Research Square

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Modified thoracoabdominal nerve block through perichondrial approach (M- TAPA) versus erector spinae plane block (ESPB) for open hepatic echinococcosis resection at high altitude: a prospective, randomised, parallel- group, non-inferiority trial

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Abstract

Background

Postoperative pain after open hepatic echinococcosis resection impedes recovery; in patients acclimatised to 3650 m, chronic hypoxia and reduced oxygen reserve amplify the risk of opioid-related respiratory depression. Whether the modified thoracoabdominal nerve block through the perichondrial approach (M-TAPA), performed entirely supine, is non-inferior to erector spinae plane block (ESPB) for opioid consumption in this population is unknown. We tested whether M-TAPA is non-inferior to ESPB for 24-h opioid consumption.

Methods

Eighty adults (ASA I-II) scheduled for elective open hepatic echinococcosis resection were randomised 1:1 to bilateral M-TAPA or bilateral ESPB, each block receiving 30 mL of 0.2% ropivacaine per side. The primary endpoint was 24-h cumulative morphine equivalent, with a prespecified non-inferiority margin of 5 mg. Continuous data were compared with the Welch t test or the Mann-Whitney U test, reporting mean differences or Hodges-Lehmann median differences with 95% confidence intervals (CIs).

Results

All 80 patients completed the trial. Twenty-four-hour morphine equivalent was 15.6 ± 8.3 mg with M-TAPA and 20.2 ± 8.5 mg with ESPB; the mean difference was − 4.6 mg (95% CI -8.3 to -0.8; P = 0.017 by Welch t test; P = 0.009 by Mann-Whitney U). The CI upper bound (-0.8 mg) was below the 5-mg margin, demonstrating non-inferiority of M-TAPA, and the CI excluding 0 supports superiority. Active NRS scores at 4 to 72 h and PCA press counts at all time points favoured M-TAPA (all P ≤ 0.020). Intraoperative blood loss (277.5 ± 160.9 vs 361.2 ± 200.8 mL; P = 0.069) and fluid infusion volume (P = 0.053) did not differ between groups. Recovery milestones were comparable, except that time to first semi-liquid and solid diet was shorter with M-TAPA (P = 0.013 and 0.030).

Conclusions

In high-altitude patients undergoing open hepatic echinococcosis resection, bilateral M-TAPA was non-inferior to ESPB for 24-h opioid consumption and produced numerically lower opioid use and better dynamic pain control, with no safety signal. The fully supine implementation avoids the prone repositioning required for ESPB. A larger confirmatory trial is warranted.

Trial registration

Chinese Clinical Trial Registry (ChiCTR2400081984; registered 18 March 2024, prospectively).

Introduction

High-altitude hypobaric hypoxia drives adaptive cardiorespiratory remodelling in permanent plateau residents, including compensatory polycythaemia, elevated pulmonary artery pressure and blunted hypoxic ventilatory reflexes [1, 2]. These adaptations narrow perioperative oxygen reserve, increase the incidence of postoperative pulmonary complications and alter the pharmacokinetics of anesthetic and analgesic drugs [4, 5]. Systemic opioids suppress brainstem respiratory centres, so an excessive opioid load against a background of limited oxygen reserve can readily convert a modest desaturation event into life-threatening hypoxaemia [3]. Opioid-sparing regional techniques are therefore of particular value in this population, and enhanced recovery after surgery (ERAS) pathways at altitude prioritise them [6].

Transversus abdominis plane block (TAPB) is widely used for abdominal analgesia, but upper abdominal incisions often fall within the surgical field [7]. Erector spinae plane block (ESPB), described in 2016, is performed at a site remote from the incision [8], and a body of evidence generated predominantly in low-altitude centres, including randomised trials and a meta-analysis of abdominal surgery, indicates that ESPB effectively reduces perioperative opioid consumption after abdominal and open surgical procedures [9]. A practical limitation of ESPB, however, is that the target fascial plane is usually approached with the patient prone or in the lateral decubitus position. This positional change is usually accomplished preoperatively in awake patients, though it may occasionally be performed after induction of anesthesia; in either case, it adds procedural time and may be poorly tolerated in patients with abdominal wounds, drains or limited respiratory reserve [9, 25].

