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Comparative effectiveness of fascial plane blocks for postoperative analgesia in laparoscopic sleeve gastrectomy: a systematic review and network meta-analysis of randomized controlled trials

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Abstract

Introduction:

Globally, laparoscopic sleeve gastrectomy (LSG) is the most frequently performed bariatric surgery. Multiple fascial plane blocks are used for postoperative analgesia, but their comparative efficacy remains unclear.

Methods:

A systematic search through January 2026 identified controlled trials comparing fascial plane blocks —including TAP, ESPB, QL, EOI, M-TAPA, PVB, and RS — against each other, Placebo, systematic analgesia (SA), or port-site infiltration (PSI) in LSG. The primary outcome was 24-hour opioid consumption (morphine milligram equivalents, MME). Secondary outcomes included pain scores at 2 to 24 hours, postoperative nausea and vomiting (PONV), and complications. A frequentist network meta-analysis was conducted, with certainty of evidence appraised by GRADE.

Results:

Twenty-three Randomized Controlled Trials (RCTs) included 2,005 patients were included. The EOI block achieved the greatest opioid-sparing effect versus SA (mean difference [MD] – 19.66 mg MME; SUCRA 83%). At 24 hours, only ESPB significantly reduced pain intensity (MD -0.44). The QL block significantly decreased PONV incidence compared to placebo (odds ratio 0.31). No major block-related adverse events were reported. Overall, the quality of evidence ranged from moderate to low.

Conclusions:

Fascial plane blocks are effective and safe for analgesia after LSG. The EOI block offers superior opioid reduction, ESPB provides sustained pain relief, and QL reduces PONV. Selection of techniques should be individualized based on patient and institutional factors.

Key Points

• EOI block ranked highest in reducing 24-hour opioid use (SUCRA 83%).

• ESPB uniquely reduced pain significantly at 24 hours post-surgery.

• QL block significantly reduced PONV incidence versus Placebo (OR 0.31).

• No major complications were reported in 23 RCTs using fascial blocks.

Introduction

LSG is the most frequently performed bariatric surgery worldwide, representing approximately 61% of bariatric procedures in the United States in 2025, followed by Roux-en-Y gastric bypass (RYGB) at 17% [1]. Effective postoperative analgesia is crucial to enhance recovery, minimize opioid related adverse effects, and promote early mobilization. Pain after LSG is multifactorial, comprising somatic pain from incisions and trocar sites, visceral pain due to surgical manipulation and peritoneal distension, and referred shoulder pain secondary to diaphragmatic irritation by residual pneumoperitoneum [2–4]. These pain components involve distinct pathophysiological mechanisms, necessitating target analgesic strategies.

Ultrasound -or laparoscopy-guided fascial plane blocks —including the transversus abdominis plane (TAP), erector spinae plane (ESPB), quadratus lumborum (QL), and external oblique intercostal (EOI) blocks, and other more recent techniques— have been evaluated for postoperative analgesia after LSG. However, existing evidence is primarily limited to pairwise comparisons, lacking a comprehensive synthesis that simultaneously evaluates all available regional techniques. This gap hinders clear understanding of their relative efficacy and complicates evidence-based clinical decision-making. A network meta-analysis (NMA) allows integration of direct and indirect evidence, providing a comparative ranking of multiple intervention and addressing this critical need.

The primary aim is to compare the relative efficacy of fascial plane blocks in reducing 24-hour opioid consumption, pain intensity, and the incidence of PONV. Secondary objectives included ranking interventions by efficacy and safety, as well assessing network consistency and transitivity.

Methods

Study Design and Registration

This systematic review and network meta-analysis was conducted following the Preferred Reporting items for Systematic Review and Meta-Analyses extension for network meta-analyses (PRISMA-NMA) guidelines [5]. The protocol was prospectively registered in an international systematic review registry.

Selection Criteria

Studies were selected based on the PICOS framework as follows:

- Population: We included RCTs enrolling adult patients (≥ 18 years) with obesity undergoing primary, elective laparoscopic sleeve gastrectomy (LSG).

- Interventions: Eligible interventions consisted of ultrasound- or laparoscopy- guided bilateral fascial plane blocks performed either prior to the induction of general anesthesia or under general anesthesia. These blocks included, but were not limited to, the TAP any approach, ESPB, QL, EOI, modified thoracoabdominal nerve block via perichondral approach (M-TAPA), paravertebral block (PVB) and rectus sheath block (RS).
- Comparators: Comparators comprised other fascial plane blocks, Placebo or sham blocks, standard systemic analgesia (SA), and local anesthetic port-site infiltration (PSI).
- Outcomes: the primary outcome was cumulative postoperative opioid consumption within 24 hours, standardized to intravenous morphine milligram equivalents (MME). Secondary outcomes included postoperative pain intensity (VAS or NRS scale) at 2, 6, 12, and 24 hours; incidence of PONV, and block-related complications.
- Study design: Only parallel-group RCTs were eligible for inclusion.

Exclusion criteria: encompassed non-randomized or quasi-randomized studies, conferences abstracts, editorials, and studies not published in English or Spanish. Trials involving revisional bariatric surgery, procedures other than sleeve gastrectomy (e.g, Roux-en-Y gastric bypass), or concomitant surgeries were excluded. Studies combining fascial plane blocks with other regional anesthesia techniques (such as epidural or spinal anesthesia) that prevented isolation of the fascial block effect, as well as those administering unilateral blocks, were also excluded.

Search Strategy and Data Sources

A comprehensive literature search was performed across PubMed, Scopus, Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Library, and LILACS, covering all records from inception through January 21, 2026. The search combined controlled vocabulary (MeSH) and free-text terms related to “sleeve gastrectomy”, “fascial plane block”, “erector spinae plane block”, “transversus abdominis plane block”, “quadratus lumborum block” and “postoperative pain”. Detailed search strategies for each database are provided in the Supplementary Material (Appendix 1). To identify ongoing and unpublished trials, ClinicalTrials.gov and the WHO international Clinical Trials Registry Platform (ICTRP) were systematically searched. Additionally, citation tracking and forward/backward reference screening of included studies and relevant reviews were conducted with the AI-based tool Research Rabbit to ensure comprehensive literature capture.

Study Selection

Two independent reviewers (## and ##) screened titles and abstracts using Rayyan against predefined eligibility criteria. Full texts of potentially relevant articles were independently by the same reviewers. Discrepancies were resolved through discussion or consultation of a third reviewer (#). The selection process was documented following the PRISMA flow diagram.

Data Extraction

Data was independently extracted by three reviewers (##, ## and ##) using a standardized piloted form. Extracted variables included study identifiers, patient demographics (age, sex, BMI, comorbidities), intervention details (block type, anesthetic agent, volume, concentration, timing), comparators, co-interventions, and outcome measures (means, standard deviations, event counts). For studies reporting medians and interquartile ranges, means and SDs were estimated using Wan et al method [6]. Total opioid consumption at 24 hours was standardized to intravenous morphine milligram equivalents (MME) via established equianalgesic conversions (http://www.globalrph.com/narcotic). When only 48-hour cumulative consumption was reported, 24-hour consumption was imputed assuming linear opioid use.

Risk of Bias

Methodological quality of individual studies was independently assessed by two reviewers (## and ##) using the Cochrane RoB-2 tool for randomized controlled trials [7]. Five domains were evaluated: randomization process, deviations, from intended interventions, missing outcome data, outcome measurement, and selective reporting. Discrepancies were resolved by consultation with a third reviewer (##).

