Meta-Analysis

Efficacy of Thoracolumbar Interfascial Plane Block for Postoperative Analgesia in Lumbar Spine Surgery: A Meta-analysis of Randomized Clinical Trials

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Background: Thoracolumbar interfascial plane (TLIP) block as a novel plane block technique was proposed in 2015 and can be performed in patients undergoing lumbar spine surgery. However, no meta-analysis demonstrates the effects of TLIP block on postoperative pain undergoing lumbar spine surgery.

Objectives: The purpose of this study is to evaluate the postoperative analgesic efficacy of TLIP block with patient-controlled analgesia (PCA) undergoing lumbar spine surgery compared to be given PCA alone after lumbar spine surgery.

Study Design: This meta-analysis pooled all data published in randomized controlled trials (RCTs) examining the efficacy of TLIP following lumbar spine surgery.

Methods: We conducted a comprehensive search of PubMed, Web of Science, Embase databases, the Cochrane Library, and Google Scholar for randomized controlled trials (RCTs) up to December 2020. According to the inclusion and exclusion criteria established in advance, "TLIP" and "lumbar spine surgery" related MeSH terms and free-text words were used. All of the data on visual analog scales (VAS) scores, PCA compression frequency, PCA consumption, and nausea rates were reported. All analyses were performed with RevMan 5.4 software.

Results: A total of 9 RCTs with 618 patients meet the inclusion criteria. The results demonstrated that VAS scores for pain during movement and while at rest were markedly lower in the TLIP group than those in the control group in all the postoperative periods (1-2 h, 12 h, 18 h, and 24 h) ($P < 0.05$). VAS scores at rest 1-2 h postoperatively (MD: -2.16; 95% CI: [-3.86, -0.46]); 12 h (MD: -1.22; 95% CI: [-2.33, -0.11]); 18 h (MD: -1.40; 95% CI: [-1.55, -1.24]); 24 h (MD: -1.38; 95% CI: [-1.94, -0.81]); VAS scores at movement 1-2 postoperatively (MD: -2.26; 95% CI: [-4.28, -0.23]); 12 h (MD: -2.11; 95% CI: [-3.13, -1.10]); 18 h (MD: -1.63; 95% CI: [-1.77, -1.48]); 24 h (MD: -1.47; 95% CI: [-1.98, -0.95]). Meanwhile, PCA compression frequency, PCA consumption, and nausea rates were significantly lower in the TLIP group after lumbar spine surgery ($P < 0.05$): PCA compressions frequency (MD: -4.08; 95% CI: [-5.28, -2.88]); PCA consumption (MD: -14.30; 95% CI: [-20.68, -7.92]); nausea rates (RR: 0.47; 95% CI: [0.32, 0.68]).

Limitations: Despite 9 RCTs, the sample size was still small, so more high-quality RCTs with large samples will be urgently required for stronger evidence to support TLIP block in lumbar spine surgery.

Conclusions: The TLIP block is an effective strategy to improve postoperative pain at rest/movement and to reduce PCA consumption in patients undergoing lumbar spine surgery, which exerts significant analgesia. In the future, it is worth being applied in lumbar spine surgery extensively.

Key words: Thoracolumbar interfascial plane block, postoperative analgesia, lumbar spine surgery, patient-controlled analgesia, VAS scores, meta-analysis

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It is reported that 30%-64% of patients have poorly controlled pain following spine surgery, which seems to be a major obstacle to their recovery (1). Poor postoperative pain control can increase the risk of complications such as pulmonary embolism, deep vein thrombosis, pneumonia, myocardial infarction, and may eventually progress to chronic pain (2,3). Patient-controlled analgesia (PCA) or epidural analgesia is commonly applied in spine surgery. However, PCA is usually prone to opioid-related adverse events, such as nausea, vomiting, and respiratory depression. The epidural injection is strongly associated with hematomas, infections, and other side effects (4,5). Currently, many regional analgesic techniques (such as erector spinae plane block, transversus abdominis plane block, serratus anterior plane block, and inter-semispinal plane block) are used for providing long-lasting postoperative analgesia, and significantly decrease opioid requirements while avoiding the risk of neuraxial and plexus blocks complications (6-10).

In recent years, thoracolumbar interfascial plane (TLIP) block has gained popularity as a useful postoperative pain relief technique undergoing a variety of spinal operations, which first reported by Hand et al (11) in 2015, blocks the dorsal rami of the thoracolumbar nerves by injecting a local anesthetic into the fascial plane anesthetic between the multifidus and longissimus muscles at approximately the level of third lumbar vertebra (L3). This technique has a high success rate, in particular if it is used by ultrasound guidance, as ultrasound promotes visualization, thereby decreasing potential complications. And the modified TLIP block (injection of local anesthetics to the interfascial plane between the iliocostal and longissimus muscles) has been reported as a method of decreasing the risk of neuraxial and plexus blocks complications, which are easier to perform than the first TLIP block reported (12,13). Although an increasing number of clinical trials have highlighted the analgesic effectiveness of TLIP block (13,14), no meta-analysis has demonstrated the effects of TLIP block on postoperative pain after undergoing lumbar spine surgery.

In this meta-analysis, we evaluated the analgesic efficacy of TLIP block following lumbar spine surgery. The primary outcomes were the difference in visual analog scale (VAS) scores at 1-2 h, 12 h, 18 h, and 24 h at rest/movement postoperatively in the TLIP block with PCA comparing it to PCA alone. The secondary outcomes were to evaluate PCA compression frequency, PCA consumption, and nausea rates.

Methods

The study is a meta-analysis, which is reported based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement (15).

Search Strategy

Randomized controlled trials (RCTs) were retrieved from the National Library of Medicine's PubMed database, Web of Science, Embase databases, the Cochrane Library, and Google Scholar up to December 2020. The search was performed independently by 2 authors (Z.X. Hu & J. Han) using the search terms "thoracolumbar interfascial plane block," "TLIP block," "analgesia," "pain," "postoperative," "postoperation," "lumbar spine surgery," "lumbar spinal surgery" with the "AND or OR." No language restriction was applied. An attempt to identify additional papers not found by the above methods was made by examining the reference lists of all identified studies.

