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Review

The effectiveness of preoperative oral carbohydrate loading on postoperative nausea and vomiting in adults receiving total intravenous anaesthesia compared to inhalational anaesthesia: A systematic review and meta-analysis

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HIGHLIGHTS

- Prolonged fasting is still a prevalent issue, even in the allowance of liberal fluid intake.
- Meta-analysis of 25 RCTs (n = 2491) supports clinical benefits of OCL, comparing TIVA with IA.
- PONV risk is reduced with IA, and PONV severity is reduced in either type of anaesthesia approach, more significantly in TIVA.
- Findings reinforce the clinical benefits of preoperative oral carbohydrate loading for PONV regardless of anaesthesia approach.

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ABSTRACT

Background: Preoperative oral carbohydrate loading is thought to reduce postoperative nausea and vomiting (PONV). However, it is unknown if the benefit of carbohydrate loading is maintained in the presence of total intravenous anaesthesia (TIVA). The aim of this systematic review was to determine whether oral carbohydrate loading reduced PONV compared to overnight fasting between adult elective surgery patients receiving TIVA or inhalational general anaesthesia.

Methods: A search of seven databases was conducted until March 2024. Randomised controlled trials conducted with patient aged 18 years or older were included. Two reviewers independently screened titles, abstracts and full texts, and assessed risk of bias using the Cochrane ROB-2 Tool. Study data was pooled using random effects meta-analyses.

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Results: We included 26 studies in this review, and 25 in the meta-analyses ($n = 2491$). Preoperative oral carbohydrate loading reduced the overall risk (log RR: –0.35, 95 % CI: −0.62 to −0.08, $I^2 = 51.11$ %) and severity (SMD: -0.46, 95 % CI: −0.68 to −0.24, $I^2 = 62.09$ %) of PONV, and pain severity (MD: -0.69, 95 % CI: −1.13 to −0.25, $I^2 = 83.98$ %) compared to prolonged fasting when pooled across both anaesthesia approaches. The risk of PONV was reduced in patients receiving inhalational anaesthesia, but not in those receiving TIVA, while the reduction in severity was more significant in TIVA.
Conclusion: Oral carbohydrate loading reduces the severity of PONV and pain, regardless of the anaesthesia approach, compared to prolonged fasting. These findings support the clinical advantages of oral carbohydrate loading for postoperative outcomes, regardless of anaesthesia approach.

1. Introduction

Postoperative nausea and vomiting (PONV) affects approximately a third of general surgery patients. PONV is consistently described by patients as one of the most undesirable perioperative experiences [1–3]. Beyond the negative impact on patient experience, PONV is also associated with delayed recovery, prolonged hospital length of stay, and increased healthcare costs [4].

Prevention of PONV is a pillar of enhanced recovery pathways for various types of surgery to mitigate adverse effects, improve post-operative outcomes, and enhance patient satisfaction [1,5]. Prolonged preoperative fasting exacerbates the metabolic stress response from surgery, contributing to increased insulin resistance, higher rates of surgical complications, and PONV [6–9]. Therefore, preoperative oral carbohydrate loading is suggested as a strategy to shorten preoperative fasting times, with evidence suggesting potential benefits for reducing metabolic disturbances and improving recovery [10,11]. However, the evidence on the efficacy of preoperative oral carbohydrate loading in preventing PONV remains inconclusive and may contribute to why the adoption of reduced fasting practices is not more widespread [9,12]. Multimodal strategies to address PONV, including total intravenous anaesthesia (TIVA) have been integrated into routine care with benefits demonstrated for patients at high risk of PONV [13,14]. Despite this, prolonged fasting and PONV remain a common issue [15–19]. Additionally, most studies have not differentiated between patients receiving TIVA and those receiving inhalational anaesthesia, leaving a significant gap in understanding the interplay between anaesthetic techniques, carbohydrate loading, and PONV outcomes.

The primary aim of this systematic review was to evaluate the effects of preoperative oral carbohydrate loading compared to standard pre-operative fasting on the risk and severity of PONV in adult patients undergoing elective surgery, and whether these effects differ between TIVA or inhalational general anaesthesia. The secondary aim was to evaluate the effects of preoperative oral carbohydrate loading on post-operative pain and hospital length of stay.

2. Methods

This systematic review was registered with the NIHR International prospective register of systematic reviews (PROSPERO: CRD42021222171) and reported according to the Preferred Reporting Items for Systematic Review and Meta-Analyses statement (PRISMA) [20]. See Appendix 4 for PRISMA Checklist. Some outcomes listed in the registration were unable to be synthesised due to a lack of reporting across the included studies. The outcomes to be reported in the registry included the rate, dose, number and types of prophylactic and rescue antiemetics in the main outcomes, and gastrointestinal complications such as postoperative ileus, bloating, flatulence and patient satisfaction in the secondary outcomes. However, due to lack of reporting, these outcomes could not be analysed.

2.1. Search strategy

Seven electronic databases (MEDLINE, Science Direct, Scopus, CINAHL, Cochrane, Web of Science, and Clinical Key) were searched for peer-reviewed articles from inception until 1st of March 2024. The search results were imported to a web-based reference management tool: Covidence™ (Veritas Health Innovation, Melbourne, Australia). The reference lists of included articles were snowballed and duplicates removed. See Appendix 1 for the full search strategy.

2.2. Selection criteria

Randomised controlled trials (RCTs) were included if they reported the effect of preoperative oral carbohydrate loading compared to overnight fasting on the incidence or severity of PONV, post-operative nausea, and post-operative vomiting, in patients aged 18 years or older undergoing elective surgery under either TIVA or inhalational anaesthesia. The review inclusion criteria are presented in Box 1. Each title/abstract were independently screened by two of five reviewers (HD, SM, JM, AS, OG), and a third reviewer resolved conflicting decisions (MS, OG). One study published in Turkish was included in the analysis as the research team had the capacity to translate it into English [21] (Box 1). Inter-rater reliability analysis with Cohen's Kappa showed "fair" agreement among four of the five reviewers (Appendix 3).

Box 1
Systematic review inclusion criteria

Study type
Randomised controlled trials
Language
English or Turkish
Population
Adult patients undergoing elective surgery under either TIVA or inhalational anaesthesia
Intervention
Preoperative oral carbohydrate loading
Control
Overnight fasting
Outcome
Postoperative nausea and/or vomiting
Postoperative pain
Hospital length of stay

