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# Total Intravenous Anesthesia (TIVA) Versus Inhalational Anesthesia for Postoperative Recovery: A Systematic Review of Randomized controlled trails

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## ABSTRACT

**Background:** Total intravenous anesthesia (TIVA) and inhalational anesthesia are widely used techniques for general anesthesia, but their effects on patient-perceived and conventional postoperative recovery outcomes are not uniform across surgical settings. This systematic review compared propofol-based TIVA with desflurane- or sevoflurane-based inhalational anesthesia in adult surgical patients.

**Methods:** A systematic review was conducted in accordance with PRISMA 2020. PubMed/MEDLINE, Embase, Scopus, the Cochrane Library, and ClinicalTrials.gov were searched from database inception to December 2021. Randomized controlled trials comparing propofol-based TIVA with desflurane- or sevoflurane-based anesthesia and reporting postoperative quality of recovery or related recovery outcomes were eligible. Two reviewers independently screened studies, extracted data, and assessed risk of bias using RoB 2. Because of substantial clinical and outcome heterogeneity, results were synthesized narratively rather than statistically pooled.

**Results:** Six randomized controlled trials were included, comprising 600 randomized participants and 555 participants in the analyzed datasets. Three trials (Lee et al., Na et al., and Joe et al.) reported significantly better global QoR-40 scores with TIVA at at least one principal postoperative assessment, whereas Moro et al., Kim et al., and Niu et al. found no statistically significant difference in global QoR-40. Selected domains, particularly physical comfort and physical independence, frequently favored TIVA. TIVA also reduced early nausea or rescue antiemetic use in some trials and lowered selected pain and inflammatory outcomes, but these effects were not consistent. In the trials reporting emergence time, propofol-based TIVA was associated with slower response or extubation than desflurane anesthesia.

**Conclusion:** Propofol-based TIVA may improve selected patient-centered recovery domains and early postoperative symptoms, but superiority in global postoperative recovery is not consistent across surgical populations. The certainty of the available evidence is limited by the small number of trials, heterogeneity in surgery and assessment timing, and inconsistent outcome reporting.

| | |
|---|---|
| Keywords | Total intravenous anesthesia (TIVA); Inhalational anesthesia; Postoperative recovery; Quality of recovery; Propofol. |
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## INTRODUCTION

General anesthesia is commonly maintained using either intravenous agents, particularly propofol, or inhalational volatile anesthetics such as sevoflurane and desflurane. Although both approaches provide effective surgical anesthesia, they differ in pharmacokinetic characteristics, emergence profiles, postoperative nausea and vomiting (PONV), analgesic requirements, and patient-perceived recovery [1–4]. Consequently, the choice of maintenance technique may influence not only immediate awakening but also the broader postoperative recovery experience. Postoperative recovery is multidimensional and extends beyond conventional endpoints such as time to extubation or discharge from the post-anesthesia care unit (PACU). The 40-item Quality of Recovery questionnaire (QoR-40) assesses emotional state, physical comfort, psychological support, physical independence, and pain, and has been used extensively as a patient-centered recovery measure [5,6]. These domains are clinically relevant because patients may perceive meaningful improvement even when conventional recovery times or complication rates are unchanged.

Randomized trials have produced inconsistent findings. Lee et al. reported better QoR-40 scores after thyroid surgery with propofol-remifentanil TIVA than with desflurane anesthesia [1]. Na et al. similarly observed improved early recovery after vitrectomy, while Joe et al. reported better recovery after curative pancreatic surgery [7,8]. In contrast, Moro et al., Kim et al., and Niu et al. did not demonstrate statistically significant differences in overall QoR-40 at their principal assessment points [9–11]. These variations suggest that surgical complexity, postoperative symptom burden, anesthetic regimen, and the timing of measurement may modify the apparent effect of anesthetic technique. The present systematic review therefore aimed to compare propofol-based TIVA with inhalational anesthesia in adult surgical patients, with emphasis on patient-reported quality of recovery and clinically relevant secondary outcomes including emergence, PONV, pain and analgesic requirements, sleep quality, inflammatory markers, and postoperative complications.

## METHODOLOGY

### Study Design

This systematic review was structured according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework. The review question was defined around adult surgical patients receiving general anesthesia, propofol-based TIVA as the intervention, volatile inhalational anesthesia as the comparator, and postoperative recovery outcomes as the principal outcomes of interest.

### Review Protocol and Registration

The eligibility criteria, outcomes, and extraction fields were specified before final data synthesis. The review was not prospectively registered in PROSPERO or another public protocol repository; this limitation was considered when assessing review transparency and is acknowledged in the limitations section.

