-operative management. This involves strategies, such as minimising unnecessary bowel preparation, utilising multimodal analgesia to reduce opioid consumption, and promoting early post-operative feeding and mobilisation. These interventions are designed to alleviate surgical stress and expedite patients' post-operative recovery [1, 2]. Previous research has consistently demonstrated the benefits of ERAS, including reductions in the average length of stay (LOS), decreased incidence of post-operative complications and mortality, cost-effectiveness, and enhancement of patients' quality of life [3]. The ERAS protocols are now widely implemented across various surgical specialties, including colorectal surgery [4], urology [5], cardiothoracic surgery [6], hepatobiliary surgery [7], and orthopaedics [8]. However, its application in gynaecological surgery [9], particularly in transvaginal pelvic floor reconstruction, has been adapted from experiences in colorectal and gastrointestinal surgery, with numerous decisions lacking robust supporting evidence [10]. Additionally, patients undergoing transvaginal pelvic floor reconstruction surgery are often older individuals, with more fragile neurological, respiratory, and circulatory systems. To reduce post-operative complications in these patients, ERAS strategies, such as low-opioid anaesthesia, multimodal pain management [11], and prophylactic anti-emetics [12], are necessary. Beyond patient age and vulnerability, gynaecological surgeries differ from colorectal procedures in terms of anatomy, surgical techniques, complication risks, wound healing, and psychosocial factors [4], necessitating the development of customised ERAS protocols for optimal patient outcomes.

A single-centre retrospective observational study focusing on pelvic floor reconstruction surgery demonstrated that patients in the ERAS group experienced earlier assisted walking by 17 h and earlier intestinal recovery by 9 h compared to those in the conventional care group. Implementation of the ERAS protocol was associated with a significantly shorter LOS (70.25 (52.50, 97.87) h vs. 121.35 (93.65, 168.70) h, $P<0.001$) and lower hospital costs (42,793.57 (2560.3) RMB vs. 46,838.65 (2584.08) RMB, $P<0.001$). However, no discernible difference in surgical outcomes or post-operative complications was observed between the ERAS and conventional care groups [13]. Despite these promising findings, there is currently a paucity of prospective randomised controlled trials (RCTs) investigating the application of ERAS for transvaginal pelvic floor reconstruction surgery in older patients.

Therefore, we conducted a trial to evaluate the efficacy of the ERAS protocol compared with conventional treatment in older patients undergoing transvaginal pelvic floor reconstruction surgery. We hypothesised that the adoption of the ERAS principles could shorten LOS, lower costs, mitigate post-operative pain, and reduce complications in this patient population.

Methods

Ethical approval

The study was approved by the Medical Ethics Committee of the Chongqing Health Center for Women and Children (registration number: 2023–040) and was retrospectively registered with the Chinese Clinical Trial Registry (www.chictr.org.cn; registration number: ChiCTR2400084608). The date of the first registration was 21/05/2024. All participants provided written informed consent, and the protocols strictly adhered to the principles of the Declaration of Helsinki.

Sample size calculation

The duration of post-operative LOS was considered as the primary endpoint. According to a pilot study, the ERAS protocol reduced LOS by 12 h relative to the conventional treatment strategies (65.55 (14.14) h vs. 77.15 (17.91) h). We established a significance level (alpha) of 0.05, targeting a power of 90%. Using the Power Analysis and Sample Size software, version 2024 (NCSS, LLC, Kaysville, USA), we determined that each group needed a sample size of 44. After factoring in a 10% dropout rate, a minimum of 50 patients per group was required, totalling at least 100 participants.

Selection of patients

Patients aged 60–80 years with pelvic organ prolapse scheduled for transvaginal pelvic floor reconstruction surgery and an American Society of Anesthesiologists (ASA) physical status of I or II were included in this study. The exclusion criteria included complications such as gynaecological malignant tumours, acute infections, mental illness (inability to communicate or accurately provide numerical rating scale (NRS) score [14]), poorly controlled blood glucose (fasting blood glucose greater than 200 mg/dL), and other contraindications, including those related to non-steroidal anti-inflammatory drugs (NSAIDs), use such as peptic ulcers, known NSAID allergies, and a history of aspirin-induced asthma. Patients who required emergency surgery were also excluded. Withdrawal criteria included patients' refusal to continue with the study protocol or the need for an unexpected extension of surgery.

Randomisation, allocation, and concealment

Prior to admission, patients were randomised into either the conventional group (group C) or ERAS group (group E) using a computer-generated random number list in a 1:1 ratio. Group C received treatment under the conventional peri-operative care protocol, whereas Group E received treatment under the ERAS protocol. Owing to the need for clinical staff to conduct patient education, prescribe medications, and provide post-operative analgesia, complete blinding was not feasible. Data collection and analysis were conducted by a dedicated researcher who was blinded to the group assignments throughout the study.

Study outcomes

The primary outcome was post-operative LOS. The secondary outcomes were the other rehabilitation indexes, including duration to first oral intake, duration to first ambulation, duration to first intestinal exhaust, duration of post-operative urinary catheterisation and hospitalisation expense, complications, vital signs, post-operative pain within 30 days after surgery, routine blood test, and cognitive function.

Study protocol

The protocol was developed based on the guidelines for vulvar and vaginal surgery [10], as well as those for peri-operative care in gynaecology and oncology, following the ERAS Society recommendations [9].

