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ORIGINAL RESEARCH

Effect of Liposomal Bupivacaine for Fascia Iliaca Compartment Block on Early Postoperative Recovery Quality in Elderly Patients Undergoing Total Hip Arthroplasty: A Retrospective Cohort Study

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Introduction: This retrospective cohort study aimed to determine whether liposomal bupivacaine used in suprainguinal fascia iliaca compartment block (S-FICB) is superior to 0.33% ropivacaine in improving the quality of early postoperative recovery in elderly patients with hip fractures who underwent total hip arthroplasty (THA). Outcomes included: 15-item Quality of Recovery Scale (QoR-15); Numerical Rating Scale (NRS) for pain; Pittsburgh Sleep Quality Index (PSQI); Harris Hip Score; plus rescue analgesic use and hospital stay. It should be noted that the observed benefits are limited to the early postoperative period.

Methods: A retrospective analysis was conducted on 200 elderly patients (aged 65–85 years) with hip fractures who underwent total hip arthroplasty (THA). Patients were divided into two groups based on the local anesthetic they received for S-FICB: the ropivacaine group (RG group, n = 100) or the liposomal bupivacaine group (LBG group, n = 100). QoR-15 and Harris scores were recorded preoperatively and on days 1, 3, 5 postoperatively. NRS and PSQI were recorded preoperatively and on days 1, 2, 3, 5. Rescue analgesic consumption and hospital stay were recorded.

Results: On postoperative day 1, QoR-15 was higher in LBG vs RG (113.25±3.825 vs 105.6±3.75, P=0.0004). NRS was lower in LBG within the first 48 postoperative hours ($P < 0.05$). PSQI was better in LBG on postoperative days 1 and 2 ($P < 0.01$). Harris score was higher in LBG on postoperative day 1 ($P = 0.0007$). Rescue analgesic use and postoperative hospital stay were lower in LBG ($P < 0.05$).

Conclusion: Liposomal bupivacaine is superior to ropivacaine in the early postoperative recovery and analgesia of elderly THA patients. However, this advantage is primarily limited to the early postoperative period. Prospective validation is required given the retrospective design.

Keywords: liposomal bupivacaine, geriatric orthopedics, multimodal analgesia, quality of postoperative recovery, suprainguinal fascia iliaca compartment block

Introduction

Currently, single-dose local anesthetic infiltration or single-episode nerve blockage cannot fully cover the postoperative pain window for patients undergoing orthopedic surgery,[1] typically lasting no more than 16 hours. Once the effective duration of the local anesthetic ends, pain rebound may occur. The current solution involves using continuous catheter technology to extend the duration of regional analgesia.[2] However, catheter placement procedures performed

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to extend analgesia duration also carry risks, including infection, catheter dislodgement, displacement, drug leakage at the puncture site, and difficulty in catheter removal,[3] which may further exacerbate severe pain or neuropathic symptoms. Therefore, anesthesiologists have long sought a local anesthetic that can provide continuous analgesia for 72 hours after a single infiltration anesthesia or nerve block, thereby retaining the analgesic effects of local anesthetics while avoiding the local trauma and complications associated with catheter placement. Thus, liposomal bupivacaine was developed.

Liposomal bupivacaine is the first ultra-long-acting local anesthetic to be approved. The first reports on their physicochemical properties and safety in healthy volunteers date back to 2004.[4] The drug utilizes DepoFoam (Pacira Pharmaceuticals, Inc., San Diego, CA, USA) technology to encapsulate the active ingredient within multi-vesicular liposomes.[5] Each tiny vesicle consists of numerous aqueous compartments containing bupivacaine, separated by lipid bilayers. Once administered, as time progresses, the rupture of a single vesicle occurs, and bupivacaine is released only from the ruptured vesicle, while the overall vesicle structure remains intact, thereby achieving sustained-release effects. Perets et al demonstrated that in total hip replacement surgery, using local infiltration around the joint cavity for pain relief, liposomal bupivacaine can be used safely and effectively,[6] and the analgesic effect is better than ropivacaine;[7] During hip fracture surgery, this drug can be safely and effectively applied for postoperative analgesia in iliac fascia block.[8] Meanwhile, the results of multiple previous studies have not identified the cardiac and/or neurotoxicity of liposomal bupivacaine.[9–12] All these clinical studies indicate that liposomal bupivacaine can be safely and effectively used in hip surgery. The postoperative analgesic effect of liposomal bupivacaine can last up to 72 hours, fully covering nearly the entire perioperative period, providing patients with satisfactory analgesia. Patients still experience a thick cloth-like sensation in the local skin of the area where the nerve block was administered, consistent with previous research findings,[8] indirectly demonstrating the consistency of efficacy between domestically produced drugs and the original research drug. Additionally, this drug has minimal impact on the heart and exhibits high safety.[13]

In recent years, with the intensification of population aging, the incidence of hip-related diseases has risen sharply and the demand for hip joint surgery has increased significantly. Total hip arthroplasty (THA) is one of the most common and successful orthopedic surgeries. Among various surgical methods, including posterior approach, direct lateral approach, anterolateral approach and direct anterior approach, direct anterior approach surgery (DAA) is widely popular due to its small incision and quick postoperative recovery. Hip pain receptors are densely distributed in the base of the hip labrum. Local anesthetics are mainly injected into the muscle layer and subcutaneous tissue around the joint. However, this local infiltration anesthesia (LIA) technique - typically using a “cocktail” therapy of a mixture of morphine, ropivacaine, and adrenaline - produces relatively weak analgesic effects.[14] Consequently, the S-FICB has also emerged.[15] For DAA-THA, anesthetic management may include neuraxial anesthesia (spinal or epidural) or general anesthesia, often combined with peripheral nerve blocks such as S-FICB to optimize postoperative recovery. The S-FICB puncture site is located above the iliac spine, distant from the DAA surgical incision, thereby avoiding the risk of incision contamination.[16] Previous studies have also found that the S-FICB provides more satisfactory analgesic effects compared to the classic “bow tie sign” (composed of the internal oblique and sartorius muscles, the needle is advanced cephalad within the plane, penetrating the iliac fascia to inject and separate the iliac fascia from the iliac muscles) approach for fascia iliaca compartment block in total hip arthroplasty.[17]

Previous randomized controlled trials and meta-analyses have shown that liposomal bupivacaine is safe and effective in various surgical Settings, including orthopedic and anorectal surgeries.[18–20] However, in this type of hip fracture population, there is still a research gap in the combination of liposomal bupivacaine and S-FICB for the early multi-dimensional recovery quality of THA through the DAA method. Therefore, this study used this drug for ultrasound-guided oblique position fascia iliaca compartment block above the inguinal region, aiming to investigate the effect of liposomal bupivacaine on the quality of postoperative recovery in elderly patients with hip fractures undergoing total hip arthroplasty while ensuring adequate analgesia. The objective is to explore methods and strategies to enhance postoperative recovery quality in such surgeries, providing a solid theoretical and practical foundation for clinical application.