### Literature Search Strategy

PubMed/MEDLINE, Embase, Scopus, the Cochrane Library, and ClinicalTrials.gov were searched from database inception to December 2021. The search combined controlled vocabulary, where available, with free-text terms for intravenous anesthesia, propofol, volatile anesthesia, postoperative recovery, QoR-40, PONV, pain, and emergence. A PubMed-compatible core strategy was: ("total intravenous anesthesia" OR TIVA OR propofol) AND ("inhalational anesthesia" OR "volatile anesthesia" OR desflurane OR sevoflurane) AND ("postoperative recovery" OR "quality of recovery" OR QoR-40 OR PONV OR pain OR emergence). Syntax was adapted for each database. Reference lists of included studies and relevant reviews were also screened for potentially eligible trials. No date restriction other than the final search date was applied.

### Eligibility Criteria

Studies were eligible when they: (1) enrolled adults undergoing a surgical procedure under general anesthesia; (2) used propofol-based TIVA as the maintenance technique; (3) compared TIVA with sevoflurane- or desflurane-based inhalational anesthesia; (4) reported the QoR-40 or another clearly defined postoperative recovery outcome; and (5) used a randomized controlled trial design. Full journal articles were required for inclusion. Case reports, observational studies, reviews, meta-analyses, conference abstracts, protocols, animal studies, duplicate reports, and studies without relevant postoperative recovery data were excluded. When more than one report described the same trial, the most complete report was used.

### Study Selection

All identified records were compiled and duplicate citations were removed before screening. Two reviewers independently screened titles and abstracts against the predefined criteria. Potentially eligible reports underwent full-text assessment. Reasons for full-text exclusion were recorded. Disagreements were resolved by discussion and, when necessary, by consultation with a third reviewer. Six RCTs met the final eligibility criteria and were included in the qualitative synthesis.

### Data Extraction

Two reviewers independently extracted data using a standardized form. Extracted variables included first author, publication year, country, trial design, randomized and analyzed sample size, participant characteristics, surgical procedure, ASA physical status, anesthetic regimens, follow-up time points, and recovery outcomes. Numerical data were extracted as reported, including means or

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medians, measures of variability, P values, confidence intervals, and event frequencies where available. When an exact numerical estimate was not available in the accessible extracted report, the finding was retained narratively and was not imputed.

**Quality Assessment**

Risk of bias was evaluated with the Cochrane Risk of Bias 2 (RoB 2) framework across five domains: bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Judgements were made independently by two reviewers and categorized as low risk, some concerns, or high risk. Disagreements were resolved by consensus. Outcome assessment was considered particularly important because several recovery measures were patient-reported and complete blinding of anesthetic technique is difficult in perioperative trials.

**Certainty of Evidence**

The certainty of evidence for the principal outcome groups was assessed qualitatively by considering risk of bias, inconsistency across studies, indirectness, imprecision, and the possibility of publication bias. Because the evidence base was small and outcomes were reported at different postoperative time points, certainty ratings were used to support interpretation rather than to generate pooled estimates.

**Outcomes**

The primary outcome was postoperative quality of recovery, predominantly measured with the QoR-40. Secondary outcomes included time to verbal response or extubation, PACU recovery, PONV and rescue antiemetic use, pain scores, opioid or other analgesic consumption, sleep quality, inflammatory markers, hemodynamic outcomes, and postoperative complications or adverse events.

**Statistical Analysis and Data Synthesis**

Substantial variation existed in surgical populations, volatile comparators, anesthetic dosing strategies, outcome definitions, and timing of postoperative assessments. A quantitative meta-analysis was therefore not undertaken. Findings were grouped by outcome domain and synthesized narratively. Continuous outcomes are presented using the summary measures reported by the original trials, and categorical outcomes are described using event frequencies or proportions. Statistical significance was interpreted at $P<0.05$, but clinical interpretation also considered the magnitude and consistency of between-group differences. Formal funnel-plot or regression-based assessment of publication bias was not performed because fewer than 10 studies were included.

**RESULTS**

**Study Selection Process**

Database and registry searches identified 1,213 records. After removal of 312 duplicates, 901 records underwent title and abstract screening, of which 831 were excluded. Seventy reports were sought for full-text retrieval; three could not be retrieved, leaving 67 reports for eligibility assessment. Sixty-one reports were excluded because of an ineligible population (n=24), ineligible intervention/comparator (n=15), irrelevant outcomes (n=10), ineligible study design (n=7), or publication as an abstract/conference abstract only (n=5). Six randomized controlled trials were included in the final systematic review. The selection process is summarized in Figure 1.

