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Paragastric autonomic neural blockade for pain after laparoscopic sleeve gastrectomy: a systematic review of randomized controlled trials.

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Summary
Background Laparoscopic sleeve gastrectomy (LSG) is a widely performed bariatric procedure, effective for sustained weight loss and improving obesity-related comorbidities. However, postoperative visceral pain and postoperative nausea and vomiting (PONV) remain significant challenges that adversely affect recovery and patient outcomes. Current analgesic strategies, especially opioid-based approaches, often inadequately address visceral pain and may exacerbate PONV. Paragastric autonomic neural blockade (PG-ANB) is a novel technique aimed at directly targeting pain pathways, aligning with enhanced recovery after surgery (ERAS) principles.

Methods A systematic review of MEDLINE, Cochrane Library, and PubMed databases identified randomized controlled trials (RCTs) evaluating PG-ANB in LSG. Eligible studies were assessed for clinical outcomes, including pain scores, PONV rates, and analgesic requirements.

Results Four studies were included, showing that PG-ANB significantly reduced postoperative pain scores at multiple intervals (1, 6, and 12 h). The PONV rates were lower in the first 8 h, with reduced use of rescue antiemetics. Moreover, PG-ANB decreased opioid requirements and facilitated earlier mobilization. Intraoperative reductions in heart rate and mean arterial pressure 10 min after PG-ANB suggested effective autonomic blockade. Minor complications, bleeding, and hematoma formation were self-limited.

Conclusion Paragastric autonomic neural blockade is effective in managing early postoperative pain and PONV after LSG, reducing opioid use and enhancing recovery. Future research should explore its long-term benefits, optimize its duration of effect, and validate findings in larger and broader populations.

Keywords Laparoscopic sleeve gastrectomy · Bariatric surgery · Autonomic nerve block · Digestive system surgical procedures · Autonomic neural blockade

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Introduction

Obesity is a pervasive and escalating global health issue, affecting approximately one in eight individuals worldwide, or around 890 million adults (World Health Organization, WHO). The prevalence of obesity contributes to a higher risk of comorbidities such as type 2 diabetes mellitus (T2DM), hypertension, certain cancers, and cardiovascular disease, all of which place a substantial burden on healthcare systems and

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resources [1]. Addressing obesity has therefore become a critical public health priority, with both medical and surgical interventions explored extensively for their effectiveness in achieving sustained weight loss and improving overall health outcomes. In recent years, studies have indicated that surgical approaches to obesity management, particularly bariatric surgery, often yield more substantial weight loss, greater reduction in wait circumference, and a higher T2DM remission rate than medical management alone [2]. One of the bariatric surgeries to help reduce weight is LSG. Among the expansive breadth of bariatric procedures, LSG has emerged as one of the most performed surgeries, accounting for up to 60% of all bariatric procedures globally [3]. Laparoscopic sleeve gastrectomy involves the reduction of stomach size, which promotes weight loss by restricting food intake and influencing hormonal pathways to reduce appetite [4].

A significant problem arising from these procedures is the presence of visceral pain, which is associated with autonomic symptoms such as nausea and vomiting. Visceral pain is complex and multifactorial; the literature includes multiple noxious stimuli that contribute to visceral pain. Its etiology lies in mechanical traction, dilation, spasm, inflammation, ischemia, and chemical stimulation [5]. PONV is a common sign of visceral pain following LSG [6]. Since vagal nerves constitute one of the main afferent pathways involved in triggering PONV [7], there are many hypotheses of why this complication occurs frequently. One hypothesis is incision and damage to branches of the vagus nerve [7], causing abnormal responses to be transmitted by afferent fibers to the vomiting center. Another suggests increased intraluminal pressure from decreased extensibility and compliance of the postoperative gastric pouch [8].

Current strategies for managing post-LSG pain include a range of both non-opioid- and opioid-based analgesic approaches as well as nerve blocks, such as the transversus abdominis plane (TAP) and erector spinae plane (ESP) blocks. Although these techniques are effective in addressing somatic pain, symptoms of visceral pain are often a chief complaint following LSG [9–12]. Furthermore, while useful, opioid-based analgesia can exacerbate PONV due to its impact on gastrointestinal motility and peripheral afferent pathways [13, 14].

Enhanced recovery after surgery (ERAS) protocols have become a cornerstone of modern surgical care, aiming to optimize patient recovery through multimodal strategies that minimize physiological stress and enhance postoperative outcomes. These protocols emphasize evidence-based practices such as preoperative counselling, tailored anesthetic techniques, early mobilization, and effective pain management strategies including opioid-sparing approaches [15–17]. In bariatric surgery, ERAS implementation has demonstrated significant benefits, including reduced postoperative complications, shorter hospital stays, and improved patient satisfaction [18]. A critical component of ERAS is the management of postoperative pain. Visceral pain has been shown to be the predominant pain type following laparoscopic surgery including sleeve gastrectomies [9, 19]. Poorly controlled pain, particularly visceral pain, can hinder recovery [20], increase opioid consumption, and exacerbate complications such as PONV [21].

To address this, autonomic neural blockade has emerged as a promising approach for managing visceral pain. Various blocks, such as celiac, splanchnic, and hypogastric blocks, have been employed to target the specific nerve pathways responsible for transmitting pain signals from abdominal and pelvic organs [22, 23]. Recent and historic literature has suggested that these techniques are effective for controlling pain and reducing opioid requirements [24–27].

