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The efficacy of combined lateral and anterior quadratus lumborum blocks in postoperative pain management following pelvic tumor resection: a randomized controlled trial

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Abstract

Background A wide range of pain management techniques have been investigated following pelvic tumor resection and reconstruction surgery; however, the optimal components remain a subject of debate. In this prospective randomized controlled trial, we assessed the postoperative analgesic efficacy of integrating lateral quadratus lumborum block (Lateral-QLB) and anterior quadratus lumborum block (Anterior-QLB) with multimodal analgesia (MMA) regimen, compared to MMA regimen alone, in patients undergoing pelvic tumor resection and reconstruction.

Methods A total of 56 patients were randomly allocated to either the QLB group ($n=28$) or the No Block group ($n=28$). The QLB group received an ultrasound-guided Combined quadratus lumborum block (a combination of Lateral-QLB and Anterior-QLB), with 20 mL of 0.375% ropivacaine administered on each approach. The No Block group received standardized multimodal analgesia. Both groups followed an identical postoperative patient-controlled intravenous analgesia protocol. Outcomes included opioid consumption (intravenous morphine milligram equivalents, IV MME) at multiple time points within 48 h postoperatively, time to first opioid request, resting/activity-related pain scores, postoperative neurological assessments (lower extremity motor and sensory function), recovery quality quantified using QoR-15 (Quality of Recovery-15) scores on postoperative days (POD) 1, 2, and 7, and chronic pain prevalence during a 3-month follow-up.

Results The QLB group exhibited significant reductions in cumulative IV MME at 24 h (18.56 ± 6.63 vs. 24.29 ± 5.69 mg, $p=0.001$) and 48 h (27.87 ± 9.95 vs. 41.29 ± 9.67 mg, $p<0.001$), along with an extended time to the first opioid request (median 5.0 vs. 4.0 h, $p=0.005$). Resting/activity pain scores were consistently lower ($p=0.008$/$p=0.003$), accompanied by transient sensory changes in the abdomen/thigh without motor impairment. QoR-15 scores significantly favored the QLB group ($p<0.05$), with lower chronic pain rates at 3 months post-surgery compared to the No Block group (7.1% vs. 32.1%, $p=0.021$).

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Conclusion The ultrasound-guided QLB demonstrated superior analgesic efficacy and reduced morphine consumption compared to patients without the block. Our findings provide evidence supporting the hypothesis that QLB is an effective component of multimodal analgesia for individuals undergoing pelvic tumor resection and reconstructive surgery.

Keywords Analgesia, Pelvic tumors, Postoperative pain, Quadratus lumborum block

Introduction

Radical pelvic tumor resection, involving multiplanar anatomical structures (including sacral-iliac complex and pelvic viscera), necessitates extensive oncological excision with concomitant osseous stability reconstruction [1]. This procedure inevitably induces dual injury mechanisms to the lumbosacral plexus (L1-S3 segments) through mechanical traction and ischemia-reperfusion pathophysiology. Intraoperative interventions (periosteal stripping, myofascial transection, and orthopedic implant placement) activate peripheral nociceptors, transmitting nociceptive signals via T10-L4 dorsal root ganglia to central pain processing networks, thereby precipitating a mixed persistent inflammatory-neuropathic pain syndrome [2, 3]. Prospective surgical cohort analysis revealed a substantial proportion of patients developed moderate-to-severe acute postoperative pain (NRS ≥ 6) during the critical 48-hour recovery window, with a clinically significant subset progressing to chronic postsurgical pain [4], which exhibited significant correlations with functional recovery impairment and quality-of-life deterioration. The selection of rational and effective analgesic measures holds paramount importance in promoting early rehabilitation, expediting pelvic stability reconstruction, swiftly restoring lower limb motor function, and enhancing quality of life.

Current acute pain management following pelvic tumor resection primarily employs MMA regimens combining mechanistically distinct interventions for synergistic efficacy. While providing partial pain relief, existing MMA protocols present notable clinical limitations. Opioid analgesics exert central μ-opioid receptor-mediated analgesic effects through nociceptive signal suppression. Although effective, their non-selective receptor activation induces systemic complications: (1) Dose-dependent respiratory depression from brainstem μ-receptor interactions [5]; (2) Gastrointestinal dysmotility via dual mechanisms of inhibited peristalsis and heightened sphincter tone [6]. The analgesic effectiveness of epidural anesthesia critically depends on cephalocaudal spread of local anesthetics within the epidural compartment. This non-selective blockade frequently induces extensive thoracolumbar sympathetic chain inhibition, precipitating two clinically significant consequences: (1) systemic vasodilation with refractory hypotension, particularly problematic in geriatric patients and those with hypovolemia [7], and (2) autonomic dysregulation manifesting as gastrointestinal hypomotility and bladder detrusor muscle dysfunction [8]. These physiological derangements necessitate intensive hemodynamic monitoring and complicate postoperative recovery trajectories. Transversus abdominis plane blocks and iliohypogastric-ilioinguinal nerve blocks provide abdominal wall analgesia through blockade of T7-L1 ventral rami [9], while demonstrating only a 20% reduction in visceral pain [10]; Similarly, lumbar plexus and femoral nerve blocks, though effective for lower extremity analgesia, cause motor fiber blockade in mixed nerves, resulting in ≥ 30% quadriceps/adductor weakness that delays ambulation and increases thromboembolic risk [11]. Henceforth, alternative analgesic techniques with fewer systemic side effects are warranted to effectively manage the complex mixed pain following pelvic tumor resection.