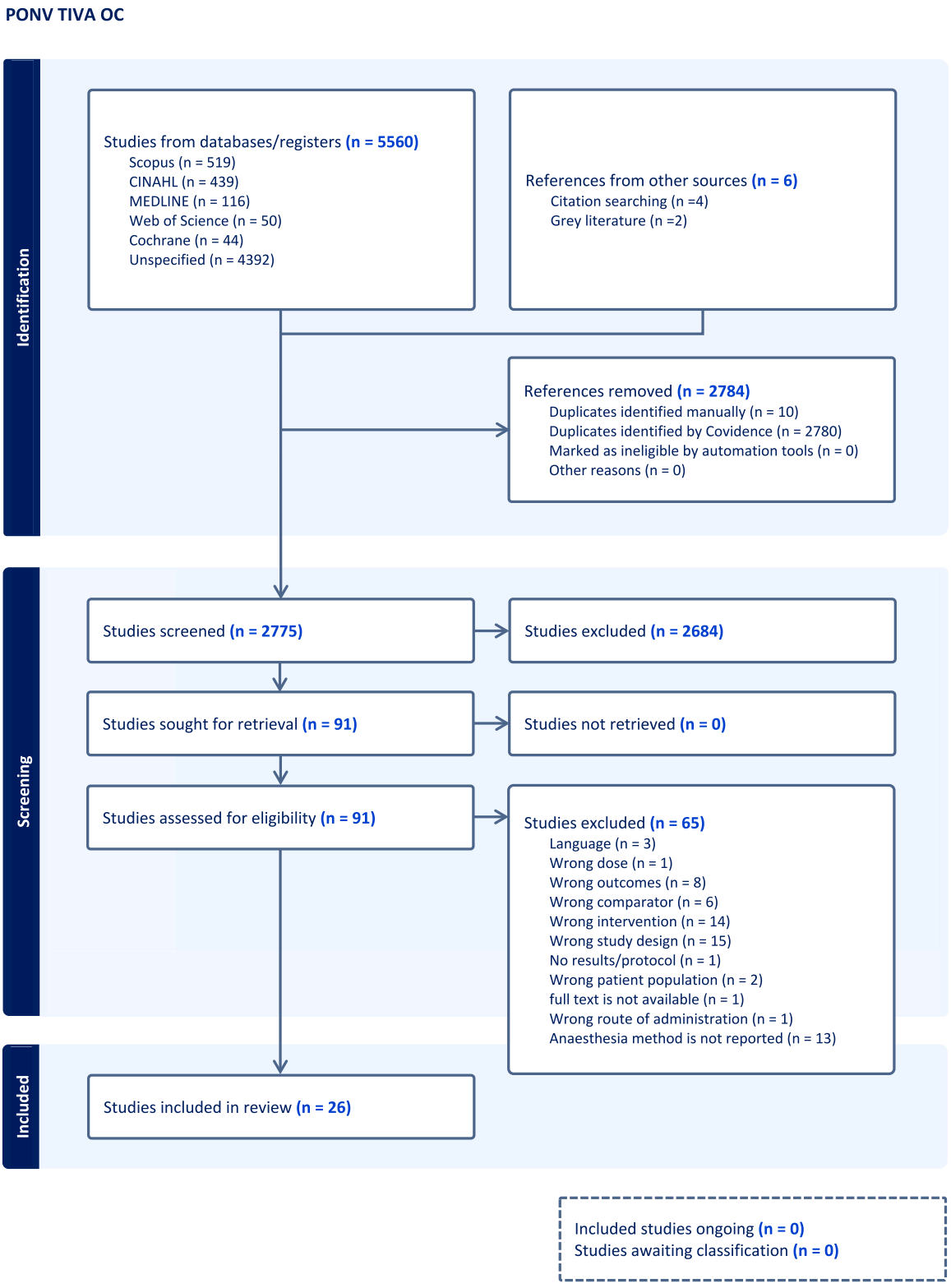


Fig. 1. PRISMA Flow Chart.

Table 1
Characteristics of studies included in the review.

Study Details	Surgery (Protocol and Adherence)	Intervention - Oral CHO protocol (Timing)	Demographics	Control	Intervention
Balabolu et al. 2023	Laparoscopic cholecystectomy	Unspecified, 25 g / 200 ml/ 100 kcal	N	50	50
India		(120 min)	Age (mean ± SD)	46.84 ± 12.02	47.26 ± 13.06
IA			Sex (n, % Female)	31 (62 %)	29 (58 %)
			ASA Score I-IV (n %)	I: 39 (78 %) II: 11 (22 %)	I: 35 (70 %) II: 15 (30 %)
Bisgaard et al. 2004	Laparoscopic cholecystectomy	Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal	N	43	43
Denmark		(146 min)	Age (mean ± SD)	42.75 ± 10.76	44.25 ± 10.3
TIVA			Sex (n, % Female)	34 (79 %)	37 (86 %)
			ASA Score I-IV (n %)	43 (100 %)	43 (100 %)
Cakar et al. 2017	Thyroidectomy	Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal	N	30	30
Türkiye		(120 min)	Age (mean ± SD)	50.1 ± 9.9	48.2 ± 9.8
IA			Sex (n, % Female)	18 (60 %)	14 (46.7 %)
			ASA Score I-IV (n %)	II: 28 (93 %) III: 2 (7 %)	II: 26 (86 %) III: 4 (14 %)
Faria et al. 2009			N	10	11
Brazil		Nidex, 25 g/200 ml/100 kcal	Age (mean ± SD)	47.5 ± 11.64	44.5 ± 14.44
TIVA	Laparoscopic cholecystectomy	(120 min)	Sex (n, % Female)	10 (100 %)	11 (100 %)
			ASA Score I-IV (n %)	I: 4 (40 %) II: 6 (60 %)	I: 5 (45 %) II: 6 (55 %)
Gumuskaya et al. 2022		Honey in water, 50 g/100 ml/ 200 kcal	N	74	68
Türkiye	Thyroidectomy	(250 min)	Age (mean ± SD)	47.1 ± 14.4	45.7 ± 12.3
IA	Laparoscopic Cholecystectomy		Sex (n, % Female)	63 (85 %)	52 (76 %)
			ASA Score I-IV (n %)	N/A	N/A
Hausel et al. 2005		Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal	N	58	55
Sweden		(120 min)	Age (mean ± SD)	48.0 ± 14.9	48.3 ± 14.6
IA	Laparoscopic cholecystectomy		Sex (n, % Female)	45 (78 %)	41 (75 %)
			ASA Score I-IV (n %)	N/A	N/A
Helminen et al. 2019		ProvideXtra Fresenius Kabi, 67 g/200 ml/300 kcal	N	56	57
Finland		(180 min)	Age (mean ± SD)	46 ± 11	47 ± 13
IA	Laparoscopic cholecystectomy		Sex (n, % Female)	43 (77 %)	48 (84 %)
			ASA Score I-IV (n %)	I: 39 (70 %) II: 17 (30 %)	I: 33 (59 %) II: 24 (41 %)
Järvelä et al. 2008		Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal	N	51	50
Finland		(120 min)	Age (mean ± SD)	66.8 ± 11.4	64.0 ± 8.6
IA	Coronary artery bypass surgery		Sex (n, % Female)	6 (12 %)	11 (22 %)
			ASA Score I-IV (n %)	N/A	N/A
Karlsson et al. 2016	Gastric bypass surgery	Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal	N	26	25
Sweden	(ERAS 100 % adherence; Surgery, anaesthesia, pain, and PONV management were identical across groups.)	(120 min)	Age (mean ± SD)	46 ± 12	45 ± 13
TIVA			Sex (n, % Female)	100 (100 %)	100 (100 %)
			ASA Score I-IV (n %)	I: 53 (53 %)	I: 57 (57 %) II: 43 (43 %)
Lauwick et al. 2009		Maltodextrin, 50 g/400 ml/ 200 kcal	N	100	100
Belgium		(120 min)	Age (mean ± SD)	46 ± 13	45 ± 13
IA	Thyroidectomy		Sex (n, % Female)	100 (100 %)	100 (100 %)
			ASA Score I-IV (n %)	I: 53 (53 %)	I: 57 (57 %) II: 43 (43 %)

(*continued on next page*)

Table 1 (*continued*)

Study Details	Surgery (Protocol and Adherence)	Intervention - Oral CHO protocol (Timing)	Demographics	Control	Intervention
				II: 47 (47 %)	
Liang et al. 2018 China IA	Laparoscopic liver resection (ERAS 100 % adherence; Anaesthesia, pain, and PONV management were standardised across groups.)	Unspecified, 50 g/ 400 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	61 60 ± 10.35 22 (36 %) I: 8 (13 %) II: 48 (79 %) III: 5 (8 %)	58 53 ± 13.91 25 (43 %) I: 12 (21 %) II: 35 (60 %) III: 11 (19 %)
Li et al. 2022 China TIVA	Gastrointestinal surgery	Unspecified, 50 g/ 355 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	32 66 ± 11 14 (44 %) II: 21 (66 %) III: 11 (34 %)	31 62 ± 8 9 (29 %) II: 23 (74 %) III: 8 (26 %)
Mathur et al. 2023 India IA	Laparoscopic Cholecystectomy	Unspecified, 50 g/400 ml/ 200 kcal (180 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	45 18–60 N/A 45 (100 %)	45 18–60 N/A 45 (100 %)
Mousavie et al. 2021 Iran TIVA	Laparoscopic Cholecystectomy	Unspecified, 25 g / 200 ml/ 100 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	26 41 ± 13 20 (76.92 %) I: 18 (69 %) II: 8 (31 %)	26 38 ± 11 20 (76.92 %) I: 13 (50 %) II: 13 (50 %)
Öbrink et al. 2019 Sweden IA	Laparoscopic cholecystectomy Gynaecologic laparoscopy	ProvideXtra Fresenius Kabi, 67 g/200 ml/300 kcal (180 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	36 40 ± 12 36 (100 %) N/A	37 43 ± 13 37 (100 %) N/A
Özdemir et al. 2011 Türkiye IA	TAH-BSO / inguinal herniorrhaphy	Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	30 47.66 ± 8.89 N/A N/A	30 45.66 ± 10.09 N/A N/A
Sada et al. 2014 Kosovo TIVA	a) Colorectal resection b) Open abdominal cholecystectomy	Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	52 59.1 ± 12 18 (69) 52 (100 %)	44 55.8 ± 13.5 16 (73) 52 (100 %)
Šerclová et al. 2009 Czech Republic IA	Open intestinal surgery (fast-track 100 %)	Nutricia Pre-Op, 50 g/ 400 ml/ 200 kcal (120–240 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	52 37.6 ± 12.5 20 (38.5 %) N/A	51 35.1 ± 11.0 31 (60.8 %) N/A
Wang et al. 2019a China TIVA	Endoscopic mucosal dissection (ERAS; compliance is not clear)	Unspecified, (3 % energy, 5 % CHO)/ 355 ml (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	50 55.59 ± 2.10 13 (26 %) I: 5 (10 %) II: 32 (64 %) III&IV N/A	50 57.50 ± 2.30 13 (26 %) I: 7 (14 %) II: 29 (58 %) III&IV N/A
Wang et al. 2019b China IA	Craniotomy (ERAS; all variables reported)	Maltodextrin, 50 g/400 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	70 49 ± 13.6 44(63 %) I: 17 (24 %) II: 53 (76 %)	70 51 ± 13.8 48 (69 %) I: 13 (19 %) II: 57 (81 %)