Materials and Methods

Ethical Approval

This retrospective analysis included 200 elderly patients with hip fractures who underwent total hip arthroplasty (THA) at our hospital. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the First Hospital Affiliated to the University of Science and Technology of China (Anhui Provincial Hospital) (Ethics Approval No. 2026-re116). As the study was retrospective, patients' consent was not required. At the same time, we anonymized the data, and protected patients' privacy.

Sample Size Calculation

In our preliminary retrospective analysis, we examined 40 patients (20 in the ropivacaine group and 20 in the liposomal bupivacaine group). We found that the QoR-15 score on the first postoperative day was 106.5 ± 4.42 in the ropivacaine group and 113.25 ± 5.01 in the liposomal bupivacaine group, with a mean difference of 6.75 between groups. The mean difference between the groups was 7.27, with a 95% confidence interval of [6.5–8.4]. To determine the superiority margin, a threshold of 4.8 was selected based on previous studies indicating that a margin of 4.8 is clinically meaningful for early postoperative recovery in elderly orthopedic surgery.[21] As the lower bound of the confidence interval (6.5) exceeded the superiority margin, the data confirmed that the experimental group (LBG) significantly surpassed the control group (RG) in the QoR-15 score on the first postoperative day, demonstrating superiority. The threshold was set to ensure that any observed differences remain within clinically acceptable ranges. Under conditions of a unilateral Type I error rate of 0.025, statistical power of 90%, and a 1:1 ratio between groups, the calculated total sample size was 200 cases (100 per group).

Design and Patients

We retrospectively collected the clinical data of 200 elderly patients who underwent total hip arthroplasty (THA) due to hip fractures via the DAA approach from November 2024 to April 2025. The inclusion criteria included patients aged 65 to 85 who underwent elective total hip arthroplasty due to hip fractures. American Society of Anesthesiologists' Physical Condition Classification II–III. The body mass index (BMI) is between 18 and 30 kg/m^2. Complete medical records, including preoperative and postoperative follow-up data (QoR-15, NRS, PSQI score, Harris score, etc) Exclusion criteria include severe heart, lung, liver or kidney dysfunction recorded in the medical record (eg, preoperative partial pressure of arterial oxygen (PaO_2) < 60 mmHg or peripheral oxygen saturation (SpO_2) < 92%), and a record of cerebrovascular accident (such as stroke or transient ischemic attack) within 3 months before the operation Documented severe preoperative infection or systemic inflammatory response. Perioperative massive hemorrhage (estimated blood loss of 800 milliliters) recorded in the surgical and anesthesia records. The medical records are incomplete or key follow-up data are missing (for example, the QoR-15 score at a specific time point is missing). According to the different local anesthetics used in ultrasound-guided S-FICB, the patients were divided into two groups: ropivacaine group (RG, n=100) and liposome bupivacaine group (LBG, n=100).

Anesthesia Method

All clinical data and scale assessments were obtained from the electronic medical record system and the anesthesia follow-up documentation system.

Ultrasound-Guided Suprainguinal Fascia Iliaca Compartment Block

According to the documented procedural notes, all patients received ultrasound-guided suprainguinal fascia iliaca compartment block (S-FICB) prior to anesthesia induction as part of their multimodal analgesic regimen. S-FICB was performed using a high-frequency linear probe (10–15 MHz) positioned in an oblique sagittal orientation. Ultrasound landmarks were identified from superficial to deep: the external oblique, internal oblique, and transversus abdominis muscles; the iliac fascia covering the iliac muscle; and the iliac bone. A 22-gauge, 80-mm needle was inserted in-plane from the caudal to cephalic direction under continuous ultrasound guidance. The needle tip penetrated the iliac fascia and was positioned between the iliac fascia and iliac muscle. After confirming correct placement, the local anesthetic was