Inclusion and Exclusion Criteria

The inclusion criteria were as followings: (1) Population: all adult patients undergoing lumbar spine surgery (18 years old and older); (2) Study design: only RCTs; (3) Interventions: TLIP block; (4) Comparison: placebo (normal saline or no block); (5) the study included at least one of the following outcomes: VAS scores at rest and movement (0-24 h postoperatively), PCA compression frequency, PCA consumption, and/or nausea rates. The exclusion criteria were as follows: (1) failure to meet the inclusion criteria; (2) animal studies; (3) history of relevant allergy to any of the medications used in spine surgery; (4) have severe abnormal liver and kidney function or respiratory or circulatory diseases; (5) case reports, reviews, comments, letters, and editorials.

Data Extraction and Quality Assessment

Two independent observers (ZH and JH) extracted data from all the included studies and any discrepancy was resolved through consensus or consulting a third author (HW). Each paper was rigorously reviewed for eligibility in our analysis. The basic features include first author name, published year, country, study type, surgical methods, disease diagnosis, ASA (American Society of Anesthesiologists) physical status, anesthesia methods, PCA, age, gender, BMI (body mass index), surgical duration, TLIP block. Data were extracted from text or tables. A VAS for pain was converted into a 10-point scale. Continuous data were recorded using mean ± SD (mean and standard deviation), whereas dichotomous data on the presence or absence of adverse effects were extracted and converted to incidence. Data presented only as median (interquartile range) were converted to mean ± SD using the previously described methodology (16).

Two investigators (ZH and JH) performed a quality assessment of each included RCT based on the Cochrane Handbook for Systematic Reviews (17). The assessment included the following elements: (1) random sequence generation; (2) allocation concealment; (3) blinding of participant and personnel; (4) blinding of outcome assessment; (5) incomplete outcome data; (6) selective reporting; (7) other bias. Every section had a high risk of bias, low risk of bias, and unclear risk of bias depending on the actual content of the included study.

Statistical Analysis

All meta-analyses were performed using Review Manager (RevMan) 5.4 software (The Cochrane Collaboration, Copenhagen, Denmark). For continuous outcomes, we calculated the mean difference (MD) with a 95% confidence interval (CI), such as VAS scores at rest and movement, PCA compression frequency, and PCA consumption. For dichotomous outcomes, we measured relative risk (RR) with 95% CI, such as nausea rates. We conducted a heterogeneity test on the included RCT studies and calculated the statistics. When $I^2 > 50\%$ or $P < 0.1$, high heterogeneity of studies included was indicated, and a random-effect model was applied. Otherwise, a fixed-effect model was applied. Forest plots were constructed. $P < 0.05$ was considered to be statistically significant. For some comparisons, one-way sensitivity analyses were conducted by deleting a single study from the overall publications individually to evaluate the reliability of the results. Publication bias was assessed by using the funnel plot.

In addition, Ammar et al (18) and Ueshima et al (19) expressed VAS scores at rest/movement as medians (25% to 75%, interquartile range). To reasonably convert the median (interquartile range) to mean (standard deviation), we used a common conversion formulation accepted in the literature (20).

Results

Study Selection

The database search produced 172 studies, and 9 RCT studies (18,19,21-27) were eventually eligible for meta-analysis. Figure 1 shows the process and results of the study screening.

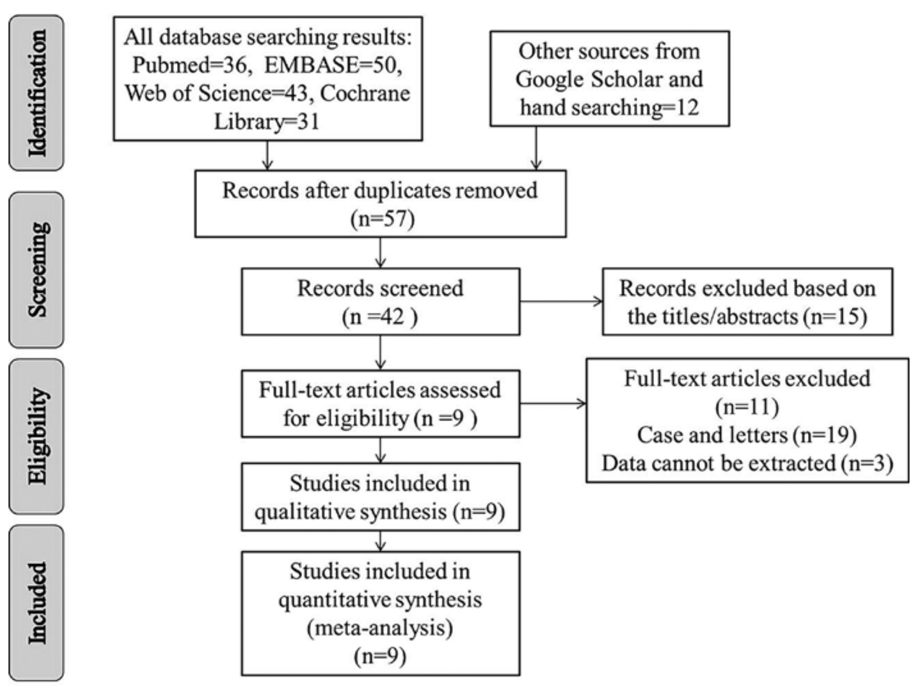

Fig 1. *Flow diagram of the study selection process for the meta-analysis.*

Characteristics of Selected Studies

In total, 9 RCT studies with 618 patients were included in this study. The basic characteristics of 9 RCT studies were generalized in Table 1. Seven studies were conducted in China, one study in Japan, and one study in Egypt. Eight RCT studies reported accurate surgical method as lumbar fusion (and internal fixation), lumbar discectomy, and primary lumbar laminoplasty, however, only one study provided an ambiguous surgical method as spinal surgery.

Risk of Bias

The Cochrane Handbook for Systematic Review of Interventions was used to assess the risk of bias of the RCTs. As shown in Fig. 2, a total of 9 studies were considered to have a low risk of bias. Nine studies adopted the method of random sequence generation, 3 studies reported the allocation concealment, and 3 studies described the blinding of outcome assessment and personnel. None of the 9 RCTs found incomplete results data, selective reports, and other bias.

Outcomes of the Meta-Analysis

We summarized the evaluation tools to assess the effect of TLIP block for postoperative analgesia during lumbar spine surgery after carefully reading and analyzing the 9 RCTs; the results of this meta-analysis of outcome measures are shown in Table 2, which included VAS scores at rest/movement (1-2 h, 12 h, 18 h, 24 h postoperatively), PCA compression frequency, PCA consumption, and nausea rates. Among them, VAS scores at rest/movement are the primary outcome measures, which are considered the gold standard of pain quantification.