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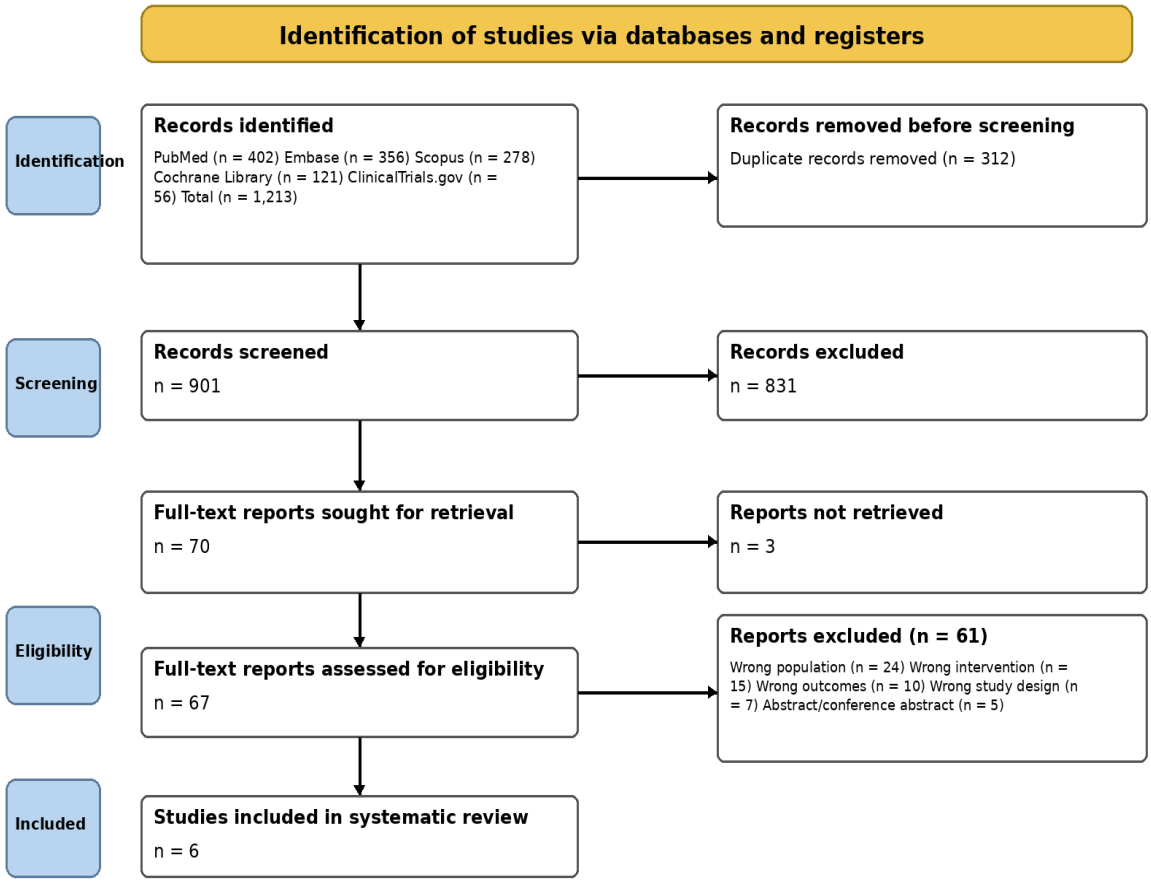


**Figure 1: PRISMA 2020 flow diagram of study selection**

### Study Characteristics and Patient Demographics

The six included trials randomized 600 participants; 555 participants were represented in the analyzed datasets. Individual analyzed sample sizes ranged from 68 to 116 participants. Surgical populations included thyroid surgery, otorhinolaryngological surgery, vitrectomy, corrective lower-limb osteotomy, total laparoscopic hysterectomy, and curative pancreatic surgery. Participants were generally ASA physical status I–III. One trial enrolled only women undergoing thyroid surgery and one enrolled women undergoing laparoscopic hysterectomy, while the remaining trials included mixed-sex surgical populations. Across individual trials, baseline characteristics were reported as broadly comparable between randomized groups. Propofol-remifentanil TIVA was compared with either desflurane- or sevoflurane-based inhalational anesthesia. The principal study characteristics are summarized in Table 1.

**Table 1: Characteristics of the Included Randomized Controlled Trials**

| Study (Year) | Country | Study design | Sample size | Patient population / surgery | TIVA regimen | Inhalational regimen | Recovery outcomes / assessment |
|---|---|---|---|---|---|---|---|
| Lee et al. (2015) | Republic of Korea | Prospective randomized controlled trial; outcome assessor blinded | Randomized: 80 Analyzed: 76 (TIVA 38; desflurane 38) | Women 20–65 y; thyroid surgery | Propofol + remifentanil by effect-site TCI | Desflurane + remifentanil infusion | QoR-40 preoperative, POD1 and POD2; PONV, antiemetic/analgesic use, hospital stay. |
| Moro et al. (2016) | Brazil | Prospective randomized clinical trial; double-blind (patients/investigators) | Randomized: 120 Analyzed: 110 (TIVA 54; inhalation 56) | Adults 18–65 y; ASA I–II; otorhinolaryngological surgery | Remifentanil + propofol (2 mg/kg bolus; 4–6 mg/kg/h infusion) | Remifentanil + sevoflurane (2% maintenance) | Primary: QoR-40 at 24 h; PACU stay, shivering, urinary retention, hypothermia, PONV, pain, analgesic use. |
| Na et | Republ | Single-center randomized | Randomize | Adults 20–80 y; | Propofol + | Desflurane | Primary: QoR-40 at 6 h; |