Statistical Methods

The primary outcome, cumulative 24-hour opioid consumption, was expressed as mean difference (MD) with 95% confidence intervals (CIs), standardized in intravenous MME. Secondary continuous outcomes, including pain scores (VAS/NRS 0–10) were also analyzed using MD with 95% CIs. Dichotomous outcomes, such as postoperative nausea and vomiting (PONV) incidence and block-related complications, were quantified using risk ratios (RR) or odd ratios (OR) with 95% CIs.

A frequentist random-effects NMA was performed using the *netmeta* package in R (version 4.1; R Foundation for Statistical Computing, Vienna, Austria). Network geometry was depicted via diagrams where node size reflected patient numbers and edge thickness indicated the number of direct comparisons. Intervention hierarchy was determined using the surface under the cumulative ranking curve (SUCRA) values and mean ranks, with higher SUCRA scores indicating greater likelihood of superior efficacy. Transitivity was qualitatively assessed by comparing distributions of key effect modifiers such as BMI, age, and anesthesia protocols.

Inconsistency, heterogeneity, publication bias analysis and certainty of evidence

Statistical heterogeneity within direct comparison was measured using the I^2 and Tau^2. Inconsistency was evaluated globally via the design-by-treatment interaction model and locally through node-splitting for each closed loop, with p-values 0.05 indicating significant inconsistency. Publication bias was assessed for the outcomes using comparison adjusted funnel plots and Egger´s regression test when at least ten studies were available.

Certainty of evidence for primary and key secondary outcomes was appraised using the GRADE approach adapted for NMA [8], considering risk of bias, indirectness, inconsistency, imprecision, and publication bias.

Results

Study selection

The initial search yielded 519 records; after removing 118 duplicates, 401 titles and abstracts were screened. Of these, 284 were excluded for not meeting inclusion criteria, resulting in 117 reports sought for full retrieval. Seven were unavailable, leaving 110 full-text articles assessed for eligibility. Following detailed review, 87 were excluded due to study design (n = 35), inappropriate intervention (n = 21), population criteria (n = 13), publication type (n = 10), irrelevant outcomes (n = 6), or language (n = 2). Ultimately, 23 RCTs met all criteria and were included (Fig. 1). Full details of the search strategy are available in Supplementary Material.

Characteristics of included studies

The 23 RCTs encompassed 2,005 adult patients undergoing LSG, published between 2014 and 2026. Studies were predominantly conducted in Turkey (n = 8), Egypt (n = 5), and China (n = 4), with others from Saudi Arabia, Italy, Thailand, and the USA. Participant age ranged from 30.4 to 43.3 years; BMI ranged 35.6–50.9 kg/m². Female patients predominated in most trials, with proportions from 24% to 95%. Reporting on obesity-related comorbidities was variable, with type 2 diabetes prevalence ranging 6.7–45.7%, hypertension 6.7–61%, and obstructive sleep apnea 0-98.7%.

Interventions and Comparators

The 23 trials evaluated 13 distinct analgesic interventions, grouped as follows:

- **Fascial plane blocks**: Erector spinae plane block (ESPB, n = 354 patients), Transversus abdominis plane bloc (TAP) and variants, including subcostal TAP (n = 251), laparoscopic-guided TAP (LAP-TAP, n = 134), continuous laparoscopic TAP block (LAP-TAPCont, n = 45), and oblique subcostal TAP (OSTAP, n = 21), Quadratus lumborum block (QLB, n = 152), External oblique intercostal block (EOI, n = 118), Modified thoracoabdominal nerve block via perichondrial approach (M-TAPA, n = 58), Paravertebral block (PVB, n = 53), and Rectus sheath block (RS, n = 35).
- **Comparators**: Placebo or sham block (n = 345), systemic analgesia (SA, n = 288), and port-site infiltration (PSI, n = 148).

TAP blocks and ESPB were the most frequently studied (each in eight trials). SA served as the predominant control in eight studies, placebo in six, and PSI in five. Other interventions were less commonly evaluated. Substantial heterogeneity existed in block protocols regarding anesthetic type (mainly bupivacaine 0.25%, and ropivacaine 0.33–0.5%), volume (15-60ml per side), and timing (pre-incision, post induction, or post-surgery). Baseline patient characteristics and rescue analgesia regimen were relatively consistent, supporting transitivity in the network.

Rescue Analgesia and Opioid Consumption

All included trials reported postoperative opioid consumption within 24 hours, standardized to intravenous morphine milligram equivalents (MME). Rescue analgesia protocols varied, most commonly involving patient-controlled analgesia (PCA) using opioids such as morphine, tramadol, fentanyl, oxycodone or nalbuphine. Control groups showed wide variation in baseline opioid use (0.140 to 88.1 MME), reflecting institutional differences in perioperative pain management. Detailed study characteristics are summarized in Table 1.

Table 1
Baseline characteristics of included randomized controlled trials

Author (year)	Country	Groups (n)	Age ± DE	BMI ± DE	F (%)	T2D (%)	HTA (%)	OSA (%)	Block Characteristics	Control Group (type)	Rescue Analges route)
Kavakli A[9] (2024)	Turkey	EOI (28) SA (29)	36.3 ± 12.1 38.0 ± 11.7	44.7 ± 5.3 45.5 ± 7.2	53.6 69	NR	NR	25 34.5	EOI Block: Bilateral at 6th -7th rib, bupivacaine 0.25%, 20ml per side (40ml total). Post-induction, US-guided	Systemic analgesia. All patients received intraop tramadol 100mg and paracetamol 1g.	PACU: Morphine bolus if NRS ≥ 4 PCA Morphine (bolus 1mg, lock + Rescue: Dexk 50ml IV (max 4x
Ozel ES[10] (2025)	Turkey	EOI (30) SA (30)	32.9 ± 11.6 36.9 ± 10,7	42.4 ± 4.5 43.4 ± 6.2	76.7 83.3	40 11.8	6.7 11.8	0 11.8	EOI Block: bilateral at 6th -7th rib, bupivacaine + epinephrine, 30ml per side (60ml total). Preoperative (30min before surgery), US-guided. Block success confirmed by dermatomal assessment	Systemic Analgesia. All patients received intraop tenoxicam 20mg, tramadol 100mg, and morphine 0.05 mg/kg/IBW.	PCA Morphine (bolus, lockout 1 Rescue: Meperi IV in PACU or 5(Ward for NRS ≥
Yang G[11] (2024)	China	ESPB (54) PVB (53)	31.6 ± 6.4 32.5 ± 5.8	35.9 ± 2.4 35.8 ± 2.5	74.1 79.2	NR	NR	NR	ESPB: Ropivacaine 0.33%, 20ml per side (T8, pre-incision, ultrasound-guided) PVB: Ropivacaine 0.33%, 20ml per side (T8, pre-incision, ultrasound-guided)	ESPB vs PVB	PCA with oxyco 20mg + flurbipr 200mg in 100m (bolus 5ml, lock no basal infusic
Turunc E [12] (2024)	Turkey	EOI (30) M-TAPA (28)	34.1 ± 10.5 37.9 ± 12.6	44.5 ± 4.6 45.7 ± 6.6	73 71.4	20 14.3	10 10.7	0 7.1	EOI Block: Bilateral, bupivacaine 0.25%, 30ml per side (60ml total). Post-surgery, pre-extubating, US-guided. M-TAPA Block: Bilateral, bupivacaine 0.25%, 30ml per side (60ml total). Post-surgery, pre-extubating, US-guided	EOI vs M-TAPA. Both groups received multimodal analgesia	PCA Morphine (bolus, lockout 8 rescue meperid iv in PACU or 5(ward for NRS ≥
Ul Huda A [13] (2024)	Saudi Arabia	ESPB (25) SA (25)	39.13 ± 8.52 33.33 ± 13.3	NR	24 64	NR	NR	NR	ESPB T9 bilateral, ropivacaine 0.25%, 15 ml per side (30ml total) (Post-induction, US-Guided)	Systemic analgesia	PCA morphine (1mg bolus, 8mi no basal) + resc morphine 2mg i
Wang Y[14] (2023)	China	ESPB (76) Placebo (75)	32.8 ± 6.5 33.0 ± 6.4	37.6 ± 3.9 38.4 ± 5.9	87 89	22 19	18 15	42 48	ESPB: bilateral at T7, ropivacaine 0.33%, 30ml per side (60ml total). Pre-intubation, USG-guided	Placebo block: 0.9% saline 30ml per side). All patients received multimodal analgesia (intraop flurbiprofen, PCA oxycodonde/flurbiprofen	PCA Oxycodone flurbiprofen 300 100ml (bolus 5r 5min) + rescue 40ml IV for VAS
Doymus O [15](2024)	Turkey	EOI (30) PSI (30)	39.2 ± 11.6 37.8 ± 13.2	46.5 ± 3.3 47.04 ± 6.04	73.3 70	NR	NR	NR	EOI block: Bilateral, bupivacaine 0.25% 30ml per side (60ml total). Preoperative, US-	PSI (Port-site infiltration): Bupivacaine 0.25%, 5ml per port (5 ports, 25ml total). Post intubation, pre-incision, surgeon administered.	PCA Fentanyl (1 bolus 25mcg, lo min, no basal) + Meperidine 25m PACU for VAS ≥