VAS Scores at Rest Postoperatively

Seven studies with 411 patients (206 TLIP and 205 control) illustrated VAS scores at rest 1-2 h after lumbar spine surgery. A random-effects model was applied because notable heterogeneity was found among the studies (I^2 = 100%). There was a significant difference in VAS scores at rest 1-2 h postoperatively between groups (MD: -2.16; 95% CI: [-3.86, -0.46], P = 0.01, I^2 = 100%) (Fig. 3A). Considering high heterogeneity among RCTs, a sensitivity analysis was conducted to figure out some sources. However, the above outcomes did not change by sequentially omitting each study.

Five studies with 297 patients (149 TLIP and 148 control) illustrated VAS scores at rest 12 h after lumbar spine surgery. There was significant heterogeneity among the studies (I^2 = 97%). A random-effects model was adopted; there was a significant difference in VAS scores at rest 12 h postoperatively between groups (MD: -1.22; 95% CI: [-2.33, -0.11], P = 0.03, I^2 = 97%) (Fig. 3B).

Two studies with 114 patients (57 TLIP and 57 control) illustrated VAS scores at rest 18 h after lumbar spine surgery. There was no significant heterogeneity among the studies (I^2 = 0%). A fixed-effects model was used; there was significant reduction in VAS scores at rest 18 h postoperatively in patients who received TLIP block compared with control (MD: -1.40; 95% CI: [-1.55, -1.24], P < 0.00001, I^2 = 0%) (Fig. 3C).

Seven studies with 411 patients (206 TLIP and 205 control) illustrated VAS scores at rest 24 h after lumbar spine surgery. A random-effects model was applied because there was significant heterogeneity among the studies (I^2 = 97%). There was a significant difference in VAS scores at rest 24 h postoperatively between groups (MD: -1.38; 95% CI: [-1.94, -0.81], P < 0.0001, I^2 = 97%) (Fig. 3D).

VAS Scores at Movement Postoperatively

Four studies with 244 patients (122 TLIP and 122 control) reported VAS scores with movement 1-2 h after lumbar spine surgery. A random-effects model was applied because notable heterogeneity was found among the studies (I^2 = 100%). There was a significant difference in VAS scores with movement 1-2 h postoperatively between groups (MD: -2.26; 95% CI: [-4.28, -0.23], P = 0.03, I^2 = 100%) (Fig. 4A).

Three studies with 199 patients (100 TLIP and 99 control) illustrated VAS scores with movement 12 h after lumbar spine surgery. There was significant heterogeneity among the studies (I^2 = 87%). A random-effects model was adopted; there was a significant difference in VAS scores with movement 12 h postoperatively between groups (MD: -2.11; 95% CI: [-3.13, -1.10], P < 0.0001, I^2 = 87%) (Fig. 4B). Considering notable heterogeneity among RCTs, a sensitivity analysis was performed to figure out some sources. After removing the Ammar et al study, the heterogeneity of VAS scores with movement 12 h was significantly decreased (I^2= 46%), which means this RCT article is the main factor of heterogeneity. Meanwhile, the result did not change after heterogeneity decreasing (MD: -2.39; 95% CI: [-2.62, -2.17], P < 0.00001, I^2 = 46%) (Fig. 4C).

Two studies with 114 patients (57 TLIP and 57 control) illustrated VAS scores with movement 18 h after lumbar spine surgery. There was no significant hetero-

Table 1. *Characteristics of all the trials included in the meta-analysis.*

Study	Country	Study type	Surgical methods	Disease diagnosis	ASA (range)	Anesthesia methods	PCA	Group	Local anesthetic	Age (years)	Gender M : F	BMI (kg/ m2)	Surgical duration (min)
Shi 2019 (22)	China	RCT	spinal surgery	lumbar disc herniation, lumbar spinal stenosis, others	I-II	general anesthesia	100 µg sufentanil + 10 mg tropisetron + 100 ml 0.9% saline	TLIP	20 mL ropivacaine (0.25%) on each side†	44.02 ± 5.77†	22/15†	NP†	NP†
								control	NP‡	43.16 ± 6.08‡	23/14‡	NP‡	NP‡
Guo 2018 (23)	China	RCT	posterior lumbar fusion	lumbar spinal stenosis	I-II	general anesthesia	100 µg sufentanil+ 10 mg tropisetron + 100 mL 0.9% saline	TLIP	20 mL ropivacaine (0.5%) on each side†	58 ± 7†	6/14†	NP†	215 ± 51†
								control	None‡	58 ± 8‡	7/13‡	NP‡	217 ± 43‡
Li 2019 (24)	China	RCT	single-level posterior lumbar fusion and internal fixation	lumbar disc herniation, lumbar spinal stenosis, lumbar spondylolisthesis	I-II	general anesthesia	150 µg sufentanil + 8 mg tropisetron + 150 mL 0.9% saline	TLIP	20 mL ropivacaine (0.375%) on each side†	49.4 ± 7.7†	12/13†	23.5 ± 2.6†	197.8 ± 59.8†
								control	NP‡	49.5 ± 7.1‡	10/15‡	21.6±2.8‡	201.1 ± 56.5‡
Yu 2019 (25)	China	RCT	Posterior lumbar fusion	NP	I-II	general anesthesia	100 µg sufentanil + 10 mg tropisetron + 100 mL 0.9% saline	TLIP	20 mL ropivacaine (0.5%) on each side†	58 ± 7.4†	21/28†	NP†	215±51†
								control	NP‡	58±8‡	10/14‡	NP‡	217±43‡
Ammar 2018 (18)	Egypt	RCT	lumbar discectomy	lumbar disc herniation	I-II	general anesthesia	1 mg morphine	TLIP	10 mL 0.25% bupivacaine + 10 mL 1% lidocaine on each side†	42.00 ± 8.21†	21/14†	NP†	132.88 ± 24.48†
								control	None‡	43.05 ± 6.88‡	23/12‡	NP‡	124.5±34.3‡
Chen 2019 (21)	China	RCT	lumbar spinal fusion	NP	I-II	general anesthesia	4.5 µg/kg sufentanil + 150 ml 0.9% saline	TLIP	30mL ropivacaine (0.375%)†	58.65 ± 8.51†	16/14†	22.68 ± 1.66†	173.17 ± 38.18†
								control	30 mL 0.9% saline‡	53.90 ± 11.57‡	15/15‡	23.25 ± 3.0‡	159.83 ± 24.69‡
Ueshima 2019 (19)	Japan	RCT	elective, primary lumbar laminoplasty	spinal canal stenosis	I-II	general anesthesia	fentanyl	TLIP	20 mL levobupivacaine (0.375%)on each side†	70 ± 10.74†	23/12†	24 ± 3.48†	165 ± 54.07†
								control	20 mL saline on each side‡	68 ± 16.07‡	19/15‡	23.7 ± 3.56‡	135 ± 61.48‡