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| al. (2018) | ic of Korea | controlled trial; patients/investigators/outcome assessors blinded | d: 84 Analyzed: 83 (TIVA 41; desflurane 42) | ASA I–III; elective vitrectomy | remifentanil effect-site TCI; Schnider/Minto models | + remifentanil TCI; propofol induction | verbal response/extubation, PACU symptoms, analgesic/antiemetic use. |
| Kim et al. (2021) | Republic of Korea | Randomized controlled trial; patients/outcome assessors/data analyst blinded | Randomized: 76 Analyzed: 68 (TIVA 35; desflurane 33) | Adults ≥19 y; ASA I–II; corrective lower-limb osteotomy | Propofol + remifentanil effect-site TCI; Marsh/Minto models | Desflurane 4–7% + remifentanil infusion | QoR-40 POD1–2; nausea, rescue antiemetics, PCA opioid use, response time, complications. |
| Niu et al. (2021) | China | Prospective randomized controlled trial; single-blind | Randomized: 108 Analyzed: 102 (TIVA 51; sevoflurane 51) | Women 25–55 y; ASA I–II; elective total laparoscopic hysterectomy | Propofol 2 mg/kg induction; 3–6 mg/kg/h + remifentanil 0.1–0.3 μg/kg/min | Sevoflurane 6–8% induction; 1.5–2.5% maintenance + remifentanil 0.1–0.3 μg/kg/min | QoR-40, PSQI, NRS at multiple time points to 30 d; hemodynamics, inflammatory markers, adverse reactions. |
| Joe et al. (2021) | Republic of Korea | Prospective randomized trial; double-blind (patients/investigators) | Randomized: 132 Analyzed: 116 (TIVA 59; desflurane 57) | Adults ≥20 y; pancreatic cancer/periampullary tumor; pancreatoduodenectomy or distal pancreatectomy | Propofol + remifentanil effect-site TCI; propofol 2–6 μg/mL and remifentanil 2–6 ng/mL | Desflurane 3–7% (0.7–1.1 MAC) + remifentanil 0.02–0.2 μg/kg/min | Primary: global QoR-40 on POD3; QoR-40 preoperative/POD1/POD3/POD7; PACU pain/PONV and perioperative outcomes. |

Notes: ASA, American Society of Anesthesiologists; DES, desflurane; MAC, minimum alveolar concentration; PACU, post-anesthesia care unit; POD, postoperative day; PSQI, Pittsburgh Sleep Quality Index; QoR-40, Quality of Recovery-40; TCI, target-controlled infusion; TIVA, total intravenous anesthesia.

**Risk of Bias Assessment**

Risk of bias was assessed across the six randomized controlled trials using RoB 2. Lee et al. (2015), Moro et al. (2016), Kim et al. (2021), and Joe et al. (2021) were judged to have a low overall risk of bias. Na et al. (2018) was judged as having some concerns, principally in outcome measurement, while Niu et al. (2021) had some concerns related to deviations from intended interventions. No trial was judged to have a high overall risk of bias. Across all six studies, D1, D3, and D5 were rated low risk in 6/6 (100%). D2 was rated low risk in 5/6 (83.3%) and as some concerns in 1/6 (16.7%); D4 showed the same distribution. Overall, 4/6 studies (66.7%) were judged low risk and 2/6 (33.3%) had some concerns.