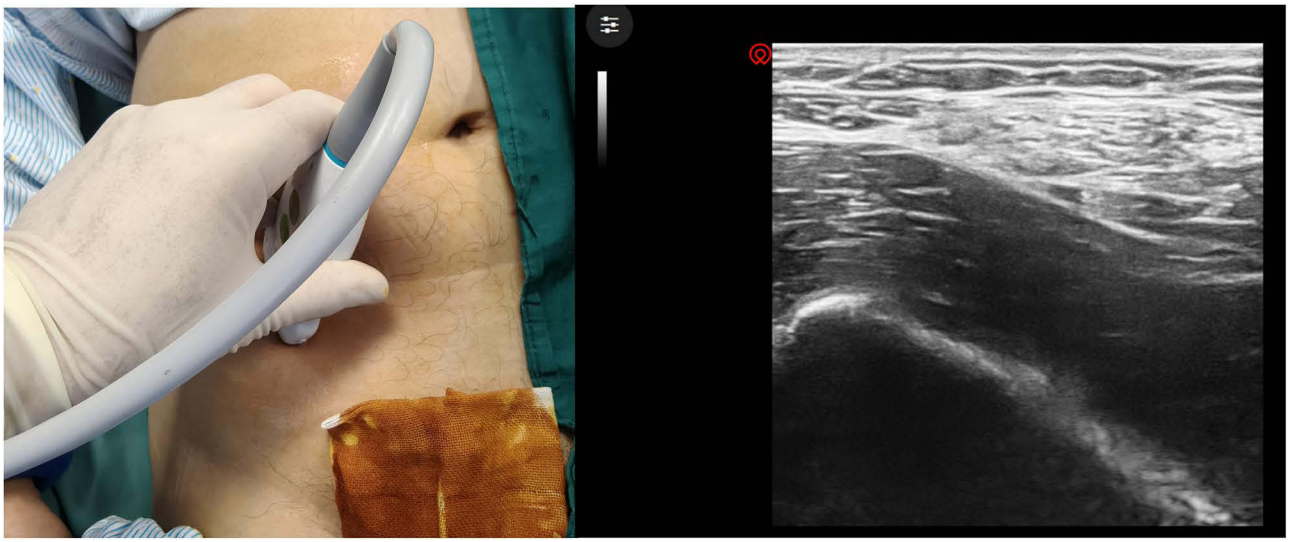

Figure 1 The practical operation of S-FICB.
Notes: (left) Body surface localization of iliac fascia block operation; (right) Ultrasonic manifestations of S-FICB: Ultrasound anatomy, from superficial to deep, includes: the external oblique, internal oblique, and transverse abdominis muscles (which may proximally fuse into a tendinous membrane); the iliac fascia (a high-echo linear structure) over the iliac muscle (low-echo); and the iliac bone (high-echo with acoustic shadowing).

slowly injected as a single dose, with real-time ultrasound observation of cephalad spread. Sensory block was assessed 30 minutes post-injection by cold sensation testing in the femoral nerve (anterior thigh) and lateral femoral cutaneous nerve (lateral thigh) distributions. Successful block was defined as reduced or absent cold sensation in both nerve territories compared to the contralateral limb (Figure 1).

General Anesthesia

ManagementReview of anesthesia records indicated that general anesthesia was induced with propofol (1–1.5 mg/kg) and sufentanil (0.2–0.3 μg/kg), followed by cisatracurium (0.2–0.3 mg/kg) to facilitate endotracheal intubation. Mechanical ventilation was initiated with a tidal volume of 6–8 mL/kg and respiratory rate of 10–12 breaths/min, maintaining end-tidal partial pressure of carbon dioxide ($PETCO_2$) at 35–40 mmHg. Anesthesia was maintained with propofol (3–6 mg/kg/h) and remifentanil (0.1–1 μg/kg/min), with intermittent cisatracurium as needed, targeting a bispectral index of 50–60. Propofol and remifentanil infusions were discontinued prior to the end of surgery.

Postoperative Analgesia Plan

Postoperative analgesia was provided via a patient-controlled analgesia (PCA) pump containing sufentanil (1.5μg/kg) and ondansetron (16 mg) diluted to 100 mL with normal saline. PCA settings included a 1.5 mL bolus, 15-minute lockout interval, and no continuous infusion. Rescue analgesics, including NSAIDs (parecoxib sodium 40 mg or flurbiprofen 50 mg) and opioids (pentazocine 30 mg), were administered based on NRS scores and PCA usage, with vital signs monitored after each dose. All perioperative data, including anesthetic agents, dosages, and analgesic consumption, were extracted from electronic medical records.

Data Collection

All perioperative data were retrospectively extracted from electronic medical records and structured follow-up documentation. Patient baseline characteristics, including age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and chronic medical history, were recorded. Perioperative data included surgical duration, anesthesia duration, post-anesthesia care unit (PACU) length of stay, and total hospital length of stay. Postoperative complications, such as emergence agitation, postoperative nausea and vomiting, falls, pressure ulcers, and deep vein thrombosis, were documented.

Inflammatory markers, including C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and neutrophil-to-lymphocyte ratio (NLR), were collected within 12 hours preoperatively and approximately 12 hours postoperatively. Postoperative recovery outcomes were assessed at predefined time points: the 15-item Quality of Recovery (QoR-15) scale and Harris Hip Score were evaluated preoperatively and on postoperative days 1, 3, and 5; pain intensity using the Numerical Rating Scale (NRS) was assessed preoperatively and at 12 hours, and on days 1, 2, 3, and 5 postoperatively; sleep quality using the Pittsburgh Sleep Quality Index (PSQI) was evaluated preoperatively and on postoperative days 1, 2, 3, and 5. Analgesic consumption, including NSAID and opioid dosages (the latter converted to morphine equivalents), was recorded throughout the postoperative hospital stay, along with any documented adverse events related to local anesthetics.

Statistical Analysis

All statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism version 9.0 (GraphPad Software, San Diego, CA, USA). Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Normally distributed data were presented as mean ± standard deviation and compared between groups using the independent samples *t*-test. Non-normally distributed data were presented as median with interquartile range (IQR) and compared using the Mann–Whitney *U*-test. Categorical variables were expressed as frequencies and percentages, and comparisons between groups were performed using the chi-square test or Fisher's exact test, as appropriate. For the primary outcome, the QoR-15 score on postoperative day 1 was compared between the liposomal bupivacaine group and the ropivacaine group using an independent samples *t*-test, with superiority determined based on the pre-defined clinically important difference. For secondary outcomes, between-group comparisons at individual time points were performed using appropriate parametric or non-parametric tests as described above. Post hoc correlation analyses were conducted to explore the relationships between postoperative recovery quality and other key outcomes. Spearman's rank correlation coefficients were calculated to assess associations between QoR-15 scores and corresponding NRS pain scores, PSQI sleep quality scores, and inflammatory marker levels (CRP, NLR, and ESR). Correlation strength was interpreted as follows: $|r| < 0.3$, weak correlation;$0.3 \leq |r| < 0.5$, moderately correlated;$|r| \geq 0.5$, strong correlation.[22] * Indicates $p < 0.05$; ** indicates $p < 0.01$; *** indicates $p < 0.001$; **** indicates $p < 0.0001$.