(*continued on next page*)

Table 1 (*continued*)

Study Details	Surgery (Protocol and Adherence)	Intervention - Oral CHO protocol (Timing)	Demographics	Control	Intervention
Wang et al. 2022 China IA	Craniotomy (ERAS 100 % compliance)	Unspecified, 12.5 % carbohydrate/ 250 ml (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	75 50.6 + −/ 9.7 43 (57.3 %) I: 48 (64 %) II: 27 (36 %)	76 52.9 ± 10.5 46 (60.5 %) I: 52 (68.4 %) II: 24 (31.6 %)
Wendler et al. 2022 Brazil TIVA	Gastrojejunal bypass (ERAS; Anaesthesia, pain, and PONV management were standardised across groups.)	Maltodextrin, 50 g/400 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	40 36.4 ± 9.5 N/A N/A	40 39.8 ± 10.0 N/A N/A
Yi et al. 2020 Malaysia TIVA	Gynaecological tumour resection (ERAS; Anaesthesia, pain, and PONV management were standardised across groups.)	Unspecified, 50 g/237 ml/ 250 kcal (180 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	56 51.2 ± 11.9 56 (100 %) I: 18 (32 %) II: 36 (64 %) III: 2 (4 %)	62 49.5 ± 12.2 62 (100 %) I: 28 (45 %) II: 33 (53 %) III: 1 (2 %)
Yildiz et al. 2013 Türkiye IA	Laparoscopic Cholecystectomy	Nutricia Pre-Op 50 g/ 400 ml/ 200 kcal (120–180 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	30 43.56 ± 9.82 22 (73 %) I-II: 30 (100 %)	30 47.63 ± 8.83 25 (83 %) I-II: 30 (100 %)
Zhang et al. 2022f: first operation China TIVA	Gynaecological Laparoscopy	Unspecified, 50 g / 355 ml / 200 kcal (138 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	50 48.0 ± 8.8 50 (100 %) I: 41 (82 %) II: 9 (18 %)	50 47.1 ± 11.0 50 (100 %) I: 40 (80 %) II: 10 (20 %)
Zhang et al. 2022s: second operation China TIVA	Gynaecological Laparoscopy	Unspecified, 50 g / 355 ml / 200 kcal (156 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	50 43.2 ± 10.2 50 (100 %) I: 40 (80 %) II: 10 (20 %)	50 44.5 ± 9.8 50 (100 %) I: 41 (82 %) II: 9 (18 %)
Yilmaz et al. 2013 * Türkiye IA	Laparoscopic cholecystectomy	Nutricia Pre-Op 50 g/ 400 ml/ 200 kcal (120 min)	N Age (mean ± SD) Sex (n, % Female) ASA Score I-IV (n %)	20 45.73 ± 10.39 N/A I-II: 20 (100 %)	20 42.57 ± 14.42 N/A I-II: 20 (100 %)

ERAS: Enhanced Recovery After Surgery; IA: Inhalational anaesthesia; PONV: Postoperative nausea and vomiting; TIVA: Total intravenous anaesthesia; *The study could not be included in the meta-analysis.

2.3. Data extraction

Two of four reviewers (OG, NG, HD, LB) independently extracted data using a piloted Microsoft Excel spreadsheet. Two of four reviewers (NG, OG, LB, HD) assessed the risk of bias independently using the Cochrane ROB-2 Tool [22]. Conflicts were resolved by team consensus or were resolved by a third independent reviewer (MS). The corresponding authors of studies that met the inclusion criteria but did not report on the anaesthesia method were contacted. Those who responded to the inquiry of the type of anaesthesia were included in this review.

2.4. Data synthesis

Meta-analysis was performed in the software package Stata BE 18 (64-bit; Stata Corp LLC.) using the inverse-variance method with random effects models, with between-study variance estimated using restricted maximum likelihood, where data were available on the intervention and outcomes that met our inclusion criteria. Treatment effects for risk of PONV were expressed as risk ratio (RR). Standardised mean difference (SMD) was used for PONV severity measured using different scales and was interpreted according to Hedges' g (0.2 = small, 0.5 = moderate, and 0.8 = large) [23]. Hospital length of stay was expressed as weighted mean difference. Pain was measured using the Visual Analogue Scale (VAS). Studies were stratified into subgroups by



Fig. 2. Risk of Bias.

the technique for general anaesthesia delivery (TIVA or inhalational anaesthesia). Heterogeneity was quantified using the I-squared statistic (I^2), with values greater than 50 % indicating substantial heterogeneity [24]. A leave-one-out sensitivity analysis was conducted to determine how removing each study would affect the overall effect size of the remaining studies. A fixed-effects meta-regression was also conducted to explore the impact of mean surgery duration as an independent variable for each outcome of interest.

Studies that reported the risk of PONV without clear identification of either nausea or vomiting as separate events were analysed as combined PONV. Studies that reported medians and ranges were converted into mean and standard deviation (SD) [25]. Log risk ratio effect sizes were used to assess the risk of postoperative nausea and vomiting as a combined measure. We selected the period with the highest incidence or severity in which outcomes were reported multiple times within the postoperative 24-h period. When studies reported postoperative vomiting or nausea occurrence separately, we considered postoperative vomiting results for meta-analysis, with the assumption that a patient with vomiting would also experience nausea. Two studies reported only postoperative nausea were also included as postoperative nausea and vomiting occurrence [26,27]. In one study, SD was calculated from the reported standard error difference between the groups [28,29].

We excluded a study from the meta-analysis due to limited outcome reporting, as the mean severity or incidence of postoperative PONV or pain could not be derived from available data [30]. We excluded studies where the anaesthesia type was not indicated and the authors did not respond to our request for further information. A more detailed explanation for data synthesis can be found in Appendix 2: Data Manipulations.

3. Results

3.1. Study characteristics

Out of the 26 studies included in the review, one did not report the extractable data for outcomes (Fig. 1). Therefore, 25 studies were included in the meta-analysis, which enrolled a total of 2491 patients. Of those, 1624 received inhalational anaesthesia (818 control; 806 intervention) and 867 received TIVA (435 control; 432 intervention) (Table 1).

The studies were conducted in 12 countries: six from China, five from Turkey, three from Sweden, two each from Brazil, Finland, and India, and one each from Belgium, the Czech Republic, Denmark, USA, Iran, Kosovo, and Malaysia. Among the participants, 1500 were female, and 656 were male (69 % female; 31 % male); four studies did not report gender data [21,27,30,31]. The average participant age was 48 years, calculated by averaging the reported ages in the studies (Table 1).