Table 1 (cont.). *Characteristics of all the trials included in the meta-analysis.*

Study	Country	Study type	Surgical methods	Disease diagnosis	ASA (range)	Anesthesia methods	PCA	Group	Local anesthetic	Age (years)	Gender M : F	BMI (kg/ m2)	Surgical duration (min)
Ning 2020 (27)	China	RCT	single-level lumbar fusion	NP	I-II	general anesthesia	150 µg sufentanil + 150 mL 0.9% saline	TLIP	20 mL ropivacaine (0.375%) on each side†	51 ± 11†	38/29†	23.2 ± 2.6†	125 ± 17†
								control	None‡	54 ± 10‡	34/33‡	24.1 ± 2.6‡	121 ± 17‡
Cheng 2019 (26)	China	RCT	single-level lumbar internal fixation	single-level lumbar fracture	I-III	general anesthesia	150 µg sufentanil + 150 mL 0.9% saline	TLIP	20 mL ropivacaine (0.375%) on each side†	56.2 ± 3.4†	12/12†	23.0±2.3†	120.4±28.3†
								control	None‡	56.0 ± 2.8‡	12/12‡	23.2 ± 3.1‡	124.7 ± 29.6‡

†TLIP group; ‡Control group; RCT, randomized controlled trial; ASA, American Society of Anesthesiologists; PCA, patient-controlled analgesia; BMI, body mass index; TLIP, thoracolumbar interfascial plane; M, male; F, female; NP, not provided.

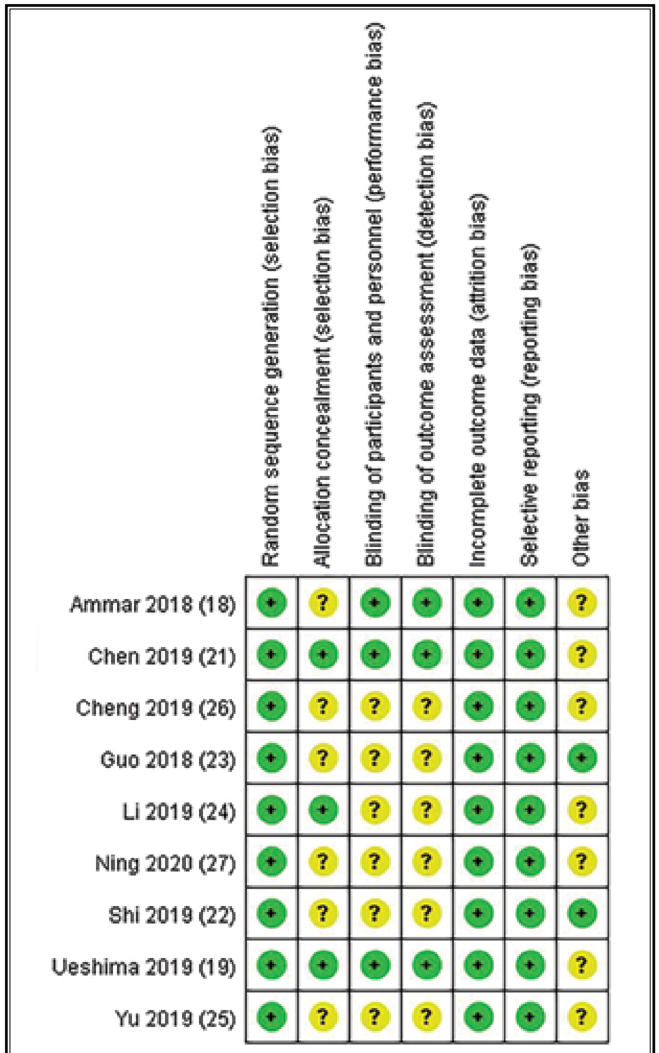

Fig 2. *Risk of bias summary.*

geneity among the studies ($I^2 = 48\%$). A fixed-effects model was used; there was significant reduction in VAS scores with movement 18 h postoperatively in patients received TLIP block compared with control (MD: -1.63; 95% CI: [-1.77, -1.48], $P < 0.00001$, $I^2 = 48\%$) (Fig. 4D).

Five studies with 313 patients (157 TLIP and 156 control) reported VAS scores with movement 24 h after lumbar spine surgery. There was significant heterogeneity among the studies ($I^2 = 92\%$). A random-effects model was applied; there was a significant difference in VAS scores with movement 24 h postoperatively between groups (MD: -1.47; 95% CI: [-1.98, -0.95], $P < 0.00001$, $I^2 = 92\%$) (Fig. 4E). Considering notable heterogeneity among RCTs, a sensitivity analysis was performed to figure out some sources. After removing the Chen et al study, the heterogeneity of VAS scores with

Table 2. *Results of the meta-analysis of outcome measures.*

Outcome	Number of studies	Patients T/C	MD (95% CI)	*P* Value	Heterogeneity *P* Value (I^2)
VAS scores					
Rest					
1-2 h	7	206/205	-2.16 [-3.86, -0.46]	0.01	< 0.00001(100%)
12 h	5	149/148	-1.22 [-2.33, -0.11]	0.03	< 0.00001(97%)
18 h	2	57/57	-1.40 [-1.55, -1.24]	< 0.00001	0.82(0%)
24 h	7	206/205	-1.38 [-1.94, -0.81]	< 0.00001	< 0.00001(97%)
Movement					
1-2 h	4	122/122	-2.26 [-4.28, -0.23]	0.03	< 0.00001(100%)
12 h	3	100/99	-2.11 [-3.13, -1.10]	< 0.0001	0.0003(87%)
18 h	2	57/57	-1.63 [-1.77, -1.48]	< 0.00001	0.16(48%)
24 h	5	157/156	-1.47 [-1.98, -0.95]	< 0.00001	< 0.00001(92%)
PCA compression frequency	6	227/202	-4.08 [-5.28, -2.88]	< 0.00001	< 0.00001(98%)
PCA consumption	3	106/81	-14.30 [-20.68, -7.92]	< 0.0001	< 0.00001(98%)
Nausea rates	8	287/261	RR 0.47 [0.32, 0.68]	< 0.0001	0.72(0%)

VAS, Visual Analog Scale; MD, mean difference; RR, risk ratio; T, TLIP; C, Control; PCA, patient-controlled analgesia.

movement 24 h was significantly decreased (I^2 = 0%), which means this RCT article is the main factor of heterogeneity. At the same, the result did not change after heterogeneity decreasing (MD: -1.18; 95% CI: [-1.31, -1.05], $P < 0.00001$, I^2 = 0%) (Fig. 4F).