Results

Patient Characteristics and Baseline Data

The baseline demographic and clinical characteristics of the study population are summarized in Table 1. A total of 200 patients were included in the final analysis, with 100 patients in the liposomal bupivacaine group (LBG) and 100 patients

Table 1 Patient Characteristics and Baseline Data

Items	RG (n=100)	LBG (n=100)	Statistic	*P*
Age, M (Q_1, Q_3)	73.00 (70.00, 75.25)	72.00 (68.00, 75.00)	Z=−1.42	0.155
Sex, n (%)			χ^2=1.31	0.253
Female	53 (53.00)	61 (61.00)		
Male	47 (47.00)	39 (39.00)		
BMI (kg/m^2), mean ± SD	23.86±3.52	24.72±3.37	1.457	0.148
Number of preoperative comorbid conditions, n (%)			χ^2=3.01	0.281
0~1	70 (70.00)	73 (73.00)		
1~2	29 (29.00)	23 (23.00)		
≥3	1 (1.00)	4 (4.00)		
Comorbidity, (n%)				
Cardiovascular disease, n (%)			χ^2=0.58	0.447
No	90 (90.00)	93 (93.00)		
Yes	10 (10.00)	7 (7.00)		

(*Continued*)

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Table 1 (Continued).

Items	RG (n=100)	LBG (n=100)	Statistic	*P*
Abnormal lung function, n (%)			χ^2=0.44	0.506
No	90 (90.00)	87 (87.00)		
Yes	10 (10.00)	13 (13.00)		
DM, n (%)			χ^2=0.00	1.000
No	89 (89.00)	89 (89.00)		
Yes	11 (11.00)	11 (11.00)		
Cerebrovascular Diseases, n (%)			χ^2=1.41	0.236
No	69 (69.00)	61 (61.00)		
Yes	31 (31.00)	39 (39.00)		
HBP, n (%)			χ^2=0.08	0.777
No	50 (50.00)	48 (48.00)		
Yes	50 (50.00)	52 (52.00)		
Inflammatory index, M (Q_1, Q_3)				
CRP (mg/L)	4.9 (3.34, 7.21)	5.7 (3.30, 7.86)	Z=−1.15	0.251
ESR (mm/h)	20.5 (15.2, 25.0)	21.5 (13, 32)	Z=1.21	0228
NLR	3.7 (2.6, 5.0)	3.8 (2.5, 4.6)	Z=0.5	0.617
ASA classification, n (%)			χ^2=0.520	0.471
II	17 (17.00)	21 (21.00)		
III	83 (83.00)	79 (79.00)		

Abbreviations: LBG, liposomal bupivacaine group; RG, Ropivacaine group; IQR, Interquartile Range; BMI, Body Mass Index; SD, Standard Deviation; HBP, Hypertensive Blood Pressure; DM, Diabetes Mellitus; CRP, C-Reactive Protein; ESR, Erythrocyte Sedimentation Rate; NLR, Neutrophil-to-Lymphocyte Ratio; ASA, American Society of Anesthesiologists.

in the ropivacaine group (RG). The two groups were well balanced with respect to age, sex distribution, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and the prevalence of common comorbidities including hypertension, diabetes mellitus, and coronary heart disease. No statistically significant differences were observed between the groups for any of these baseline variables (all P > 0.05). The demographic characteristics of the study cohort (eg, median age, BMI distribution, prevalence of comorbidities) were consistent with those reported in large-scale national registry studies in China and contemporary studies on elderly patients undergoing total hip arthroplasty[23,24] This indicates that our sample was similar to the target population, thus supporting the generalization of our study results to similar clinical scenarios.

Scale Scoring Criteria

On the first postoperative day, the QoR-15 score in the LBG group was 113.25 ± 3.825, which was significantly higher than the 105.6 ± 3.75 in the RG group (mean difference: 7.65; 95% confidence interval [CI]: 6.45 to 8.85; P = 0.0004) (Figure 2A). Since the lower bound of the 95% CI (6.45) exceeded the pre-defined superiority margin of 4.8, the result demonstrates that liposomal bupivacaine was superior to ropivacaine in improving the quality of recovery on postoperative day 1. However, no statistically significant differences in QoR-15 scores were observed between the groups on postoperative days 3 and 5 (RG: 126.8 ± 2.3 vs LBG: 127.5 ± 3.1, $P = 0.076$; RG: 133.5 ± 3.3 vs LBG: 134.5 ± 2.3, $P = 0.063$) (Figure 2A). Similarly, the Harris score for the RG one day post-operation was 48.5 (46.25, 51), also significantly lower than the LBG at 50.5 (48.25, 53) ($P = 0.0007$). No significant between-group differences in Harris hip scores were found on postoperative days 3 and 5 [RG: 52 (51, 53) vs LBG: 53 (51, 54), $P = 0.068$; RG: 63 (62, 64) vs LBG: 64 (61, 67), $P = 0.057$] (Figure 2B). Furthermore, on the first postoperative day, the PSQI score for the RG was 12 (11, 13), indicating significantly poorer sleep quality compared to the LBG with a score of 11 (10, 12) ($P = 0.0003$). By the second postoperative day, the RG group's PSQI score remained higher at 10 (8, 11) compared to the LBG group's score of 9 (8, 10) ($P = 0.0038$). Subsequently, PSQI scores on days 3 and 5 [RG: 7 (6, 9) vs LBG: 7 (5.5, 9.25), $P = 0.73$; RG: 5 (4, 6) vs LBG: 5 (5, 6), $P = 0.64$] showed no statistically significant differences between the two groups