As a fascial plane block technique, the QLB exhibits distinct anatomical advantages by utilizing the multilayered structure of the thoracolumbar fascia to achieve targeted drug dissemination pathways for pelvic pain modulation [12]. Specifically, the lateral approach targets the interface between the posterolateral aspect of the quadratus lumborum muscle and the posterior layer of the thoracolumbar fascia, thereby facilitating cephalad spread of local anesthetics along the transversus abdominis plane [13]. This pathway primarily covers the somatic sensory innervation of the anterolateral abdominal wall, including key nerves such as the iliohypogastric and ilioinguinal nerves, thus providing effective analgesia for surgical incisions extending from the iliac crest to the pubic symphysis [14]. The anterior approach delivers agents via the pre-quadratus lumborum space to the surface of the psoas major, facilitating caudad diffusion along the lumbar plexus nerve sheath [15]. This trajectory effectively blocks deep musculoskeletal nociception, particularly by suppressing proprioceptive pain signaling from sacroiliac joint disarticulation and posterior pelvic ring procedures [16, 17]. Notably, the anterior approach enables local anesthetic diffusion into the prevertebral space, targeting lumbar sympathetic lateral branches to suppress pelvic splanchnic nociception [18]. Anatomical evidence confirms this spread concurrently blocks soma to-visceral pain cross-talk, reducing postoperative referred visceral pain through dual neural pathway inhibition [19]. When combined with lateral approach and anterior approach, this method creates synergistic drug dissemination within the thoracolumbar fascial continuum,

theoretically establishing a continuous neural blockade spanning the T10 to L4 dermatomes [19–22]. This comprehensive coverage aligns with the multisegmented innervation requirements of pelvic tumor resection, addressing somatic pain from abdominal wall incisions (T10-L1), deep osseous structure manipulation (L2-S1), and visceral discomfort during pelvic organ retraction [21–23]. To our knowledge, the majority of existing studies on QLB have primarily focused on gynecological and general surgical fields, randomized controlled trials assessing its effectiveness for post-pelvic-tumor-resection pain remain conspicuously absent. We hypothesized that the incorporation of a Lateral-QLB and an Anterior-QLB into in the multimodal analgesia regimen would be linked to superior postoperative pain management and significant reduction in opioid utilization.

Materials and methods

Study design and participants

The present prospective randomized controlled trial was conducted at the Department of Anesthesiology, People's Hospital of Peking University, and obtained approval from the Institutional Review Board (Ethics Committee of Peking University People's Hospital, approval number 2023PHB435-001). This study was registered with the Chinese Clinical Trial Registry (ChiCTR2400088440). Adherence to the Consolidated Standards of Reporting Trials (CONSORT) guidelines was meticulously maintained, and the trial was conducted in accordance with the principles delineated in the Declaration of Helsinki [24].

Patients meeting the inclusion criteria during the screening process and not having any exclusion criteria are eligible for enrollment. Additionally, patients have the autonomy to voluntarily withdraw from the trial at their discretion. Inclusion criteria were as follows: (1) Age range from 18 to 65 with no limitations based on gender, (2) American Society of Anesthesiologists (ASA) physical status I to III, (3) Resect pelvic tumors from zone I to zone III, (4) Voluntary participation and provision of informed consent. The exclusion criteria for the study were delineated as follows: (1) Severe organ dysfunction (cardiac, hepatic, or renal insufficiency) or coagulopathy, (2) Insufficient literacy to complete self-assessment instruments, (3) Documented hypersensitivity to protocol medications, (4) History of psychotropic medication use, severe insomnia, neurocognitive impairment, or perioperative neurocognitive disorders, (5) Pelvic ring zone IV tumor resection involving sacral/sacroiliac joint intervention, (6) Preoperative peripheral neuropathy or opioid therapy for malignant compression-induced pain, (7) Requirement for secondary surgical intervention within 24 h postoperatively or Intensive Care Unit stay exceeding 24 h post-surgery and (8) Pre-existing functional limitations in hip mobility or ipsilateral lower extremity movement.

Randomization and blinding

Participants were recruited by the study staff on the day prior to surgery, and written informed consent was subsequently obtained. Computer-generated randomization techniques were employed to allocate patients into either the QLB group or the No Block group in a 1:1 ratio, utilizing a block size of six patients. Before the trial initiation, study subject serial numbers were generated in accordance with the predetermined sample size. The randomization process was conducted by the Department of Medical Statistics using computer-based methods. If a patient was enrolled, an opaque card containing the randomization information was provided to the anesthesiologist by a research assistant on the day of surgery. In this study, research assistant who had access to the randomization schedule but were not otherwise involved prepared the cards. The anesthesiologists were unblinded and responsible for administering the block, while other healthcare team members and investigators involved in data collection and postoperative follow-up remained blinded to group assignments. Patients were also blinded as they had received general anesthesia induction with tracheal intubation before block administration. Enrollment ceased upon reaching the predetermined sample size.

Block procedure

After the initiation of general anesthesia, the QLB were administered to the patient. A curvilinear low-frequency ultrasound probe was initially positioned perpendicularly to the midaxillary line between the twelfth rib and the iliac crest. Gradually move the probe to the dorsal side until the transversus abdominis muscles fuse into the dense starting segment of the thoracolumbar fascia, where the typical "shamrock" sign is seen (with psoas major muscle in ventral, quadratus lumborum in middle, and erector spinae in dorsal). The nerve block needle was inserted in-plane, oriented from a posterolateral to anteromedial direction, until the needle tip was advanced through the quadratus lumborum muscle into the fascial space between the quadratus lumborum and psoas major muscle. After negative aspiration, a mixture of 20 ml of 0.375% ropivacaine was injected. Subsequently, the needle was retracted to the aponeurosis at the lateral border of the quadratus lumborum and transversus abdominis muscles, where the same volume of medication was administered. Repeated injections of medication administered through two puncture sites led to a pronounced fusiform separation between the anterior and lateral portions of the quadratus lumborum muscle. All block

procedures were conducted by experienced anesthesiologists with specialized expertise in regional anesthesia. (Fig. 1).

Anesthesia and perioperative care

Before the completion of the QLB procedure, the patient was positioned supine for general anesthesia administration. Anesthesia induction involved midazolam at a dose of 0.02–0.04 mg/kg, etomidate at a dose of 0.2–0.4 mg/kg, sfentanyl at a dose of 0.3–0.4 μg/kg, and cisatracurium at a dose of 0.2–0.3 mg/kg. The bispectral index was maintained within the range of 40–55 by employing a combination of propofol, remifentanil, and cisatracurium. Hemodynamic fluctuations were effectively managed by anesthesiologists through the administration of sufentanil (0.05–0.10 μg/kg) and vasoactive agents under their supervision. Thirty minutes prior to the completion of the surgery, patients were administered an injection of 100 mg flurbiprofen for analgesia and 5 mg tropisetron hydrochloride for prophylaxis against postoperative nausea and vomiting (PONV). Additionally, a local infiltration anesthesia was performed around the incision site during skin closure using 10 ml of 0.5% ropivacaine. The surgical procedures were consistently performed by a dedicated team of orthopedic surgeons. After the surgical procedure, patients were transferred to the Post anesthesia care unit (PACU) for extubation and administration of advanced medical interventions.