Group C

Patients were instructed to fast from solid foods for 8 h and to restrict clear liquid intake for 2 h before surgery, with exception for pre-operative medications. Intravenous access was established, and intensive blood pressure monitoring was commenced prior to anaesthesia induction. The anaesthesia induction sequence involved the administration of sufentanil (0.2–0.3 μg/kg), etomidate (0.2–0.3 mg/kg), and rocuronium (0.3 mg/kg). Subsequently, a laryngeal mask was placed and connected to the anaesthesia machine for ventilation in volume-controlled ventilation mode, maintaining the end-tidal carbon dioxide pressure within 35–40 mmHg. Anaesthesia maintenance was achieved through target-controlled infusion (TCI) of propofol and remifentanil, supplemented with additional rocuronium (0.15 mg/kg) every 30 min. Throughout the surgery, body temperature was continuously monitored. If the temperature dropped below 36 °C, a warming blanket was used to initiate warming. Following surgery, patients were connected to a patient-controlled intravenous analgesia (PCIA) pump, containing sufentanil (75 μg), dexmedetomidine (100 μg), and dexamethasone (10 mg), diluted with 0.9% saline solution to a total volume of 100 ml. The infusion was set at a continuous rate of 2 ml/h, with a bolus dose of 2 mL and a lockout time of 15 min.

Group E

Four weeks prior to surgery, smoking and alcohol cessation were initiated, and any existing anaemia was treated. Upon admission, a collaborative effort involving surgeons, anaesthetists, and nurses was undertaken to educate patients on the objectives of ERAS, peri-operative management processes (including surgical and anaesthetic procedures), steps that patients must comply with, post-operative recovery, and discharge criteria. Because of delayed gastric emptying caused by reduced gastric motility and contraction strength in older patients [15], we extended the fasting period slightly beyond the other ERAS protocols-pre-operative fasting for solid foods for 8 h, and 3 h before surgery, intake of clear sugared beverages, and analgesics (gabapentin (300 mg) [16], paracetamol (500 mg) [10], and celecoxib (200 mg) [10, 17]) for pain management. Intravenous access and intensive blood pressure (BP) monitoring were performed. Lidocaine (1 mg/kg) was intravenously infused before anaesthesia. The anaesthesia induction sequence mirrored that of the conventional group. Additionally, a pre-operative intravenous injection of dexamethasone (5 mg) was administered. Anaesthesia maintenance involved TCI of propofol and remifentanil, supplemented with continuous lidocaine infusion at 1 mg/kg/h. Body temperature was continuously monitored throughout the surgery, and a warming blanket was used at all times to provide active warming. Patients received parecoxib (40 mg), ondansetron (5 mg) at the end of the surgery, and metoclopramide (10 mg) was added when post-operative nausea and vomiting (PONV) scores were ≥ 3 [18]. Upon regaining consciousness, patients initiated oral intake of water and analgesics, including gabapentin (300 mg), paracetamol (500 mg), and celecoxib (200 mg), every 8 h. Early post-operative feeding commenced 3 h after surgery, and patients were actively encouraged and supported in ambulation as soon as possible.

Throughout the surgical procedures, both groups maintained a bispectral index (BIS) within the range of 40 to 60 and heart rate (HR) between 50 and 100 beats per minute (bpm). In instances where the HR fell below 50 bpm, atropine (0.3mg) was administered; conversely, if the HR exceeded 100 bpm, the depth of anaesthesia was increased. Systolic blood pressure (SBP) was controlled to fluctuate within 30% of the pre-operative baseline value. If there was a decline surpassing 30% of the baseline range, ephedrine was administered (3–5 mg); however, if the increase exceeded 30% of the baseline range,

the depth of anaesthesia was increased accordingly. The study adhered to the standardised research protocol (Fig. 1).

Data collection

Trained researchers meticulously gathered all peri-operative data, including patient demographics and peri-operative information, such as routine blood test results and Mini-Mental State Examination (MMSE) scores, to assess cognitive function [19]. Intraoperative details including vital signs, surgical duration, blood loss, doses of anaesthetics and vasopressors, fluid infusion volumes, and duration of post-operative laryngeal mask respiratory support were recorded. Post-operative data consisted of pain assessments using NRS scores, where 0 denoted 'no pain' and 10 denoted 'worst pain imaginable' [14] and supplementary analgesia requirements. Recovery data included the duration