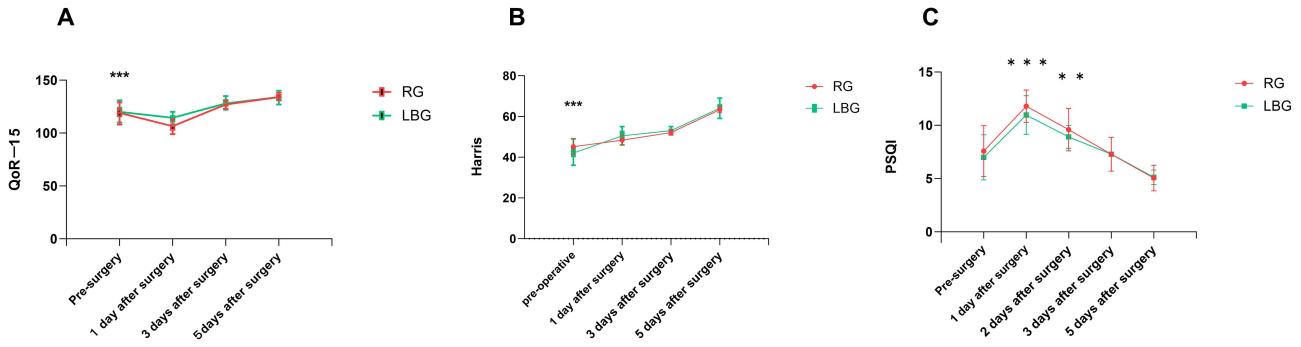

Figure 2 Postoperative scale scores for both groups.
Notes: (**A**) Comparison of QoR-15 scores between the two groups (1 day preoperatively, and 1, 3, 5 days postoperatively); (**B**) Comparison of Harris hip scores between the two groups (1 day preoperatively, and 1, 3, 5 days postoperatively); (**C**) Comparison of PSQI scores between the two groups (1 day preoperatively, and 1, 2, 3, 5 days postoperatively). ** indicates p < 0.01; *** indicates p < 0.001.
Abbreviations: LBG, liposomal bupivacaine group; RG, Ropivacaine group; QoR-15, 15-Item Quality of Recovery Scale; PSQI, Pittsburgh Sleep Quality Index.

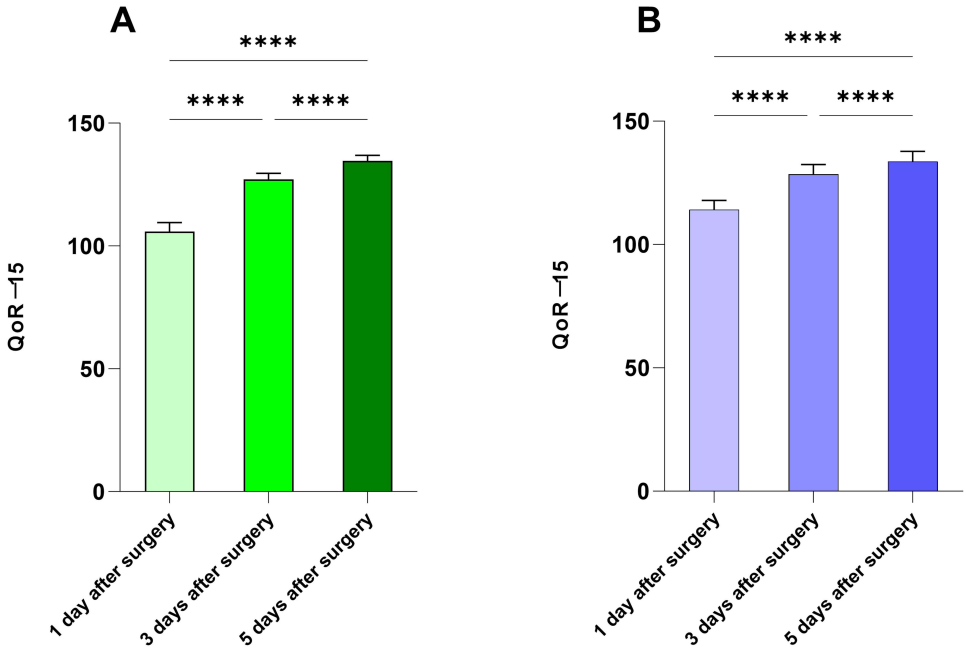

Figure 3 One-way ANOVA of QoR-15 after surgery in two groups.
Notes: (**A**) One-way ANOVA of QoR-15 score after surgery in RG group; (**B**) One-way ANOVA of QoR-15 score after surgery in LBG group. **** indicates p < 0.0001.
Abbreviation: QoR-15, 15-Item Quality of Recovery Scale.

(Figure 2C). A steady increase in QoR-15 scores was observed in both groups at each successive postoperative assessment, reaching the minimum clinically important difference (MCID) threshold[21] (Figure 3A and B).

Correlation Analysis of QoR-15 Scores

Correlation analysis revealed that the postoperative QoR-15 score was significantly negatively correlated with NRS scores [r = −0.3139, 95% CI (−0.34 – −0.069), *P* <0.0001], PSQI scores [r = −0.2123, 95% CI (−0.2667 – −0.1356), *P* = 0.0025], NLR levels [r = −0.3136, 95% CI (0.18–0.43), *P* <0.0001] and CRP levels [r = −0.1664, 95% CI (−0.3007 – −0.0228), *P* = 0.0185]. Although the correlation is weak, it also means that the degree of pain increases, the quality of sleep deteriorates and the inflammatory index increases, and the corresponding postoperative recovery quality also decreases (Figures 4A–C and 5A). However, no significant correlations were observed between NLR or ESR levels and the postoperative QoR-15 scores (both P > 0.05; Figure 5B and C).

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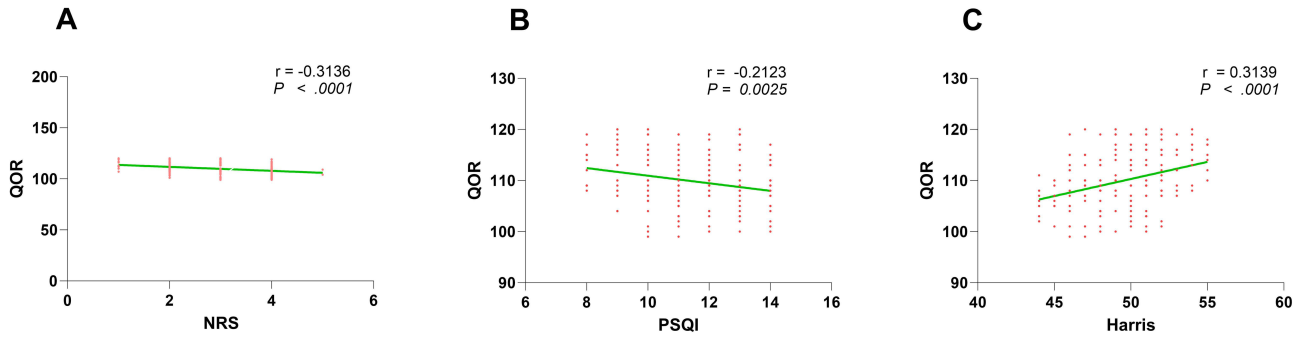

Figure 4 The correlation between postoperative scale score and QOR-15score was analyzed.
Notes: (**A**) Analysis of the correlation between postoperative NRS scores and QoR-15 scores; (**B**) Analysis of the correlation between postoperative PSQI scores and QoR-15 scores; (**C**) Analysis of the correlation between postoperative Harris scores and QoR-15 scores.
Abbreviations: QoR-15, 15-Item Quality of Recovery Scale; PSQI, Pittsburgh Sleep Quality Index; NRS, Numerical Rating Scale.