Among the more recent approaches, PG-ANB stands out as a novel technique specifically designed to target pain following LSG. It involves injection of local anesthetics into the paragastric region to provide effective pain relief directly at the surgical site of the LSG [19]. Recent commentaries by Daes et al. [28] and Felix et al. [29] highlight the emerging role of autonomic neural blockade in minimally invasive procedures. Similar to other neural blocks, this technique could deliver targeted relief for visceral pain, thus minimizing the need for opioid-based analgesics, which are often associated with exacerbation of postoperative nausea and vomiting. Given these benefits, PG-ANB has significant potential as an alternative for managing postoperative visceral pain following LSG.

This systematic review aims to assess the efficacy of paragastric autonomic neural blockade in alleviating visceral pain following LSG.

Methods

Search strategy

A comprehensive search of the MEDLINE (Embase), MEDLINE (Ovid), Cochrane Library, and PubMed electronic databases was performed on 28 October 2024. A combination of keyword terms, Boolean operators, and medical subject headings was used in searches, as derived from a comprehensive literature review. The search terms used included “autonomic nerve block” and “digestive system surgical procedures” as keywords or Medical Subject Headings. The included articles were screened, and their reference lists were checked manually. The search strategy is available in the Supplementary Material.

Eligibility criteria

The eligibility criteria were studies that looked at the use of paragastric autonomic neural blockade in laparoscopic sleeve gastrectomy.

Inclusion criteria comprised

- sleeve gastrectomy
- paragastric autonomic neural blockade
- full text
- written in English
- clinical Outcomes

Exclusion criteria consisted of

- no clinical outcomes
- not written in English
- review article
- conference abstract
- supplement
- posters

Study selection

The eligibility of articles was assessed by two independent reviewers (CB and GC). The PRISMA guidelines [30] were followed (Table S1). Disagreements were

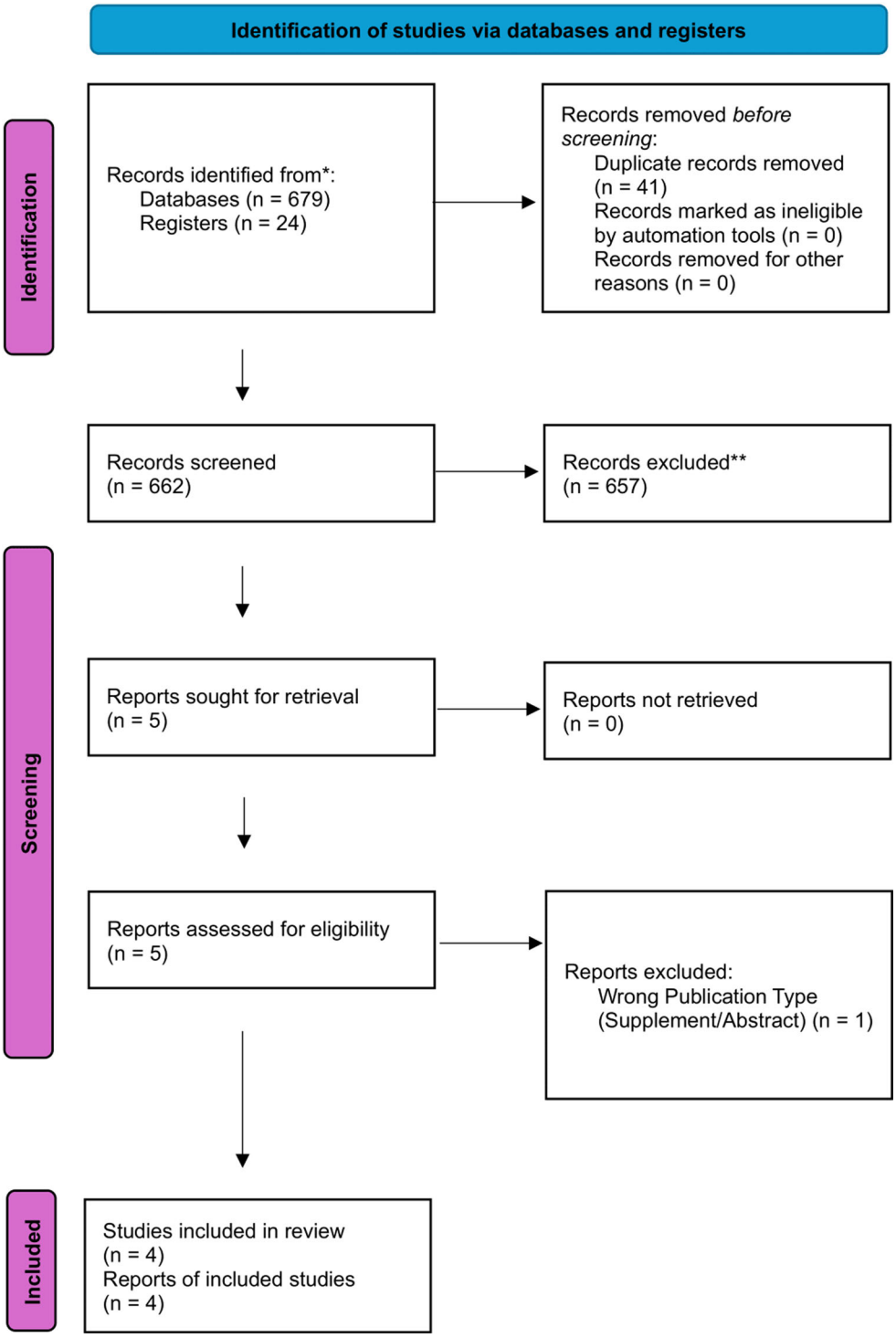

Fig. 1 PRISMA flow diagram outlining the study selection process *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Table 1 Study characteristics