Postoperative analgesia

All patients were administered patient-controlled intravenous analgesia (PCIA)with a standard regimen of hydromorphone 20 mg hydromorphone (10doses in total) diluted to 100 mL (1mL per bolus, lock time 10 min, no background dose) for each patient after recovery room. Patients received preoperative education from healthcare professionals on pain intensity assessment and proper utilization of PCIA the day before the surgery. Postoperative pain was evaluated using a 10-point Numeric Rating Scale (NRS) during rest and moving episodes at 1-,2-,6-,12-, 24-, and 48-hours post-surgery with 0 signifying no pain and 10 signifying the worst possible pain. If the patient's resting NRS pain score remains ≥ 4 after utilizing the analgesia pump, administration of rescue analgesia (an oral polypill consisting of oxycodone 5 mg and acetaminophen 325 mg was given for rescue analgesia, repeated as necessary) is recommended.

Outcome measures

Primary outcome

The primary outcome assessed was the utilization of intravenous opioids within 24 h following surgery. To facilitate comparison, all opioids were converted to intravenous morphine milligram equivalents (IV MME), utilizing the following conversion factors: 1 mg intravenous morphine is equivalent to 3 mg oral morphine, 1 μg intravenous sufentanil, 0.15 mg intravenous hydromorphone, 10 μg intravenous remifentanil, and 2 mg oral oxycodone; 1 mg oral morphine is equivalent to 100 mg oral acetaminophen.

Secondary outcome

The secondary outcomes included the following: opioid consumption 48 h after surgery; pain scores on the NRS at 1, 2, 6, 12, 24, and 48 h post-surgery for rest and movement states; intraoperative opioid consumption; time to first postoperative opioid requirement; use of rescue analgesics after surgery; neurologic assessment (motor and sensory) of the operative extremity in the PACU, including evaluation of sensation to cold and pin-prick

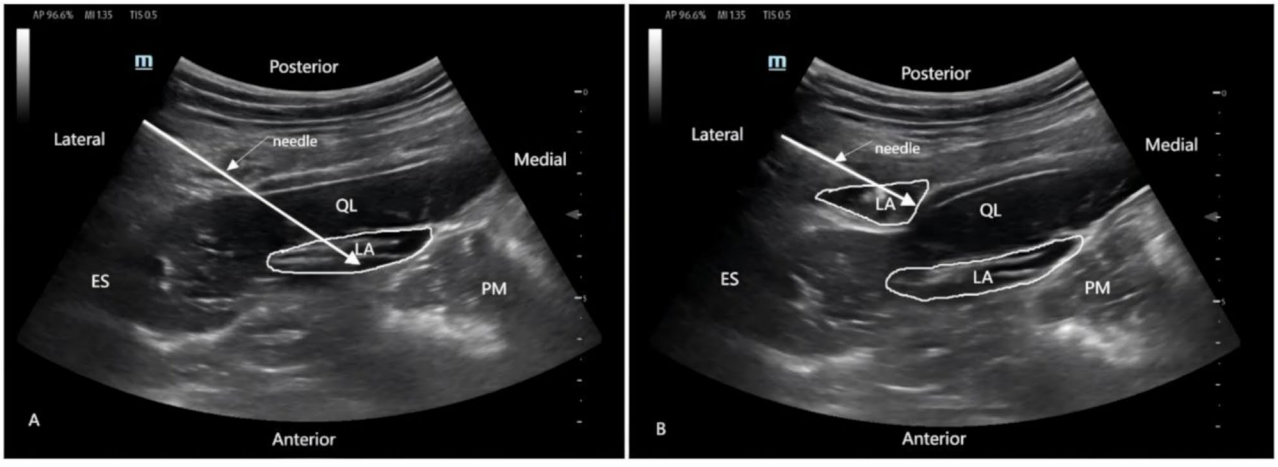

Fig. 1 Ultrasound location of the quadratus lumborum muscle with the Shamrock sign, (**A**) Ultasound-Guided anterior quadratus lumborum block, (**B**) Ultrasound-Guided lateral quadratus lumborum block. QL: quadratus lumborum muscle, ES: erector spinae, PM: psoas major muscle, TP: transverse process, LA: local anesthesia

on the anterior abdomen, anterior thigh, and lateral thigh; assessment of quadriceps strength, plantarflexion, and dorsiflexion of the foot using a scale ranging from 0 (none) to 5 (normal strength); incidence of PONV; occurrence of other adverse reactions during and after surgery such as itching, puncture site infection, abdominal organ injury, local anesthesia toxicity, hypokinesia, and paresthesia; evaluation of Quality of Recovery (QoR) on postoperative days 1,2,and 7 using the QoR-15 questionnaire [25]; the incidence of chronic pain three months after surgery(NRS > 4 at rest).

Sample size Estimation

The power analysis was conducted based on the primary endpoint of IV MME within the initial 24-hour postoperative period in a preliminary study. IV MME was selected as the primary outcome, aligning with previous research on pain management in pelvic tumor resection. In the preliminary study, 16 patients were assigned to either QLB group or No Block group ($n = 8$ in each group). In the QLB group, the mean IV MME was 18.60 ± 6.62 mg, while it was 24.30 ± 5.71 mg in the No Block group. The student's t-test was employed, assuming a type I error rate of 0.05 and a power of 0.90. The required sample size per group was determined to be 25 patients in order to detect statistically significant differences between groups. Considering potential loss and possible errors at around 10%, we decided to include 28 patients in each group for this trial.