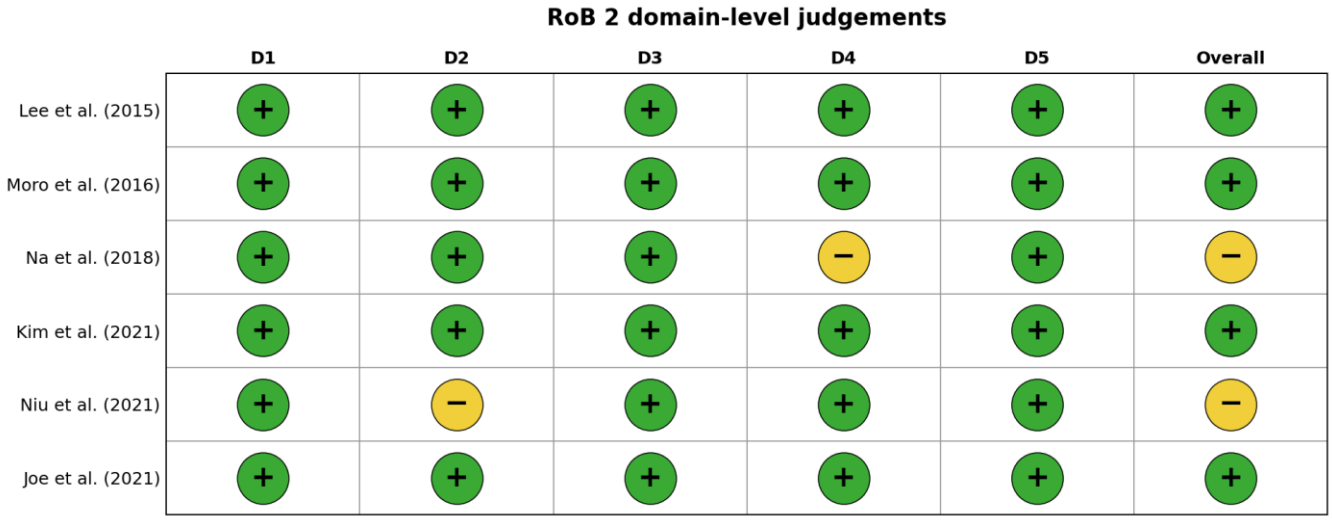


**Figure 2: Traffic-light plot of RoB 2 judgements for included studies**

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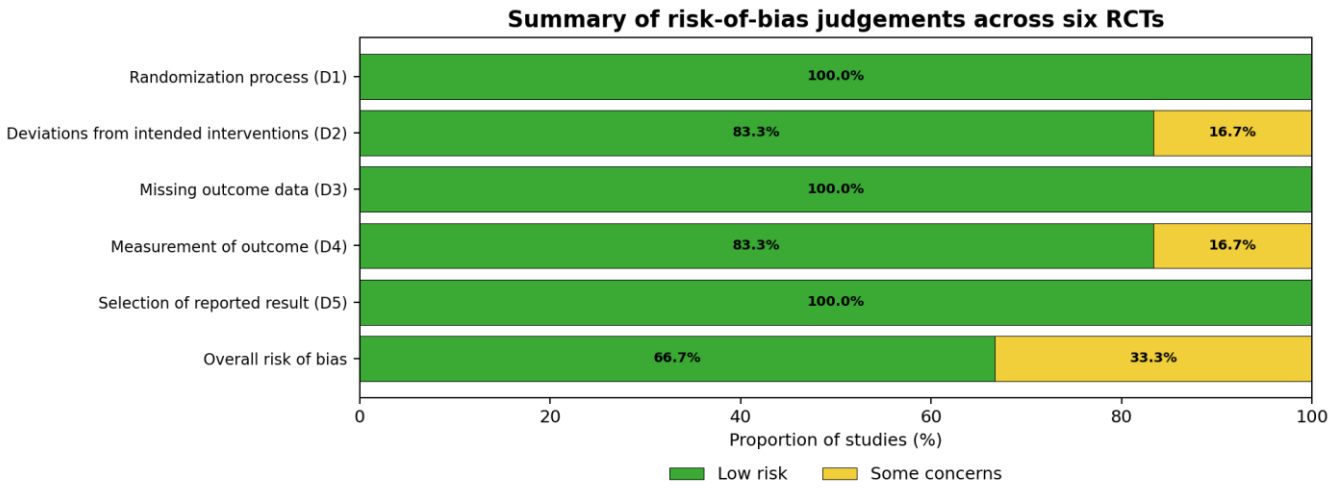


**Figure 3: Summary of risk-of-bias judgements across the included studies**

### Certainty of Evidence

The overall certainty of evidence was judged as low for global QoR-40, PONV, pain/analgesic outcomes, and postoperative complications because findings were inconsistent, individual trials were relatively small, and outcomes were measured at different postoperative time points. Evidence for slower emergence with TIVA was judged as low-to-moderate because the direction of effect was consistent in the trials that reported this outcome but was based on a limited number of studies. These ratings indicate that the direction of some effects is suggestive, but the magnitude of benefit remains uncertain.

**Table 2: Qualitative Certainty of Evidence for Major Recovery Outcomes**

| Outcome | Evidence pattern | Main limitations | Certainty |
|---|---|---|---|
| Global QoR-40 | Three trials favored TIVA at a principal time point; three found no statistically significant global difference. | Heterogeneous surgery and timing; small trial set; inconsistent effect. | Low |
| Emergence / extubation | Trials reporting emergence generally found slower response/extubation with TIVA vs desflurane. | Few studies; different emergence definitions. | Low–moderate |
| PONV / antiemetic use | Early benefit in some trials, but not consistently maintained across studies/time points. | Variable prophylaxis and timing; inconsistent results. | Low |
| Pain / analgesic use | Selected pain outcomes favored TIVA; overall opioid-sparing effect inconsistent. | Different pain scales and analgesic regimens. | Low |
| Complications / safety | No consistent major safety difference identified. | Events uncommon and trials not powered for rare complications. | Low |

### Systematic Review of Outcomes

The six included studies assessed recovery across different surgical populations using patient-reported and conventional perioperative outcomes. QoR-40 was the principal recovery instrument in all included trials, although assessment time points varied from 6 hours after surgery to several postoperative days. Secondary outcomes included emergence, PONV, pain, analgesic requirements, sleep quality, inflammatory markers, hemodynamic variables, and postoperative complications. The direction and magnitude of effect were not uniform across trials.