The thoracoabdominal nerve block via the costal perichondrial approach (TAPA) was introduced in 2019; a single injection at the costal angle blocks the anterior cutaneous branches of T6 to T12 and anesthetizes the upper abdominal skin, muscle and parietal peritoneum [10]. Moving the target to the inferior border of the costal cartilage produced the modified version (M-TAPA), which is performed entirely with the patient supine, avoiding the repositioning required for ESPB, while providing wider dermatomal spread and shorter procedure time [11, 12]. Small comparative studies suggest M-TAPA provides opioid-sparing analgesia at least comparable to ESPB, oblique subcostal TAP block and quadratus lumborum block for laparoscopic cholecystectomy and gynaecologic laparoscopy [15–18]. A randomised trial by Wan and colleagues compared unilateral M-TAPA with placebo in laparoscopic renal cyst decompression, and the population, surgical approach and dose regimen differ enough from hepatic surgery that its results do not transfer directly [18].

All existing studies of these blocks in abdominal surgery were conducted in low-altitude populations, predominantly in minimally invasive laparoscopic procedures. In the specific high-altitude context, TAP block improved analgesia after open hepatic echinococcosis resection, and an ERAS programme has been shown feasible in patients from the Tibet plateau, but no randomised comparison of M-TAPA with ESPB has been performed in open hepatic surgery at high altitude [19, 20]. We therefore conducted a

single-centre, prospective, randomised, parallel-group, non-inferiority trial at 3650 m to compare M-TAPA with ESPB in adults undergoing open hepatic echinococcosis resection. We hypothesised that M-TAPA would be non-inferior to ESPB for 24-h postoperative opioid consumption, with the practical advantage of being performed entirely in the supine position, obviating the repositioning required for ESPB.

Methods

Ethics and Study Design

This prospective, randomised, non-blinded, parallel-group, non-inferiority trial was approved by the Medical Ethics Committee of the People's Hospital of Xizang Autonomous Region (approval reference ME-TBHP-23-25; initial review 1 December 2023, final approval 28 December 2023) and registered with the Chinese Clinical Trial Registry (ChiCTR2400081984; https://www.chictr.org.cn; registered 18 March 2024). The first patient was enrolled on 22 March 2024 and the last on 27 August 2025. The trial was conducted in accordance with the Declaration of Helsinki and is reported following the CONSORT 2025 statement. All participants gave written informed consent before randomisation, and no protocol changes were made during the trial.

Participants

Consecutive adults aged 18 to 75 years, ASA I-II, permanent residents of high-altitude areas in Lhasa, scheduled for elective open surgical resection of hepatic echinococcosis under general anesthesia at the People's Hospital of Xizang Autonomous Region between December 2023 and August 2025, were screened. Exclusion criteria were pregnancy; emergency surgery; severe hepatic, renal, cardiac or respiratory dysfunction; long-term anticoagulant therapy or coagulation disorders; skin infection at planned puncture sites; chronic preoperative pain or daily opioid intake; allergy to amide local anesthetics; central nervous system or severe psychiatric disease; or prior reconstructive abdominal wall surgery.

Randomisation and Allocation Concealment

An independent statistician not involved in clinical data collection generated a 1:1 computer-derived random allocation sequence with a block size of 4 using SAS 9.4 (SAS Institute, Cary, NC, USA). Randomisation numbers were sealed in sequentially numbered, opaque envelopes, opened only by the attending anesthetist performing the nerve block after confirmation of informed consent. Blinding of block operators was not feasible because of the mandatory positional difference between the two interventions (supine vs prone). All postoperative pain, recovery and adverse event data were collected by trained research nurses blinded to group allocation to mitigate detection bias.

Anesthesia and Blocks

All ultrasound-guided blocks were performed by attending anesthesiologists experienced in ultrasound-guided regional anesthesia and were completed before induction of general anesthesia using a 6–13 MHz high-frequency linear transducer and a 22-G, 10-cm block needle. Bilateral injection of 30 mL of 0.2% ropivacaine was administered on each side in both groups.

M-TAPA (Group M): with the patient supine and after standard disinfection and draping, the sterile-sheathed transducer was placed in the sagittal plane over the costal cartilage angle and tilted caudally to visualise the lateral costochondral junction. The needle was advanced in-plane to the lateral surface of the costal cartilage; after negative aspiration, 30 mL of 0.2% ropivacaine was injected. The procedure was repeated on the contralateral side.

ESPB (Group E): the patient was placed prone with a thoracic cushion. The transducer was positioned 2.5 to 3 cm lateral to the T7 spinous process in a parasagittal longitudinal plane. The needle was advanced in-plane until the tip lay in the fascial plane deep to the erector spinae muscle; injectate spread separating the muscle from the transverse process was confirmed sonographically, then 30 mL of 0.2% ropivacaine was injected bilaterally.