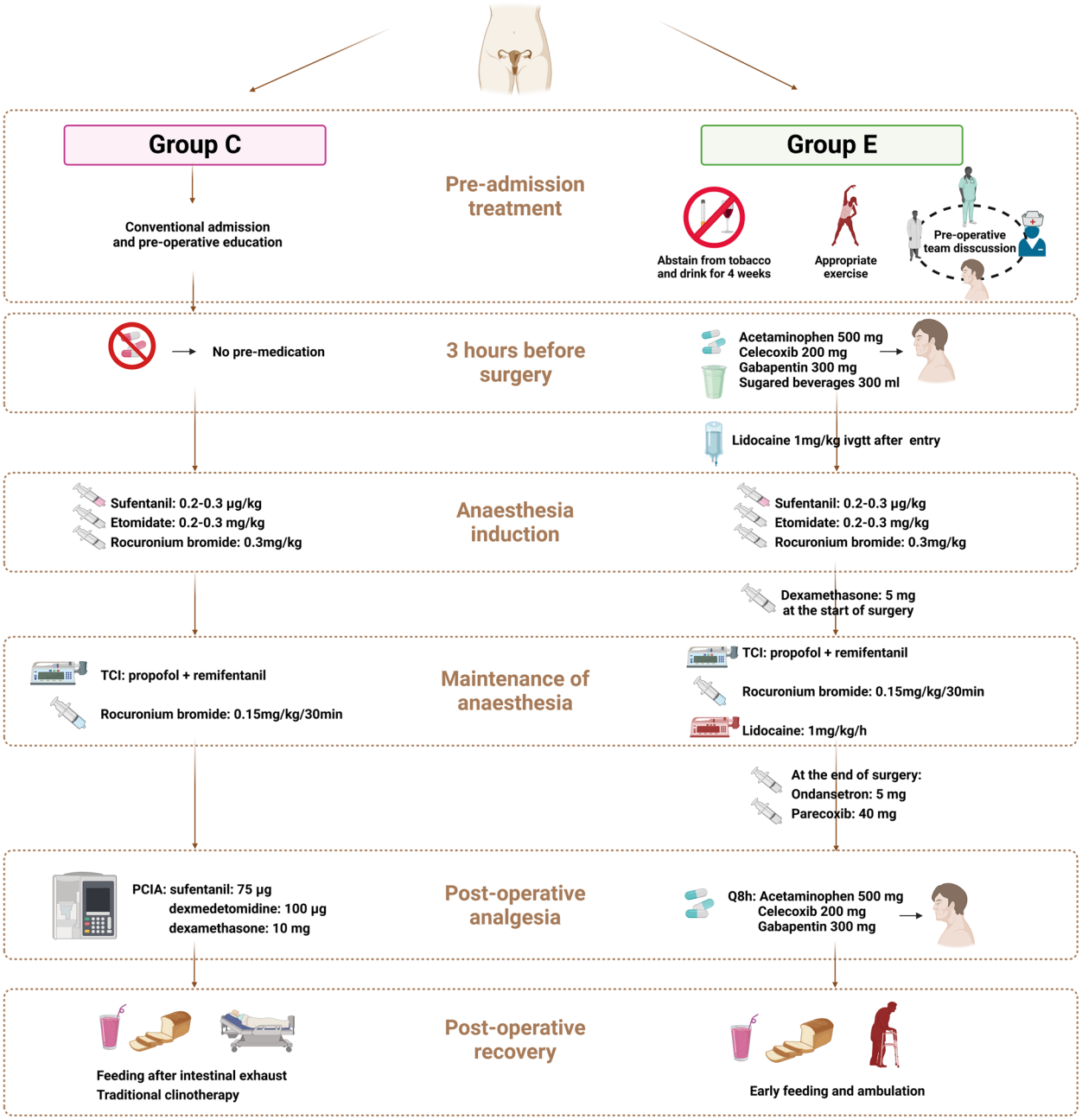

Fig. 1 Graphical abstract. Abbreviations: TCI, target-controlled infusion; PCIA, patient-controlled intravenous analgesia

to the first post-operative intestinal exhaust, oral intake and ambulation, duration of post-operative urinary catheterisation, post-operative LOS, and hospitalisation costs. Follow-up data included NRS scores for pain recorded at 7 and 30 days post-operatively, as well as instances of rehospitalisation after surgery.

Complications included hypotension or hypertension, defined as a decrease or increase in SBP greater than 30%, respectively, compared to pre-anaesthesia levels; bradycardia or tachycardia, defined as an HR below 50 bpm or above 100 bpm, respectively; hypoxaemia, indicated by oxygen saturations below 92% despite supplemental oxygen; pruritus; post-operative urinary retention (POUR), characterised by residual urine volumes exceeding 150 ml or inability to urinate post-catheter removal; ileus, confirmed through clinical symptoms; post-operative respiratory tract infections, confirmed through clinical symptoms and imaging; incision infections, evidenced by symptoms and positive bacterial cultures; post-operative deep venous thrombosis, verified via ultrasound; and PONV grading (Grade I—no nausea, Grade II—mild nausea, mild abdominal discomfort, no vomiting, Grade III—evident nausea and vomiting, but no material expelled, Grade IV—severe vomiting, expulsion of gastric contents necessitating medication).

Statistical analysis

All statistical analyses were performed using Statistical Package for Social Science (SPSS) for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA). Normality was assessed using the Shapiro-Wilk test. Quantitative data are presented as mean (standard deviation) or median (inter-quartile range) and were compared between the two groups using the Student's *t*-test (for data with a normal distribution) or the Mann-Whitney *U*-test (for data with an abnormal distribution). The Mann–Whitney *U*-test was selected because it does not assume normality and is more appropriate for non-parametric data, providing a robust alternative when the assumption of normality is violated. The Generalised estimation equation (GEE) was used to test repeated non-normal measures, such as vital signs, MMSE scores, white blood cell (WBC) count, and haemoglobin (HGB) level. Categorical data are presented as numbers (percentages) and were compared using the Pearson chi-squared or Fisher's exact tests. The Mann–Whitney *U*-test was used to compare ranked data including satisfaction evaluation scores, NRS scores for pain, PONV, and the ASA physical condition. Statistical significance was set at a two-tailed *P*-value of < 0.05. *P*-values are reported with three significant digits to maintain consistency throughout the manuscript.

Results

A total of 100 patients were initially enrolled in this study from 04/09/2023 to 30/04/2024. However, three patients were lost to follow-up, and two patients withdrew due to refusal to continue with the study protocol. Consequently, data from the remaining 95 patients (group C: 49; group E: 46) were analysed (Fig. 2).

Demographics

No significant difference in age, weight, height, ASA physical status classification, education level, physical condition, smoking status, or alcohol consumption was observed between the groups (Table 1).