PCA Compression Frequency

Six studies with 429 patients (227 TLIP and 202 control) illustrated PCA compression frequency after lumbar spine surgery. There was significant heterogeneity among the studies (I^2 = 98%). A random-effects model was applied, there was a significant difference in PCA compression frequency between groups (MD: -4.08; 95% CI: [-5.28, -2.88], $P < 0.00001$, I^2 = 98%) (Fig. 5A).

PCA Consumption

Three studies with 187 patients (106 TLIP and 81 control) illustrated PCA consumption after lumbar spine surgery. PCA solution contained sufentanil 100 μg and tropisetron 10 mg diluted to 100 ml with 0.9% normal saline. There was significant heterogeneity among the studies (I^2 = 98%). A random-effects model was applied; there was a significant difference in PCA compressions between groups (MD: -14.30; 95% CI: [-20.68, -7.92], $P < 0.0001$, I^2 = 98%) (Fig. 5B).

Nausea Rates

Eight studies with 548 patients (287 TLIP and 261 control) illustrated nausea rates after lumbar spine surgery. A fixed-effects model was applied because no significant heterogeneity was found among the studies (I^2 = 0%). There was a significant difference in nausea rates between groups (RR: 0.47; 95% CI: [0.32, 0.68], $P = 0.72$, I^2 = 0%) (Fig. 6A). The funnel plot regarding nausea rates was presented in Fig. 6B. The shape of the funnel plot appeared to be symmetrical, suggesting that there was a very low risk of publication bias.

None of the included RCT studies reported on complications (such as wound infection, allergic reactions, neurologic symptoms) due to the performance of TLIP block.

Discussion

Spine surgery is commonly characterized by diffuse and severe pain in the postoperative period (28). Effective postoperative management of pain can significantly contribute to better surgical outcomes (29). Recently, novel modalities of regional analgesic techniques such as TLIP block are increasingly performed in patients undergoing lumbar spine surgery aimed at reducing postoperative pain and enhancing early recovery (11,12,30). It offers advantages, including being less invasive and having a better safety profile. However, some studies have demonstrated that the TLIP block could not provide enough analgesic time for lumbar spine surgery. Guo et al (23) found that the patients who received TLIP block had markedly lower VAS scores during only the first 18 h postoperatively; during the 19 postopera-

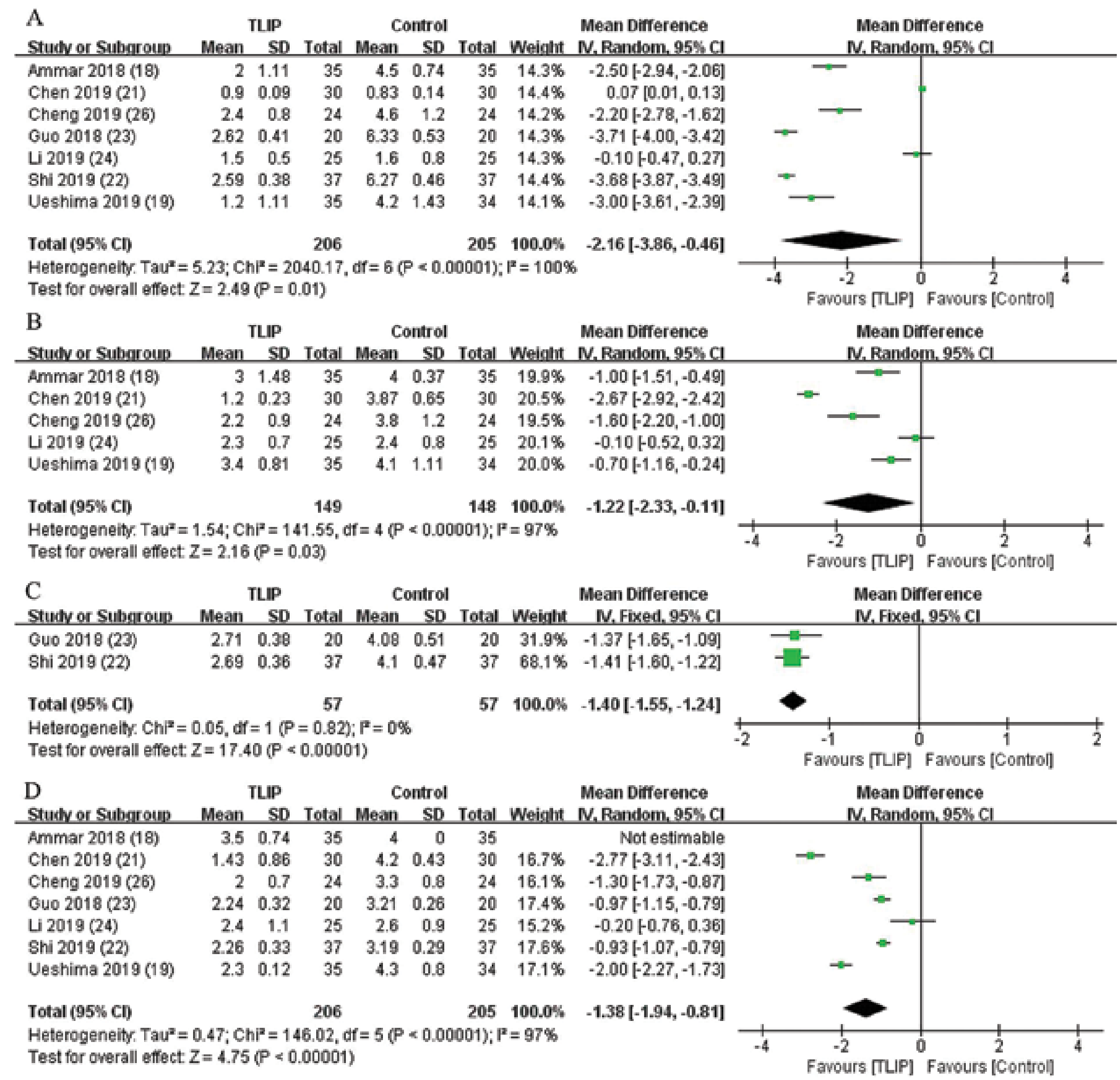

Fig 3. *Forest plot for the meta-analysis of postoperative VAS scores at rest. A: postoperative VAS scores at 1-2 h; B: postoperative VAS scores at 12 h; C: postoperative VAS scores at 18 h; D: postoperative VAS scores at 24 h. [95% CI: 95% confidence intervals, df: degrees of freedom, Random: random effects model, Fixed: fixed effects model, IV: inverse variance]*