General anesthesia was induced with sufentanil 0.3–0.5 mcg/kg, cisatracurium 0.15–0.2 mg/kg and propofol 2–3 mg/kg, followed by tracheal intubation. Anesthesia was maintained with propofol 4–10 mg/kg/h targeting a bispectral index of 45–60 and remifentanil 3 mcg/kg/h titrated in 1 mcg/kg/h steps to keep mean arterial pressure and heart rate within 20% of baseline (maximum 6 mcg/kg/h); supplementary sufentanil 0.1 mcg/kg was given if the maximum remifentanil rate failed to restore haemodynamic stability. Vasoactive agents (phenylephrine 50 mcg, ephedrine 6 mg, noradrenaline 4 mcg boluses or infusion), atropine for bradycardia and esmolol for tachycardia were used per institutional protocol. Parecoxib sodium 40 mg was administered before surgical closure. PONV prophylaxis was stratified by the Apfel score, with ondansetron 5 mg as rescue. Patients were transferred to the post-anesthesia care unit intubated and extubated once standard criteria were met. Hydromorphone patient-controlled analgesia (PCA; no background infusion, bolus 0.2 mg, lockout 10 min, 1-h limit 1 mg) was started on the ward; breakthrough pain (NRS > 4 after two boluses) was treated with oral oxycodone/paracetamol 5 mg/375 mg or intramuscular morphine 5 mg.

Outcomes

The primary outcome was cumulative 24-h postoperative morphine-equivalent consumption, converted using standardised ratios: 3 mg oral oxycodone = 2 mg IV morphine; 0.1 mg IV fentanyl = 10 mg IV morphine; 0.2 mg IV hydromorphone = 1.2 mg IV morphine [21]. Secondary outcomes were cumulative opioid consumption at 48 and 72 h; resting and active NRS pain scores at 2, 4, 6, 24, 48 and 72 h; PCA press counts at 24, 48 and 72 h; intraoperative blood loss, fluid infusion volume, urine output and anesthetic consumption; gastrointestinal recovery endpoints (time to first flatus, first bowel movement, first out-of-bed mobilisation, first oral fluid intake, first semi-liquid and solid diet); PONV and dizziness at all time points; and block-related adverse events (local anesthetic systemic toxicity, pneumothorax,

puncture-site haematoma, nerve injury). Data were entered into the electronic case report form within 24 h by nurses blinded to allocation. Adverse events were recorded prospectively at each study time point by blinded research nurses through direct questioning and review of the electronic medical record.

Sample Size Calculation

Sample size was calculated in PASS 15.0 (NCSS, Kaysville, UT, USA) for a non-inferiority design. Assuming 24-h morphine-equivalent consumption of 9.0 ± 6.8 mg after ESPB (from a previous abdominal hysterectomy cohort [22]) and 8.2 ± 5.9 mg after M-TAPA in our pilot data, with a non-inferiority margin of 5 mg, one-sided alpha 0.025 and power 0.90, 34 patients per arm were required; allowing 15% attrition, 40 patients per group (80 total) were enrolled.

Statistical Analysis

Distribution was assessed with the Shapiro-Wilk test and histogram inspection. Continuous variables are reported as mean ± SD when normally distributed and median [IQR] otherwise; categorical variables as counts (percentages). Between-group comparisons used the Welch t test for normally distributed data, reporting the mean difference with 95% CI, and the Mann-Whitney U test otherwise, reporting the Hodges-Lehmann median difference with 95% CI. Binary variables were compared using the chi-square or Fisher exact test, with the risk difference and its 95% CI reported. Two-sided $P < 0.05$ was considered significant. Non-inferiority was judged by whether the upper bound of the 95% CI for the between-group difference (M-TAPA minus ESPB) fell below the prespecified 5-mg margin; a CI upper bound below 0 was considered supportive of superiority. Analyses were performed in Python 3.13 (pandas 3.0.5, scipy 1.18.0).

Results

Participant Flow

Between March 2024 and August 2025, 172 patients were screened. Ninety-two were excluded (28 did not meet inclusion criteria, 17 met exclusion criteria, 47 because research personnel were unavailable). The remaining 80 were randomised 1:1 to M-TAPA (n = 40) or ESPB (n = 40). All received the allocated block, completed 72-h follow-up and were analysed on an intention-to-treat basis (Figure 1). No patient was lost to follow-up.