Primary outcome

Implementation of the ERAS protocol led to a significant reduction in the post-operative LOS. Specifically, the post-operative LOS for the ERAS group was shortened by approximately 9 h compared to that of the conventional group (74.00 (69.00, 96.00) h vs. 65.00 (59.00, 78.25) h, $P = 0.001$) (Table 2).

Secondary outcome

Other rehabilitation indexes

Moreover, the duration to the first post-operative oral intake was notably shorter in the ERAS group than in the conventional group (5.00 (2.50, 7.00) h vs. 3.00 (2.00, 4.00) h, $P = 0.010$). No statistically significant differences in the other rehabilitation indexes were observed between the two groups (Table 2).

Anaesthesia and surgery data

Notable differences were observed between the groups: the ERAS group demonstrated a shorter time from discontinuation of anaesthesia to removal of the laryngeal mask and a lower dosage of remifentanil (Table 3).

Peri-operative vital signs

During the peri-operative period, no statistically significant difference in BP or oxygen saturation was observed between the two groups. However, HR in the ERAS group was lower than that in the conventional group (Fig. 3).

Post-operative pain

Furthermore, compared with the conventional group, the ERAS group exhibited significantly lower NRS scores for resting pain at 2, 12, and 24 h post-operatively and at 7 days post-operatively. Additionally, the NRS scores for movement-associated pain from 2 to 48 h postoperatively were lower in the ERAS group (Fig. 4). Moreover, none of

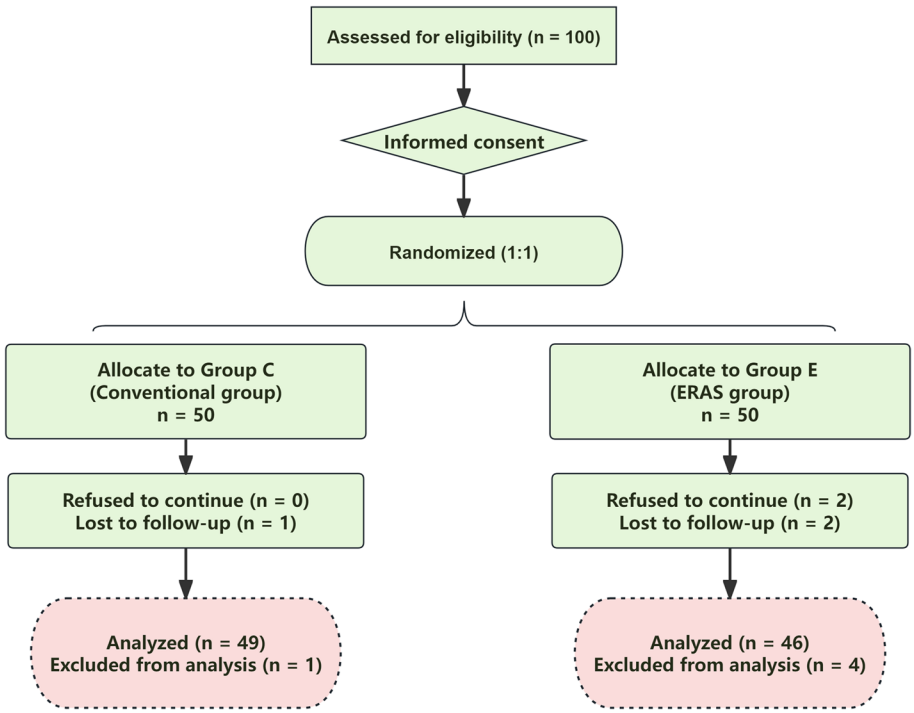

Fig. 2 Flow chart of the study

Table 1 Demographic data

Characteristic	Group C (*n* = 49)	Group E (*n* = 46)
Age, years	68.00 (61.00, 72.00)	68.39 [4.87]
ASA (I/II), *n*	20/29	15/31
Height, cm	154.29 (4.84)	153.00 (150.00, 157.25)
Weight, kg	57.84 (6.95)	57.24 (7.20)
Level of education (illiteracy/primary school/junior high school/senior high school/university or above), *n*	12/13/14/4/6	15/12/15/4/0
Physical condition, *n* (%)		
Hypertension	7 (14.28)	11 (23.91)
Diabetes	3 (6.12)	5 (10.87)
Cardiovascular disease	4 (8.16)	0
Anaemia	1 (2.04)	0
Arrhythmias	2 (4.08)	0
Nephropathy	1 (2.04)	0
Hypoalbuminaemia	1 (2.04)	0
Smoking status, *n* (%)	2 (4.08)	0
Alcohol use, *n* (%)	0	0

Data are given as median (inter-quartile range), mean [standard deviation], and *n* (%), as appropriate

ASA, American Society of Anesthesiologists

the patients in the ERAS group required additional analgesia, and the incidence was significantly lower than that in the conventional group (Table 4).