NR: Nor reported, MME: Morphine Milligram Equivalents, ESPB: Erector spinae plane block, PVB: paravertebral block, TAP: Transversus Abdominis Plane Blo transversus abdominis plane block, OFA: Opioid-Free Anesthesia, T2D: Type 2 Diabetes, OSA: Obstructive Sleep Apnea, VAS: Visual Analog Scale, PCA: Patie

Author (year)	Country	Groups (n)	Age ± DE	BMI ± DE	F (%)	T2D (%)	HTA (%)	OSA (%)	Block Characteristics	Control Group (type)	Rescue Analges route)
									guided (45min before surgery)		
Catalgo R [16](2024)	Italy	LAP-TAP (54) Placebo (56)	43.2 ± 11.1 43.3 ± 12.2	42 ± 4.3 42.9 ± 4.9	75.9 75	11.1 10.7	22.2 26.8	9.3 8.9	LG-TAP Block: Bilateral, ropivacaine 0.5%, 15ml per side (30ml total). At start of surgery, after trocar placement, surgeon administered, laparoscopic guided.	Placebo (0.9% saline 15ml per side, same technique).	PACU: Fentanyl for NRS ≥ 6 unti Ward: Paracetar q8h, Ketorolac 3 NRS ≥ 6 (max 9(Rescue: Morphi for NRS ≥ 6 (ma
Karaveli A [17] (2025)	Turkey	ESPB (20) SA (20)	40.1 ± 13.6 41.5 ± 12.4	43.2 ± 4.1 43.1 ± 3.2	95 85	25 25	30 25	NR	ESPB: Bilateral at T7, bupivacaine 0.25%, 20ml per side (40ml total). Preoperative, US-guided. Block success confirmed by cold test.	SA (systemic analgesia). All patients received multimodal analgesia (intraop paracetamol, tramadol; postop paracetamol q8h)	Rescue: Tramac IV for NRS ≥ 4
Ghandour MAM [18] (2026)	Egypt	QL (22) PSI (22)	35.3 ± 8.1 36.2 ± 11.4	44.2 ± 3.9 44.2 ± 3.6	68.2 72.7	18.2 22.7	22.7 13.6	NR	QL block: Transmuscular approach, bupivacaine 0.25%, 30ml per side (60ml total). Preoperative, US-guided	PSI: preperitoneal infiltration Bupivacaine 0.25%, 60ml total, infiltrated in preperitoneal space around trocars. Intraop laparoscopic-guided	Morphine 0.1mg IV bolus q4-6h f (max 10mg). Pa 1g q6h and Keto 30mgq12h
Said AM[19] (2017)	Egypt	LAP-TAPCont (45) SA (45)	32.1 ± 4.9 32.8 ± 5.4	36.1 ± 2.4 35.6 ± 2.7	68.9 62.2	11.9 8.9	8.9 6.7	NR	TAP Continuous: Bilateral continuous TAP block via laparoscopically placed catheters, bupivacaine 0.25% infusion at 4ml/per side (total 96ml/24h). Intraop surgeon-administered, laparoscopic-guided	SA (systemic analgesia) with IV morphine	Morphine 2.5mg NRS ≥ 4
Xue Q [20] (2022)	China	TAP block (76) QL block (76) Placebo (73)	30.4 ± 7.5 32.7 ± 6.9 32.4 ± 7.3	43.3 ± 7.5 41.8 ± 5.2 42.2 ± 6.1	73.6 77.6 73.9	31.6 30.3 31.5	34.2 32.9 38.4	96.1 98.7 95.9	TAP block: Bilateral subcostal approach, ropivacaine 0.33% + dexmedetomidine 1mcg/kg, 30ml total. Pre-anesthesia, US-guided QL block: Bilateral transmuscular approach, ropivacine 0.33% + dexmedetomidine 1mcg/kg, 30ml total. Pre-anesthesia, US-guided	Placebo (0.9% saline 30ml, injected in TAP or QL plane). All patients received intraoperative dexmedetomidine and postop PCA with sufentanil	PCA: Sufentanil +dexmedetomic (2mcg/kg) in 4ł Rescue: Nalbufi IV in PACU or Di lidocaine 75mg for VAS ≥ 4
Samerchua A[21](2026)	Thailand	RS (35) PSI (34	33 ± 5.2 35.5 ± 11.9	42.9 ± 6 43.4 ± 8.6	28.6 32.3	45.7 38.2	48.6 55.9	91.4 85.3	RS block: Bilateral rectus sheath block, bupivacaine 0.25% + lidocaine 1% + epinephrine + dexamethasone 10mg, 20ml per side (40ml total).	PSI: Same local anesthetic mixture (40ml total) infiltrated at port sites. Intraoperative, surgeon administered, laparoscopic guided	PACU: Morphine 0.03mg/kg IV q NRS ≥ 4. Immed rescue for NRS Morphine 0.03n q4h

NR: Nor reported, MME: Morphine Milligram Equivalents, ESPB: Erector spinae plane block, PVB: paravertebral block, TAP: Transversus Abdominis Plane Blo transversus abdominis plane block, OFA: Opioid-Free Anesthesia, T2D: Type 2 Diabetes, OSA: Obstructive Sleep Apnea, VAS: Visual Analog Scale, PCA: Patie