Study title	Authors	Publication year	Study design	Cohort size	Gender distribution (M%/F%)	Procedure	Comparator group	Control group
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	Daes J; Morrell DJ; Hanssen A; Caballero M; Luque E; Pantoja R; Luquetta J; Pauli EM	2022	RCT	145	33.8%/66.2%	LSG	TAP block + PG-ANB	TAP block only
Efficacy and Safety of Paragastric Neural Blockade in Controlling Pain, Nausea, and Vomiting After Sleeve Gastrectomy: A Randomized Controlled Trial [8]	Katar MK; Turan UF	2024	RCT	90	23.3%/76.7%	LSG	PG-ANB	Not reported
Impact on Anesthetic Agent Consumption After Autonomic Neural Blockade as Part of a Combined Anesthesia Protocol: A Randomized Clinical Trial [33]	Daes J; Pantoja R; Luquetta J; Luque E; Hanssen A; Rocha J; Morrell DJ	2024	RCT	80	57.5%/42.5%	LSG	PG-ANB—onset	PG-ANB—terminal
Impact of Autonomic Neural Blockade Timing During Laparoscopic Sleeve Gastrectomy on Pain, Postoperative Nausea and Vomiting, and Analgesic Consumption [32]	Daes J.; Luque E.; Hanssen A.; Marroquin L.; Morrell D.J.	2024	RCT (secondary analysis of [19])	78	59.7%/40.3%	LSG	PG-ANB—onset	PG-ANB—terminal

F female, *LSG* laparoscopic sleeve gastrectomy, *M* male, *PG-ANB* paragastric autonomic neural blockade, *RCT* randomized controlled trial, *TAP* transversus abdominis plane.

resolved by consensus. This systematic review was registered with PROSPERO (CRD42024618116). Article titles and abstracts were initially screened using Covidence. The remaining articles had a full-text review, and articles were included or excluded based upon the eligibility criteria. The PRISMA flow diagram [30] of the study shows a summary of the screening process (Fig. 1).

PG-ANB technique

The original description of the PG-ANB technique by Daes et al. [19] involved introduction of a capped 25-gauge short needle attached to a venous catheter extension into the abdomen via the left 12-mm port; 20 mL of non-diluted 0.5% bupivacaine was then infiltrated at six locations in the fatty tissue of the paragastric area, with careful aspiration prior to each injection. These areas included the lesser omentum along the vagus nerve and distal branches at the esophagogastric junction, proximal stomach, mid-stomach, distal antrum, the area overlying the hepatic artery, and the area overlying the left gastric artery in the posterosuperior paragastric area.

The author provides visual instruction at https://youtu.be/BGs_1VpuVUw.

Table 2 Intervention agents and complications

Study title	PG-ANB agent	TAP block agent	Complications/ adverse effects of intervention
PG-ANB vs. control			
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	20 mL of non-diluted 0.5% bupivacaine	40 mL of 50% diluted 0.5% bupivacaine	Self-limited bleeding at infiltration site ($n=3$)
Efficacy and Safety of Paragastric Neural Blockade in Controlling Pain, Nausea, and Vomiting After Sleeve Gastrectomy: A Randomized Controlled Trial [8]	18 mL 0.5% undiluted bupivacaine	Not reported	Hematoma ($n=4$) Controlled with local compression
Terminal vs. onset			
Impact on Anesthetic Agent Consumption After Autonomic Neural Blockade as Part of a Combined Anesthesia Protocol: A Randomized Clinical Trial [33]	20 mL non-diluted 0.5% bupivacaine plus dexamethasone	40 mL of 50% diluted 0.5% bupivacaine	Self-limited bleeding at infiltration site ($n=2$)
Impact of Autonomic Neural Blockade Timing During Laparoscopic Sleeve Gastrectomy on Pain, Postoperative Nausea and Vomiting, and Analgesic Consumption [32]	20 mL non-diluted 0.5% bupivacaine plus dexamethasone	40 mL of 50% diluted 0.5% bupivacaine	Self-limited bleeding at infiltration site ($n=2$)

PG-ANB autonomic neural blockade, *TAP* transversus abdominis plane

Table 3 Patient hemodynamics—heart rate and mean arterial pressure

Study title	Intra-/ postoperative	Timepoint	Heart rate (HR)			Mean arterial pressure (MAP)		
PG-ANB vs. control								
			PG-ANB—mean BPM (SD)	*Control—mean BPM (SD)*	*P-value*	*PG-ANB—mean mm Hg (SD)*	*Control—mean mm Hg (SD)*	*P-value*
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	Intraoperative	Prior	73.7 (11.8)	71.6 (13.0)	0.3185	73.1 (14.8)	72.3 (12.6)	0.7235
		10 min	64.2 (9.9)	68.9 (12.5)	0.0115*	62.8 (10.8)	69.0 (11.3)	0.0010*
		Difference	9.6 (9.6)	–2.7 (11.3)	0.0001*	–10.3 (–9.7)	–3.3 (11.6)	0.0001*
	Postoperative	1h	78.4 (13.9)	84.3 (14.8)	0.0146*	101.2 (13.6)	101.8 (18.0)	0.8062
		8h	78.1 (12.3)	79.2 (13.2)	0.5882	96.3 (14.1)	98.5 (12.1)	0.3170
		24h/POD1	75.6 (13.3)	78.1 (13.8)	0.2765	98.4 (11.8)	95.6 (11.9)	0.1679
Onset vs. terminal								
			Onset—mean BPM (SD)	*Terminal—mean BPM (SD)*	*P-value*	*Onset—mean mm Hg (SD)*	*Terminal—mean mm Hg (SD)*	*P-value*
Impact on Anesthetic Agent Consumption After Autonomic Neural Blockade as Part of a Combined Anesthesia Protocol: A Randomized Clinical Trial [33]	Intraoperative	Baseline	80.78 (13.9)	78.07	N/A	89.35 (11.7)	87.1 (12.8)	N/A
		Division of omentum	78.3	80.65	N/A	81.2	83.6	N/A
		First staple	78.2	82.7	N/A	80.7	84.4	N/A
		Last staple	77.1	84.8	N/A	81.05	90.60	N/A
		Average of the periods	77.9 (11.6)	82.8 (12.7)	N/A	81.25 (12.5)	86.6 (12.7)	N/A
		Difference	2.88 (13.0)	4.73 (10.9)	0.0062*	8.1 (14.0)	0.5 (16.5)	0.0290*