Eighteen studies reported PONV as binary data (count of occurrence), ten studies reported severity using either the Numeric Rating Scale (NRS) or Visual Analog Scale (VAS), and one used the Rhodes Index of Nausea and Vomiting (R-INVR). Five out of the nine studies reported VAS in categories (mild/moderate/severe). The means and SDs were calculated using the Cochrane recommended formula (Appendix 2: Data manipulations). For the secondary outcomes, 14 studies reported pain with VAS and 12 reported hospital length of stay.

3.2. Risk of bias assessment

Risk of bias in the included studies is presented in Fig. 2 [22,32]. Out of 26 studies, 25 reported adequate randomisation methods and intended treatment. Two studies reported missing outcome data, two studies were at high risk for measurement of the outcome data, and four studies were at high risk for selecting the outcome results. Overall, six studies were evaluated to be at low risk, 15 demonstrated some concerns, and seven studies were at high risk for quality appraisal. No other potential sources of bias were identified for any of the included studies.

Table 2
GRADE Summary of findings.

The effectiveness of preoperative oral carbohydrate loading on postoperative nausea and vomiting in adults receiving total intravenous anaesthesia compared to inhalational anaesthesia			
Patient or population: Adult elective surgery patients Settings: In patients Intervention: Preoperative oral carbohydrate loading Comparison: Overnight fasting			
Outcomes	**Effect size (95 % CI)**	**N participants (N studies)**	**Certainty of the evidence**
PONV Severity, SMD			
Overall	-0.46 (−0.68, −0.24)	904 (10)	Moderate * ⨁⨁⨁◯
Inhalation Anaesthesia	-0.43 (−0.72, −0.14)	705 (7)	Moderate ⨁⨁⨁◯
Total Intravenous Anaesthesia	-0.54 (−0.92, −0.16)	199 (3)	Moderate ⨁⨁⨁◯
PONV Risk, LRR			
Overall	–0.35(−0.62, −0.08)	1916 (18)	Moderate ⨁⨁⨁◯
Inhalation Anaesthesia	−0.34 (−0.63, −0.06)	1275 (11)	Moderate ⨁⨁⨁◯
Total Intravenous Anaesthesia	−0.40 (−1.02, 0.22)	641 (7)	Low ** ⨁⨁◯◯
Pain, MD			
Overall	−0.69 (−1.13, −0.25)	1520 (14)	Low ⨁⨁◯◯
Inhalation Anaesthesia	−0.79 (−1.29, −0.29)	1331 (11)	Low ⨁⨁◯◯
Total Intravenous Anaesthesia	−0.22 (−0.91, 0.46)	189 (3)	Very low ** ⨁◯◯◯
Length of Stay, MD			
Overall	−0.18 (−1.07, 0.70)	1310 (12)	Moderate ⨁⨁⨁◯
Inhalation Anaesthesia	−0.51 (−2.57, 1.54)	739 (6)	Low ⨁⨁◯◯
Total Intravenous Anaesthesia	−0.04 (−0.44, 0.37)	571 (6)	Moderate ⨁⨁⨁◯

CI: Confidence interval; GRADE: Grading of recommendations assessment, development and evaluation; LRR: Log risk ratio; MD: Mean difference; SMD: Standardised mean difference; PONV: postoperative nausea and vomiting; N: number.

* Due to the inconsistency of the included studies

** Due to the inconsistency and risk of bias of the included studies.

3.3. Grading of recommendations, assessment, development, and evaluation approach

Grading of Recommendations, Assessment, Development, and Evaluation Approach (GRADE) assessment for certainty of evidence and summary of recommendations using the GRADE methodology was demonstrated in Table 2**.** Two independent reviewers conducted the evaluation, and a third reviewer resolved conflicts. A more detailed explanation for the decisions was provided as Supplementary Table S2 GRADE Assessment.

3.4. Sensitivity analysis

To assess the stability of our results, we conducted a leave-one-out (LOO) sensitivity analysis for all outcomes. Our LOO analysis shows that no single study unduly influenced the pooled effect estimate, and heterogeneity could not be eliminated or significantly reduced by omitting any individual study for PONV risk, PONV severity, or pain outcomes (Supplementary Fig. S1-S3). In contrast, removing the study by Wang et al. [33] slightly altered the overall LOS results (MD: 0.11; 95 % CI: −0.49 to 0.71; Supplementary Fig. S4).

3.5. Severity of postoperative nausea and vomiting

The 10 studies measured the severity of PONV using a scale (VAS,

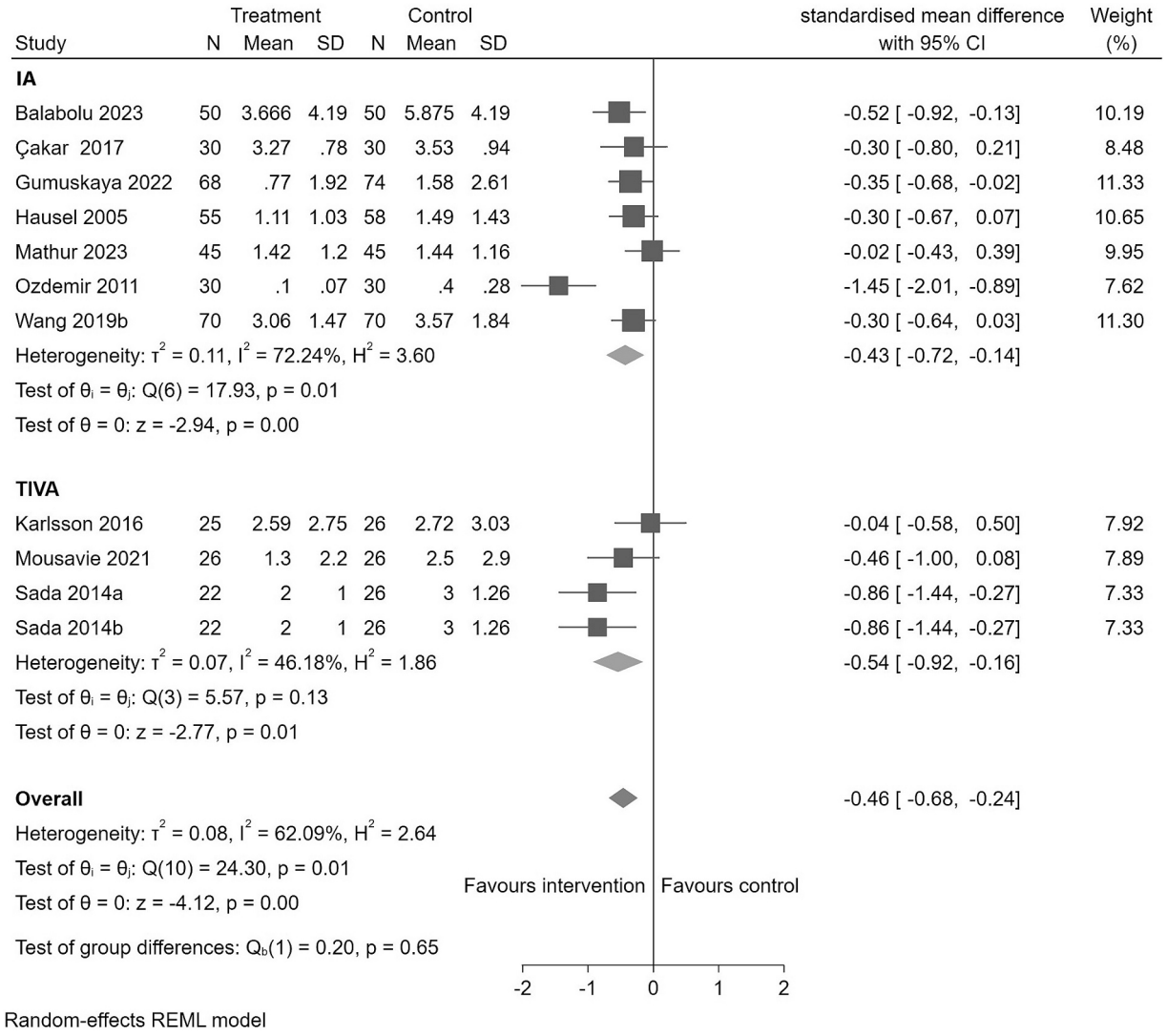


Fig. 3. Postoperative nausea and vomiting severity with preoperative oral carbohydrate loading by anaesthesia approach ($N = 904$).