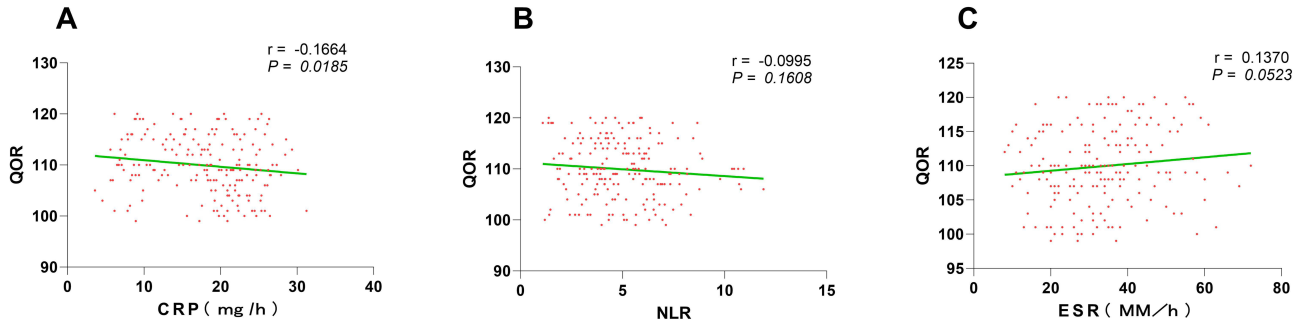

Figure 5 The correlation between inflammatory markers and QOR-15 score at 24 hours after operation was analyzed.
Notes: (**A**) Analysis of the correlation between postoperative CRP levels and QoR-15 scores; (**B**) Analysis of the correlation between postoperative NLR levels and QoR-15 scores; (**C**) Analysis of the correlation between postoperative ESR levels and QoR-15 scores.
Abbreviations: QoR-15, 15-Item Quality of Recovery Scale; CRP, C-Reactive Protein; ESR, Erythrocyte Sedimentation Rate; NLR, Neutrophil-to-Lymphocyte Ratio.

Analgesic Indicators

Postoperative NRS scores revealed that at 24 hours, LBG demonstrated lower scores than RG [4 (2, 4) vs 5 (4, 6), P =0.0071]; at 1 day, LBG scores were also lower [3 (2, 3) vs 4 (3, 5), P <0.001]; and at 2 days, LBG consistently maintained lower scores [3 (1, 3) vs 4 (4, 4), P =0.0083]. However, no differences were found on the 3rd and 5th postoperative days [RG: 2 (2, 3) vs LBG: 2 (1, 3), P = 0.78; RG: 2 (2, 2) vs LBG: 2 (1, 2), P = 0.67] (Figure 6A). Similarly, as shown in Figure 6B and C, the LBG group used fewer opioids than the RG group during the approximate hospitalization period [4.13 (1, 5.8) vs 4.43 (2.1, 6.3), P = 0.0416], and the dosage of NSAIDs used was also lower than that in the RG group [700 (550, 837.5) vs 460 (442.5, 480), P <0.0001].

Comparison of Postoperative Inflammatory Indexes Between the Two Groups

Postoperative assessment of inflammatory markers indicated elevated CRP levels in the RG [15.69 (20.89, 23.53) mg/L] compared to the LBG [12.5 (17.01, 21.64) mg/L] (P =0.023) (Figure 7A). Moreover, the RG demonstrated a higher NLR (5.43 ± 2.38) than the LBG (4.56 ± 1.76) (p =0.006) (Figure 7C). There was no significant disparity in postoperative ESR between the groups [RG: 32 (23, 39) vs LBG: 34 (22.25, 42.75), P = 0.918] (Figure 7B).

Postoperative Complications and Time Indicators

There was no statistical significance in the incidence of postoperative complications (agitation during recovery, postoperative nausea and vomiting, deep vein thrombosis of lower limbs, accidental fall and pressure ulcer) between the two groups (P >0.05). Meanwhile, there was no statistical significance in operation time and anesthesia duration between the