tive hours onward, there was no significant difference in VAS scores between the groups. Li et al (24) revealed that there were no statistically significant differences in VAS scores at all measurement times as well as the incidence of nausea between the groups. Therefore, it is important to summarize the relevant clinical RCT studies to indicate efficacy. The meta-analysis can enlargen the sample size and strengthen statistical power by pooling results of published studies, which can offer stronger evidence.

Our meta-analysis is the first to address the postoperative analgesic efficacy of TLIP block undergoing lumbar spine surgery. Based on 9 RCT studies with 618 patients, the most important finding of this meta-anal-

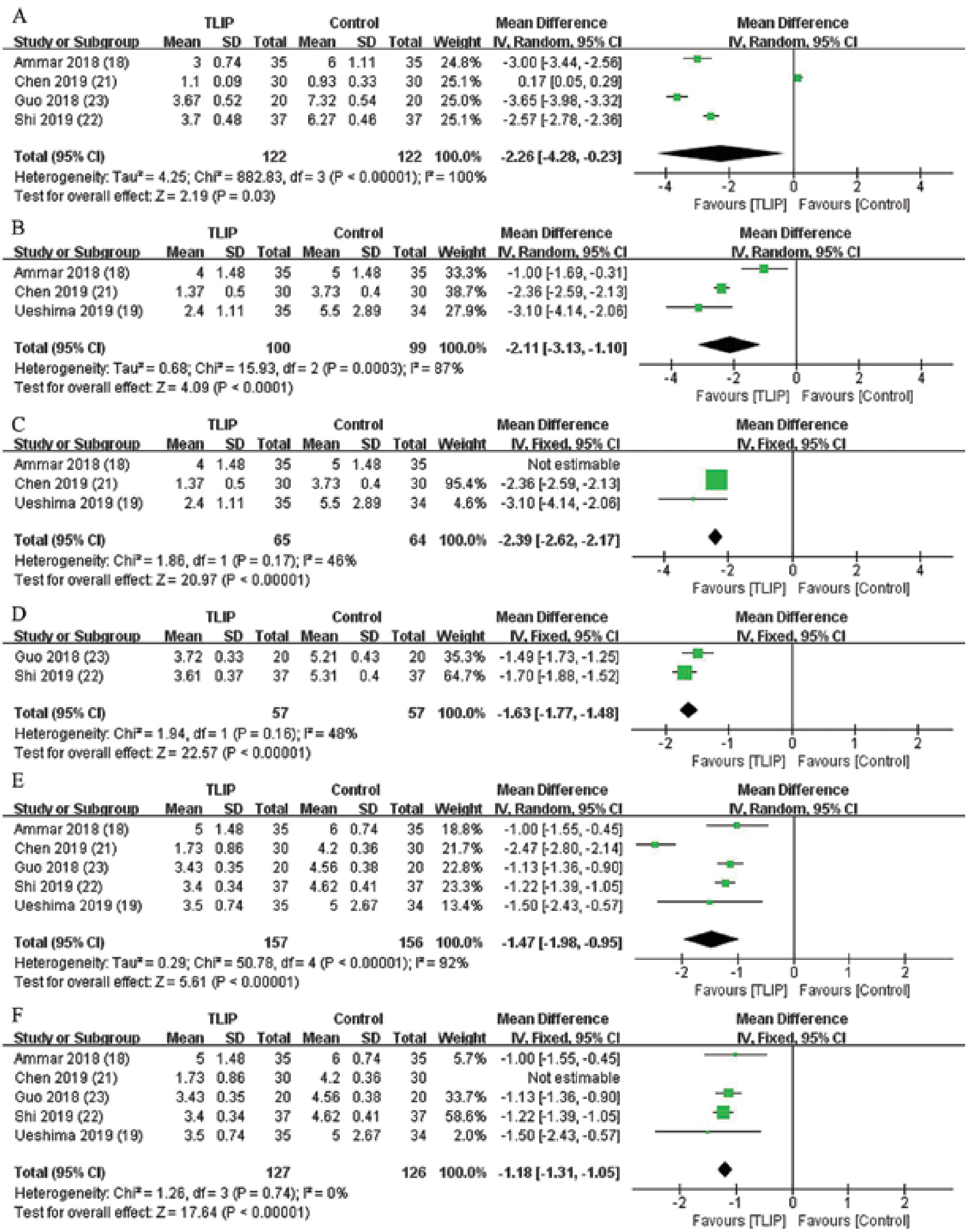

Fig 4. *Forest plot for the meta-analysis of postoperative VAS scores at movement. A: postoperative VAS scores at 1-2 h; B: postoperative VAS scores at 12 h; C: sensitivity analysis of postoperative VAS scores at 12 h; D: postoperative VAS scores at 18 h; E: postoperative VAS scores at 24 h; F: sensitivity analysis of postoperative VAS scores at 24 h. [95% CI: 95% confidence intervals, df: degrees of freedom, Random: random effects model, Fixed: fixed effects model, IV: inverse variance]*