NRS, or R-INVR). The overall pooled effect from 904 patients showed oral carbohydrate loading reduced PONV severity compared to overnight fasting, regardless of the type of anaesthesia (SMD: -0.46, 95 % CI: −0.68 to −0.24, $I^2 = 62.09$ %). The impact appeared to be larger for inhalational anaesthesia patients (SMD: -0.43, 95 % CI: −0.72 to −0.14, $I^2 = 72.24$ %) compared with TIVA (SMD: -0.54, 95 % CI: −0.92 to −0.16, $I^2 = 46.18$ %) (Fig. 3).

Meta-regression analyses demonstrated that duration of surgery was not a significant moderator of heterogeneity ($n = 10$; $\beta = -0.0003$; 95 % CI: −0.0016 to −0.0022; $p = 0.741$); between-study variance ($R^2 = 0$ %) and the residual heterogeneity was low ($\tau^2 = 0.005$; $I^2 = 8.95$ %).

3.6. Risk of postoperative nausea and vomiting

Of the 18 studies that reported on PONV risk as a binary outcome, the overall pooled effect from 1916 patients favoured reduced PONV risk with preoperative oral carbohydrate loading (log RR: –0.35, 95 % CI: −0.62 to −0.08, $I^2 = 51.11$ %) compared to overnight fasting when pooled across both anaesthesia approaches (Fig. 4). When stratified by anaesthesia type, the effect was significant for adults receiving inhalational anaesthesia (log RR: –0.29, 95 % CI: −0.53 to −0.05, $I^2 = 28.18$ %), but not for TIVA (log RR: –0.40, 95 % CI: −1.02 to 0.22, $I^2 = 56.87$ %) (Fig. 4).

Meta-regression analyses demonstrated that duration of surgery was not a significant moderator of heterogeneity ($n = 18$; $\beta = -0.0003$; 95 % CI: −0.0050 to −0.0044; $p = 0.895$); between-study variance ($R^2 = 0$ %) and the residual heterogeneity was low ($\tau^2 = 0.1032$; $I^2 = 38.92$ %).

3.7. Postoperative pain

In the 14 studies that reported on postoperative pain, the overall pooled effect of oral carbohydrate loading on 1520 patients reduced postoperative pain severity (MD: -0.69, 95 % CI: −1.13 to −0.25, $I^2 = 83.98$ %), compared to overnight fasting. The impact was significant for inhalational anaesthesia (MD: -0.79, 95 % CI: −1.29 to −0.29, $I^2 = 87.10$ %) but not for TIVA (MD: -0.22, 95 % CI: −0.91 to 0.46, $I^2 = 9.81$ %) (Fig. 5).

A significant relationship was found between postoperative pain levels and duration of surgery ($n = 13$; $\beta = -0.0042$; 95 % CI -0.0081 to −0.0002; $p = 0.038$), indicating that longer surgery duration was associated with a greater reduction in pain scores. The model explained $R^2 = 42.61$ % of the between-study variance, and the residual heterogeneity remained moderate ($\tau^2 = 0.091$; $I^2 = 45.7$ %).

3.8. Hospital length of stay

Twelve studies reported on hospital length of stay. The overall pooled effect from 1310 patients showed oral carbohydrate loading did

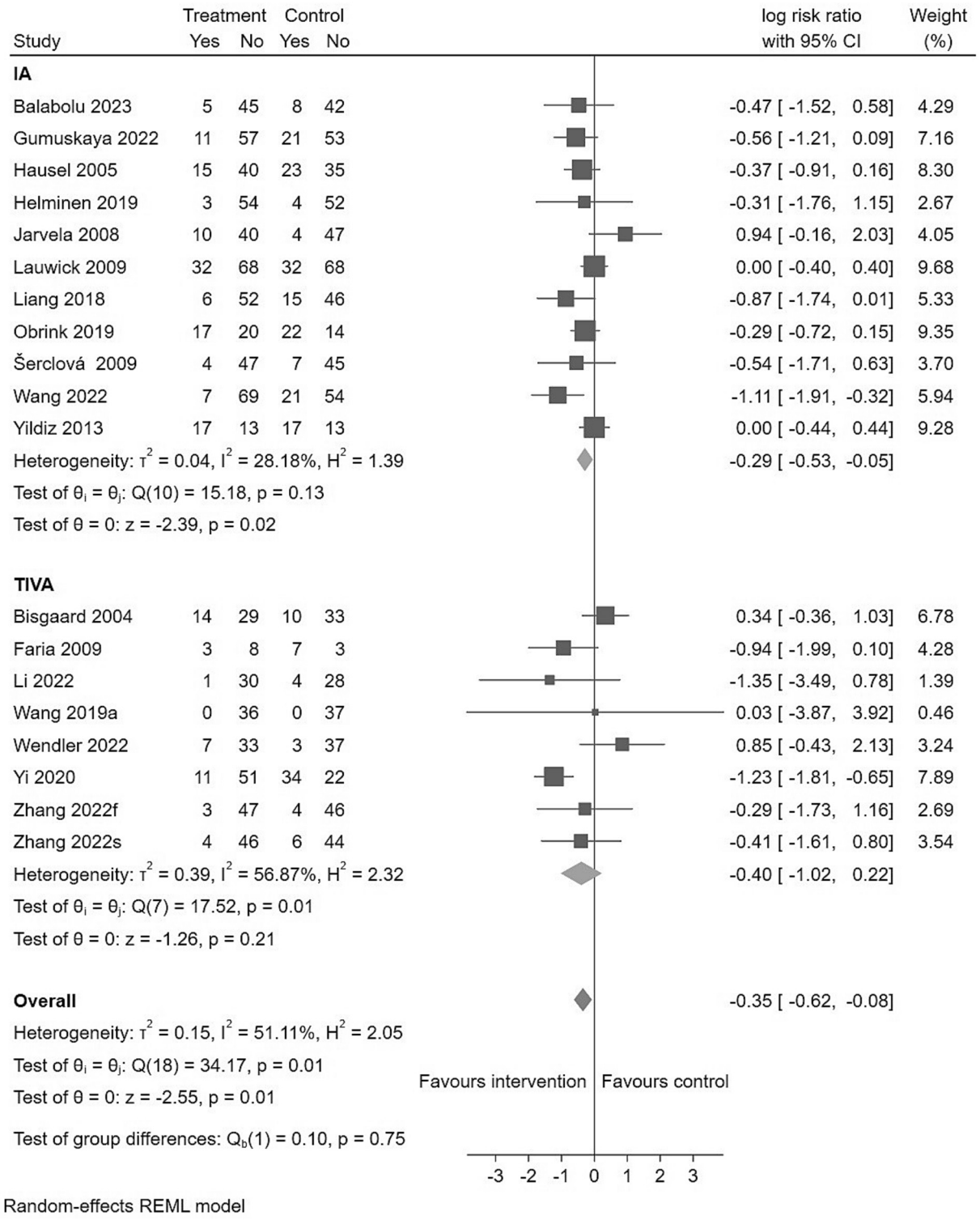


Fig. 4. Postoperative nausea and vomiting risk with preoperative oral carbohydrate loading by anaesthesia approach ($N = 1916$).

not impact hospital length of stay (MD: -0.18, 95 % CI: −1.07 to 0.70, $I^2 = 99.61$ %), regardless of anaesthetic approach, compared to overnight fasting (Fig. 6).

Meta-regression analyses demonstrated that duration of surgery was not a significant moderator of heterogeneity ($n = 12$; $\beta = -0.0089$; 95 % CI: −0.0213 to −0.0035; $p = 0.159$); between-study variance ($R^2 = 11.94$ %) and the residual heterogeneity was very high ($\tau^2 = 1.773$; $I^2 = 99.01$ %).