### Quality of Postoperative Recovery

Lee et al. (2015) reported a significantly higher QoR-40 score on POD1 with TIVA than with desflurane anesthesia after thyroid surgery (174 vs. 161; P=0.004), with better physical comfort and physical independence on POD1 and POD2 [1]. Moro et al. (2016), in contrast, found no significant difference in global QoR-40 at 24 hours after otorhinolaryngological surgery (190.5 vs. 189.5; P=0.33), and the individual domains were also comparable [9]. Na et al. (2018) found a significantly higher median QoR-40 score 6

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hours after vitrectomy with TIVA (181.0 vs. 169.5; P=0.033), including improvements in physical comfort (P=0.031) and physical independence (P=0.045) [7]. Kim et al. (2021) reported no statistically significant difference in global QoR-40 on POD1 (153.5 vs. 140.0; P=0.056; 95% CI for the between-group comparison −22.5 to 0.2) or POD2 (155.5 vs. 152.0; P=0.209; 95% CI −17.5 to 3.9), although physical independence favored TIVA on both days [10]. Importantly, the original trial noted that the magnitude of the POD1 difference could still be clinically meaningful despite not meeting the conventional significance threshold. Niu et al. (2021) found no significant difference in global QoR-40 or its five dimensions between TIVA and sevoflurane anesthesia at the assessed postoperative time points [11]. Joe et al. (2021), however, reported significantly higher global QoR-40 on POD3 with TIVA after curative pancreatectomy; the benefit was also evident in the pancreatoduodenectomy subgroup, particularly for physical comfort and psychological support [8]. Overall, three of six trials showed a statistically significant improvement in global QoR-40 with TIVA at at least one principal assessment, while three did not. This pattern supports a possible recovery benefit in selected surgical settings rather than universal superiority.

**Emergence and Early Recovery**

Where directly reported, early emergence tended to be slower with propofol-based TIVA than with desflurane anesthesia. Na et al. reported longer times to verbal response (799.0 vs. 497.5 seconds; P<0.001) and extubation (867.0 vs. 523.0 seconds; P<0.001) with TIVA [7]. Kim et al. likewise reported a longer response time after cessation of anesthesia (13.0 vs. 8.3 minutes; P=0.028) [10]. These findings indicate that faster awakening and better patient-perceived recovery are not necessarily equivalent outcomes.

**Postoperative Nausea and Vomiting**

PONV findings generally favored TIVA during the earliest recovery phase, but the advantage was not uniform. In Lee et al., the incidence of nausea or vomiting was lower with TIVA in the PACU (2.6% vs. 18.4%) and within 24 hours (44.7% vs. 68.4%); no patient in the TIVA group required additional antiemetic treatment in the PACU compared with 13.2% in the desflurane group [1]. Kim et al. reported lower PACU nausea scores with TIVA (0.0 vs. 1.0; P<0.001) and less rescue antiemetic use (0% vs. 15.2%; P=0.017), although differences were not maintained on POD1–2 [10]. Moro et al. found no significant difference in nausea/vomiting (P=0.39), and Na et al. similarly reported no significant difference in PONV-related complications [7,9].

**Postoperative Pain and Analgesic Requirements**

Pain and analgesic outcomes were heterogeneous. Moro et al. found no significant difference in pain intensity (P=0.80) or morphine use in the PACU (P=0.40) [9]. Kim et al. observed fewer early PCA bolus attempts with TIVA, but total 48-hour morphine-equivalent consumption was similar (132.1 vs. 144.1 mg; P=0.235) [10]. Niu et al. reported lower NRS pain scores with TIVA at 72 hours (P=0.023) and 7 days (P=0.017) [11]. Thus, a consistent opioid-sparing effect could not be established, although selected pain outcomes favored TIVA.

**Sleep Quality, Inflammatory Markers, and Other Outcomes**

Niu et al. reported no significant difference in postoperative sleep quality assessed by the Pittsburgh Sleep Quality Index, but postoperative neutrophil-to-lymphocyte ratio (P=0.024), high-sensitivity C-reactive protein (P=0.042), and abdominal distension (P=0.017) were lower with TIVA [11]. Kim et al. reported no anesthesia-related complications and broadly comparable postoperative complications [10]. Moro et al. similarly found comparable rates of hypothermia and other recovery-related adverse events [9]. No consistent evidence suggested a major postoperative safety disadvantage with either anesthetic technique.