Peri-operative complications

The ERAS group exhibited a notably lower incidence of PONV at 2 h and 12 h post-operatively than the

Table 2 Post-operative recovery data

Characteristic	Group C (*n* = 49)	Group E (*n* = 46)	*P*-value
Post-operative length of stay, h	74.00 (69.00, 96.00)	65.00 (59.00, 78.25)	0.001
Duration to first intestinal exhaust, h	12.00 (5.00, 14.50)	7.00 (5.00, 13.00)	0.072
Duration to first oral intake, h	5.00 (2.50, 7.00)	3.00 (2.00, 4.00)	0.010
Duration to first ambulation, h	22.00 (18.00, 24.00)	19.65 (15.50, 23.00)	0.059
Duration of post-operative urinary catheterization, h	45.00 (42.00, 48.00)	45.50 (42.00, 48.00)	0.695
Hospitalisation expense, RMB	18,516.33 [3439.42]	18,621.23 [4068.31]	0.892

Data are given as median (inter-quartile range), mean [standard deviation], and *n* (%) as appropriate

Table 3 Anaesthesia and surgery data

Characteristic	Group C (*n* = 49)	Group E (*n* = 46)	*P*-value
Duration of surgery, min	56.00 (42.50, 79.00)	64.71 [24.59]	0.413
Infusion volume, ml	500.00 (400.00, 500.00)	400.00 (300.00, 500.00)	0.532
Urine volume, ml	100.00 (100.00, 110.00)	100.00 (100.00, 200.00)	0.096
Bleeding volume, ml	30.00 (30.00, 50.00)	30.00 (30.00, 50.00)	0.908
Duration to laryngeal mask removal, min	10.00 (7.00, 11.50)	8.00 (6.00, 10.00)	0.041
Propofol consumption, mg	430.00 (285.00, 645.00)	350.00 (220.00, 470.00)	0.061
Remifentanil consumption, μg	300.00 (250.00, 490.00)	200.00 (155.00, 325.00)	< 0.001
Ephedrine consumption, mg	0.00 (0.00, 6.00)	0.00 (0.00, 6.00)	0.174
Atropine consumption, mg	0.00 (0.00, 0.30)	0.00 (0.00, 0.30)	0.937

Data are given as median (inter-quartile range), mean [standard deviation], and *n* (%) as appropriate

conventional group. No statistically significant differences were observed between the two groups regarding other complications, including bradycardia, hypotension, or POUR (Table 5).

Blood routine test and cognitive function

Post-operatively, both groups exhibited an elevation in WBC count and a reduction in HGB level compared to their pre-operative levels, with no significant difference observed between the groups. At 24 h post-operatively, both groups experienced a decline in cognitive function, as indicated by MMSE scores, with no significant difference between them (Fig. 5).

Discussion

We observed that the peri-operative application of the ERAS protocol in older patients undergoing transvaginal pelvic floor reconstruction surgery can reduce post-operative hospital stay and time to first oral intake. It can also shorten the duration of post-operative pharyngeal mask airway support, decrease opioid drug use, alleviate post-operative pain, and reduce post-operative complications.

Patients in the ERAS group tended to have a quicker post-operative discharge, potentially because of enhanced post-operative analgesia, a lower incidence of PONV, earlier initiation of oral intake and ambulation [9], and the encouraging and educational role of the medical team [20]. However, successful implementation of the ERAS protocol requires high patient compliance and close collaboration among various departments, physicians and nurses, demanding additional time and patience from the personnel involved, which might impede its adoption. In Germany, a survey assessing the effectiveness of ERAS clinical pathways for patients with ovarian cancer undergoing cytoreductive surgery revealed that 21% of the surveyed hospitals had an ERAS adoption rate exceeding 80%, and only 8.4% had adoption rates exceeding 90% [21]. Disparities exist in the implementation rates of various ERAS measures in gynaecological and gynaecologic oncology in China, with certain measures, such as the implementation rate of omitting mechanical bowel preparation before tumour surgery, being as low as 0.5% [22].

POUR is the most common complication following pelvic floor surgery, with an incidence ranging from 15 to 45% [23, 24], and is a significant factor delaying discharge. Transvaginal pelvic floor reconstruction surgery is thrice more prone to POUR than minimally invasive sacrocolpopexy [25], possibly due to increased pelvic floor tension secondary to pain [26] or greater disruption of local autonomic nerves