Statistical analysis

Normal distributions were assessed using the Shapiro-wilk test. Normally distributed data with standard deviations were presented as mean ± SD, while non-normally distributed data were reported as medians with interquartile ranges. Categorical data were expressed as frequencies and percentages, and compared using a Chi-square test or Fisher's exact test when appropriate. Student's t-test was used for normally distributed data, while Mann-Whitney U test was employed for non-normally distributed data comparison. The Kaplan-Meier survival curve was employed to depict the duration from completion of surgery to administration of the initial dose of rescue analgesia; log-rank analysis determined group differences. The NRS scores and QoR-15 questionnaire were subjected to repeated measures analysis of variance for statistical analysis. The criterion for determining statistical significance was set at $p < 0.05$ (two-tailed). SPSS V.26 software was utilized for all data analyses. Data analyses were conducted by an independent statistician with specialized expertise in the field.

Results

A total of 107 patients who underwent pelvic tumor resection with reconstruction between August 27, 2024, and February 10, 2025 were considered eligible; however, 51 patients were excluded due to various reasons: not meeting the inclusion criteria (30 cases), declining participation (6 cases), having a history of chronic pain (10 cases), or experiencing cognitive dysfunction (5 cases). Consequently, a total of 56 randomly assigned patients were included in the analysis (Fig. 2). The two groups did not exhibit any statistically significant differences in terms of demographic characteristics (Table 1).

Morphine consumption

The primary outcome analysis revealed that QLB combined with multimodal analgesia demonstrated superior analgesic efficacy compared to multimodal analgesia alone. QLB recipients showed significantly reduced 24-hour postoperative IV MME requirements (18.56 ± 6.63 mg vs. 24.29 ± 5.69 mg, $p = 0.001$), with this analgesic benefit extending to cumulative 48-hour consumption (27.87 ± 9.95 mg vs. 41.29 ± 9.67 mg, $p < 0.001$). Intraoperative opioid utilization analysis demonstrated a 12.8% reduction in total IV MME ($\Delta = 6.43$ mg, $p < 0.001$) through combined sufentanil and remifentanil optimization in the QLB group. Patients receiving QLB exhibited a clinically meaningful delay in postoperative opioid demand initiation (Fig. 3), with median morphine-free intervals of 5.0 h (95% CI 4.9-6.0) versus 4.0 h (95% CI 3.3–4.6) in No Block ($p = 0.005$, log-rank test). While no statistically significant difference emerged in rescue block requirements ($p = 0.265$), a clinically relevant trend was observed (2 vs 6 cases in QLB and No Block groups, respectively), suggesting potential secondary benefits of the intervention (Table 2).

Pain intensity scores

Resting-state pain assessments revealed differential analgesic trajectories between cohorts (Fig. 4). Multivariate analysis of postoperative NRS scores demonstrated sustained analgesia in QLB recipients across critical timepoints (1–48 h), with resting scores consistently lower than conventional management ($p = 0.008$). Provocative movement protocols uncovered more pronounced intergroup disparities-dynamic NRS measurements during standardized mobilization tasks showed QLB maintained superior pain control relative to controls ($p = 0.003$).

Neurologic assessment (motor and sensory)

The sensory and motor examinations were conducted by a research staff member using standardized techniques. Both groups exhibited comparable results in the assessment of motor function for the operated extremity, with no statistically significant differences observed