4. Discussion

4.1. Summary of findings

This systematic review and meta-analysis of RCTs demonstrated that oral carbohydrate loading significantly reduced the risk and severity of PONV when pooled across both anaesthesia approaches. The reduction in severity of PONV was more significant among inhalational anaesthesia patients. However, preoperative oral carbohydrate loading did

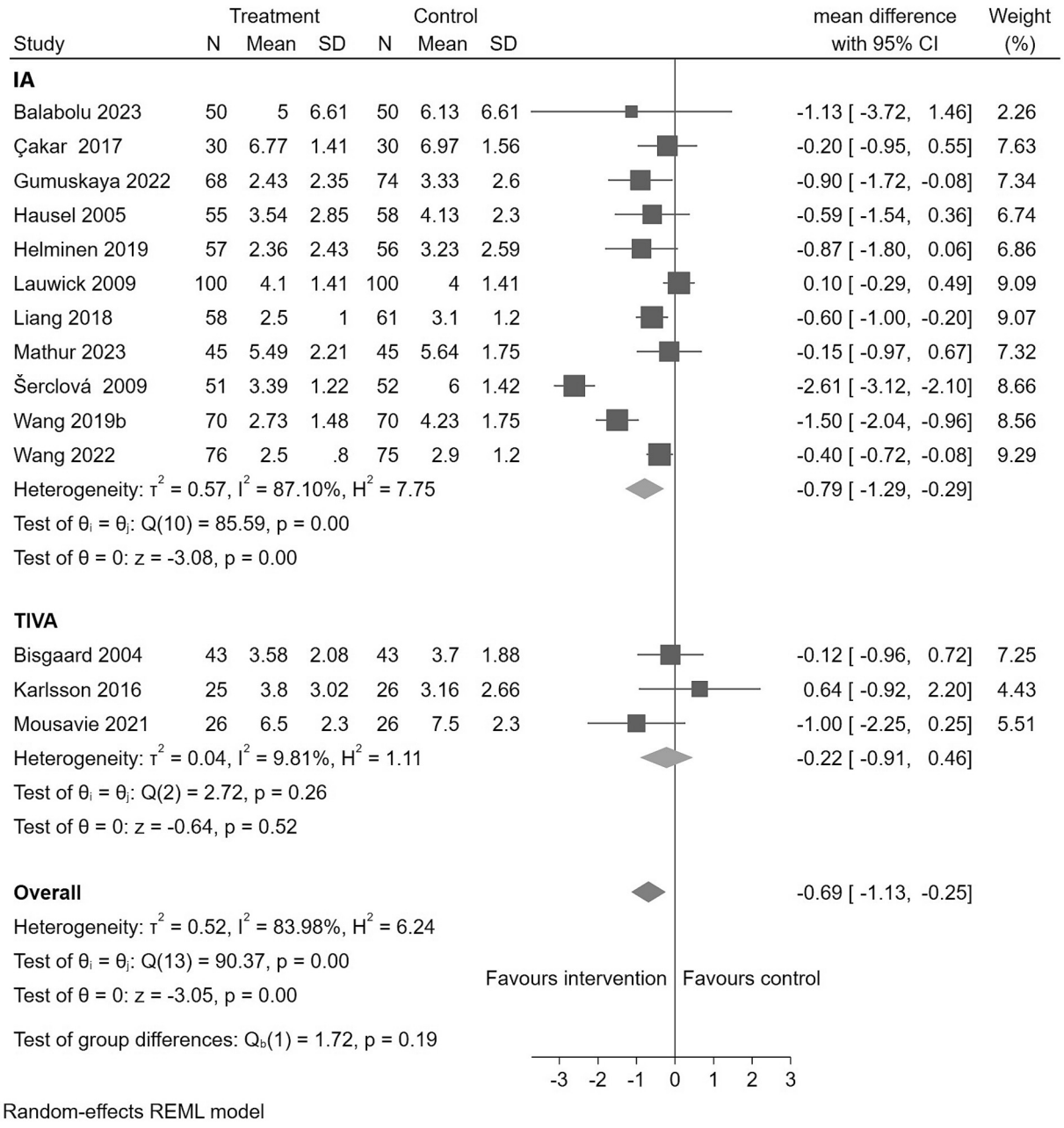


Fig. 5. Postoperative pain levels with preoperative oral carbohydrate loading by anaesthesia approach ($N = 1520$).

not significantly reduce the risk of PONV in patients receiving TIVA. Oral carbohydrate loading was associated with reduced postoperative pain among patients receiving inhalational anaesthesia, but was not effective in TIVA. There was no significant impact on hospital length of stay regardless of the anaesthetic approach. One study that was not included in the meta-analysis reported significant improvements in PONV with preoperative oral carbohydrate loading [26]. Our findings indicate a potential role for preoperative oral carbohydrate loading in reducing the risk and severity of PONV. This meta-analysis reconciles previously conflicting findings in the literature regarding the effectiveness of oral carbohydrate loading on reducing the incidence of PONV, clarifying the potential role of anaesthesia approach [34–37].

Previous reviews have not accounted for the interactions between preoperative oral carbohydrate loading in the presence of different anaesthesia techniques [38,39]. Oral carbohydrate loading is thought to modulate metabolic responses, maintain blood glucose stability, and reduce the inflammatory response [13,40–42]. Oral carbohydrate loading might, therefore, provide increased benefit in the presence of inhalational anaesthesia, given that inhalational anaesthesia has been shown to have less desirable metabolic effects compared to TIVA [1,38,39].

The lack of association between PONV risk and preoperative oral carbohydrate loading in TIVA patients may be confounded by several factors. In consideration of the gender, 22 out of 25 studies reported gender information. In TIVA studies; both control and intervention subgroups had significantly higher female percentages compared to the inhalational anaesthesia studies. As the female gender is an accepted risk factor for PONV [43], the effect may be masked due to this discrepancy. Moreover, the smaller sample size of the TIVA studies (TIVA:641; IA: 1275) may have masked the true effect of oral carbohydrates. Evidence supporting the clinical benefits of TIVA suggests that any additional benefits from carbohydrate loading may be limited to reducing severity. Additionally, PONV severity might be more significant for patient discomfort [44–46].