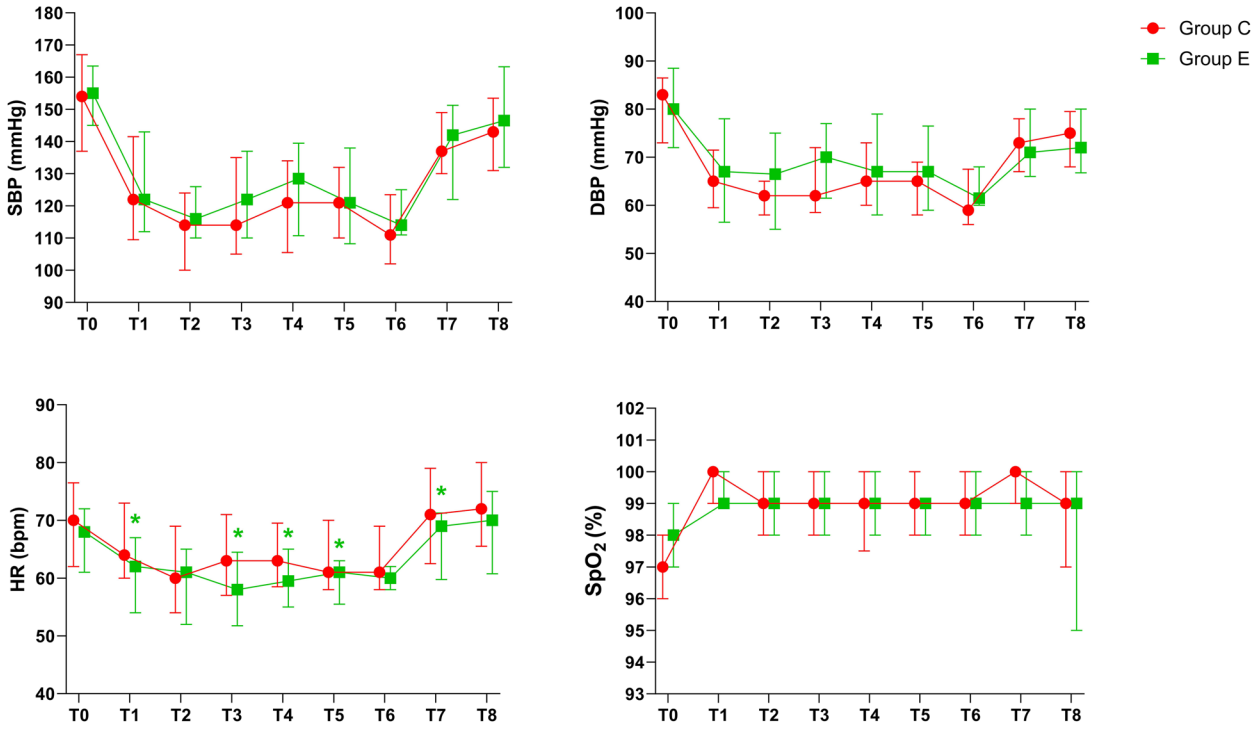

Fig. 3 Changes in haemodynamic parameters during repeated measuring. * Significant differences between two groups ($P < 0.05$). Time points are T0 (mean vital signs from entering the operating room until before anaesthesia induction); T1 (immediately after laryngeal mask insertion); T2 (at the start of surgery: immediately after insertion of the vaginal speculum); T3 (5 min after surgery started); T4 (10 min after surgery started); T5 (30 min after surgery started);T6 (end of surgery: immediately after removal of the gynaecological speculum), T7 (immediately after removal of the laryngeal mask); T8 (immediately upon entering PACU). Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; PACU, post-anaesthesia care unit

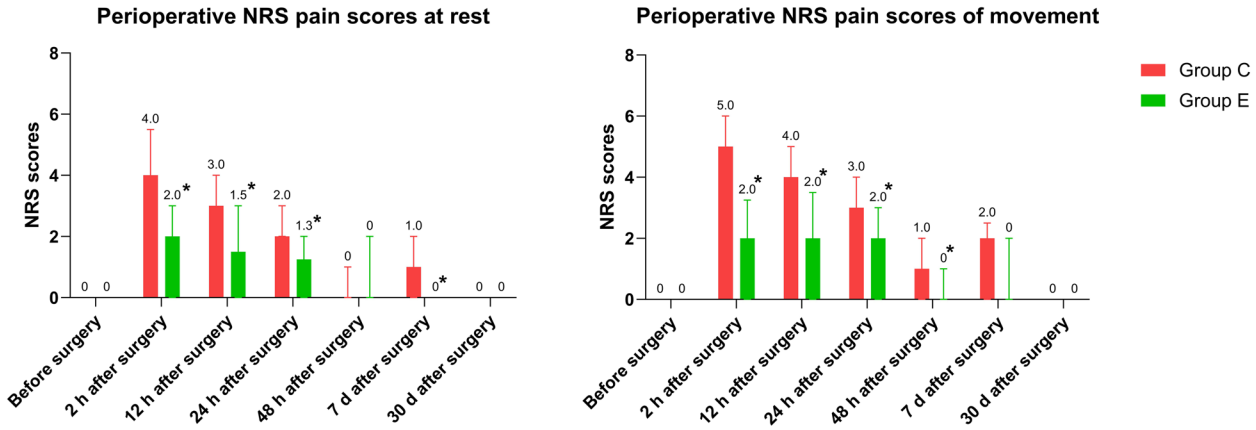

Fig. 4 Postoperative NRS pain scores. * Significant differences between two groups ($P < 0.05$). Abbreviations: NRS, numerical rating scale. 0 denoted 'no pain' and 10 denoted 'worst pain imaginable'

with split-thickness vaginal wall dissections [27]. Consequently, the duration of urinary catheterisation is often longer in transvaginal pelvic floor reconstruction surgery than in other types of surgery. However, no standardised duration of post-operative urinary catheterisation has been established under the ERAS protocol [28]. Some studies suggest conducting a trial of spontaneous voiding within 24 h post-operatively [29], whereas others indicate that urinary catheterisation should be retained for 48–96 h post-operatively

Table 4 Post-operative additional analgesia

Characteristic	Group C (*n* = 49)	Group E (n = 46)	*P*-value
2 h post-operative additional analgesia, *n* (%)	13 (26.53)	0	< 0.001
12 h post-operative additional analgesia, *n* (%)	8 (16.33)	0	0.006
24 h post-operative additional analgesia, *n* (%)	0	0	/
48 h post-operative additional analgesia, *n* (%)	2 (4.08)	0	0.495

Data are given as median (inter-quartile range), mean [standard deviation], and *n* (%) as appropriate