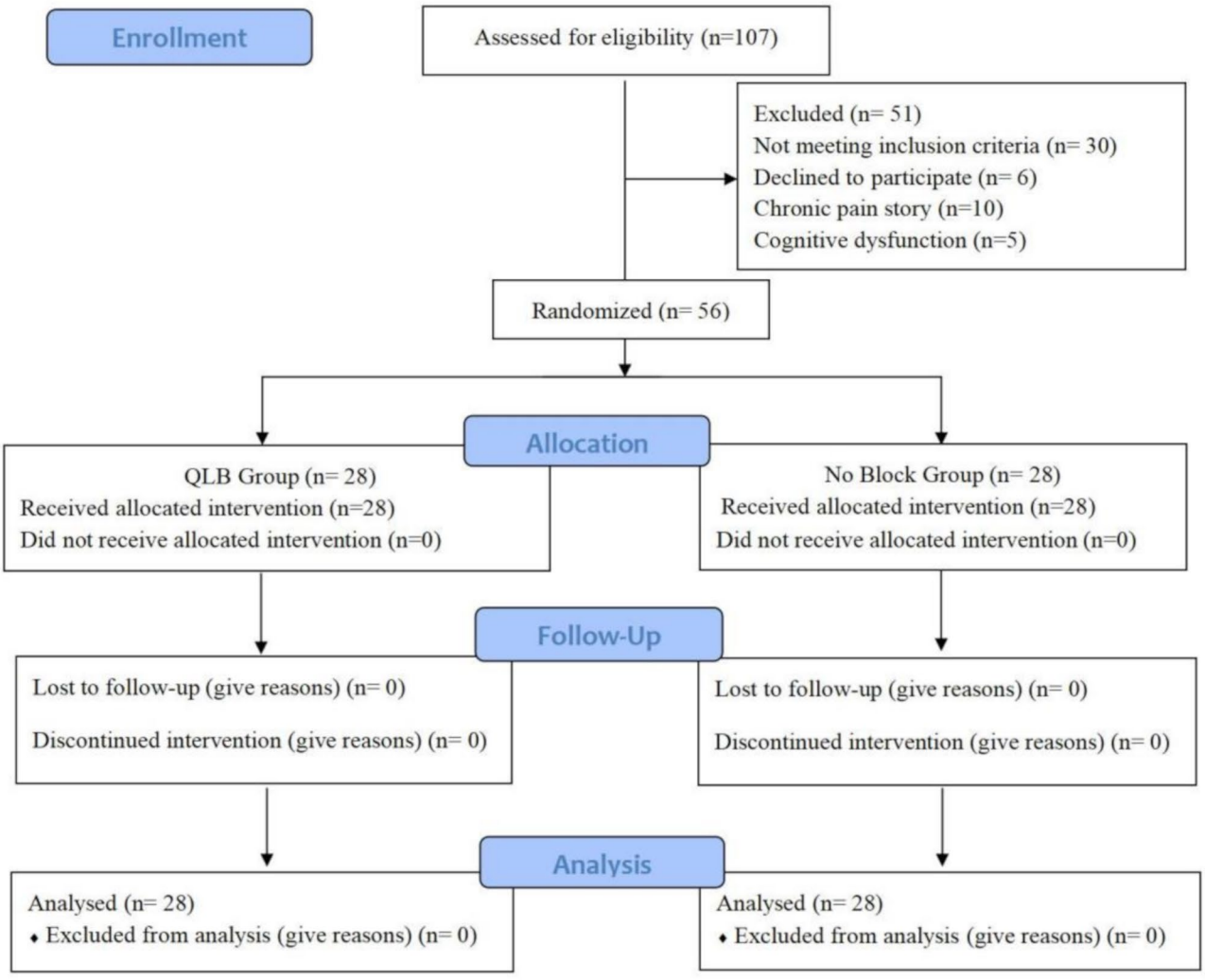

Fig. 2 The flow chart of the study

in quadriceps strength, plantar flexion, and dorsiflexion changes on the operative side within the QLB group ($p = 0.186$, $p = 0.286$, $p = 0.238$ respectively). Postoperative sensory evaluation revealed a significant reduction in cold and pinprick sensation over the abdomen and anterior thigh in the QLB group. The sensory blockade following QLB exhibited variability. The loss of cold and pinprick sensation was typically observed within the T10 to L4 dermatomal distribution. All QLB procedures resulted in cutaneous sensory blockade in the anterior thigh and anteromedial region of the lower leg, corresponding to the L1–L3 dermatomes (Fig. 5).

Adverse events

The incidence of PONV demonstrated statistically significant differences between the two groups ($p = 0.043$). There were no observed occurrences of any other adverse events in either group. The incidence of chronic pain at three months was 7.1% in the QLB group and 32.1% in the No Block group, with a significant difference ($p = 0.021$) (Table 3).

Satisfaction with pain management

The QoR-15 questionnaire was administered on postoperative days 1, 2, and 7 to assess five dimensions of postoperative and anesthesia recovery: comfort, emotional well-being, physical independence, patient support, and pain [26]. Quantitative recovery metrics demonstrated progressive advantages in the QLB cohort. QoR-15 scale assessments revealed statistically and clinically significant intergroup differences at 24 h postoperative (108.79 ± 6.21 vs. 104.50 ± 7.62; $p = 0.025$), with sustained superiority persisting through POD2 ($p = 0.028$) and POD7 ($p = 0.005$) evaluations (Table 3). Notably during early postoperative rehabilitation stage, the satisfaction level of patients in the QLB group was considerably greater than that of patients in the No Block group.

Table 1 Baseline and perioperative characteristics of the patients

Variables	QLB Group ($n=28$)	No Block Group ($n=28$)	*p* Value
Age, (mean ± SD, years)	43.71 ± 8.96	42.07 ± 7.80	*0.467*
Sex, (*n*, %)			*0.432*
male	16(57.1)	12(42.9)	
female	12(42.9)	16(57.1)	
Height, (mean, cm)	171.21 ± 5.78	170.82 ± 5.63	*0.760*
Body weight, (mean ± SD, kg)	74.11 ± 9.23	73.64 ± 9.09	*0.822*
BMI, (mean ± SD, kg/m^2)	25.22 ± 3.04	25.12 ± 2.92	*0.409*
Comorbidities (*n*, %)			*0.263*
Diabetes	5(17.9)	2(7.1)	
Hypertension	7(25.0)	5(17.9)	
Diabetes + Hypertension	2(7.1)	1(3.6)	
ASA, (*n*, %)			*0.400*
I	14(50.0)	18(64.3)	
II	6(21.4)	6(21.4)	
III	8(28.6)	4(14.3)	
Surgical site, (*n*, %)			*0.156*
right	10(35.7)	15(53.6)	
left	18(64.3)	13(46.4)	
Surgical time, (median IQR, min)	285(234–345)	265(245–325)	*0.105*

Data are presented as mean ± SD, median or number (%)
BMI, body mass index; ASA, American Society of Anesthesiologists

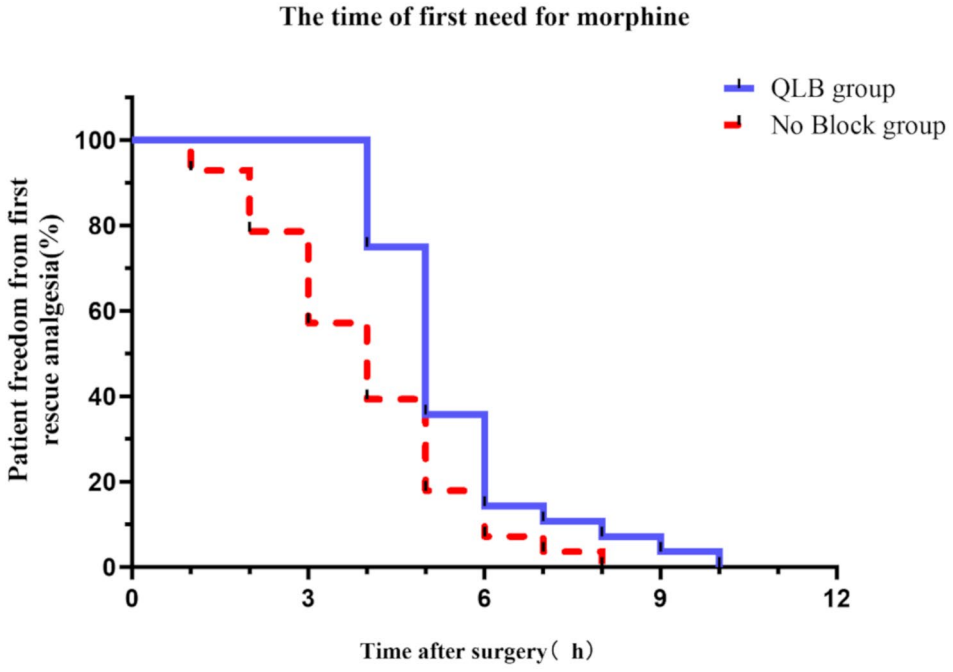

Fig. 3 Time of first need for morphine demonstrated by the Kaplan-Meier survival curves

Discussion

This prospective randomized controlled trial comparatively evaluated the clinical efficacy of a MMA regimen incorporating dual quadratus lumborum block (Lateral-QLB combined with Anterior-QLB) versus MMA alone in patients undergoing pelvic tumor resection and reconstruction, specifically analyzing perioperative analgesic optimization, prevention of persistent postoperative pain, and systematic safety characterization. To the best of our knowledge, this study represents the first comparative analysis of the efficacy and safety of the QLB for providing postoperative analgesia in patients undergoing pelvic tumor resection and reconstruction.