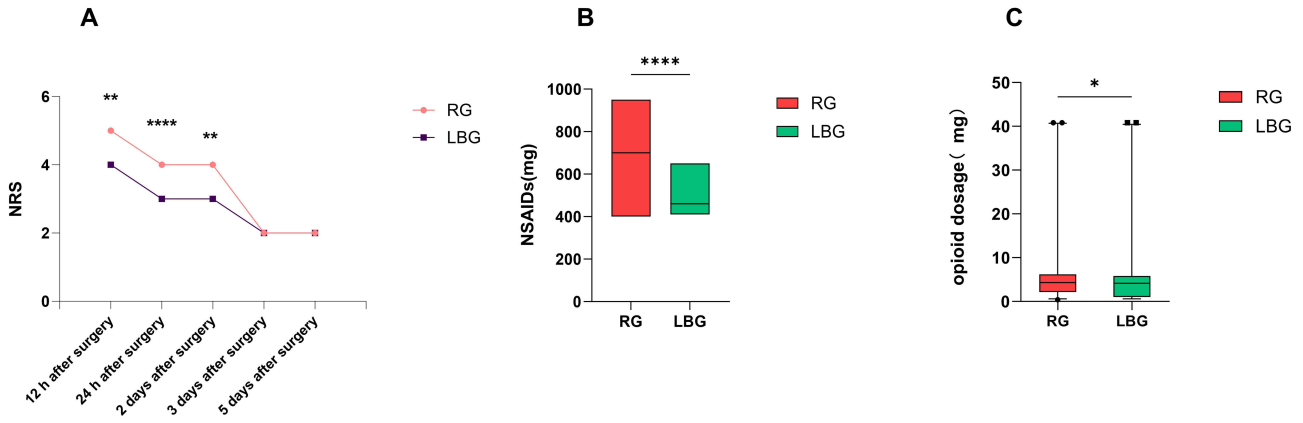

Figure 6 Analgesic indicators.
Notes: (**A**) Two sets of postoperative NRS line graphs; (**B**) Postoperative rescue analgesic doses of NSAIDs in the two groups of patients; (**C**) The postoperative rescue analgesic doses of opioids in the two groups of patients. * indicates $p < 0.05$; ** indicates $p < 0.01$; **** indicates $p < 0.0001$.
Abbreviations: LBG, liposomal bupivacaine group; RG, Ropivacaine group; NRS, Numerical Rating Scale.

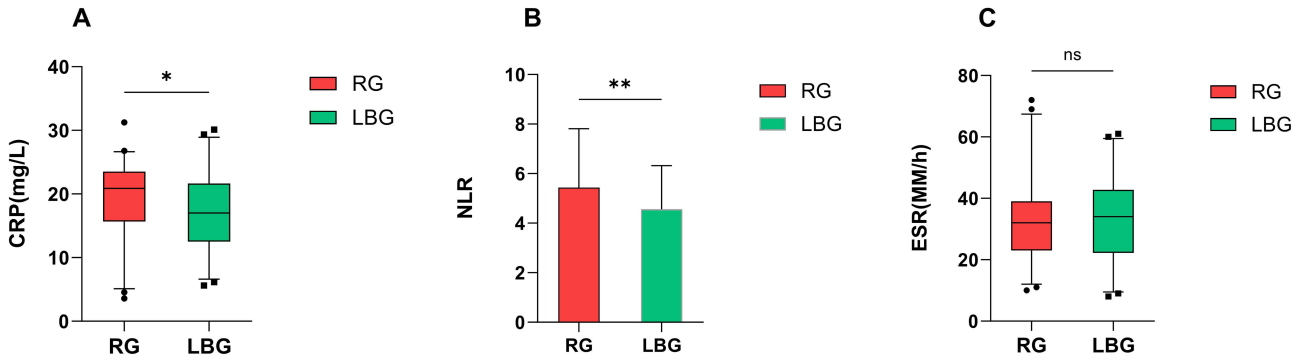

Figure 7 Inflammatory indexes of the two groups at 12 hours after operation.
Notes: (**A**) Comparison of CRP levels between the two groups at 12 hours postoperatively; (**B**) Comparison of NLR between the two groups at 12 hours postoperatively; (**C**) Comparison of ESR between the two groups at 12 hours postoperatively. * indicates $p < 0.05$; ** indicates $p < 0.01$.
Abbreviations: LBG, liposomal bupivacaine group; RG, Ropivacaine group; NRS, Numerical Rating Scale; CRP, C-Reactive Protein; ESR, Erythrocyte Sedimentation Rate; NLR, Neutrophil-to-Lymphocyte Ratio; ns, no statistical significance.

two groups. However, the length of hospital stay was shorter in the LBG group than in the RG group [4 (3, 5) vs 5 (5, 5), $P = 0.042$] (Table 2). At the same time, from the start to the end of the project, we did not find any cardiac and/or neurological toxicity caused by local anesthetics in the two groups.

Table 2 Postoperative Complication Incidence and Time-Related Indicators

Items	RG (n=100)	LBG (n=100)	Statistic	*P*
Postoperative complication				
Emergence agitation, n (%)			χ^2=0.033	0.885
No	82 (82.00)	81 (81.00)		
Yes	18 (18.00)	19 (19.00)		
PONV, n (%)			χ^2=0.036	0.849
No	84 (84.00)	83 (83.00)		
Yes	16 (16.00)	17 (17.00)		
Accidental fall, n (%)			χ^2=0.205	0.651
No	98 (98.00)	97 (97.00)		
Yes	2 (2.00)	3 (3.00)		

(*Continued*)

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Table 2 (Continued).

Items	RG (n=100)	LBG (n=100)	Statistic	*P*
Pressure ulcer, n (%)			χ^2=0.388	0.561
No	98 (98.00)	99 (99.00)		
Yes	2 (7.00)	1 (1.00)		
DVT, n (%)			χ^2=0.096	0.756
No	95 (95.00)	94 (94.00)		
Yes	5 (5.00)	6 (6.00)		
Time index, M (Q_1, Q_3)				
Length of stay in hospital (day)	5 (5, 5)	4 (3, 5)	Z=1.32	0.042
Length of stay in the PACU (min)	56 (44, 68)	55.5 (42.5, 68.75)	Z=1.62	0.064
Duration of anesthesia (min)	70 (60, 85)	77.5 (66, 90.75)	Z=1.81	0.070
Operation time (min)	66 (53, 78)	64.5 (55, 73.5)	Z=1.73	0.160

Abbreviations: LBG, liposomal bupivacaine group; RG, Ropivacaine group; IQR, Interquartile Range; PONV, Postoperative Nausea and Vomiting; DVT, Deep Vein Thrombosis; χ^2, Chi-square value; Z, Z-score.

Discussion

For the primary outcome, the QoR - 15 score in the liposomal bupivacaine group (113.25 ± 3.825) was significantly higher than that in the ropivacaine group (105.6 ± 3.75). This result was not only statistically significant but also exceeded the pre - set MCID threshold of 4.8,[21] confirming its clinical relevance and strongly supporting the above conclusion. In a study of liposomal bupivacaine for transverse abdominal fascia block after cesarean section, it was also suggested that the application of this drug had excellent results for the recovery quality and analgesic satisfaction of patients on the first day after operation.[25] At the same time, a number of studies on the use of the drug in joint surgery have also shown positive results.[26–29] These studies on the improvement of postoperative recovery quality by liposomal bupivacaine are generally consistent with the results of our study. Although our research indicates that the early recovery effect of liposomal bupivacaine is superior to that of ropivacaine, it must be admitted that not all studies have reported consistent results. For instance, some randomized controlled trials have found that after total knee arthroplasty or shoulder surgery, liposomal bupivacaine shows no significant differences in pain scores or postoperative recovery quality.[30–32] These differences may be caused by variations in surgical sites, block techniques, patient populations, or outcome evaluation times.