BPM beats per minute, *N/A* Not applicable, *PG-ANB* paragastric autonomic neural blockade, *POD1* postoperative day 1, *SD* standard deviation
*Statistically significant *p*-value

Table 4 Postoperative pain scores PG-ANB vs. control

Study	Timepoint	PG-ANB (mean VAS score, SD)	Control (mean VAS score, SD)	P-value
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	1 h	4.0 (2.7)	6.2 (2.2)	< 0.0001*
	6h	–	–	–
	8h	2.8 (2.2)	4.4 (2.1)	< 0.0001*
	24h/POD1	3.1 (2.1)	3.0 (2.2)	0.8174
Efficacy and Safety of Paragastric Neural Blockade in Controlling Pain, Nausea, and Vomiting After Sleeve Gastrectomy: A Randomized Controlled Trial [8]	1h	3.1 (1.5)	5.4 (2.3)	< 0.001*
	6h	3.1 (2.0)	4.9 (2.2)	< 0.001*
	8h	3.0 (1.9)	4.4 (2.1)	0.002*
	24h/POD1	3.0 (1.8)	3.6 (1.7)	0.060

PG-ANB paragastric autonomic neural blockade, *POD1* postoperative day 1, *SD* standard deviation, *VAS* visual analogue scale
*Statistically significant *p*-value

Risk of bias assessment

All RCTs included in the review were assessed for risk of bias using the Joanna Briggs Institute Critical Appraisal tools for use in JBI Systematic Reviews—Checklist for Randomized Controlled Trials ([31]; Table S2). No studies were excluded during this process.

Data extraction

Data from the included studies were collected using a data collection spreadsheet in Excel (Microsoft Corporation, Redmond, WA, USA). The spreadsheet contained the following: title, author, DOI, year, design, country, cohort size, gender, comparator, control group, ANB agent, operation, anesthesia protocol, TAP block agent, postoperative recovery protocol, intraoperative timepoints, postoperative timepoints,

Table 5 Comparison of analgesia usage between PG-ANB and control groups

Study	Opioid/non-opioid	Analgesia	Timepoint	PG-ANB (n, %)/ Onset	Control (*n*, %)/ Terminal	*P*-value
PG-ANB vs. control						
~				*PG-ANB (n, %)*	*Control (n, %)*	~
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	Non-opioid	0 doses	0–1h	56, 77.8%	32, 42.5%	0.0003*
			1–8h	3, 4.2%	3, 4.1%	0.0001*
			8–24	1, 1.4%	0, 0%	0.2977
		1 or more doses	0–1h	16, 22.2%	42, 57.5%	NR
			1–8h	69, 95.8%	70, 75.9%	NR
			8–24	71, 98.6%	73, 100%	NR
	Opioid	0 doses	1 h	67, 93.1%	61, 83.6%	0.1394
			8 h	62, 86.1%	44, 60.3%	0.0010*
			POD1	56, 77.8%	59, 80.8%	0.8878
		1 dose	1 h	5, 6.9%	10, 13.7%	NR
			8 h	10, 13.9%	24, 32.9%	NR
			POD1	13, 18.1%	11, 15.1%	NR
		2 doses	1 h	0, 0%	2, 2.7%	NR
			8 h	0, 0%	5, 6.9%	NR
			POD1	3, 4.2%	3, 4.1%	NR
Efficacy and Safety of Paragastric Neural Blockade in Controlling Pain, Nausea, and Vomiting After Sleeve Gastrectomy: A Randomized Controlled Trial [8]	Opioid	First-line rescue doses	~	8, 17.8%	33, 73.3%	< 0.001*
		Second-line rescue doses	~	2, 4.4%	14, 31.1%	0.001*
Onset vs. Terminal						
~				*Onset*	*Terminal*	~
Impact of Autonomic Neural Blockade Timing During Laparoscopic Sleeve Gastrectomy on Pain, Postoperative Nausea and Vomiting, and Analgesic Consumption [32]	Opioid	Total doses	24 h	177	145	NR
		Doses per patient		4.8	4.15	
		Doses beyond baseline		1.4	1.48	

NR Not reported, *PG-ANB* paragastric autonomic neural blockade; *POD1* postoperative day 1
*Statistically significant *p*-value