Table 2 Patient data regarding analgesic requirements

Variables	QLB Group ($n=28$)	No Block Group ($n=28$)	p Value
Postoperative opioid consumption			
IV MME at24h, (mean ± SD, mg)	18.56 ± 6.63	24.29 ± 5.69	*0.001*
IV MME at48h, (mean ± SD, mg)	27.87 ± 9.95	41.29 ± 9.67	*< 0.001*
Intraoperative opioid consumption			
Sufentanyl, (mean ± SD, μg)	43.75 ± 4.02	50.18 ± 5.12	*< 0.001*
Remifentanil, (median (IQR), mg)	1.80(1.60–2.05)	2.20(1.93–2.48)	*0.002*
Intraoperative IV MME, (median (IQR), mg)	61.2 (58.4–64.9)	71.8 (68.3–75.5)	*< 0.001*
Rescue analgesics, (*n*, %)	2(7.1)	6(21.4)	*0.265*

Data are presented as mean ± SD, median (IQR)or number

IV MME: intravenous injection morphine milligram equivalents

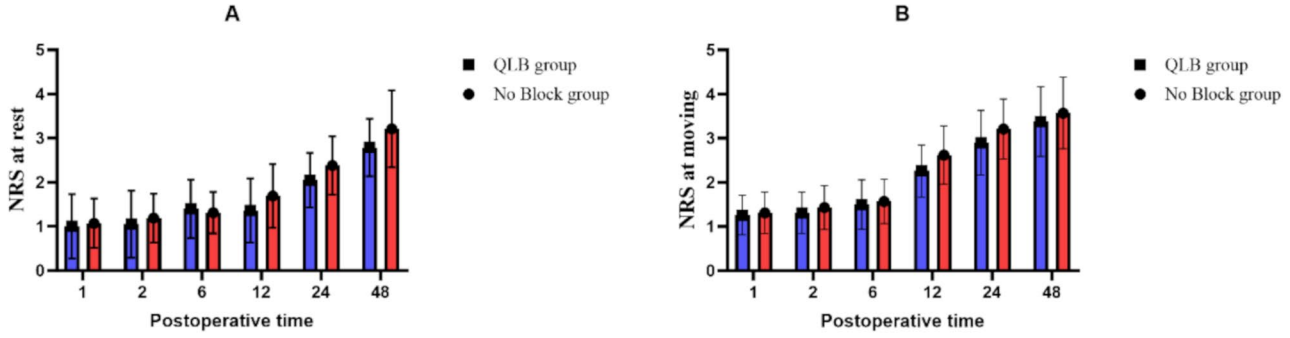

Fig. 4 Postoperative pain score. A at rest. B at moving. Data were analyzed using 2-way ANOVA, followed by Sidak's multiple comparisons for each point. Data were shown as mean ± SD. *$p < 0.05$. Abbreviations: NRS-numeric rating scale

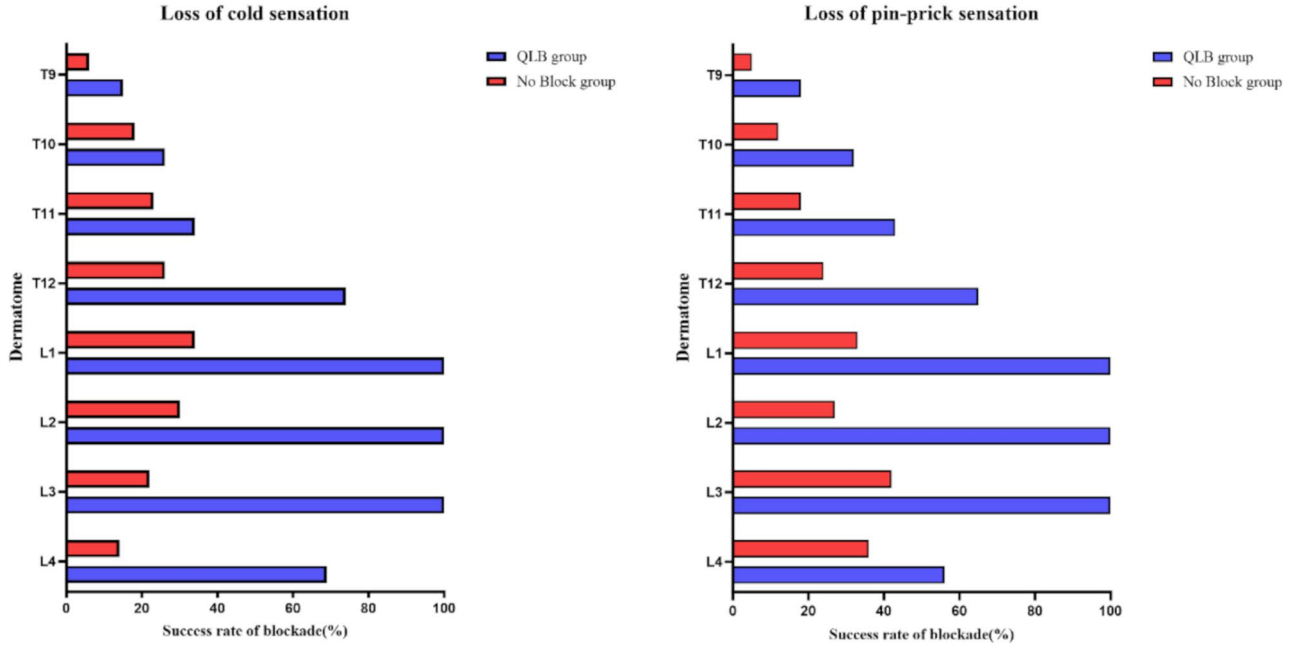

Fig. 5 Cutaneous sensory blockade in PACU. The bar graph depicts the success rate of blockade at each dermatome for the two groups, with results presented as a percentage

The opioid-sparing effect of QLB manifested in two temporal dimensions: acute-phase (0–24 h) consumption decreased by Δ23.6% ($p = 0.001$) and sustained-phase (24–48 h) reduction reached Δ34.1% ($p < 0.001$) versus conventional analgesia recipients. This pharmacodynamic advantage translated to clinically meaningful outcomes, with only 3/28 (10.7%) QLB patients requiring rescue analgesic requests versus 9/28 (32.1%) controls.