Baseline Characteristics

Baseline demographic and clinical variables (age, sex, weight, height, BMI, ASA grade, smoking history, hypertension, diabetes mellitus, coronary artery disease) showed no significant intergroup differences (Table 1). Mean age was 38.3 ± 15.7 years (M-TAPA) vs 40.5 ± 14.4 years (ESPB) (P = 0.519); 47.5% (19/40) vs 45.0% (18/40) were women (P = 1.000).

Intraoperative Data

Total anesthesia duration, surgical duration, urine output and cumulative propofol, sufentanil and remifentanil consumption were similar between groups (Table 2). Intraoperative blood loss did not differ: 277.5 ± 160.9 mL with M-TAPA versus 361.2 ± 200.8 mL with ESPB (P = 0.069; mean difference -83.8 mL, 95% CI -164.7 to -2.8), and the result was stable after Winsorization and adjustment for surgical duration (Supplementary Table S1). Total fluid infusion volume was 1502.5 ± 610.0 mL versus 1875.8 ± 857.7 mL (P = 0.053).

Primary Outcome

Twenty-four-hour morphine equivalent was 15.6 ± 8.3 mg with M-TAPA and 20.2 ± 8.5 mg with ESPB (Table 3). The mean difference was -4.56 mg (95% CI -8.29 to -0.83; Welch t = -2.43, P = 0.017; Mann-Whitney U = 528, P = 0.009). The upper bound of the 95% CI (-0.83 mg) was below the prespecified 5-mg non-inferiority margin, demonstrating non-inferiority of M-TAPA; because the CI also excluded 0, the results support superiority. Per-protocol analysis gave the same conclusion.

Secondary Analgesic Outcomes

Cumulative morphine equivalent at 48 h was 33.4 ± 15.1 mg with M-TAPA versus 43.4 ± 18.9 mg with ESPB (mean difference -10.0 mg, 95% CI -17.7 to -2.4; P = 0.011), and at 72 h 43.2 ± 20.2 mg versus 56.7 ± 25.7 mg (mean difference -13.5 mg, 95% CI -23.8 to -3.2; P = 0.011) (Table 3). Resting NRS did not differ at 2 h (P = 0.176) or 4 h (P = 0.053), was lower with M-TAPA at 6 h (P = 0.039) and remained lower at 24, 48 and 72 h (P < 0.001, P < 0.001 and P = 0.041). Active NRS was lower with M-TAPA at 4 h (P = 0.002), 6 h (P = 0.001), 24 h and 48 h (both P < 0.001) and 72 h (P = 0.001), but did not differ at 2 h (P = 0.318). PCA press counts were lower with M-TAPA at every time point (24 h: 16.6 ± 8.9 vs 21.3 ± 8.9, P = 0.009; 48 h: 18.8 ± 9.1 vs 24.4 ± 10.9, P = 0.017; 72 h: 10.5 ± 5.7 vs 14.1 ± 7.0, P = 0.019).

Adverse Events

PONV and dizziness were recorded at all time points (Table 4). At 2 h, PONV occurred in 1/40 (2.5%) of M-TAPA and 2/40 (5.0%) of ESPB patients (P = 1.000); at 24 h, 3/40 (7.5%) of M-TAPA and 0/40 of ESPB patients (P = 0.241). No significant intergroup differences were detected at any time point. No block-related complication (local anesthetic systemic toxicity, pneumothorax, puncture-site haematoma, nerve injury) occurred in either group.

Recovery

Time to first flatus (21.5 [13.8, 35.2] vs 21.0 [13.8, 38.0] h; P = 0.610), first bowel movement (61.0 [38.8, 81.0] vs 70.0 [55.2, 84.5] h; P = 0.145), first out-of-bed mobilisation (40.0 [22.8, 48.0] vs 44.0 [28.0, 54.2] h; P = 0.094) and first oral fluid intake (24.5 [17.0, 42.0] vs 38.0 [18.0, 44.0] h; P = 0.287) did not differ (Table 5); time to first semi-liquid diet was shorter with M-TAPA (44.0 [30.8, 55.8] vs 57.0 [44.8, 74.5] h; P = 0.013), as was time to first solid diet (95.0 [87.8, 129.0] vs 108.0 [98.0, 139.0] h; P = 0.030). Postoperative ileus (0/40 vs 1/40), intestinal fistula (1/40 vs 1/40) and reoperation (0/40 vs 1/40) were rare and comparable (all P = 1.000).