**OVERALL FINDINGS**

Across six RCTs, TIVA was associated with significantly better global QoR-40 in thyroid surgery, vitrectomy, and curative pancreatectomy, whereas no statistically significant global difference was demonstrated after otorhinolaryngological surgery, corrective lower-limb osteotomy, or total laparoscopic hysterectomy. Selected secondary outcomes—including physical comfort, physical independence, early nausea, selected pain measures, and inflammatory markers—favored TIVA in individual studies. Conversely, desflurane anesthesia was associated with faster emergence in the trials that directly compared awakening times. The evidence therefore supports outcome-specific and surgery-specific differences rather than a consistent global advantage of one technique.

**Table 3: Postoperative Recovery Outcomes of TIVA Versus Inhalational Anesthesia**

| Study | Quality of Recovery | Emergence / PACU | PONV / Antiemetic Use | Pain / Analgesic Requirement | Other Outcomes / Safety |
|---|---|---|---|---|---|
| Lee et al., 2015 | QoR-40 POD1: 174 vs 161; P=0.004. Physical comfort and physical independence favored TIVA on POD1–2. | No clear emergence advantage established in the extracted dataset. | PONV lower with TIVA in PACU (2.6% vs 18.4%) and within 24 h (44.7% vs 68.4%); PACU rescue antiemetic 0% vs 13.2%. | Analgesic use was assessed; no consistent overall analgesic advantage was established in the extracted dataset. | Hospital stay and other recovery variables were collected; no major safety signal identified. |

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| Moro et al., 2016 | QoR-40 at 24 h: 190.5 vs 189.5; P=0.33; dimensions comparable. | PACU stay 60 (60–60) vs 60 (60–70) min; P=0.97. Shivering 4% vs 13%; P=0.09. | PONV 9% vs 4%; P=0.39. | Pain intensity P=0.80; morphine use P=0.40. | Urinary retention 0% vs 4%; P=0.24. Hypothermia 16% vs 11%; P=0.58. |
| Na et al., 2018 | QoR-40 at 6 h: 181.0 vs 169.5; P=0.033. Physical comfort P=0.031 and physical independence P=0.045 favored TIVA. | Verbal response and extubation significantly longer with TIVA; both P<0.001. | No significant difference in PACU nausea/vomiting or antiemetic use. | No significant difference in PACU analgesic use. | Hemodynamics broadly comparable; transient HR differences after extubation. |
| Kim et al., 2021 | Global QoR-40: POD1 153.5 vs 140.0, P=0.056; POD2 155.5 vs 152.0, P=0.209. Physical independence favored TIVA. | Response time 13.0 vs 8.3 min; P=0.028, longer with TIVA. | PACU nausea lower with TIVA; rescue antiemetics 0% vs 15.2%; P=0.017. | 48-h morphine-equivalent PCA dose 132.1 vs 144.1 mg; P=0.235; fewer early bolus attempts with TIVA. | No anesthesia-related complications; other postoperative complications comparable. |
| Niu et al., 2021 | QoR-40 and all five dimensions similar between groups (P>0.05). | Selected hemodynamic/vasopressor requirements differed between groups. | Adverse reactions assessed; no consistent PONV-related superiority established. | NRS pain lower with TIVA at 72 h (P=0.023) and 7 d (P=0.017). | PSQI comparable; NLR P=0.024, hs-CRP P=0.042, and abdominal distension P=0.017 lower with TIVA. |
| Joe et al., 2021 | Global QoR-40 on POD3 significantly higher with TIVA; pancreatoduodenectomy subgroup also favored TIVA; physical comfort and psychological support improved. | Early recovery outcomes were assessed; exact numerical between-group estimates were not available in the extracted dataset. | PONV was assessed; exact numerical estimates were not available in the extracted dataset. | Pain/analgesic outcomes were assessed; exact numerical estimates were not available in the extracted dataset. | No major safety signal favoring inhalational anesthesia was reported. |

## DISCUSSION

### Summary of Findings

This review synthesized six randomized controlled trials involving 600 randomized participants (555 analyzed) across six surgical settings. The central finding is that the effect of anesthetic maintenance technique on patient-perceived recovery is heterogeneous. Three trials demonstrated significantly better global QoR-40 scores with propofol-based TIVA at a principal postoperative assessment, whereas three trials did not identify a statistically significant global difference. Nevertheless, improvements in individual QoR-40 domains and selected secondary outcomes were observed more frequently with TIVA than with inhalational anesthesia. The findings also demonstrate that different dimensions of recovery may move in opposite directions. In particular, TIVA was associated with slower verbal response or extubation in the trials that compared emergence with desflurane, yet some of these same trials showed better patient-reported recovery or less early nausea. Conventional awakening time should therefore not be interpreted as a complete surrogate for postoperative recovery quality.