Author (year)	Country	Groups (n)	Age ± DE	BMI ± DE	F (%)	T2D (%)	HTA (%)	OSA (%)	Block Characteristics	Control Group (type)	Rescue Analges route)
									Pre-incisional, US-Guided		
Mu T[22] (2025)	China	ESPB (84) TAP (84)	30.5 ± 7.14 31.7 ± 7.8	37.2 ± 4.8 37.7 ± 5.7	67.9 65.5	15.5 22.6	10.7 21.4	25 16.7	ESPB: Bilateral at T9, ropivacaine 0.33%, 20ml per side (40ml total). Preoperative, US-guided TAP: Subcostal approach, ropivacaine 0.33%, 20ml per side (40ml total). Preoperative, US-Guided	ESPB vs TAP. Both groups received multimodal analgesia with PCA tramadol and parecoxib	PCA Tramadol (80ml; infusion 1 bolus 1ml, lock + Rescue Flurbi axetilo 100mg I ≥ 4 (max 200mg
Ashor TM[23] (2023)	Egypt	ESPB (32) QLB (34) Placebo (35)	33.8 ± 5.4 34.3 ± 6.8 34.7 ± 6.7	45.6 ± 4.1 45.2 ± 4,4 44.4 ± 4.8	81.3 85.3 82.9	12.5 8.8 8.6	46.9 41.2 42.9	NR	ESPB: Bilateral at T7, bupivacaine 0.25%, 30 ml per side (60ml total). Post-surgery, pre-extubating, US-guided QLB: posterior approach, bupivacaine 0.25%, 30ml per side (30ml total). Post-surgery, pre-extubation, US-guided	Placebo: Sham block (subcutaneous 0.9% saline 2ml at each block site). All patients received standardized analgesia (acetaminophen 1g q6h, PCA nalbufina)	PCA nalbufina (infusion 2mg/h, 0.5mg, lockout Rescue ketorola for breakthroug (max 120mg/da
Abdelhamid BM [24] (2020)	Egypt	ESPB (22) TAP (22) SA (22)	37.1 ± 10.4 35.9 ± 8.8 35.7 ± 8.6	44.7 ± 2.5 35.9 ± 8.8 35.7 ± 8.6	68.2 40.5 45.5	NR	NR	NR	ESPB: bilateral at T9, bupivacaine 0.25%, 15ml per side (30ml total). Post-induction, US-guided TAP: subcostal approach, bupivacaine 0.25%, 30ml per side (60ml total). Post-induction, US-Guided	SA: systemic analgesia with opioids, all patients received acetaminophen 1g q6h	Acetaminophen VAS ≥ 3 + Rescu pethidine 50mg ≥ 5
Coskun M[25] (2019)	Turkey	TAP (21) PSI (21)	42.4 ± 9.2 38.7 ± 10.4	50.2 ± 7.2 48.4 ± 7.2	81 57.1	23.8 14.3	28.6 28.6	NR	TAP: subcostal approach, bupivacaine 0.5%+lidocaine 2%, mixture, 20ml per side (40ml total). Post-intubation, pre-incision, US-guided	PSI: bupivacaine 0.25%, 5ml per port (5 ports, 25ml). At start of surgery, surgeon-administered, laparoscopic-guided.	PCA Tramadol (bolus, 10mg, loc 10min). Acetam 1g IV q6h
Tülübaş EK[26] (2019)	Turkey	LAP-TAP (80) Placebo (85)	37.9 ± 10.61 37.8 ± 10.14	48.03 ± 6.77 50.96 ± 8.73	62.5 61.1	25 38.8	12.5 38.8	NR	LapTAP: Laparoscopic-guided bilateral TAP block (Petit triangle + subcostal), bupivacaine 0.25%, 20ml in Petit triangle + 10ml subcostal per side (60ml total). Intraop, surgeon-administered	Placebo (0.9% saline, same volume an technique). All patients received premedication (acetaminophen 1gr, tramadol 100m, midazolam 3mg IV) and postop PCA with tramadol	PCA tramadol (bolus 10ml, loc 12min, no basa Tenoxicam 20m and 8h postop

NR: Nor reported, MME: Morphine Milligram Equivalents, ESPB: Erector spinae plane block, PVB: paravertebral block, TAP: Transversus Abdominis Plane Blo transversus abdominis plane block, OFA: Opioid-Free Anesthesia, T2D: Type 2 Diabetes, OSA: Obstructive Sleep Apnea, VAS: Visual Analog Scale, PCA: Patie

Author (year)	Country	Groups (n)	Age ± DE	BMI ± DE	F (%)	T2D (%)	HTA (%)	OSA (%)	Block Characteristics	Control Group (type)	Rescue Analges route)
Ibrahim M[27] (2014)	Egypt	OSTAP (21) PSI (21) Placebo (21)	38.3 ± 10.2 36.7 ± 9.3 37.4 ± 11.3	48.5 ± 10.4 46.1 ± 9.3 46.4 ± 8.7	76.2 71.4 66.6	NR	NR	NR	OSTAP: Oblique subcostal TAP block, bupivacaine 0.25%, 30ml per side (60ml total). Pre-incision, US-guided PSI: port site infiltration, bupivacaine 0.25%, 30ml total divided into 4 ports. Pre-incision, surgeon-administered	Placebo: saline TAP (30ml/site) + saline infiltration (30ml total). All patients received standardized analgesic (acetaminophen, lornoxicam)	PACU: fentanyl IV, morphine 1– meperidine 20-4 moderate-sever Ward: Acetamin IVq6h, lornoxica IVq12 + Rescue 2-6mg IVq3h
Helmy[28] (2025)	Egypt	ESPB (41) SA (40)	39.8 ± 12.2 37.1 ± 12.4	45.8 ± 3.0 45.9 ± 3.5	46.3 55	12.2 38	61 60	NR	ESPB: bilateral at T8, (10ml bupivacaine 0.5 + 5ml lidocaine 2% + 5ml saline per side mixture), 20ml per side (40ml total). Post-surgery, pre-extubating, US-guided	SA: systemic analgesia. All patients received multimodal analgesia (intraop ketorolac, acetaminophen)	Acetaminophen Ketorolac 60mg dose at 6h + Re Nalbuphine 5mg NRS ≥ 4
Baytar C[29] (2025)	Turkey	M-TAPA (30) SA (30)	34.8 ± 9.4 34.5 ± 10.3	46.7 ± 5.4 48.6 ± 6.3	70 83.3	NR	NR	NR	M-TAPA: Block bilateral at 10th costal cartilage, bupivacaine 0.25%, 20ml per side (40ml total). Post-intubation, pre-incision, US-guided	SA: systemic analgesia. All patients received multimodal analgesia (intraop lidocaine, acetaminophen, tramadol)	PACU: fentanyl for NRS ≥ 4. Ward: PCA Tran (bolus 10mg, lo 20min, no basal Rescue: diclofe IM or Pethidine IV LBW for NRS
Shariat A[30] (2025)	EE.UU	QLB (20) PSI (20)	36.53 ± 9.6 38.17 ± 11.5	42.8 ± 6.4 42.6 ± 4	80 85	NR	NR	NR	QLB: posterior Quadratus Lumborum block): bilateral, posterior approach, bupivacaine 0.25%, 15ml per side (30ml total). Post-surgery, pre-extubating, US-guided	PSI: bupivacaine 0.25%, 30ml total infiltrated into port incision by surgeon at closing	Acetaminophen IV q6h for VAS ≤ Rescue: Hydron 0.3mg IV q4h fo pain VAS ≥ 6
Sherif A [31] 2015	Egypt	TAP (48) SA (47)	40.9 ± 8.75 40.4 ± 8.71	38.7 ± 2.17 38.9 ± 2.18	20.8 25.5	NR	NR	NR	TAP block: Bilateral, bupivacaine 0.5%, 20ml per side (40ml total). Postoperative (pre-extubating), US-guided	SA: All patients received PCA morphine and acetaminophen	PCA morphine (lockout 20min, 10mg/6h)+acet 1g IV q6h