Discussion

Principal Findings

In 80 adults undergoing open hepatic echinococcosis resection at 3650 m, bilateral M-TAPA met the prespecified non-inferiority criterion against bilateral ESPB for 24-h morphine-equivalent consumption: the mean difference was − 4.56 mg with a 95% CI (-8.29 to -0.83) lying entirely below the 5-mg margin. The CI also excluded 0, supporting a numerical superiority of M-TAPA. Every prespecified secondary analgesic endpoint favoured M-TAPA, including active NRS scores at 4 to 72 h, cumulative opioid consumption at 48 and 72 h, and PCA press counts at all time points.

Comparison With Other Blocks

The existing M-TAPA literature is concentrated in laparoscopic and gynaecologic settings. Tanaka and colleagues reported 24-h morphine-equivalent consumption near 18 mg after M-TAPA in 32 women undergoing open gynaecologic surgery, close to our M-TAPA arm [12]. Alver and colleagues found lower tramadol use with M-TAPA after laparoscopic inguinal hernia repair [16], and Atsumi and colleagues reported comparable analgesic requirements between M-TAPA and quadratus lumborum block in gynaecologic laparoscopy [17]. The lateral cutaneous branch coverage of M-TAPA was characterised anatomically by Ohgoshi and colleagues [14], and clinical experience has confirmed its safety across abdominal procedures [13, 15]. Our results in open hepatic surgery, where the incision often runs from the right flank to the xiphoid, are consistent with that pattern.

Wan and colleagues found that unilateral M-TAPA reduced 24-h opioid consumption by 22% and lowered NRS scores at all time points versus placebo in laparoscopic renal cyst decompression [18]. Our comparator was an active block rather than placebo, and the median active-NRS differences of 1 to 2 units at 4 to 72 h are comparable in size to the between-group separation they observed. ESPB data in upper abdominal surgery are mixed: a meta-analysis by Viderman and colleagues estimated a modest opioid-sparing effect of ESPB after abdominal surgery [9]. The original dye-spread work by Tulgar and colleagues showed consistent T7-T11 anterior cutaneous spread for M-TAPA, in contrast to the predominantly posterior spread of ESPB at T7, which offers a mechanistic rationale for our dynamic-pain findings [10, 11].

In addition to efficacy, the execution of the two blocks differed in a way that may matter clinically. ESPB requires a dedicated prone or lateral decubitus position, whereas M-TAPA is completed in the supine position already established for surgical preparation, without any positional change. The positional change required for ESPB, whether performed preoperatively in awake patients or after induction of anesthesia, adds procedural time and may be poorly tolerated in patients with abdominal wounds, drains or limited ventilatory reserve; it is of particular concern in high-altitude patients, in whom ventilation may already be compromised [25]. This practical advantage, together with the opioid-sparing effect demonstrated here, supports M-TAPA as a convenient alternative to ESPB in this setting.

Clinical Relevance of Opioid Sparing at High Altitude

The 4.6-mg reduction in 24-h morphine-equivalent consumption and the consistently lower dynamic NRS scores observed here carry specific weight in a high-altitude population. At 3650 m, patients live with chronic hypoxia and reduced oxygen reserve; a systematic review of oxygen saturation thresholds for opioid-induced respiratory depression indicates that respiratory events can occur even at modest opioid doses, and the hypobaric environment narrows the window for detecting and correcting desaturation [3]. In a recent high-altitude trial, intraoperative opioid-free anesthesia reduced perioperative desaturation and opioid-related adverse events compared with conventional opioid-based general anesthesia, and paediatric data from high-altitude centres show that intraoperative desaturation is common and largely opioid-modifiable [23, 24]. By shifting analgesic reliance from systemic opioids to a fascial plane block, M-TAPA addresses the root cause of opioid-mediated respiratory risk rather than merely treating its consequences.

The physiologic rationale is supported by altitude-specific pharmacology: hypobaric hypoxia alters hepatic drug metabolism and the pharmacodynamics of sedative and analgesic drugs, and regional anesthesia at high altitude has been shown to reduce vasopressor requirements and improve haemodynamic stability compared with general anesthesia techniques [5, 25]. We acknowledge, however, that the present trial did not measure oxygen saturation nadirs, desaturation episodes or postoperative pulmonary complications directly; the inference that opioid sparing translates into fewer respiratory events in high-altitude patients remains hypothesis-generating and should be tested in a dedicated trial.

Safety, Recovery and Feasibility

Neither group experienced any block-related complication. Both blocks were performed with patients awake, and all patients tolerated the prone positioning required for ESPB; block performance and haemodynamic stability were comparable between groups, consistent with the observation that regional techniques remain reliable at altitude [25]. Time to first semi-liquid and solid diet was shorter with M-TAPA, while other recovery milestones were comparable, a pattern consistent with the earlier reduction in opioid exposure. PONV and dizziness were similar at every time point, in line with published M-TAPA cohorts [13, 15].