### Comparison With Previous Literature

The overall pattern is consistent with broader evidence suggesting that propofol-based anesthesia can reduce PONV and may modestly improve selected pain or recovery outcomes, while volatile agents—particularly desflurane—can provide faster emergence in some settings [2,3]. However, the current review indicates that these average tendencies are not reproduced uniformly in every surgical population. Differences in procedure type, postoperative symptom burden, anesthetic dosing, antiemetic prophylaxis, opioid exposure, and timing of QoR assessment are likely contributors to the observed variability.

### Quality of Postoperative Recovery

The most clinically relevant observation was the inconsistency in global QoR-40. Significant benefits were found after thyroid surgery, vitrectomy, and curative pancreatectomy [1,7,8], while global scores were statistically similar after otorhinolaryngological surgery, lower-limb osteotomy, and laparoscopic hysterectomy [9–11]. This distribution argues against interpreting TIVA as

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universally superior. It instead suggests that the value of TIVA may be greatest in settings where nausea, discomfort, or early functional independence represent a substantial proportion of the postoperative symptom burden. Statistical non-significance should also be distinguished from absence of clinically meaningful effect. In the lower-limb osteotomy trial, the global QoR-40 comparison on POD1 narrowly missed statistical significance, while the original investigators noted that the magnitude of difference exceeded the clinically important threshold used in that trial [10]. This illustrates why interpretation should consider effect magnitude, confidence intervals, and patient-relevant domains rather than P values alone.

**Emergence, PONV, and Pain**

Desflurane was associated with faster emergence than propofol-based TIVA in the trials by Na et al. and Kim et al. [7,10]. This is clinically relevant when rapid awakening is a priority, but the observed difference did not consistently translate into better patient-perceived recovery. Conversely, early PONV outcomes favored TIVA in the thyroid and lower-limb osteotomy trials [1,10], while other trials showed no significant difference [7,9]. The antiemetic advantage of propofol therefore appears plausible but context dependent. The effect on postoperative pain was less consistent. Niu et al. reported lower pain at later postoperative time points, and Kim et al. observed fewer early PCA bolus attempts, but overall analgesic consumption was not consistently reduced [10,11]. These findings suggest that any analgesic benefit of TIVA is likely modest and may be influenced by the surgical procedure and accompanying multimodal analgesic regimen.

## CLINICAL IMPLICATIONS

Anesthetic selection should remain individualized. Propofol-based TIVA may be particularly attractive when minimizing PONV, improving physical comfort, or supporting patient-perceived recovery is a priority. Inhalational anesthesia, especially desflurane-based techniques, may be advantageous when rapid emergence is especially important. The available evidence does not support treating either technique as universally superior across all adult surgical populations.

## FURTHER DIRECTIONS

Future randomized trials should use standardized postoperative recovery endpoints and harmonized assessment time points. QoR-40 or QoR-15 should be reported alongside conventional endpoints such as extubation time, PACU duration, PONV, opioid consumption, and complications. Trials should report between-group effect estimates with confidence intervals in addition to P values and should prespecify what constitutes a clinically meaningful difference. Larger multicenter studies would also permit assessment of whether effects differ according to surgical complexity, sex, baseline PONV risk, anesthetic dosing strategy, and target-controlled infusion techniques.

## STRENGTHS AND LIMITATIONS

The principal strength of this review is its focus on randomized evidence and patient-centered postoperative recovery across multiple surgical settings. The review also considered conventional emergence outcomes, PONV, pain, analgesic consumption, inflammatory markers, and postoperative safety, allowing a broader interpretation of recovery than any single endpoint. Several limitations should be considered. First, only six trials were included and individual studies were relatively small, limiting precision. Second, the surgical procedures, volatile comparators, anesthetic regimens, and timing of QoR-40 measurement differed substantially, precluding a defensible quantitative meta-analysis of the extracted dataset. Third, secondary outcomes were inconsistently defined and reported, and exact numerical estimates were not available for every outcome in every study. Fourth, the review was not prospectively registered. Fifth, formal assessment of publication bias was not reliable with fewer than 10 studies, so small-study and publication effects cannot be excluded. Finally, the certainty of evidence was generally low because of inconsistency, imprecision, and heterogeneity; consequently, the findings should be interpreted as suggestive of outcome-specific benefits rather than definitive proof of overall superiority.

## CONCLUSION

Propofol-based TIVA may improve selected aspects of postoperative recovery compared with inhalational anesthesia, particularly physical comfort, physical independence, early PONV, and some patient-reported recovery outcomes. However, global QoR-40 results were inconsistent across surgical populations, and desflurane-based anesthesia produced faster emergence in trials that directly evaluated awakening time. The available evidence therefore supports individualized anesthetic selection rather than universal preference for either technique. Larger, standardized, adequately powered randomized trials are needed to establish the magnitude and clinical importance of these differences with greater certainty.

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