Table 6 Postoperative nausea and vomiting scores for PG-ANB vs. control

Study	Timepoint	Nausea			Vomiting			
PG-ANB vs. control								
		PG-ANB (n, %)	*Control (n, %)*	*P-value*	*PG-ANB (n, %)*	*Control (n, %)*	*P-value*
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	1 h postop	23, 31.9%	45, 61.6%	0.0003*	2, 2.8%	20, 27.4%	<0.0001*
	8 h postop	17, 23.6%	33, 45.2%	0.0062*	12, 16.7%	36, 49.3%	<0.0001*
	24 h/POD1	41, 56.8%	33, 45.2%	0.1574	35, 48.6%	35, 49.3%	0.9324
		PG-ANB mean PONV score	*Control mean PONV score*	*P-value*	*PG-ANB—additional antiemetic requirement (n, %)*	*Control—additional antiemetic requirement (n, %)*	*P-value*
Efficacy and Safety of Paragastric Neural Blockade in Controlling Pain, Nausea, and Vomiting After Sleeve Gastrectomy: A Randomized Controlled Trial [8]	NR	0.47 ± 0.89	1.67 ± 1.95	0.001*	5, 11.1%	16, 35.6%	0.006*
Onset vs. terminal							
		Onset (n, %)	*Terminal (n, %)*	*P-value*	*Onset (n, %)*	*Terminal (n, %)*	*P-value*
Impact of Autonomic Neural Blockade Timing During Laparoscopic Sleeve Gastrectomy on Pain, Postoperative Nausea and Vomiting, and Analgesic Consumption [32]	1 h	3, 8.1%	3, 8.1%	1.000	0, 0%	0, 0%	NR
	8 h	7, 18.9%	3, 8.6%	0.3092	4, 10.8%	1, 2.9%	0.3580
	24 h/POD1	9, 24.3%	6, 17.1%	0.5656	0, 0%	0, 0%	NR

NR not reported, *PG-ANB* paragastric autonomic neural blockade, *POD1* postoperative day 1, *PONV* postoperative nausea and vomiting
*Statistically significant *p*-value

pain scale, intraoperative pain, postoperative pain, nausea, vomiting, sialorrhoea, hiccups, postoperative HR, intraoperative mean arterial pressure (MAP), postoperative MAP, patient satisfaction, mobilization, anesthetic consumption, opioid consumption, early recovery, operation time, Aldrete scale, complications.

Results

Search results

A search of MEDLINE (Embase), Cochrane Library, MEDLINE (Ovid), and PubMed revealed 703 papers. Thereof, 41 duplicates were removed. From the remaining 662 papers, 9 were screened in the full-text review, after which 4 papers met the eligibility criteria [8, 19, 32, 33]. The characteristics of the included studies are summarized in Table 1. Three of the four included papers are RCTs, while the fourth is a secondary analysis derived from one of these RCTs.

Adverse effects

Among the four studies included in this review, the only reported complication was bleeding at the infiltration site; this bleeding was either self-limited or controlled with local compression and occurred in 2% to 5% of cases (Table 2).

Hemodynamics

Table 3 demonstrates the effects of PG-ANB on hemodynamics (HR and MAP). Daes et al. [19] reported that 10 min after PG-ANB, the mean heart rate decreased from 73.7 ± 11.8 to 64.2 ± 9.9 beats per minute (p = 0.0001), and mean arterial pressure decreased from 73.1 ± 14.8 to 62.8 ± 10.8 mm Hg (p = 0.0001). However, there were no statistically significant differences between the PG-ANB and control group in terms of hemodynamic measurements at any other timepoint. These results were reproduced in two of the other included studies by Daes et al. [32, 33]. Additionally, one of these studies showed reductions in HR and MAP at the same timepoint irrespective of whether the blockade was performed at the onset or end of LSG [32]. Similarly, Kağan Katar et al. [8] found that the mean pulse decreased from 78.98 ± 13.27 to 73.42 ± 11.56 bpm (p < 0.001), systolic blood pressure from 115.29 ± 15.66 to 104.69 ± 12.99 mm Hg (p < 0.001), and diastolic blood pressure from 65.27 ± 10.72 to 60.71 ± 9.49 mm Hg (p < 0.001) 10 min after PG-ANB. A separate study [33] comparing PG-ANB administration at the onset versus the end of LSG found that onset administration produced statistically significant reductions in intraoperative HR (–2.88 ± 13.0 vs. +4.73 ± 10.9; p = 0.0062) and MAP (–8.1 ± 14.0 vs. –0.5 ± 16.5; p = 0.0290) from baseline to the average of the defined intraoperative periods.

Table 7 Anesthesia protocols

Study title	Anesthesia protocol			
	Premedication	Induction	Maintenance	Awakening
PG-ANB vs. control				
Paragastric Autonomic Neural Blockade to Prevent Early Visceral Pain and Associated Symptoms After Laparoscopic Sleeve Gastrectomy: a Randomized Clinical Trial [19]	Pregabalin	Propofol Remifentanil Rocuronium Ondansetron Alizapride	Desflurane Remifentanil	Acetaminophen (1 g) Morphine (2–5 mg)
Efficacy and Safety of Paragastric Neural Blockade in Controlling Pain, Nausea, and Vomiting After Sleeve Gastrectomy: A Randomized Controlled Trial [8]	NR	Propofol (2.5–3.5 mg/kg) + fentanyl (1 μg/kg) + rocuronium (0.6 mg/kg)	Sevoflurane Remifentanil (0.1–0.4 μg/kg/min) Ondansetron (4 mg) Dexamethasone (8 mg) Dexketoprofen trometamol (50 mg)	Neostigmine (0.05 mg/kg) Atropine (0.01 mg/kg)
Onset vs. terminal				
Impact on Anesthetic Agent Consumption After Autonomic Neural Blockade as Part of a Combined Anesthesia Protocol: A Randomized Clinical Trial [33]	Pregabalin	Remifentanil (0.15 μg/kg/min) Propofol (1–2 mg/kg) Rocuronium (0.6 mg/kg)	Sevoflurane (1.5–2.5%) Remifentanil (0.08–0.3 μg/kg/min)	Acetaminophen (1 g) Ondansetron Dexamethasone Alizapride
Impact of Autonomic Neural Blockade Timing During Laparoscopic Sleeve Gastrectomy on Pain, Postoperative Nausea and Vomiting, and Analgesic Consumption [32]	Pregabalin	Propofol Remifentanil Rocuronium Ondansetron Alizapride	Desflurane Remifentanil	Acetaminophen (1 g) Morphine (2–5 mg)