NR: Nor reported, MME: Morphine Milligram Equivalents, ESPB: Erector spinae plane block, PVB: paravertebral block, TAP: Transversus Abdominis Plane Blo transversus abdominis plane block, OFA: Opioid-Free Anesthesia, T2D: Type 2 Diabetes, OSA: Obstructive Sleep Apnea, VAS: Visual Analog Scale, PCA: Patie

Risk of bias

Risk of bias were assessed via the Cochrane RoB-2 tool. Seven studies (30.4%) were low risk, eleven (47.8%) raised some concerns, and five (21.7%) were high risk. The main source of bias was lack of blinding (Fig. 1 Supplemental Material).

Network Geometry

The primary outcome network included 23 RCTs assessing 10 interventions, forming fully connected structures (Fig. 2), enabling estimation of relative effects through direct and indirect evidence. ESPB and SA had the largest patient numbers and study counts. Key direct comparisons included EOI versus SA, ESPB versus TAP (each in two studies). Some interventions, such as M-TAPA versus SA and RS versus PSI, were evaluated by single direct comparisons. Multiple close loops (ESPB-TAP-Placebo) facilitated consistency assessments. No disconnected subnetworks were identified.

Primary outcome: Postoperative opioid consumption at 24h

All 23 studies (2,005 patients) contributed data for the primary outcome [9-]. Forest plots (Fig. 3) demonstrated a general opioid-sparing trend for most fascial blocks versus Placebo; however, 95% CIs were wide and often included the null effect. The EOI blocks showed the greatest Mean Difference (MD) favoring opioid reduction (MD -16.03 mg MME; 95% CI -39 to 7.53). Notably, EOI significantly decreased opioid consumption compared to SA by 19.66 mg MME (MD -19.66; 95% CI -36.69 to -2.64). No fascial block demonstrated statistically significant superiority over others in pairwise comparisons (see Table 1, Supplementary material). SUCRA ranking identified EOI as the most effective for reducing opioid use, followed by PVB and ESPB (Table 2). Node-splitting detected significant inconsistency between EOI and PSI comparisons (p = 0.041), while other comparisons were consistent. GRADE rated evidence quality as moderate for ESPB and QL versus Placebo (limited by heterogeneity), low for TAP versus Placebo (due to imprecision and bias), and low for EOI and M-TAPA versus Placebo (due to indirect evidence). Funnel plot (Supplementary material Fig. 2) and Egger´s test indicated no publication bias (p = 0.178).

Table 2
SUCRA rankings

MME	EOI	PVB	ESPB	QL	M-TAPA	TAP	OSTAP	RS	PSI	LAP-TAP	LAP-TAPCont	Placebo	SA
	1 (83.00)	**2 (64.60)**	**3 (63.42)**	**4 (62.45)**	**5 (61.87)**	**6 (57.54)**	**7 (53.37)**	**8 (48.82)**	**9 (39.63)**	**10 (35.51)**	**11 (33.29)**	**12 (29.65)**	**13 (16.84)**
Pain 2h	1 (81.89)	8 (41.43)	3 (60.30)	4 (60.04)	6 (59.72)	2 (60.81)	5 (59.78)	-	9 (38.19)	-	7 (57.83)	10 (16.82)	11 (13.20)
Pain 6h	7 (45.80)	9 (43.64)	3 (67.74)	2 (71.03)	8 (44.40)	5 (57.88)	4 (66.48)	1 (80.79)	10 (35.91)	10 (56.63)	-	11 (22.84)	12 (6.85)
Pain 12h	5 (56.58)	6 (53.33)	2 (69.74)	3 (68.95)	7 (52.52)	8 (51.92)	4 (63.35)	1 (86.98)	9 (43.41)	10 (37.27)	11 (34.36)	12 (19.28)	13 (12.32)
Pain 24h	3 (71.01)	10 (40.81)	4 (59.04)	9 (43.33)	8 (51.67)	6 (58.14)	1 (73.6)	7 (55.12)	5 (58.63)	12 (24.88)	2 (72.9)	11 (27.77)	13 (13.11)
PONV	9 (32.45)	4 (76.48)	3 (76.48)	1 (80.32)	6 (51.65)	5 (62.51)	2 (77.50)	11 (22.61)	8 (32.93)	7 (51.26)	-	10 (31.63)	12 (4.11)

Pain score at 2- hours

Fourteen trials involving 1,270 patients assessed pain intensity at 2 hours postoperatively. Network meta-analysis revealed that four fascial plane blocks — EOI, ESPB, QL, and TAP—significantly reduced pain scores compared to Placebo (Fig. 4). The EOI block demonstrated the greatest analgesic efficacy, as indicated by the highest SUCRA ranking, followed by TAP and ESPB. League table analysis confirmed that EOI, TAP, QL, and ESPB significantly reduced pain relative to both Placebo and SA, with no statistically significant differences in head-to-head comparisons among the blocks (Table 2 Supplementary material). Consistency analyses showed no significant discrepancies between direct and indirect comparisons, supporting the robustness of the results. According to GRADE, the quality of evidence was moderate for ESPB, TAP and QL versus Placebo, primarily limited by heterogeneity and risk of bias; low for EOI and M-TAPA due to indirectness; and very low for PSI due to imprecision. Funnel plot (Supplementary material Fig. 3) and asymmetry tests showed no publication bias (p = 0.933).

Pain score at 6- hours postoperatively

Twenty studies with 1,815 patients evaluated pain at 6 hours postoperatively. No regional block achieved statistically significant pain relief compared to Placebo, as all CIs included zero. The RS block showed the larges numerical pain reduction (MD -2.02), though with wide and imprecise CIs. QL and OSTAP blocks demonstrated moderate but non-significant reductions, with ESPB and TAP showing similar modest effects. SA was the only intervention with a non-significant trend toward increased pain (MD 0.71) (Fig. 5). League table analyses indicated that QL, ESPB, and TAP were significantly superior to SA in pain reduction, with QL having the greatest effect size (MD -2.01; 95% CI -3.82 to -0.21). Head-to-head comparisons among regional blocks showed no significant differences, indicating comparable analgesic efficacy at this time point (Table 3 Supplementary material). SUCRA rankings placed RS, QL and ESPB as the top three treatments. No inconsistency was detected, and GRADE rated the evidence quality as moderate for ESPB, TAP, QL, and EOI versus Placebo, and low for EOI, M-TAPA, and ESPB versus TAP (imprecision). Publication bias was not evident (p = 0.81) (Supplementary material Fig. 4).