Table 5 Peri-operative complications

Characteristic	Group C (*n* = 49)	Group E (*n* = 46)	*P*-value
Intra-operative hypotension, *n* (%)	19 (38.78)	16 (34.78)	0.687
Intra-operative hypertension, *n* (%)	0	0	/
Intra-operative bradycardia, *n* (%)	18 (36.73)	21 (45.65)	0.377
Intra-operative tachycardia, *n* (%)	0	0	/
Intra-operative hyoxaemia, *n* (%)	0	0	/
Post-operative hypotension, *n* (%)	0	2 (4.35)	0.232
Post-operative hypertension, *n* (%)	0	2 (4.35)	0.232
Post-operative bradycardia, *n* (%)	2 (4.08)	0	0.495
Post-operative tachycardia, *n* (%)	1 (2.04)	0	1.000
Pruritus, *n* (%)	4 (8.16)	0	0.118
Post-operative urinary retention, *n* (%)	2 (4.08)	4 (8.70)	0.426
Ileus, *n* (%)	2 (4.08)	0	0.495
Post-operative respiratory tract infection, *n* (%)	0	0	/
Incision infection, *n* (%)	0	0	/
Post-operative deep venous thrombosis, *n* (%)	0	0	/
2 h post-operative PONV(I/II/III/IV), *n*	35/8/4/2	41/1/2/2	0.049
12 h post-operative PONV(I/II/III/IV), *n*	32/8/5/4	41/1/4/0	0.007
24 h post-operative PONV(I/II/III/IV), *n*	42/0/2/5	41/1/4/0	0.502
48 h post-operative PONV(I/II/III/IV), *n*	47/2/0/0	46/0/0/0	0.168

Data are given as median (inter-quartile range), mean [standard deviation], and *n* (%) as appropriate

PONV, post-operative nausea and vomiting

PONV graded criteria in four grades: Grade I—no nausea, Grade II—mild nausea, mild abdominal discomfort, no vomiting, Grade III—evident nausea and vomiting, but no material expelled, Grade IV—severe vomiting, expulsion of gastric contents necessitating medication

[26]. In our pilot study, we attempted to remove the urinary catheter 24 h post-operatively; however, due to a high rate of POUR, the measure was discontinued. This may be attributed to the older age of the study population, which make them susceptible to urinary retention [30]. We ultimately removed the catheter on the second post-operative day, with six patients (6.32%) requiring re-catheterisation due to urinary retention (two (4.08%) vs. 4 (8.70%), $P = 0.426$), and two of them successfully had their catheters removed in the outpatient setting within a few days after discharge. None of the patients experienced tract infections during hospitalisation or sought medical attention for post-discharge infections.

In addition to the surgical method, scope, and patient age, the known risk factors for POUR included post-operative opioid use, low body mass index (BMI), post-operative urinary tract infections, and pre-operative bladder dysfunction [31, 32]. Thus, reducing opioid use, maintaining an appropriate BMI, and treating post-operative urinary infections may help lower the risk of POUR. Early identification of POUR is essential, with assessment methods including spontaneous voiding trials, retrograde voiding tests, and ultrasound examinations. Currently, the retrograde voiding test is recommended as it has demonstrated a greater predictive value for prolonged indwelling catheterisation in RCTs [33]. Patients with POUR may undergo continuous catheterisation using an indwelling catheter or clean intermittent catheterisation (CIC) until retention is resolved. CIC is a recommended for relieving urinary retention from various causes and is recognised by the International Continence Society as the 'gold standard' for managing neurogenic bladder [34].

The evidence supporting the use of multimodal analgesia in the ERAS protocol is substantial [9]. We administered oral NSAIDs for pre-operative and post-operative analgesia [35] and intravenous lidocaine during surgery to achieve multimodal analgesia. Research has shown that peri-operative lidocaine infusion can reduce post-operative pain and complications [36], is opioid-sparing, improves bowel function recovery [37], enhances post-operative cognitive function, and alleviates inflammatory responses [38]. In our trial, compared with the conventional group, the ERAS group exhibited a significantly lower peri-operative opioid use and superior post-operative analgesia. However, no improvement was observed in post-operative cognitive function, and WBC count and HGB levels were comparable between the two groups, likely due to the short duration of surgery and good pre-operative patient condition in this trial [39]. Although there was no increase in the incidence of bradycardia, the ERAS group had a significantly slower peri-operatively HR than that of the conventional group, possibly due to the cardiac-suppressive effects of lidocaine [40].

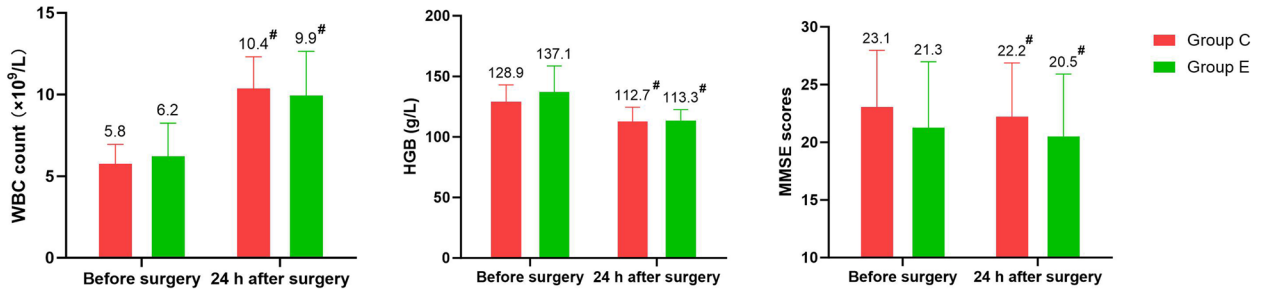

Fig. 5 Blood routine test and cognitive function. # Significant differences were observed compared to preoperative baseline. Abbreviations: WBC, white blood cell; HGB, haemoglobin; MMSE, Mini-Mental State Examination

Opioids are among the most widely used analgesics during the peri-operative period. However, their use is associated with adverse effects such as respiratory depression, nausea, vomiting, and hyperalgesia, as well as broader societal issues, including potential misuse, addiction, and overdose-related fatalities [41]. In older patients, the adverse effects of opioids can be even more pronounced owing to the fragility of their organs, presence of multiple chronic diseases, polypharmacy, and alterations in pharmacokinetics and pharmacodynamics [42]. Low-opioid anaesthesia within multimodal analgesia, a key component of the ERAS protocols, is a current research focus that has been shown to reduce PONV, decrease post-operative delirium, and accelerate recovery in older patients [43, 44]. Tianlong et al. [11] highlighted that low-dose opioid therapy with peri-operative multimodal analgesia is crucial for enhanced recovery in older patients.