Table 3 Neurologic evaluation and other secondary outcomes

Variables	QLB Group ($n=28$)	No Block Group ($n=28$)	*p* Value
Postoperative motor strength assessment, (0–5) *			
Quadriceps strength, (mean ± SD)	1.95 ± 0.70	2.19 ± 0.67	*0.186*
Plantar flexion(foot), (mean ± SD)	3.12 ± 0.77	3.33 ± 0.69	*0.286*
Dorsiflexion (foot), (mean ± SD)	3.31 ± 0.60	3.52 ± 0.71	*0.238*
PONV, (*n*, %)	3(10.7)	9(32.1)	*0.043*
Quality of Recovery 15, (mean ± SD)			
Postoperative day 1	108.79 ± 6.21	104.50 ± 7.62	0.025
Postoperative day 2	101.10 ± 8.51	95.88 ± 8.84	0.028
Postoperative day 7	101.83 ± 10.05	94.31 ± 9.35	0.005
Chronic pain at three months, (*n*, %)	2(7.1)	9(32.1)	0.021

Data are presented as mean ± SD, median or number *Motor strength assessment: (0: none;1: muscle flicker without movement;2: movement, but not against gravity;3: movement against gravity;4: movement against some resistance;5: normal strength).; Quality of Recovery 15: a 15-item questionnaire that evaluates five dimensions of postoperative and anesthesia recovery, including comfort, emotional well-being, physical independence, patient support, and pain

Additionally, patients who received QLB demonstrated significantly reduced levels of postoperative pain intensity both at rest and during movement within the initial 48 h following surgery compared to those in the No Block group. This finding suggests that the inclusion of QLB as part of a multimodal analgesia regimen results in prolonged duration and enhanced efficacy of analgesic effects.

The surgical management of pelvic tumors is particularly challenging given the region's complex anatomical relationships and the propensity for tumors to invade surrounding critical structures [27]. A multidisciplinary approach is essential to achieve both oncological clearance and functional restoration [28]. The ilioinguinal and iliohypogastric approaches are commonly employed as the primary routes for pelvic tumor resection surgery. To optimize surgical site exposure, surgeons typically extend the incision to the upper lateral margin of the ilioiliac crest and incorporate an auxiliary incision, forming a cross-shaped pattern [29]. The iliohypogastric incision begins vertically near its proximal end, curves towards the pubis, and then follows along the buttock crease towards its distal end [30]. Complete tumor resection can pose catastrophic pain to patients, necessitating comprehensive pain management encompassing the lower abdomen, hip, buttocks, and upper one-third of the thigh. The nerves primarily involved in the surgical incision include the intercostal, subcostal, lateral femoral cutaneous, iliohypogastric, ilioinguinal, femoral, obturator, and sciatic nerves [31]. Numerous studies have consistently demonstrated that blocking any of these nerves leads to decreased pain scores and reduced opioid consumption among patients undergoing the surgery. However, expanding the blockade to include a greater number of nerves innervating the hip joint may potentially lead to superior postoperative pain relief [17]. This study synergistically combines Lateral-QLB and Anterior-QLB, leveraging the multidirectional diffusion properties of the thoracolumbar fascia to achieve comprehensive perioperative analgesia for pelvic tumor resection. The Lateral-QLB targets the fascial plane between the transversus abdominis and lateral quadratus lumborum, with cephalad spread along the anterior thoracolumbar fascia to the thoracic paravertebral space [32], effectively blocking somatic pain transmission via thoracolumbar spinal nerve ventral rami (T6-L1), achieving > 90% coverage of ilioinguinal surgical zones [33]. The Anterior-QLB delivers injectate between the quadratus lumborum and psoas major, demonstrating medial diffusion to modulate the lumbar sympathetic chain (T10-L2) and lumbar plexus nerve roots (L1-L3) [34], thereby attenuating visceral referred pain through dual blockade of splanchnic plexus derivatives and inferior mesenteric nerve networks. This dual-pathway mechanism theoretically addresses the hybrid pain patterns post-pelvic oncologic surgery, particularly demonstrating unique efficacy in managing visceral nociception traditionally resistant to conventional regional techniques. Based on the anatomical structure and a comprehensive analysis of previous research, the blocked region of the Lateral-QLB combined with Anterior-QLB can essentially encompass the surgical range of pelvic tumors. Therefore, we conducted a randomized controlled trial to demonstrate the enhanced efficacy of combining Lateral-QLB with Anterior-QLB as an optimized approach for achieving adequate analgesia in resection of pelvic tumor and reconstruction.