NR Not Reported

Pain

Two of the studies [8, 19] examined in this review found statistically significant reductions in pain scores and lower analgesic requirements following PG-ANB for LSG, as seen in Table 4 and 5. Daes et al. [19] reported significantly lower visual analogue scale (VAS) pain scores in the PG-ANB group compared to controls at 1 h (4.0 ± 2.7 vs. 6.2 ± 2.2; $p < 0.0001$) and 8 h postoperatively (2.8 ± 2.2 vs. 4.4 ± 2.1; $p < 0.0001$). Furthermore, the PG-ANB group received fewer cumulative doses of non-opioid analgesics at 1 h (0 doses in 77.8% vs. 42.5%; $p = 0.0003$) and 8 h postoperatively (0 doses in 4.2% vs. 4.1%; $p < 0.0001$) as well as fewer opioid doses at 8 h (0 doses in 86.1% vs. 60.3%; $p = 0.001$; Table 5). Similarly, Kağan Katar et al. [8] reported significantly lower VAS pain scores in the PG-ANB group compared with controls at 1 h (3.1 ± 1.5 vs. 5.4 ± 2.3; $p < 0.001$), 6 h (3.1 ± 2.0 vs. 4.9 ± 2.2; $p < 0.001$), and 8 h (3.0 ± 1.9 vs. 4.4 ± 2.1; $p = 0.002$) postoperatively (Table 4). In addition, first-line opioid rescue analgesic use was lower in the PG-ANB group (17.8% vs. 73.3%; $p < 0.001$), as was second-line rescue use (4.4% vs. 31.1%; $p = 0.001$; Table 5). The timing of PG-ANB administration elicited no statistical difference in VAS scores or analgesia requirements at any timepoint (Tables 4 and 5; [32]). Additionally, this study also assessed the functional impact of PG-ANB in LSG and found that patients in the treatment arm reported higher patient satisfaction scores (4.22 ± 0.87 vs. 3.53 ± 0.75; $p < 0.001$) and had a lower time to first mobilization (174.33 ± 57.15 vs. 201.22 ± 57.88 min; $p = 0.018$) [8].

PONV

There were statistically significant reductions in PONV in the studies that compared PG-ANB to a control, as demonstrated in Table 6. Daes et al. [19] found nausea rates to be lower in the PG-ANB group than controls at 1 h (31.9% vs. 61.6%; $p = 0.0003$) and 8 h (23.6% vs. 45.2%; $p = 0.0062$) postoperatively, though by 24 h, the rates were similar between groups (56.8% vs. 45.2%; $p = 0.1574$). There were similar reductions in vomiting at 1 h (2.8% vs. 27.4%; $p < 0.0001$) and 8 h (16.7% vs. 49.3%; $p < 0.0001$) postoperatively, with no significant difference by 24 h (48.6% vs. 49.3%; $p = 0.9324$). Kağan Katar et al. [8] found that compared to the control, the PG-ANB group had a lower mean PONV score (0.47 vs. 1.67; $p = 0.001$) and required less additional antiemetic medication (11.1% vs. 35.6%; $p = 0.006$). A separate study [32] comparing the effects of PG-ANB given at the onset versus the end of LSG found no statistically significant differences between the groups at any postoperative time interval.

Intraoperative analgesia requirements

One study found that when PG-ANB was performed at the onset of LSG, patients required less intraoperative remifentanil than those who received the blockade at the end of LSG (0.16 ± 0.04 mcg/kg/min vs. 0.20 ± 0.05 mcg/kg/min; $p < 0.0001$; mcg; microgram) [33].

Discussion

Paragastric autonomic neural blockade is a novel technique designed to reduce visceral pain and associated symptoms following laparoscopic sleeve gastrectomy (LSG). Emerging evidence has suggested that PG-ANB

holds significant promise for safely and effectively alleviating both PONV and visceral pain in the early postoperative period (1–8 h) as well as for reducing intraoperative analgesia requirements and facilitating faster postoperative mobilization.

Efficacy of PG-ANB for PONV

Somatic pain can be effectively managed with TAP/ESP blocks as well as conventional pain medications; however, visceral pain is still a problem following LSG [9, 10]. Visceral pain, particularly in the context of LSG, can manifest as autonomic symptoms such as nausea and vomiting [6, 34]. The most common reason for readmission following bariatric surgery is PONV and dehydration [35]. Several studies have found that the use of PG-ANB in LSG resulted in lower reported PONV scores and lower usage of additional antiemetics [8, 19, 32]. The potential benefits associated with a reduction in PONV after LSG include reduced dehydration or electrolyte imbalances and, consequently, a lower readmission rate. Additionally, the removal of PONV as a barrier to discharge could reduce time in hospital and lower the costs associated with length of stay. However, these effects are only short lived, with PONV returning by 24 h postoperatively. Therefore, to increase the clinical utility of PG-ANB in LSG, future research will need to attempt to prolong its effects to better align with the timeline of PONV in LSG. Combination of PG-ANB with newer antiemetics or other non-pharmacologic interventions [36, 37] could further reduce PONV, particularly after the initial 8 h, as the effects of the PG-ANB begin to diminish. Additionally, measurement of readmission rates could help to gauge the effectiveness of PG-ANB for preventing the most common cause of readmission in LSG.