Pain scores at 12-hours postoperatively

Pain intensity at 12 hours postoperatively was evaluated in 21 trials involving 1,800 patients. Unlike at 6 hours, two regional blocks demonstrated statistically significant superiority over Placebo, with 95% CIs excluding zero: QL (MD -1.26; 95% CI -2.38 to -0.14) and ESPB (MD -1.25; 95% CI -2.30 to -0.19) (Fig. 6). League table analysis confirmed significant pain reduction for ESPB and QL compared to Placebo. Additionally, some regional blocks exhibited significant superiority over SA at this point, including RS (MD -2.56), QL (MD -1.51), ESPB (MD -1.50), EOI (MD -1.20) and TAP (MD -1.12). Head-to-head comparisons revealed no significant differences among fascial plane blocks (Table 4 Supplementary material). According to SUCRA rankings, the top three regional blocks were RS (86.98), ESPB (69.74), and QL (68.95). Inconsistency tests and node-splitting analyses showed no evidence of inconsistency. GRADE assessment rated the quality of evidence as moderate for ESPB, TAP, QL, and EOI versus Placebo (primarily due to substantial heterogeneity), low for EOI and M-TAPA (indirect evidence), and low for ESPB versus TAP (imprecision). Funnel plot inspection (Supplementary material Fig. 5) and Egger´s test indicated no publication bias (p = 0.127).

Pain scores at 24-hours postoperatively

The 24-hour pain assessment included 23 trials with 2,005 patients. ESPB was the only regional block to yield a statistically significant reduction in pain compared to Placebo (MD -0.44; 95% CI -0.85 to -0.03), indicating sustained analgesic effect (Fig. 7). Other interventions showed non-significant trends. Most regional blocks —TAP, ESPB, EOI, QL, and OSTAP—remained significantly superior to SA (Table 5, Supplementary material). However, no fascial plane block, aside from ESPB, significantly reduced pain versus placebo. The highest SUCRA rankings were observed for OSTAP, LAT-TAPCont, and EOI. A significant inconsistency was detected between ESPB and TAP comparisons (p = 0.026), with conflicting direct and indirect evidence. According to GRADE, evidence quality was rated low for ESPB and QL versus placebo, very low for TAP versus placebo due to heterogeneity, and low for EOI, M-TAPA, and ESPB versus TAP due to indirectness, inconsistency, and imprecision. Funnel plot assessment and Egger's test showed no evidence of publication bias (Supplementary Material, Fig. 6).

PONV

Eighteen studies (1,578 patients) assessed PONV incidence. The QL block significantly reduced PONV versus Placebo (odds ratio [OR] 0.31; 95% CI, 0.11–0.90), while other blocks demonstrated favorable but non-significant effects. SA was associated with increased PONV risk compared to placebo (OR 1.54; 95% CI, 0.38–6.20) (Fig. 8). Compared to SA, QL, TAP, and ESPB blocks significantly decreased PONV risk by ~ 70–80% (TAP vs SA OR 0.28; ESPB vs SA OR 0.28), with only QL achieving significance against Placebo (Table 6, Supplementary material). SUCRA rankings placed QL, OSTAP, and ESPB as most effective. Network consistency was generally confirmed, except for ESPB versus SA (p = 0.029). GRADE rated evidence moderate for ESPB, TAP and QL versus Placebo; low for EOI, M-TAP (indirectness), and ESPB versus SA (incoherence). No publication bias was detected (p = 0.089) (Supplementary Material Fig. 7).

Complications associated with Fascial plane blocks

No major block-related complications—such as organ injury, nerve damage, hematoma, or local anesthetic systemic toxicity—were reported across the 23 included studies. Minor adverse events were infrequent. Doymus et al reported pruritus and dry mouth (each 3.3%) in the EOI block group. Ashorr et al described block failure in the ESPB (3.0%) and QL (8.1%) groups, alongside incidences of bradycardia (ESPB 9.4%, QL 14.6%, Placebo 2.9%) and hypotension (ESPB 6.3%, QL 11.8%, Placebo 2.9%). Xue et al observed postoperative hypotension in TAP (28.9%), QL (26.3%), and Placebo (17.8%) groups. Given the low event rates, a network meta-analysis of safety outcomes was not feasible.

Discussion

This NMA of 23 trials (2,005 patients) is the first to simultaneously compare multiple fascial plane blocks for LSG. It demonstrates that several blocks reduce 24-hour opioid consumption compared to SA, with the EOI block achieving a significant reduction (MD − 19.66 MME; 95% CI − 36.69 to − 2.64). SUCRA rankings placed EOI first (83%), followed by PVB and ESPB. At 2 hours, EOI, TAP, QL, and ESPB significantly reduced pain versus placebo. No block reached significance at 6 hours, although QL, ESPB, and TAP outperformed SA. At 12 hours, QL and ESPB maintained significant pain relief, with all major blocks outperforming SA. Only ESPB sustained significant pain relief at 24 hours (MD − 0.44; 95% CI − 0.85 to − 0.03). The QL block also significantly decreased PONV (OR 0.31; 95% CI 0.11–0.90). Direct and indirect comparisons showed no clear superiority among blocks for opioid use, pain or PONV. No serious block-related complications were reported.

Our findings on 24-hour opioid consumption qualitatively align with previous meta-analyses, all demonstrating and opioid-sparing effect on fascial plane blocks. Dost et al. [32] reported a significant opioid reduction of -12.76 mg MME with the EOI block, comparable to our NMA estimate of -19.66 mg MME versus SA, albeit with wider CIs. De Cassai et al. [33], in their NMA including TAP, OSTAP, intraperitoneal anesthesia, and PSI, found no statistically significant opioid reduction versus Placebo, consistent with our finding that all CIs crossed zero versus Placebo. Wu et al. [34] directly compared ESPB and TAP blocks, reporting a -14.22 mg MME opioid reduction for ESPB versus control, like our estimate of -12.29 mg MME versus SA. Consistently, our SUCRA ranking places ESPB ahead of TAP. Lastly, Chaw et al. [35] demonstrated TAP´s superiority over intraperitoneal local anesthetics; our NMA confirm PSI´s consistent inferiority compared to more effective fascial plane blocks. Collectively, our study updates and expands prior knowledge by incorporating newer techniques (EOI, PVB, M-TAP, and RS) and providing a comprehensive ranking absent in previous meta-analyses, although direct and indirect evidence reveals no definitive superiority of any single block.

Our NMA reveals significant variability in analgesic efficacy of fascial plane blocks for LSG: The SUCRA ranking identified the EOI block as most effective in reducing 24-hour opioid consumption and 2-hour postoperative pain, followed by PVB and ESPB. This hierarchy largely reflects differences in the anatomical mechanisms and neural coverage provided by each technique. Somatic blocks such as TAP, RS, M-TAP, EOI provide reliable analgesia of the upper abdominal wall through blockade of the anterior lateral cutaneous branches of thoracolumbar nerves (T6-L1), but they offer limited relief of visceral pain [36–39]. In contrast, deeper blocks like PVB, ESPB and QL can reach paravertebral space and sympathetic chain, allowing modulation of both somatic and visceral pain [40–42]. The superior visceral coverage likely explains the sustained analgesic effect of these blocks observed at later postoperative time points.

Obesity presents technical challenges in performing these blocks, as increased tissue depth in patients with high BMI complicates ultrasound guidance, often requiring convex transducers for blocks such as TAP and QL. The EOI block may offer a practical advantage in this population owing to easily identifiable costal landmarks and its more distal injection site relative to surgical incisions. Conversely, RS blocks may be suboptimal if performed below the arcuate line, where absent posterior rectus sheath can result in ineffective local anesthetic spread [37].