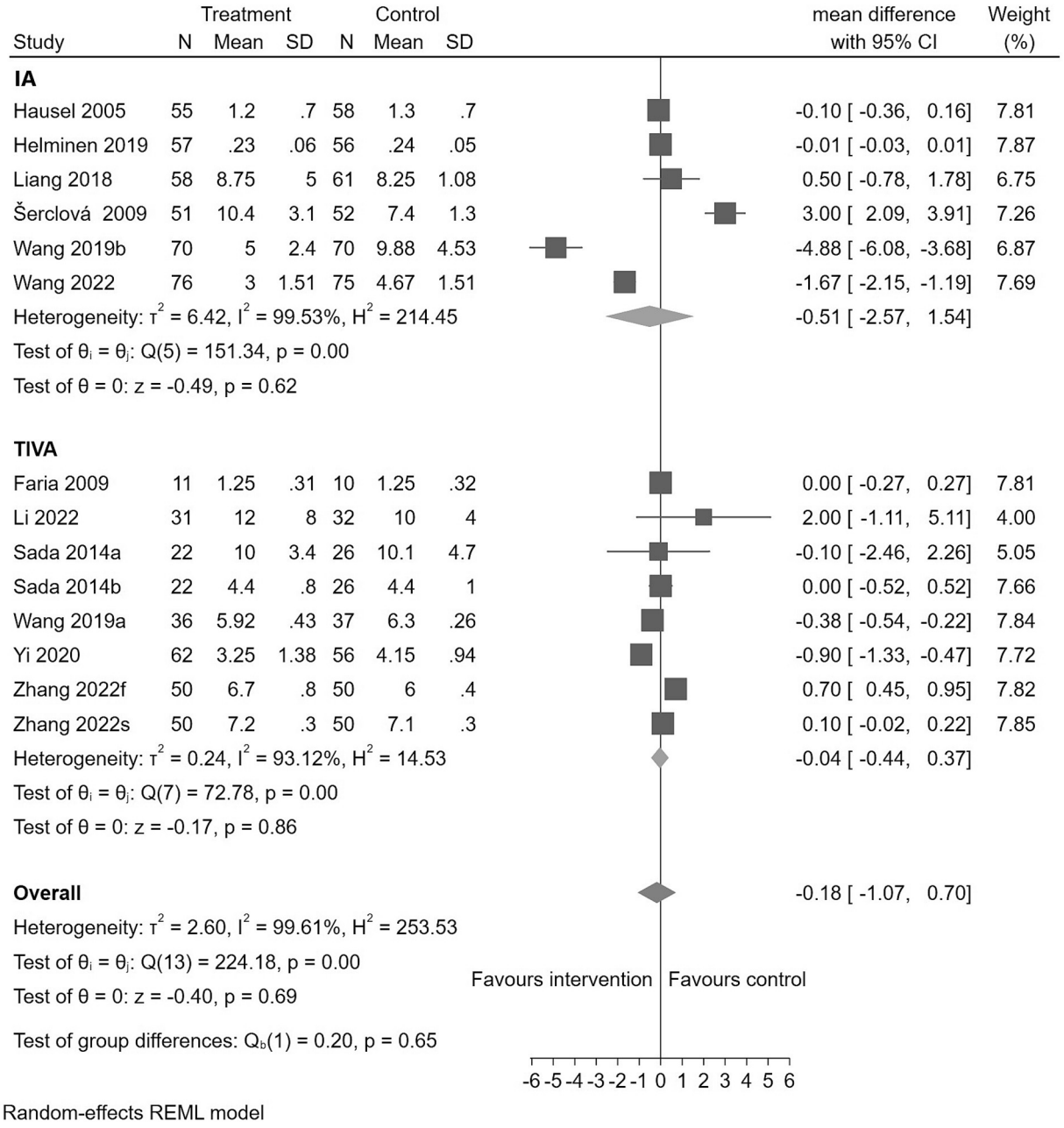


Fig. 6. Postoperative length of stay with preoperative oral carbohydrate loading by anaesthesia approach ($N = 1310$).

PONV is a multifaceted concept with many confounders to consider, which were not reported consistently across the studies included in this systematic review. The well-established risk factors for PONV are female gender, non-smoking status, history of PONV or motion sickness, duration of anaesthesia, and use of perioperative opioid analgesics [1,47]. Additionally, some studies implemented the Enhanced Recovery After Surgery (ERAS) Society protocols with a component of multimodal antiemetic prophylaxis for all patients [48,49]. In this review, seven out of 25 studies employed ERAS protocols, and five of which had a strict adherence policy that excluded participants who received care that deviated from their protocols; surgical and anaesthesia methods, antiemetic prophylaxis, and pain management were identical across control and intervention groups. In Wang et al. 2019a (N: 100; TIVA; ERAS), and Serclova et al. 2009 (N: 103; IA, fast track) studies, higher number of patients might have had NG insertion in control groups (numbers were not reported). In Wang et al.'s 2019b study (N:140; IA; ERAS), significantly more patients received multimodal PONV prophylaxis in the intervention group (ERAS:17/70,24 % vs Control:0/70,0 % $p \leq 0.0001$); the reduction of PONV risk and severity should be considered accordingly [33].

In some of the ERAS studies, the effect of reduced preoperative fasting on PONV could not be demonstrated reliably due to the confounding effect of multimodal antiemetic prophylaxis [48–50]. Fasting time was also unclear or inconsistent among participants. Most studies reported overnight or a minimum of eight hours of solid food fasting; however, the clear fluid or water fasting time varied among the control groups in some included studies [1,39].

Previous systematic reviews have been unable to determine whether preoperative oral carbohydrate loading reduces postoperative pain, while Kampman et al. 2024 indicated a meaningful reduction in postoperative pain for patients receiving TIVA [34–36,39,42]. Our meta-analysis is the first to identify reductions in pain severity with oral carbohydrate loading, across both anaesthesia approaches, and more significantly for IA. However, substantial heterogeneity and differences

across studies in perioperative pain management, opioid use, and the type of surgery should be considered when interpreting this.

The absence of effect on hospital length of stay, regardless of anaesthesia approach, aligns with previous studies [15,34,36,37], although these studies also indicated the insufficient level of evidence for length of stay. The lack of significant effects for length of stay could be explained by rapid discharge from fast-tracked or day surgery protocols, where the impact of PONV or pain is unlikely to alter planned postoperative pathways. Previous systematic reviews and meta-analyses also indicate heterogeneity in reporting length of stay, including the varying discharge criteria by country [36,51]. Despite the complexity of measuring an impact on perioperative hospital length of stay, interventions as cheap and straightforward as oral carbohydrate loading could still benefit patient experience and reduce the cost of care [15,34,36,37,51].

4.2. Limitations

Our meta-analysis was limited by the variations observed in the reported outcomes, particularly for PONV, such as the timing and tools used in measuring PONV, and other relevant assessment factors, like reporting only nausea or vomiting. This heterogeneity underscores the need for further research to standardise PONV assessment methods and reporting of the impact of reduced fasting. Additionally, one study was excluded from the meta-analysis due to variations in reporting [30], highlighting the need for improved consistency in outcome measurement and reporting in this field. PONV risk was measured according to incidence, rate, rate difference, and PONV severity using VAS (some studies referred to as NRS) and the Rhodes Index of Nausea, Vomiting, and Retching. Additionally, the PONV risk factors in the included study cohorts were inconsistently reported, making it difficult to evaluate them in the meta-analysis. In addition, many studies reporting the effects of oral carbohydrate loading on PONV did not report the type of anaesthesia and did not respond to our request for information; therefore, they could not be included in this systematic review.

5. Conclusion

This systematic review and meta-analysis suggest that preoperative oral carbohydrate loading could be a beneficial low-cost intervention to reduce PONV and pain, regardless of the general anaesthesia approach. Standardising reduced preoperative fasting protocols and timing specific to surgical contexts may enhance its effectiveness and allow more consistent patient outcomes. Integrating carbohydrate loading into preoperative care protocols could be beneficial, but further research is necessary to refine its application and establish stronger evidence and broader clinical guidelines.

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CRediT authorship contribution statement

Oya Gumuskaya: Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Hailey R. Donnelly:** Writing – original draft, Investigation, Data curation. **Nick Glenn:** Writing – original draft, Investigation, Formal analysis, Data curation. **Julee McDonagh:** Writing – original draft, Investigation, Data curation, Conceptualization. **Anita Skaros:** Writing – original draft, Investigation, Data curation. **Sophie Liang:** Writing – original draft, Formal analysis, Data curation, Conceptualization. **Brett G. Mitchell:** Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Luke Bendle:** Writing – original draft, Investigation, Formal analysis, Data curation. **Sarah Aitken:** Writing – original draft, Supervision, Formal analysis, Conceptualization. **Emile Belramoul:** Writing – review & editing, Validation, Methodology, Data curation. **Mitchell Sarkies:** Writing – original draft, Validation, Supervision, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Acknowledgments