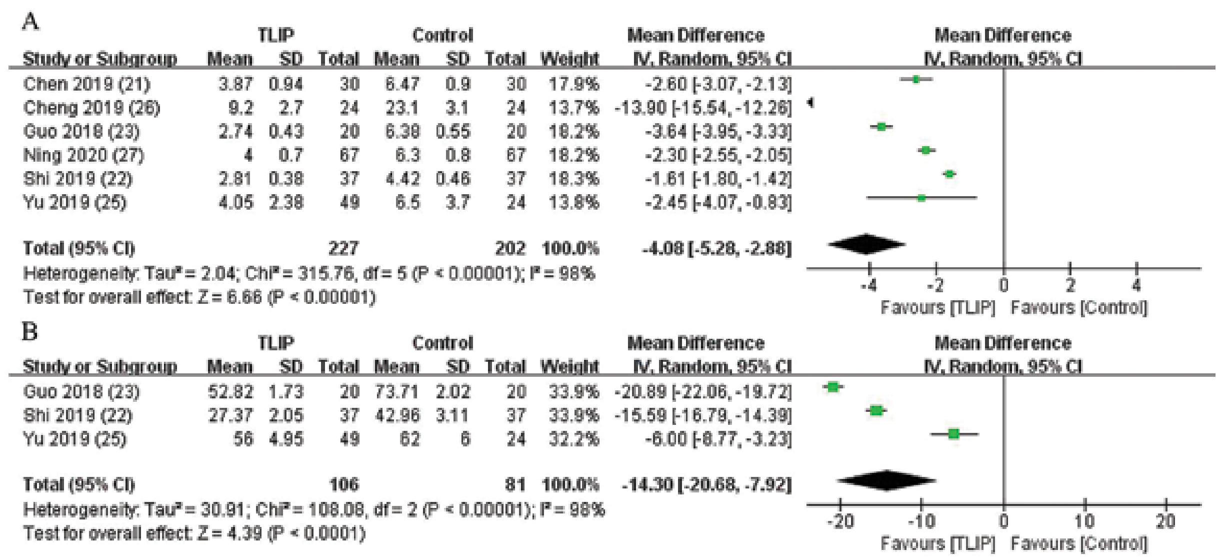

Fig 5. *A: Forest plot for the meta-analysis of PCA compression frequency; B: Forest plot for the meta-analysis of PCA consumption. [95% CI: 95% confidence intervals, df: degrees of freedom, Random: random effects model, Fixed: fixed effects model, IV: inverse variance]*

ysis is that TLIP block can remarkably decrease postoperative pain outcomes after lumbar spine surgery. TLIP block also reduces PCA compression frequency and PCA consumption, PCA consumption, and nausea rates. None of the included RCT studies reported on complications (such as wound infection, allergic reactions, neurologic symptoms) because of the performance of TLIP block. Collectively, our results indicate that TLIP block may be a promising strategy to improve analgesic outcomes after lumbar spine surgery.

To our knowledge, it has been demonstrated that pain is significant at 4 h after lumbar spine surgery and relieved after 72 h. And regional anesthesia can markedly help patients reduce postoperative pain and other discomfort (19,31). Tseng et al (32) demonstrated that patients treated with TLIP block had reported postoperative analgesia lasting over 12 h. Li et al (33) found that TLIP block could provide effective pain relief at rest at 48 h for patients after multilevel lumbar spine surgery. According to this meta-analysis, in common with previous studies, the TLIP group presented a significant reduction of VAS scores at all measurement times (1-2 h, 12 h, 18 h, 24 h postoperatively) compared to the control group, no matter at rest or during movement ($P < 0.05$), but there was a high degree of heterogeneity among the studies. Because of the high heterogeneity ($I^2 = 87\%$) in VAS scores at 12 h postoperatively during movement, a sensitivity analysis was performed by deleting the Ammar et al study. After that, the pooling results of the remaining 2 RCTs showing $I^2 = 46\%$, and prominent differences still existed regarding VAS scores between the TLIP group and the control group (Fig. 4C). Through comparing the clinical characteristics and demographic data among the 3 included studies, we discovered the biggest difference was the complexity of lumbar spine surgical procedures in patients. In the Ammar et al study, patients received lumbar discectomy, which indicated a simple surgical procedure. However, the patients of the other studies were received by a complicated procedure like lumbar spinal fusion and laminoplasty. Meanwhile, the complexity of lumbar spine surgery led to the durations of surgical operations being different. Hence, the complexity of the lumbar spine surgical procedure was the most critical factor of high heterogeneity. Secondly, the type and concentration of PCA were completely different among the included studies, which will also influence VAS scores postoperatively. Totally, after removing high heterogeneity, the results of this present meta-analysis still indicated VAS scores at 12 h during movement for patients in the TLIP group are lower than the control group. In a word, the method of surgery displays important implications for VAS scores, and our studies' amounts are not sufficient to perform the subgroup