Clinically, the choice of fascial plane block for LSG should be individualized based on specific analgesic goals and patient profile. The EOI block offers the best opioid-sparing effect at 24 hours (-19.66mg MME) and superior early pain control at 2 hours. Its technical ease in the supine position and clear anatomical landmarks make it a preferred first-line option in centers with ultrasound availability and regional anesthesia expertise. Conversely, the ESPB provides most sustained analgesia, maintaining significant pain reduction up to 24 hours postoperatively, favoring its use when prolonged pain control is

anticipated. For patients with a history or high risk of PONV, the QL block offers additional clinical benefit, being the only block to significantly reduce PONV incidence compared to Placebo (OR 0.31). Given the lack of significant differences among most active blocks in direct and indirect comparisons for key outcomes, technique selection can reasonably rely on local resource availability and team expertise. Importantly, the absence of serious complications reported supports the safety of these blocks, endorsing their integration into the enhanced recovery after surgery (ERAS) protocols.

Despite rigorous methodology, this study has limitations that should be considered when interpreting the results. Clinically, considerable heterogeneity existed in block protocols, including variations in anesthetic type, volumes (ranging from 15 to 60 ml per side), concentrations, and timing of administration (pre-incision, post-induction, or immediate postoperative). Rescue analgesia regimens and baseline opioid consumption in control groups also varied widely (0.14 to 88.1 mg MME), reflecting differences in institutional pain management practices. The lack of standardized sensory testing across trials may have introduced undetected block failures, influencing reported pain outcomes. These factors may contribute to wide CIs and inconsistency detected by node-splitting analyses (EOI vs PSI, p = 0.041; ESPB vs TAP, p = 0.026). The strength of some comparisons is limited by the small number trials for certain interventions, such as M-TAPA and RS blocks, often supported by a single direct comparison. Lack of blinding in several primary studies was identified as the main source of bias per RoB-2 assessment. Finally, generalizability is limited, as include studies typically enrolled patients with BMI up to 50.9 kg/m^2, excluding those with extreme obesity (BMI ≥ 55) or several SAOS —subpopulations that may present distinct technical challenges and analgesic needs.

Despite the promising findings of this NMA, key questions remain to consolidate the role of regional anesthesia in LSG. First, adequately powered multicenter randomized controlled trials directly comparing the highest-ranked blocks (EOI, ESPB, and QL) are essential to establish a high-certainty the best treatment. Second, the optimal dose-response relationships and the clinical utility of adjuvants such as dexmedetomidine require further investigation. Finally, there is an urgent need to include high-risk populations, particularly patients with BMI ≥ 55 kg/m^2, who may benefit substantially from optimized regional analgesic strategies.

Conclusions

Ultrasound-guided fascial plane blocks are effective and safe interventions for optimizing analgesia following LSG. The EOI block demonstrates the most favorable profile for 24-hour opioid reduction and early pain control, whereas the ESPB provides the most sustained analgesia by the end of the first postoperative day. The QL block uniquely reduces the incidence of PONV. Given the lack of definitive clinical superiority among active techniques in direct comparisons, block selection should be individualized based on local expertise and patient-specific needs. Future adequately powered multicenter randomized trials directly comparing these interventions are essential to consolidate these rankings and standardized application protocols.

Declarations

Conflict of interest: The authors declare no conflicts of interest

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Consent for publication: Formal informed consent was not required for this study as no individual participant data were collected or analyzed

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Figures

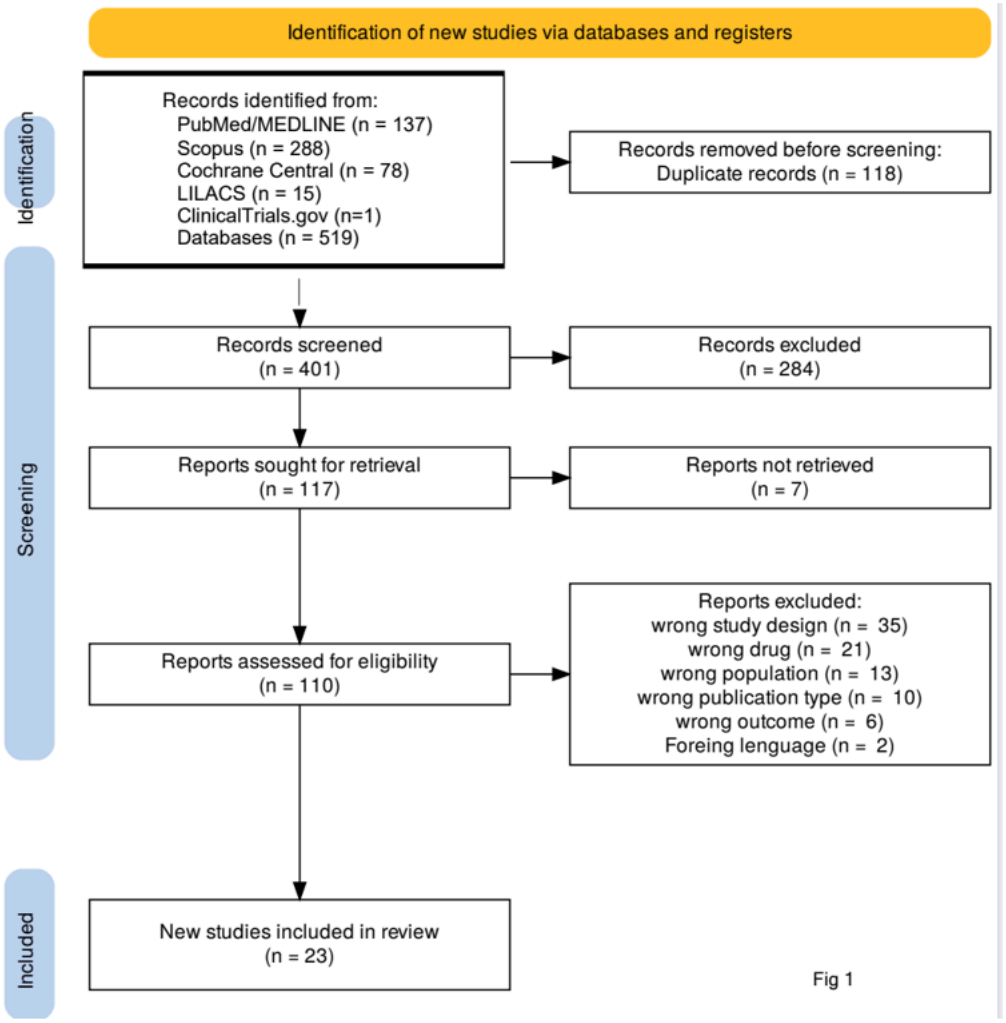

Figure 1

PRISMA diagram flow of study selection process.