Strengths and Limitations

Strengths include the prespecified non-inferiority framework and statistical analysis plan, appropriate methods with effect sizes and confidence intervals, consecutive enrolment at a single high-altitude centre, 100% follow-up, and sensitivity analyses for the secondary blood-loss endpoint. Limitations are the inability to blind operators and patients (inherent to the position difference between blocks), the modest sample size relative to the non-inferiority margin, the single-centre design, and the absence of long-term follow-up for chronic postsurgical pain. Importantly, we did not record oxygen saturation nadirs or postoperative pulmonary complications, so the respiratory benefit of the observed opioid sparing is inferred rather than measured. The population was exclusively hepatic echinococcosis at 3650 m; extrapolation to other procedures or lower altitudes requires external validation.

Conclusions

In high-altitude patients undergoing open hepatic echinococcosis resection, bilateral M-TAPA was non-inferior to bilateral ESPB for 24-h opioid consumption under a 5-mg margin and produced numerically lower opioid use and consistently lower dynamic pain scores with no safety signal. Its fully supine implementation avoids the prone repositioning required for ESPB and is particularly suited to plateau patients with limited ventilatory reserve. A larger, multicentre trial incorporating respiratory outcome measures is warranted to confirm these findings.

Abbreviations

ASA: American Society of Anesthesiologists

BIS: bispectral index

BMI: body mass index

CI: confidence interval

eCRF: electronic case report form

ERAS: enhanced recovery after surgery

ESPB: erector spinae plane block

IQR: interquartile range

LAST: local anesthetic systemic toxicity

MAP: mean arterial pressure

M-TAPA: modified thoracoabdominal nerve block through the perichondrial approach

NRS: numerical rating scale

PACU: post-anesthesia care unit

PCA: patient-controlled analgesia

PONV: postoperative nausea and vomiting

RCT: randomised controlled trial

SD: standard deviation

TAP: transversus abdominis plane

TAPB: transversus abdominis plane block

Declarations

Ethics approval and consent to participate

This trial was approved by the Medical Ethics Committee of the People's Hospital of Xizang Autonomous Region (approval reference ME-TBHP-23-25; initial review 1 December 2023, final approval 28 December 2023). Written informed consent was obtained from all participants before randomisation.

Consent for publication

Not applicable. The manuscript contains no individual person's data.

Availability of data and materials

The datasets analysed during the current study are available from the corresponding author on reasonable request, subject to institutional ethics approval. The full trial protocol and statistical analysis plan are available from the corresponding author on reasonable request and via the Chinese Clinical Trial Registry (ChiCTR2400081984).

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Yue Fu (YF) and Cideji (C) contributed equally and share first authorship. YF: conceptualisation, data curation, formal analysis, investigation, writing – original draft. C: conceptualisation, data curation, formal analysis, investigation, writing – original draft. Labaciren (L): data curation, investigation, formal analysis. Ran Zhang (RZ): conceptualisation, methodology, supervision, writing – review and editing, project administration. All authors read and approved the final manuscript.

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Use of artificial intelligence