Regarding pain-related indicators, this study found that in the first two days after surgery, the scores of the NRS in the experimental group at specific time points were all lower than those in the control group. Meanwhile, the usage of rescue analgesics (NSAIDs and opioids) during hospitalization in the experimental group was also lower than that in the control group. It is worth discussing that simply considering the analgesic effects of the two local anesthetic drugs does not seem to reach the MCID.[33] We also clearly understand that there may be statistical differences but not necessarily clinical differences. However, on the basis of a statistically significant difference in rescue analgesics, when comparing the relevant results on the first and last days after surgery, the MCID of NRS (a decrease of 1.5–2.0) and QOR - 15 (4.8) can be achieved.[34,35] Individually, the clinical relevance of differences in NRS scores may be limited. But the liposomal bupivacaine group requires less rescue analgesics, which also represents a clinical value. Interestingly, the levels of CRP and NLR in the liposomal bupivacaine group were lower than those in the ropivacaine group. Research shows that[36,37] postoperative acute pain and the increase of related inflammatory factors in the body are the results of bidirectional effects. The increase in relevant inflammatory factors such as CRP, NLR, and ESR not only increases the risk of infection[38–40] and the incidence of postoperative complications[41] but also affects the patients' postoperative cognitive function,[42] thus jointly influencing the rehabilitation outcome and increasing the hospitalization burden.

Meanwhile, through the statistical analysis of scale scores and the correlation analysis of QOR - 15 scores, we found that the side - effects caused by pain may directly affect the postoperative recovery of hip joint function and sleep quality in patients. As the pain intensity increases, sleep quality deteriorates, and hip joint function declines, the postoperative recovery quality of patients also worsens accordingly. In a study of non-cardiac surgery in the elderly, pain was clearly

identified as an independent risk factor for postoperative sleep quality.[43] At the same time, previous study has also shown that postoperative pain is an objective factor affecting hip function recovery and sleep quality.[44] Therefore, effective pain management of total hip arthroplasty is to improve the quality of postoperative recovery of patients in multiple dimensions. When interpreting the results of our study, a crucial consideration is the disconnect between the statistically significant improvement in patient-reported outcomes and the lack of a corresponding reduction in hospital stay or postoperative complications. This apparent contradiction can be explained by the nature of the measured outcomes. Outcomes such as the QoR - 15 and Harris score are multi - dimensional and objective,[45,46] encompassing objective indicators like physical comfort, psychological state, independence, as well as hip joint function and deformity; while outcomes such as the NRS score and PSQI are somewhat subjective.[44,47] This may also explain why between-group differences were most pronounced on the first postoperative day, when acute pain is most severe, and diminished at later time points.

There are several limitations to this study that should be considered when interpreting the results. First, being a retrospective study and the fact that this study was single-center and only included elderly hip fracture patients who underwent direct anterior approach total hip arthroplasty may limit extrapolation of the findings to other populations or surgical approaches. Additionally, we did not perform multivariable regression analysis to adjust for potential confounders, which may have introduced residual confounding. Future studies should incorporate such analyses to strengthen the validity of the findings. The retrospective nature also introduces the fundamental risk of selection bias. Methods such as propensity score matching could have further reduced bias, but given the relatively small sample size and the fact that baseline characteristics were well balanced between groups, we did not perform matching. Second, the assessment of outcomes was limited by the retrospective design to routinely recorded time points, which may have underestimated the complete analgesic effect, especially when the analgesic benefit was beyond the time frame of the assessment. In addition, the lack of continuous motor function monitoring and standardized long-term follow-up in routine clinical practice may affect the accuracy of functional recovery data. Finally, from a clinical perspective, our findings suggest that liposomal bupivacaine for S-FICB is a valuable option for enhancing early postoperative recovery in elderly patients undergoing THA. The prolonged analgesic effect and improved sleep quality on the first two postoperative days are particularly relevant for this population, as poor pain control and sleep disturbance are risk factors for delirium and prolonged hospitalization. Anesthesiologists may consider using liposomal bupivacaine in patients at high risk for severe postoperative pain or those with pre-existing sleep disorders. However, given the higher cost of liposomal bupivacaine compared to conventional local anesthetics, cost-effectiveness should be considered, especially in healthcare systems with limited resources. Future prospective studies should include formal cost-effectiveness analyses to guide clinical decision-making. Similarly, although no drug-related adverse events were documented, the safety of liposomal bupivacaine for this specific nerve block requires further validation in larger multicenter studies.

Conclusion

This retrospective analysis suggests that, among elderly patients undergoing total hip arthroplasty for hip fractures, the use of liposomal bupivacaine for single-injection suprainguinal fascia iliaca compartment block was associated with improved early postoperative outcomes compared to ropivacaine. Patients who received liposomal bupivacaine exhibited higher quality of recovery scores on the first postoperative day, lower pain scores within the first 48 hours, better sleep quality on the first and second postoperative days, and reduced rescue analgesic consumption throughout the hospitalization period. These findings indicate that liposomal bupivacaine may serve as a valuable component of multimodal analgesia regimens for total hip arthroplasty, primarily by enhancing the quality of early postoperative recovery. However, several limitations must be acknowledged, including the retrospective single-center design, lack of long-term follow-up, and absence of formal cost-effectiveness analysis. Given the retrospective nature of this study, future prospective trials should employ standardized assessment protocols with longer follow-up periods, compare equipotent doses of liposomal bupivacaine and ropivacaine, and include formal cost-effectiveness analyses to better define the clinical role of liposomal bupivacaine.

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Disclosure

The authors report no conflicts of interest in this work.

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