Effect of anesthetic agent on PONV

Volatile inhalational agents such as sevoflurane, desflurane, and nitrous oxide are potent emetics that increase PONV in a dose-dependent manner, particularly in the early postoperative period [38]. In contrast, propofol-based total intravenous anesthesia (TIVA) reduces PONV due to propofol's intrinsic antiemetic effects, with studies demonstrating lower PONV rates with TIVA compared with volatile maintenance [39, 40]. Therefore, the choice and dose of anesthetics are important determinants of PONV and potential confounders in clinical research.

All included studies detailed their anesthetic protocols, including agents for induction, maintenance, and awakening (Table 7). Each study used volatile agents for maintenance; whilst these agents are known emetics, identical protocols between the intervention and control arms limited differential confounding. However, this design does not mitigate the baseline emetogenic effect of volatiles. Daes et al. [19] and Daes et al. [32] did not report drug dosages or interpatient variability in anesthetic requirements, despite known potential for dose-dependent PONV. Additionally, the length of the operation differs from patient to patient and, as a result, so does the total dose of anesthetic given. Future research should standardize anesthetic regimens (e.g., mg/kg or MAC-hours), prespecify cointerventions, and investigate propofol-based TIVA combined with PG-ANB as a potentially synergistic strategy to further reduce PONV following LSG.

Efficacy of PG-ANB for postoperative pain management

Two of the studies [8, 19] examined in this review found statistically significant reductions in pain scores and lower analgesic requirements following PG-ANB for LSG, as seen in Tables 4 and 5. Daes et al. [19] found that visual analogue scale (VAS) pain scores were lower at 1 h and 8 h postoperatively in the PG-ANB group. Furthermore, the PG-ANB group received less cumulative doses of non-opioid analgesics at 1 and 8 h and fewer opioid analgesics at 8 h postoperatively. Similarly, Kağan Katar et al. [8] reported statistically significant reductions in PG-ANB VAS scores at 1, 6, and 12 h postoperatively, along with a lower usage of first- (tramadol) and second-line (pethidine) rescue analgesics. This reduction in opioid usage has the potential to reduce opioid-associated complications following LSG. Additionally, this study also assessed the functional impact of PG-ANB in LSG, and found that patients in the treatment arm reported higher patient satisfaction scores and had a lower time to first mobilization [8]. By facilitating faster patient mobilization, PG-ANB could minimize the risk of immobilization-related complications such as deep vein thrombosis (DVT). These novel findings indicate the potential of PG-ANB as an effective technique to minimize visceral pain and analgesic requirements in the 1–8 h following LSG as well as the impact this has on practical outcomes such as time to first mobilization. Future studies could measure outcomes such as time to discharge or readmission rates to assess the functional impacts of PG-ANB.

Length of block

Whilst the studies presented in this review show promise for reducing both pain and PONV for a period of between 8 and 12 h after LSG, it must be noted that visceral pain can last up to 72 h postoperatively, with a peak intensity in the first 24 h postoperatively [9, 41, 42]. One group has reported investigation into the use of liposomal bupivacaine as well as dexamethasone + bupivacaine as methods for prolonging the effects of a PG-ANB. Whilst both of these methods were reported to reduce pain scores and PONV, the duration of effect was not reported [43]. Therefore, future research should continue to both validate the

novel findings of these studies and to look at methods to prolong the effects of PG-ANBs to better align with the temporal profile of visceral pain.

Techniques

Since the initial report on PG-ANB, subsequent studies have sought to replicate its findings and expand upon the original research. However, there has been little technical variation between studies and authors. Kağan Katar et al. [8] described the same technique as Daes et al. [19] but used 18 mL of local anesthetic rather than 20 mL. Additionally, subsequent studies by Daes et al. [32, 33] utilized 0.5% bupivacaine plus dexamethasone (8 mg) rather than 0.5% bupivacaine alone. Whilst no explanation was given in the papers, it can be hypothesized that dexamethasone was incorporated into the nerve block in an attempt to prolong its effects based on low–medium-level evidence [44].

ERAS and other considerations

While most of the research surrounding PG-ANB has sought to evaluate the postoperative outcomes, this technique may also have intraoperative utility. One trial found that when PG-ANB is performed at the onset of surgery, intraoperative opioid requirements are reduced [33]; these findings are consistent with previous systematic reviews that highlight how regional anesthesia can be used to lower intraoperative opioid requirements [45]. This factor—along with reductions in PONV and pain—closely align PG-ANB with the principles of the enhanced recovery after surgery (ERAS) framework, which emphasize minimizing opioid use and optimizing pain control to enhance postoperative recovery and patient outcomes. Additionally, by lowering perioperative opioid usage, the likelihood of opioid-associated adverse effects can be reduced, and the risk of chronic opioid use can be minimized [46–50]. Additionally, the reduction of opioid and inhaled anesthesia usage has potential environmental benefits, as local anesthetic has a lower lifecycle greenhouse gas emission impact than opioids and inhaled anesthetics [51, 52].

HR and MAP as markers of successful autonomic blockade

In the three studies [8, 19, 33] that recorded hemodynamic measurements there was a statistically significant reduction in both heart rate (HR) and mean arterial pressure (MAP) 10 min after PG-ANB (Table 3); this reduction occurred irrespective of whether PG-ANB was performed at the onset or end of LSG [33]. However, these effects were short lived, with no significant difference in HR or MAP between the treatment and control arms of the study postoperatively. The authors of these studies have suggested that this reduction in HR and MAP shortly following PG-ANB is likely a result of sympathetic inhibition and could therefore be used as an intraoperative marker of an effective autonomic blockade [8, 19, 32]. However, none of these studies included placebo arms; therefore, future research could compare the injection of bupivacaine versus normal saline to validate that these reductions in HR and MAP are consequences of PG-ANB.