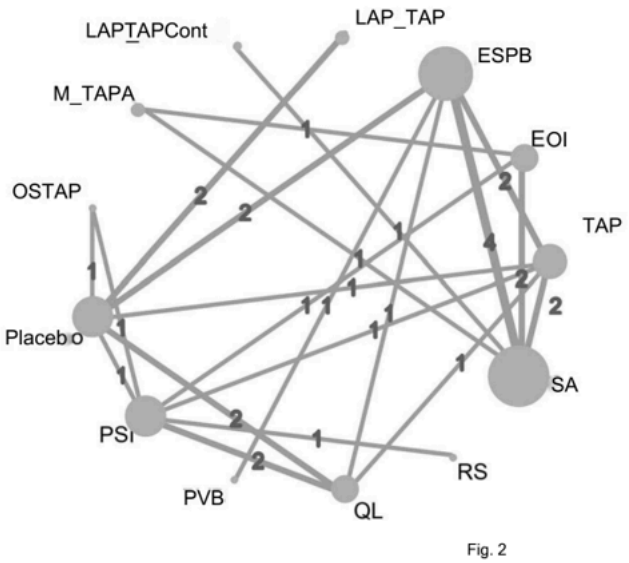

Figure 2

Network plot for primary outcome. The size of the nodes represents the number of patients assigned to each intervention. Line thickness reflects the number of RCs for each direct pair-wise comparison.

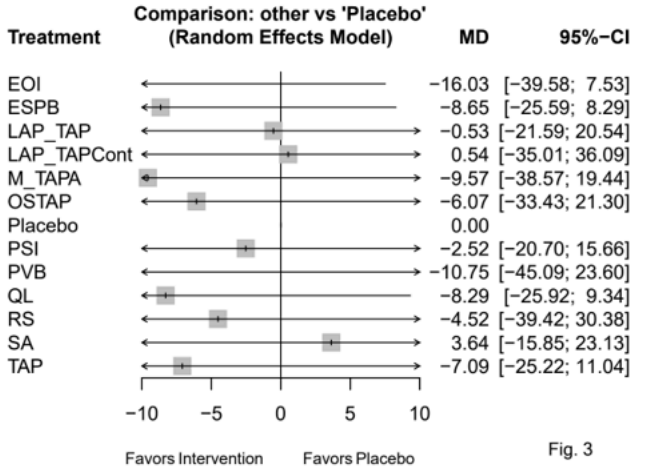

Figure 3

Forest Plot and NMA comparative Morphine consumption at 24 h

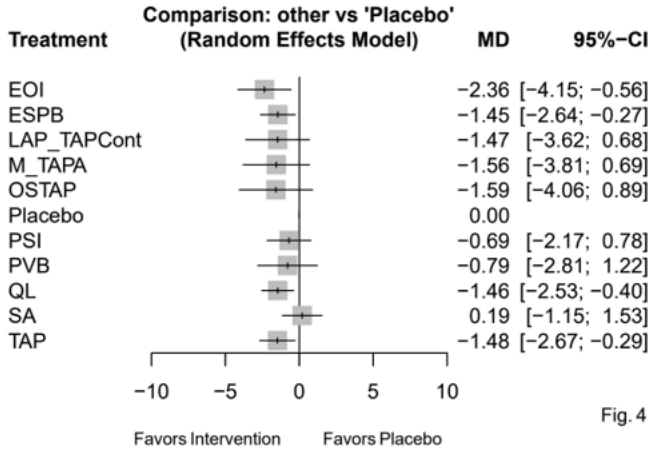

Figure 4

Forest Plot and NMA of 2-hour postoperative pain

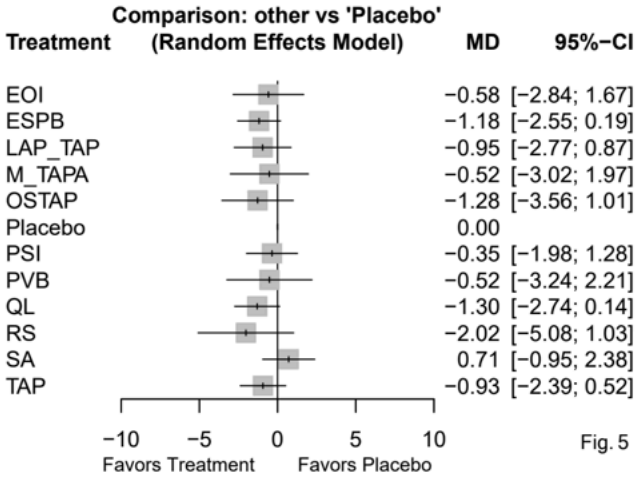

Figure 5

Forest Plot and NMA of postoperative pain at 6 hours (MD vs Placebo)

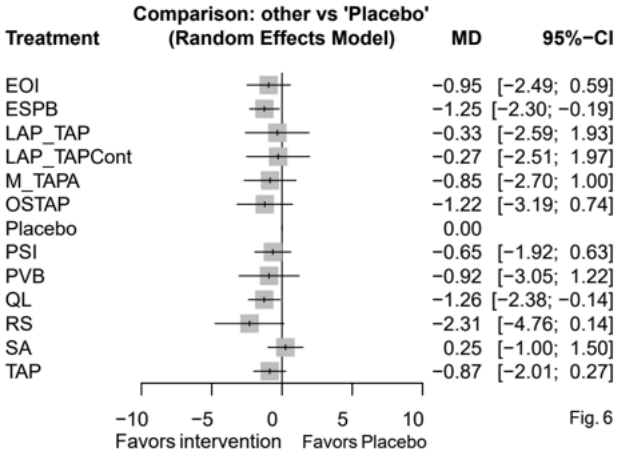

Figure 6

Forest Plot and NMA of postoperative pain at 12 hours (MD vs Placebo)

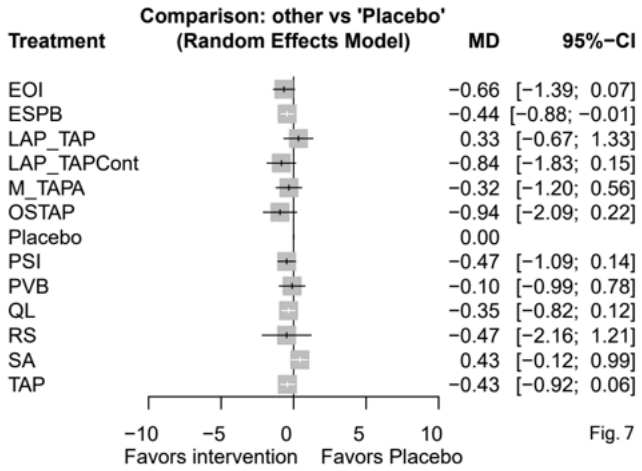

Figure 7

Forest Plot and NMA of postoperative pain at 24 hours

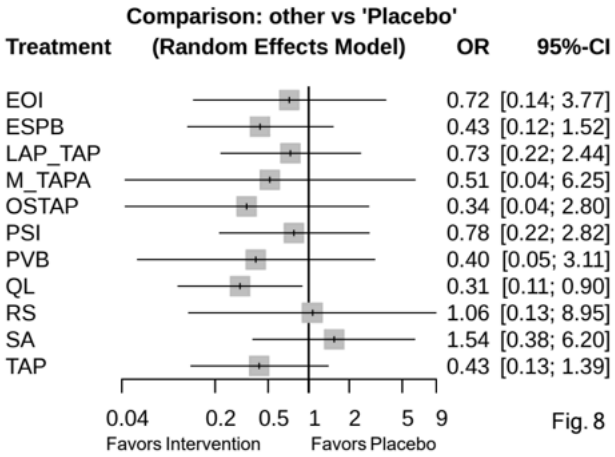

Figure 8

Forest Plot and Network Meta-analysis of PONV after LSG

Supplementary Files

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- Supplementarymaterial.docx