Gynaecological surgery is typically performed on patients who are at a high risk for PONV (female sex, non-smoking status, and requirement for post-operative opioids) [18]. In our ERAS protocol, we employed ondansetron [12] and dexamethasone [45] as prophylactic anti-emetic therapy, and added metoclopramide when the PONV score was ≥ 3 [18]. In addition, multimodal analgesia was used to reduce opioid use and alleviate post-operative pain, resulting in a significant decrease in the incidence and severity of PONV.

Our findings align with those of previous studies on ERAS protocol adoption in other surgeries, such as orthopaedics [8] and colorectal surgery [4], which have similarly demonstrated reductions in post-operative LOS and complications. However, the extent of improvement in outcomes such as post-operative pain management and discharge timing may vary across disciplines owing to differences in surgical techniques and patient populations. For instance, owing to severe post-operative pain, epidural analgesia is recommended for lower limb orthopaedic surgeries [46]. However, factors such as patient age and the risk of POUR precluded the use of post-operative epidural analgesia in our study. Moreover, unlike the substantial reduction in LOS by several days achieved with the ERAS protocol during colorectal surgery [47], the effect in our study was less pronounced. This difference may stem from variations in surgical scope, as colorectal surgeries typically require a longer recovery time, leading to a more marked reduction in LOS with ERAS. Additionally, the longer duration of urinary catheterisation in older patients undergoing transvaginal pelvic floor reconstruction surgery may contribute to the less notable decrease in LOS. These comparisons underscore the need to tailor ERAS protocols to the specific requirements of different surgical specialties in order to maximise their benefits. Furthermore, our study did not reveal an association between the ERAS protocol and reduction in hospitalisation expenses [9, 10, 47], possibly because the reduced LOS resulted from shortened post-catheterisation observation periods. In China, observation costs, including bed and nursing fees, are substantially lower than other costs, such as medication expenses, which may indicate a pricing bias under particular healthcare system structures.

This study has several limitations. The single-centre design of this study may limit the generalisability of the findings, as patient populations and healthcare practices vary across institutions. Future multi-centre studies could improve the external validity of these results. Additionally, the exclusion of patients with blood glucose disorders and peptic ulcers, while intended to reduce confounding factors, may have introduced selection bias. These conditions are common, and their exclusion could affect the representativeness of the sample and the generalisability of the findings. Moreover, there is no consensus regarding the duration of post-operative urinary catheterisation, which is a major factor affecting discharge. Further trials are needed to explore the optimal duration of catheterisation and measures to promote post-operative voiding. Finally, the Charlson Comorbidity Index was

not assessed before surgery, as the higher index scores were associated with an increased incidence of complications and LOS [48].

Conclusions

Peri-operative use of the ERAS protocol has been shown to reduce post-operative LOS and duration of oral intake in older patients undergoing transvaginal pelvic floor reconstruction surgery. Additionally, it facilitates opioid sparing, alleviates post-operative pain, and reduces the incidence of PONV.

Abbreviations

ERAS	Enhanced recovery after surgery
LOS	Length of stay
RCTs	Randomised controlled trials
ASA	American Society of Anesthesiologists
NRS	Numerical rating scale
NSAIDs	Non-steroidal anti-inflammatory drugs
TCI	Target-controlled infusion
PCIA	Patient-controlled intravenous analgesia
BP	Blood pressure
PONV	Post-operative nausea and vomiting
BIS	Bispectral index
HR	Heart rate
bpm	Beats per minute
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
MMSE	Mini-Mental State Examination
POUR	Post-operative urinary retention
SPSS	Statistical Package for Social Science
GEE	Generalised estimation equation
WBC	White blood cell
HGB	Haemoglobin
BMI	Body mass index
CIC	Clean intermittent catheterisation
PACU	Post-anaesthesia care unit

Supplementary Information

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Supplementary Material 1.

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Declaration of generative AI in scientific writing

The authors declare that they did not use AI or AI technologies in the writing process.

Authors' contributions

Study design: Xuezhu Huang. Coordination: Xuezhu Huang, Sisi Deng, Xiaofeng Lei, Shentao Lu. Patient recruitment: Shentao Lu, Ling Dai, Chunyan She. Data collection: Sisi Deng. Data interpretation: Sisi Deng. Writing of first draft of manuscript: Xuezhu Huang. Critical revision of manuscript: Xuezhu Huang. Final approval of manuscript: all authors.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study has received ethical approval from the Medical Ethics Committee of Chongqing Health Center for Women and Children (Registration number: 2023–040) and was duly registered with the Chinese Clinical Trial Registry (www.chictr.org.cn; registration number: ChiCTR2400084608). All protocols were carried out in strict accordance with the relevant guidelines and regulations. Written informed consents were obtained from all participating patients.

Consent for publication

Written informed consents were obtained from the patients for publication of this study. Copies of the written consent are available for review by the editor of this journal.

Competing interests

The authors declare no competing interests.

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