PG-ANB at onset vs. terminal

One study [33] looked at HR and MAP at various intraoperative timepoints: the mean difference from baseline HR and MAP readings of onset PG-ANB and terminal PG-ANB groups were compared, and a significant difference between the two groups was found (Table 3). We hypothesize that this reduction in hemodynamic measurements is likely a result of less sympathetic signaling due to reductions in pain [53]. However, more research is needed to determine whether reducing intraoperative hemodynamic variability is possible while still maintaining the same efficacy in terms of reductions in postoperative pain and PONV.

Bariatric and laparoscopic surgeries are associated with a range of postoperative risks, including the development of chronic pain. Chronic pain following bariatric surgery has been reported with an incidence ranging from 5% to 54% [54–56], with one study specifically citing a rate of approximately 27% for LSG [57]. While this complication is significant, previous research has suggested that interventions such as neural blockades may reduce the incidence of chronic pain [24, 26, 58]. Extrapolating from these findings, it is reasonable to hypothesize that intraoperative use of PG-ANB could potentially lower the incidence of chronic pain after LSG. However, the studies included in this review were limited to inpatient data and did not evaluate long-term outcomes, including rates of chronic pain, as no extended follow-up data were available. Future research should prioritize implementing robust follow-up protocols to assess the long-term effectiveness of PG-ANB in reducing chronic pain after LSG compared to control groups.

Limitations

One potential limiting factor is operator dependency. Whilst the technique can be performed [33] with readily available and inexpensive equipment [19], both groups that have attempted this procedure indicate there to be a small learning curve in order to perform the procedure successfully [8, 19]. When performed by skilled operators, PG-ANB increased surgery length by a statistically non-significant time of approximately 3 min on average (58.0 ± 7.5 vs. 55.2 ± 9.8 min; $p = 0.075$) [8]; however, this value is based on operations undertaken by only two surgeons, and it could be longer in those less experienced in this

technique. In terms of complications, bleeding at the infiltration site was reported in 2%–5% of cases (Table 2); however, this was self-limited or controlled with local compression. Therefore, PG-ANB appears to be relatively safe, with few associated adverse effects. However, there is a theoretical risk of accidental intravascular injection of bupivacaine. Bupivacaine exhibits higher systemic toxicity and relative cardiotoxicity than other local anesthetics [59]. If the injection is placed in the wrong location, with the highly vascularized nature of the gastrointestinal system, there is a theoretical risk of accidental intravascular injection and systematic toxicity—which may be heightened in less experienced operators. Therefore, it is recommended that future studies include a larger cohort size to further characterize the safety of PG-ANB and determine the theoretical risk profile. While this novel technique shows promise, its safety for use in the broader population remains unclear—particularly in those with bleeding disorders, given the reported complication of hematomas associated with this procedure. It is therefore recommended that further studies be undertaken to investigate whether PG-ANB in LSG confers more risk than LSG alone in the broader population. There are inconsistencies in data presentation between the reviewed studies. For instance, Daes et al. [19] reported that patients in the control group required fewer cumulative doses of analgesics postoperatively, but the referenced data and subsequent discussions suggest that the PG-ANB group required fewer doses. Similarly, Kağan Katar et al. [8] only provided a single PONV value in their results, without specifying the 6- and 24-h postoperative timepoints mentioned in their methods, thus limiting the temporal characterization of PG-ANB's effects. Such discrepancies constrain the ability to draw definitive conclusions. To our knowledge, PG-ANB for LSG has only been attempted by two groups, and there are few published studies. The outcomes of these studies did not report any complications specifically associated with LSG procedures. While it is hypothesized that PG-ANB is unlikely to impact postsurgical outcomes, future research should assess its potential effects on LSG-related complications, such as sleeve leaks or postoperative bleeding, to comprehensively establish its safety profile. Whilst the initial results are promising, the low quantity of literature and the concentration of publications between two authors carries with it a potential risk of bias. Therefore, it is recommended that these results be reproduced by other surgeons to further validate the safety and clinical utility of this technique.

Conclusion

This review provides an analysis of recent literature on PG-ANB, a novel technique aimed at reducing visceral pain and associated symptoms following laparoscopic sleeve gastrectomy. These findings indicate that PG-ANB shows promise for safely and effectively reducing both PONV and visceral pain in the initial post-LSG period as well as for reducing intraoperative analgesia requirements and facilitating faster mobilization, in alignment with ERAS frameworks. However, this review highlights the need for further research to better align the pharmacodynamic duration of PG-ANB with the temporal profile of PONV and VP following LSG. Additionally, the safety of the technique within the broader population and the theoretical risk of accidental intravascular injection must be better characterized before the technique is more widely adopted. Measuring factors such as readmission rate and time to discharge in conjunction with larger cohort sizes and longer follow-up, as well as standardizing/reporting anesthetic exposure (e.g., MAC-hours or mg/kg/min) and comparison of TIVA to inhalational agents, could further strengthen the case in favor of PG-ANB.

Data Availability Statement Data sharing is not applicable to this article as no new data were analyzed or created in this study.

Conflict of interest C. Bentley, G.J. Carmichael, J.G. Kovoor, K. Shimokawa, and M.O. Jacob declare that they have no competing interests.

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