Our study demonstrates that QLB induce pronounced sensorimotor dissociation in postoperative neurological function, a neuromodulatory characteristic of particular clinical significance in pelvic surgical procedures. In our study, sensory blockade following QLB demonstrated inconsistent results: all patients who received QLB exhibited sensory blockade spanning from the L1 to L3 dermatomes; patients exhibited diminished cold and pinprick sensation within the T10 to L4 dermatomal range. The distribution of local anesthetic in these interfacial plane blocks is primarily influenced by tissue compliance, potentially accounting for the observed variations in

blockade planes. The restoration of motor function in the lower limb is crucial for patients undergoing pelvic functional reconstruction. This study specifically assessed immediate postoperative motor function. Notably, while the QLB group experienced a decrease in cold and pinprick sensation, there was no observed impairment in motor function compared to the No Block group, as evidenced by the lack of a statistically significant difference in MRC scores of the quadriceps muscles (1.95 ± 0.70 vs. 2.19 ± 0.67, $p = 0.186$). Contrary to the retrospective study by conducted Kukreja P [23], our study demonstrated that the administration of QLB did not result in a significant motor deficit, this finding contradicts previous reports. Kadoya Y [16] investigated the incidence of quadriceps weakness after Anterior-QLB, found that only 4 patients experienced a 25% decrease in lower limb strength compared to the non-blocked side, which was considered related to QLB, with an incidence of 13.3%, lower than the preoperative estimated $35 \pm 20\%$. All patients were able to get out of bed within 24 h and walk the next day. This suggests that Anterior-QLB may offer greater benefits in terms of promoting functional recovery of the affected limb and facilitating early discharge from the hospital. In our study, both groups exhibited alterations in quadriceps strength, potentially attributable to pain or postoperative swelling limiting that restrict the moving of the quadriceps muscles. *n* previous studies, Anterior-QLB as a deeper block in close proximity to the lumbar plexus, has been frequently implicated in inducing quadriceps weakness through its blockade of the femoral nerve and other lumbar plexus branches [35]. However, the autopsy study conducted by Dam M [33]revealed that during the Anterior-QLB, the dye could diffuse to varying extents towards the intracoastal nerve, iliohypogastric nerve, and ilioinguinal nerve while enveloping the lateral femoral cutaneous nerve and femoral reproductive nerve, it did not affect the lumbar plexus or lumbar sympathetic trunk. Therefore, in theory, Anterior-QLB can offer effective postoperative analgesia for diverse hip surgeries without compromising lower limb muscle strength. The accurate administration of Anterior-QLB involves injecting the local anesthetics between the fascia posterior to the psoas major and anterior to the quadratus lumborum. Since the psoas major surrounds the lumbar plexus nerves, avoiding puncturing this muscle during surgery can reduce postoperative muscle weakness. In the absence of a control group, previous retrospective studies may have erroneously attributed standard surgery-related postoperative weakness directly to the Anterior-QLB [21]. Next, prior publications mostly used 0.4% ropivacaine (25–30 ml), our study employed a 0.375% ropivacaine solution (40 ml), in order to enhance the spread of local anesthetic and minimize potential motor weakness. Moreover, the utilization of opioids is inherently linked to falls, particularly among elderly individuals, thereby highlighting the growing significance of opioid-sparing techniques.

Opioid use decreased significantly in our trial, with statistically significant implications for early recovery. This study presents evidence supporting the safety of QLB, as there were no instances of puncture site infection, abdominal organ injury, local anesthetic toxicity, or skin itching observed. In this study, patients who received QLB experienced significantly fewer nausea and vomiting. Opioid-related side effects have the potential to hinder patients' participation in functional rehabilitation activities and subsequently result in decreased patient satisfaction. Our study took this opportunity to use the QoR-15 quality of recovery questionnaire as a secondary outcome measure [36]. Significant differences in the quality of recovery were observed between the groups at 1, 2, and 7 days in our study. The QLB significantly contributed to enhance patients' satisfaction by providing effective analgesia and minimizing opioid-related side effects, while also demonstrating a long-term benefit with a reduced incidence of chronic pain at 3 months postoperatively compared to the No Block group (7.1% vs. 32.1%, $p = 0.021$). The process of recovery is multifaceted and encompasses a diverse range of programs. Achieving successful postoperative recovery necessitates active participation and collaboration between healthcare professionals and patients. Further investigation is warranted to establish the correlation between postoperative analgesia and early recovery in pelvic tumor resection and reconstruction surgery.

Additionally, there were certain limitations inherent in this study. Firstly, the study's restrictive inclusion/exclusion criteria—the age restriction (18–65 years) excluded elderly and pediatric patients, the BMI limitation (18–25 kg/m^2) excluded obese individuals while lacking systematic documentation of chemotherapy/radiotherapy history and psychological status—introduce selection biases that may compromise generalizability, potentially overestimating QLB's efficacy in specific populations while underestimating its applicability in complex cases. Additionally, the limited sample size, calculated based on the primary outcome, was insufficient to detect subtle recuperative differences in early postoperative outcomes. Second, the study lacked visualized evidence of local anesthetic diffusion. We conduct pinprick or cold tests to ascertain the distribution of sensory block. Due to the patient's somnolence or other factors, this test lacks accuracy. Third, time to first standing and time to first ambulation were not compared between groups because the surgical clinic decides on the patient's time in our hospital.

Conclusion

In conclusion, our study has demonstrated that the implementation of Lateral-QLB combined with Anterior-QLB can significantly reduce intravenous opioid consumption and enhances analgesic outcomes following pelvic tumor resection and reconstruction surgery. Therefore, based on a meticulous assessment of the adaptation conditions and contraindications, we cautiously advocate the integration of QLB as an integral component within a multimodal analgesic regimen subsequent to pelvic tumor resection surgery.

Abbreviations

Lateral	QLB Lateral quadratus lumborum block
Anterior	QLB Anterior quadratus lumborum block
NRS	Numeric rating scale
CONSORT	Consolidated Standards of Reporting Trials
ASA	American Society of Anesthesiologists
PONV	Postoperative nausea and vomiting
PACU	Post anesthesia care unit
PCIA	Patient-controlled intravenous analgesia
IV MME	Intravenous morphine milligram equivalents
QoR	Quality of Recovery
MMA	Multimodal Analgesia
POD	Postoperative Days

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Author contributions
All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Xin Rui Yin, Xue Tian, Bing Yi Wang, Xiao Dong Tang, Yi Yang and Yi Feng. The first draft of the manuscript was written by Xin Rui Yin and all authors commented on previous versions of the manuscript. Lu Yang Jiang helped design, review, and modify the study design. All authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethical approval
The study protocol underwent a thorough review and received approval from the Academic Committee of Peking University People's Hospital (approval No. 2023PHB435-001). Our study was registered in the Chinese Clinical Trial Registry (ChiCTR2400088440). It was conducted in accordance with the Helsinki Declaration of 1964 and its subsequent amendments.

Competing interests
The authors declare no competing interests.

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