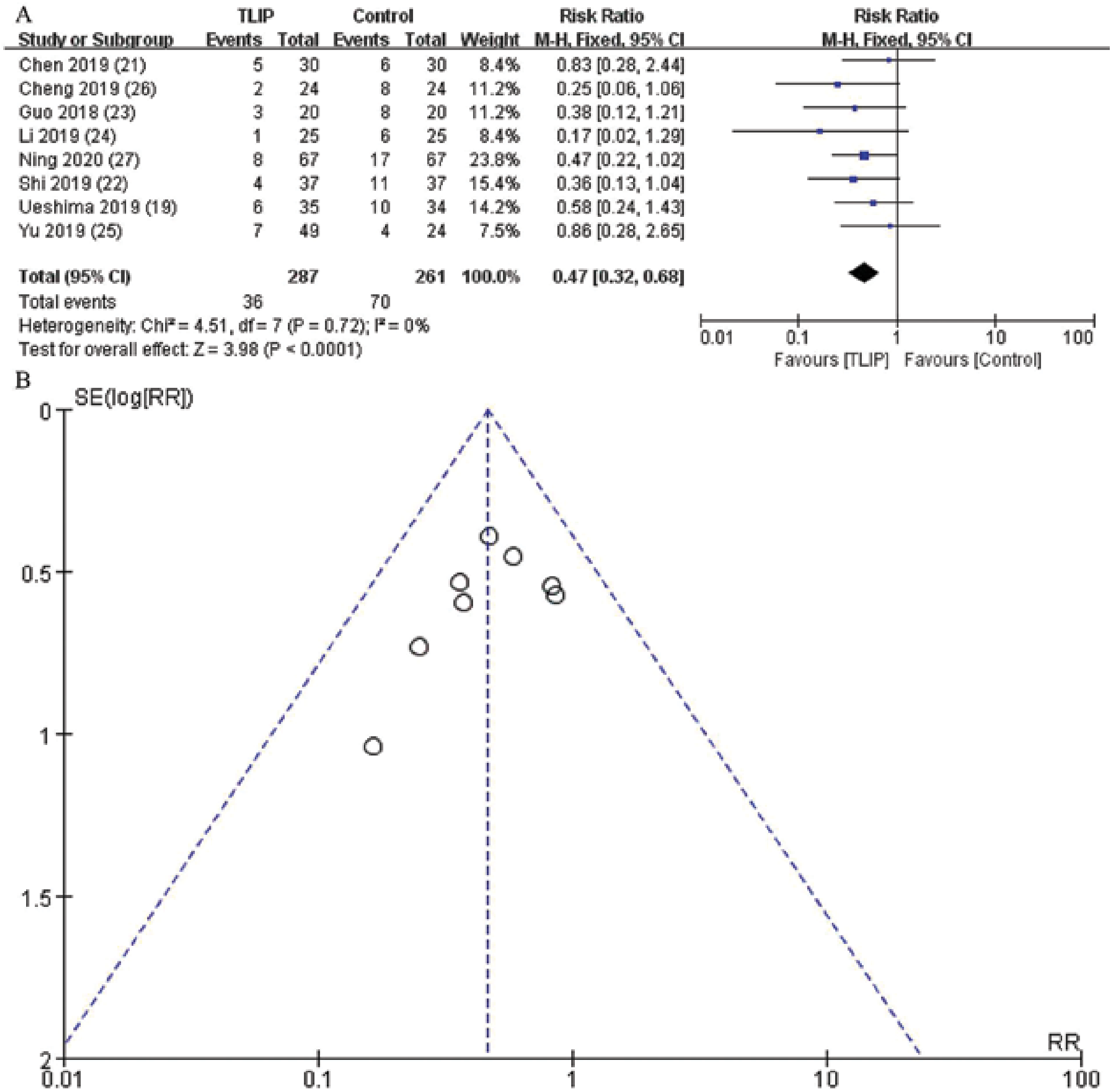

Fig 6. *A: Forest plot for the meta-analysis of nausea rates; B: Funnel plot regarding nausea rates. [95% CI: 95% confidence intervals, df: degrees of freedom, Random: random effects model, Fixed: fixed effects model, IV: inverse variance]*

analysis for it. Larger sample research studies with larger patient populations are necessary and urgently needed to demonstrate the effect of surgical methods on VAS scores.

Similarly, because of the significant heterogeneity (I^2 = 92%) in VAS scores at 24 h postoperatively during movement, a sensitivity analysis was performed by deleting the Chen et al study. After that, the pooling results of the remaining 4 RCTs showing I^2 = 0%, and notable differences still existed regarding VAS scores between the TLIP group and the control group (Fig. 4F). Several possible explanations may account for this finding. Firstly, local anesthetics had no uniform standards among 5 RCT studies. Dosing and safety were not appraised in any of the included RCT studies. There were significant differences in the safe doses of different local anesthetics, which might cause differences in the duration of TLIP block and ultimately affect VAS scores. For instance, the local anesthetic used in the Chen et al study is ropivacaine, the concentration of which was 0.375%, and the bilateral injection volume was 30 mL. The concentrations of ropivacaine used in the other 2 RCTs were 0.25% and 0.5%, respectively, and the bilateral injection volume was 40 mL. And in one RCT, the local anesthetics was levobupivacaine at a concentration of 0.375%, and the bilateral injection volume was 40 mL. And in one RCT, the local anesthetics were bupivacaine at a concentration of 0.25% + lidocaine at a concentration of 1% and the bilateral injection volume was 40 mL. Meanwhile, different local anesthetics have different half-lives, possibly leading to different effects on VAS scores at different times. As a result, there is a high degree of heterogeneity among studies. Thus, choosing the optimum anesthetic type, dose, and concentration, should be taken seriously and is important in postoperative pain relief. Secondly, VAS scores at movement 24 h postoperatively in patients who received TLIP block in the Chen et al study were markedly lower than the other four studies. VAS scores were not the primary outcome in the Chen et al study, which also led to a high degree of heterogeneity. Taken together, it is suggested that we should focus more on the primary outcomes in the design of clinical trials in the future, which are regarded as an important step.

In terms of PCA compression frequency and consumption, this meta-analysis showed that the TLIP group present a critical reduction compared to the control group. The TLIP group displayed markedly lower postoperative complications such as nausea than the control group. Regarding these results, we speculated the main reason was the advantage of the anatomical structure. The placement of local anesthetic in the thoracolumbar interfascial plane between the paraspinal muscles keeps it from being washed away. In a cadaveric study in which TLIP block technique was performed, the injected solution spread over the transverse process and colored the dorsal rami between the first and fourth lumbar nerves (34). Consequently, we believe that TLIP block can enhance the duration and quality of analgesia, which eventually can reduce postoperative PCA compression frequency and consumption. But there was significant heterogeneity among the studies. We speculated that no information was available concerning patients' VAS scores preoperatively. The status of preoperative pain could affect postoperative PCA consumption, and thereby might cause a high degree of heterogeneity. Meanwhile, in the included studies, PCA is mostly composed of opioids, while opioid-related adverse events are numerous actually, mainly including nausea and vomiting (35). In common with our study, Ahiskalioglu et al (14) showed that patients who received TLIP block consumed less PCA and suffered fewer incidences of nausea after lumbar spine surgery. Thus, it is important to underline that reducing PCA consumption is regarded as another meaningful step postoperatively.

Although this meta-analysis demonstrated that the TLIP block could be applied in postoperative pain relief undergoing lumbar spine surgery, there are several limitations in the results. First of all, there were only 9 RCTs with 618 patients included in this meta-analysis, and the sample size was still small, so more high-quality RCTs with large samples will be urgently required for stronger evidence to support TLIP block in lumbar spine surgery. Second, the detailed methods and procedures of lumbar spine surgery were different, which may lead to the risk of bias and high heterogeneity. Thirdly, the type, dose, concentration of local anesthetics, and PCA in the included studies were different, which might have a significant effect on the postoperative pooling VAS scores. Moreover, VAS scores were not evaluated before lumbar spine surgery, which might also affect postoperative VAS scores.

Conclusion

The TLIP block can provide effective postoperative analgesia for lumbar spine surgery, decrease postoperative VAS scores, and reduce PCA compression frequency and PCA consumption compared to PCA alone after lumbar spine surgery. In addition, the TLIP block significantly reduces the side effects of nausea. However, further studies are needed to testify these benefits, and more high-quality RCTs are still necessary and urgently required for further research.

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