During the preparation of this work the authors used an AI-assisted language editing tool for language and formatting assistance. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1. Bebic Z, Brooks Peterson M, Polaner DM. Respiratory physiology at high altitude and considerations for pediatric patients. Paediatr Anaesth. 2022;32(2):118–25.
2. Grocott MP, Martin DS, Levett DZ, McMorrow R, Windsor J, Montgomery HE, et al. Arterial blood gases and oxygen content in climbers on Mount Everest. N Engl J Med. 2009;360(2):140–9.
3. Manes A, Sran J, Samra I, Dhaliwal B, Soliman A, Puri N. Oxygen saturation thresholds for opioid-induced respiratory depression: a systematic review. West J Emerg Med. 2026;27(4):886–94.
4. Jianjun Z, Peng S, Tianhang F, Zexuan Z, Qian L, Guangmin X. Effect of chronic high-altitude exposure on postoperative pulmonary complications: a retrospective study. Ann Med. 2026;58(1):2627063.
5. Chen Q, Deng L, Jia Z. The effects of high-altitude hypoxic environment on the pharmacokinetics and respiratory function. Sci Rep. 2025;15(1):24426.
6. Ljungqvist O, Scott M, Fearon KC. Enhanced Recovery After Surgery: a review. JAMA Surg. 2017;152(3):292–8.
7. Tran DQ, Bravo D, Leurcharusmee P, Neal JM. Transversus abdominis plane block: a narrative review. Anesthesiology. 2019;131(5):1166–90.
8. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41(5):621–7.
9. Viderman D, Aubakirova M, Abdildin YG. Erector spinae plane block in abdominal surgery: a meta-analysis. Front Med (Lausanne). 2022;9:812531.
10. Tulgar S, Senturk O, Selvi O, Balaban O, Ahiskalioglu A, Thomas DT, et al. Perichondral approach for blockage of thoracoabdominal nerves: anatomical basis and clinical experience in three patients. J Clin Anesth. 2019;54:8–10.
11. Tulgar S, Selvi O, Thomas DT, Deveci U, Ozer Z. Modified thoracoabdominal nerves block through perichondrial approach (M-TAPA) provides effective analgesia in abdominal surgery. J Clin Anesth. 2019;55:109.
12. Tanaka N, Suzuka T, Kadoya Y, Okamoto N, Sato M, Kawanishi H, et al. Efficacy of modified thoracoabdominal nerves block through perichondrial approach in open gynecological surgery: a prospective observational study. BMC Anesthesiol. 2022;22(1):107.
13. Ciftci B, Gungor H, Alver S, Akin AN, Ozdenkaya Y, Tulgar S. Clinical experience for modified thoracoabdominal nerve block through perichondrial approach (M-TAPA) in five patients. Turk J Anaesthesiol Reanim. 2023;51(4):354–7.

14. Ohgoshi Y, Anetai H, Hanai S, Ichimura K, Kawagoe I. The key to success in blocking lateral cutaneous branches with re-modified thoracoabdominal nerves block through the perichondrial approach. J Anesth. 2024;38(5):642–9.
15. Ozen V, Acik ME, Ozen N. The modified thoracoabdominal nerve block for post-operative analgesia in paediatric laparoscopic cholecystectomy. J Minim Access Surg. 2024;20(4):452–5.
16. Alver S, Ciftci B, Gungor H, Golboyu BE, Ozdenkaya Y, Alici HA, et al. Efficacy of modified thoracoabdominal nerve block through perichondrial approach following laparoscopic inguinal hernia repair surgery: a randomized controlled trial. Braz J Anesthesiol. 2023;73(5):595–602.
17. Atsumi C, Aikawa K, Takahashi K, Okada K, Morimoto Y. The comparison of postoperative analgesic requirements between modified thoracoabdominal nerves block and quadratus lumborum block in gynecological laparoscopic surgery. JA Clin Rep. 2023;9(1):39.
18. Wan M, Dong J, Wei K, Jin J, Cao J, Yuan B. Ultrasound-guided modified thoracoabdominal nerve block for postoperative analgesia in laparoscopic renal cyst decompression: a randomized double-blind controlled trial. Front Med (Lausanne). 2025;12:1582428.
19. Su W, Deng X, Li X, Deng J, Li P, Yang M. Effect of the transversus abdominis plane block on postoperative pain and recovery in patients with hepatic echinococcosis. J Int Med Res. 2018;46(9):3563–9.
20. Yang M, Su W, Deng X, Deng J, Li P, Li X. Enhanced recovery after surgery program in patients from Tibet Plateau undergoing surgeries. J Surg Res. 2017;219:188–93.
21. Davis MP, McPherson ML, Reddy A, Case AA. Conversion ratios: why is it so challenging to construct opioid conversion tables? J Opioid Manag. 2024;20(2):169–79.
22. Hamed MA, Goda AS, Basiony MM, Fargaly OS, Abdelhady MA. Erector spinae plane block for postoperative analgesia in patients undergoing total abdominal hysterectomy: a randomized controlled study. J Pain Res. 2019;12:1393–8.
23. Tu K, Tian L, Zhu Q, Bai K, Li L, Fu M, et al. Intraoperative opioid-free anesthesia with dexmedetomidine and esketamine versus conventional general anesthesia at high altitude. High Alt Med Biol. 2026;27(1):8–16.
24. Puzhen D, Yang Y, Li X, Ciren L, Feng Y, Yan Q. Intraoperative desaturation in pediatric patients at high altitude: incidence, risk factors, and outcomes. Front Pediatr. 2026;14:1871256.
25. Aksoy M, Ince I, Ahiskalioglu A, Karaca O, Bayar F, Erdem AF. Spinal anaesthesia at low and moderately high altitudes: a comparison of anaesthetic parameters and hemodynamic changes. BMC Anesthesiol. 2015;15:123.