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References

[1] Gan TJ, et al. Fourth consensus guidelines for the Management of Postoperative Nausea and Vomiting. Anesth Anal 2020;131(2):411–48.
[2] Xie J, Cai Y, Pei F. Comparison of three different prophylactic treatments for postoperative nausea and vomiting after total joint arthroplasty under general anesthesia: a randomized clinical trial. BMC Pharmacol Toxicol 2024;25(1):12.
[3] Timerga S, Befkadu A. Prevalence and associated factors of postoperative nausea and vomiting among adult patients undergoing elective surgery. Ann Medi & Surgery 2024;86(3):1304–8.
[4] Amirshahi M, et al. Prevalence of postoperative nausea and vomiting: a systematic review and meta-analysis. Saudi Journal of Anaesthesia 2020;14(1):48–56. https://doi.org/10.4103/sja.SJA_401_19. Epub 2020 Jan 6. PMID: 31998020; PMCID: PMC6970369.
[5] Pignot G, et al. Essential elements of anaesthesia practice in ERAS programs. World J Urol 2022;40(6):1299–309.
[6] Wang X-H, et al. Effects of preoperative Oral carbohydrates on recovery after laparoscopic cholecystectomy: a Meta-analysis of randomized controlled trials. J Perianesth Nurs 2025;40(1):169–80. https://doi.org/10.1016/j.jopan.2024.03.007. Epub 2024 Jul 8. PMID: 38980237.
[7] Togo HYA, Lopes EC. Preoperative fasting reduction in burned patients: a systematic review. Burns Open 2020;4(4):176–82.
[8] Milone M, et al. Surgical stress and metabolic response after totally laparoscopic right colectomy. Sci Rep 2021;11(1).
[9] Lai L, et al. Current practice of postoperative fasting: results from a multicentre survey in China. BMJ Open 2022;12(7):e060716.
[10] Ricci C, et al. Preoperative carbohydrate loading before elective abdominal surgery: a systematic review and network meta-analysis of phase II/III randomized controlled trials. Clin Nutr 2022;41(2):313–20.
[11] Kumar SM, et al. Effect of preoperative oral carbohydrate loading on postoperative insulin resistance, patient-perceived well-being, and surgical outcomes in elective colorectal surgery: a randomized controlled trial. J Gastrointest Surg 2024;28(10).
[12] The European Society for Clinical Nutrition and Metabolism (ESPEN). The International Association for Surgical Metabolism and Nutrition (IASMEN), and T. I.S.S. (ISS). ERAS Guidelines; 2023. Available from: https://erassociety.org/guidelines/.
[13] Tong E, et al. Effects of preoperative carbohydrate loading on recovery after elective surgery: a systematic review and Bayesian network meta-analysis of randomized controlled trials. Front Nutr 2022:9.
[14] Tang Z, et al. Enhanced recovery after surgery improves short-term outcomes in patients undergoing esophagectomy. Ann Thorac Surg 2021;114(4):1197–204.
[15] Cheng P-L, et al. Effects of preoperative oral carbohydrate on postoperative discomfort in patients undergoing elective surgery: a meta-analysis of randomized controlled trials. Langenbecks Arch Surg 2021;406(4):993–1005.
[16] McCracken GC, Montgomery J. Postoperative nausea and vomiting after unrestricted clear fluids before day surgery: a retrospective analysis. Eur J Anaesthesiol 2018;35(5):337–42.
[17] Pang QY, et al. The safety of perioperative dexamethasone with antiemetic dosage in surgical patients with diabetes mellitus: a systematic review and meta-analysis. Perioper Med (Lond) 2023;12(1):4.
[18] McClave SA, Marsano-Obando LS. Preparative fasting orders for medical/surgical interventions and imaging studies: time to review and revise! Curr Gastroenterol Rep 2022;24(2):37–41.

[19] Holder-Murray J, et al. Postoperative nausea and vomiting in patients undergoing colorectal surgery within an institutional enhanced recovery after surgery protocol: comparison of two prophylactic antiemetic regimens. Korean. J Anesth 2019;72(4).
[20] Page MJ, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2020;2021:n71.
[21] Özdemir F, et al. The effect of preoperative oral carbohydrate loading on stress response in patients undergoing major or minor surgery. Turkiye Klinikleri Journal of Medical Sciences 2011;31(6):1392–400.
[22] Sterne J, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019;366:l4898.
[23] Brydges CR. Effect size guidelines, sample size calculations, and statistical power in gerontology. Innov Aging 2019 Sep 4;3(4).
[24] von Hippel PT, von Hippel PT. The heterogeneity statistic I2 can be biased in small meta-analyses. BMC Med Res Methodol 2015;15(1). 2015-04-14. **15**(1).
[25] Wan X, et al. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 2014;14 (1):135.
[26] Yildiz H, et al. Oral carbohydrate supplementation reduces preoperative discomfort in laparoscopic cholecystectomy. J Invest Surg 2013;26(2):89–95.
[27] Wendler E, et al. Shorten preoperative fasting and introducing early eating assistance in recovery after gastrojejunal bypass? Arquivos brasileiros de cirurgia digestiva : ABCD = Brazilian archives of digestive surgery 2022;**34**(3). e1606-e1606.
[28] Balabolu M, et al. Effect of preoperative carbohydrate drink and postoperative chewing gum on postoperative nausea and vomiting in patients undergoing day care laparoscopic cholecystectomy: a randomized controlled trial. World J Surg 2023;47(11):2708–17.
[29] Higgins J, Li T, Deeks J. Chapter 6: Choosing effect measures and computing estimates of effect [last updated August 2023]. In: Higgins JPT, et al., editors. Cochrane Handbook for Systematic Reviews of Interventions version 6.5. Cochrane; 2024. www.training.cochrane.org/handbook.
[30] Yilmaz N, et al. Preoperative carbohydrate nutrition reduces postoperative nausea and vomiting compared to preoperative fasting. J Res Med Sci 2013;18(10): 827–32.
[31] Mathur C, et al. Effect of preoperative Oral carbohydrate fluid on post operative nausea and vomiting in laparoscopic cholecystectomy patients under general Anesthesia. Archives of Anesthesiology & Critical Care 2023;9(4):279–87.
[32] McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): an R package and shiny web app for visualizing risk-of-bias assessments. Res Synth Methods 2020;12 (1):55–61.
[33] Wang Y, et al. Safety and efficacy of a novel neurosurgical enhanced recovery after surgery protocol for elective craniotomy: a prospective randomized controlled trial. J Neurosurg 2019;130(5):1680–91.
[34] Noba L, Wakefield A. Are carbohydrate drinks more effective than preoperative fasting: a systematic review of randomised controlled trials. J Clin Nurs 2019;28 (17–18):3096–116.
[35] Bilku DK, et al. Role of preoperative carbohydrate loading: a systematic review. Ann R Coll Surg Engl 2014;96(1):15–22.
[36] Amer MA, et al. Network meta-analysis of the effect of preoperative carbohydrate loading on recovery after elective surgery. Br J Surg 2017;104(3):187–97.
[37] Kotfis K, et al. Preoperative Oral carbohydrate (CHO) supplementation is beneficial for clinical and biochemical outcomes in patients undergoing elective Cesarean delivery under spinal anaesthesia-a randomized controlled trial. J Clin Med 2023; 12(15).
[38] Kampman JM, et al. Mortality and morbidity after total intravenous anaesthesia versus inhalational anaesthesia: a systematic review and meta-analysis. eClinicalMedicine 2024;72:102636.
[39] Ahmed MM, Lu TC, Lee Y. Total intravenous Anesthesia versus inhalation Anesthesia on postoperative analgesia and nausea and vomiting after bariatric surgery: a systematic review and Meta-analysis - PubMed. Asian J Anesthesio 2021; 59(4).
[40] Eming SA, Murray PJ, Pearce EJ. Metabolic orchestration of the wound healing response. Cell Metab 2021;33(9):1726–43.
[41] Von Ah Morano AE, et al. The role of glucose homeostasis on immune function in response to exercise: The impact of low or higher energetic conditions. J Cell Physiol 2020;235(4):3169–88.
[42] Haider KZ, Ahmed Z. Does a preoperative carbohydrate drink reduce postoperative inflammation? A systematic review and Meta-analysis. Trauma Care 2023;3(4): 294–307.
[43] Gan TJ, et al. Fourth consensus guidelines for the Management of Postoperative Nausea and Vomiting. Anesth Anal 2020;131(2):411–48.
[44] Fetzer SJ, et al. Evaluation of the Rhodes index of nausea and vomiting for ambulatory surgery patients. J Adv Nurs 2004;47(1):74–80.
[45] Boogaerts JG, et al. Assessment of postoperative nausea using a visual analogue scale. Acta Anaesthesiol Scand 2000;44(4):470–4.
[46] Wengritzky R, et al. Development and validation of a postoperative nausea and vomiting intensity scale. Br J Anaesth 2010;104(2):158–66.
[47] Apfel CC, et al. Evidence-based analysis of risk factors for postoperative nausea and vomiting. Br J Anaesth 2012;109(5):742–53.
[48] Li J, et al. Enhanced recovery after surgery (ERAS) protocol in geriatric patients underwent unicompartmental knee arthroplasty: a retrospective cohort study. Medicine 2023;102(6).
[49] Li X, et al. Preoperative carbohydrate loading with individualized supplemental insulin in diabetic patients undergoing gastrointestinal surgery: a randomized trial. International journal of surgery (London, England) 2022;98:106215.
[50] Zygmunt M, et al. Local and systemic tolerability of magnesium sulphate for tocolysis. Eur J Obstet Gynecol Reprod Biol 2003;107(2):168–75.
[51] Bisch SP, et al. Outcomes of enhanced recovery after surgery (ERAS) in gynecologic oncology – a systematic review and meta-analysis. Gynecol Oncol 2021;161(1): 46–55.