Tables

Tables 1 to 5 are available in the Supplementary Files section.

Figures

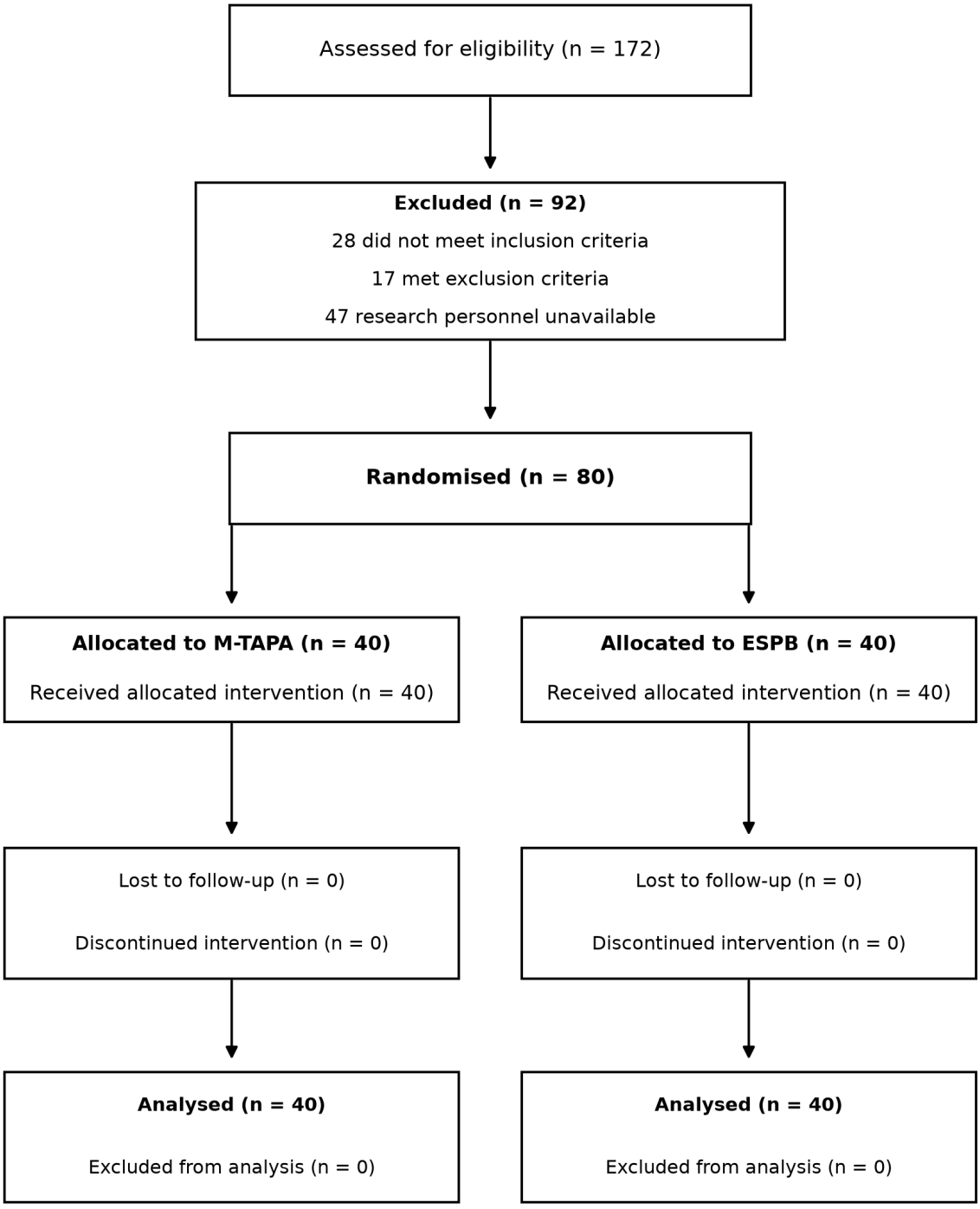

Figure 1

CONSORT flow diagram of the trial. A total of 172 patients were screened; 92 were excluded (28 did not meet inclusion criteria, 17 met exclusion criteria, 47 because research personnel were unavailable); 80 were randomised 1:1 to M-TAPA (n = 40) or ESPB (n = 40); all completed the study and were analysed.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.docx
- Table2.docx
- Table4.docx
- Table3.docx
- Table5.docx
- Additionalfile1bloodlosssensitivity.docx
- 04CONSORT2025checklist.docx