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Total Intravenous Anesthesia (TIVA) versus Inhalational Agents: A Meta-Analysis of Outcomes

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Introduction

Total Intravenous Anesthesia (TIVA) and inhalational anesthesia represent two principal modalities for the maintenance of general anesthesia, each with distinct pharmacologic profiles, benefits and limitations. This meta-analysis aims to synthesize existing comparative data on patient outcomes associated with TIVA and inhalational agents across a variety of surgical disciplines. By analyzing randomized controlled trials and cohort studies, the review focuses on parameters such as recovery profiles, Postoperative Nausea and Vomiting (PONV), hemodynamic stability, cognitive outcomes and long-term morbidity. TIVA, primarily utilizing agents such as propofol and remifentanil, offers precise control of anesthetic depth with rapid titratability and minimal environmental contamination. Inhalational agents, including sevoflurane, desflurane and isoflurane, are widely used due to ease of administration and predictable pharmacokinetics, especially in prolonged procedures. The data indicates that patients receiving TIVA generally experience shorter recovery times and lower incidence of PONV, particularly in outpatient or ambulatory surgical settings. These benefits are attributed to the antiemetic properties of propofol and the absence of volatile agents known to trigger nausea. Conversely, inhalational agents have demonstrated better control over intraoperative hypotension and are often preferred in hemodynamically unstable patients due to their vasodilatory characteristics. However, they may be associated with delayed emergence and higher rates of cognitive dysfunction in elderly patients [1-2].

Description

The studies reviewed also examined cost-effectiveness, noting that while inhalational techniques are often less expensive upfront, the faster recovery associated with TIVA can reduce total care costs. These findings emphasize the need for individualized anesthetic planning based on surgical requirements, patient comorbidities and institutional resources. The meta-analysis provides evidence that neither modality is universally superior, but each has context-dependent advantages that influence clinical outcomes. The comparative safety profiles of TIVA and inhalational anesthesia were a focal point in many of the included studies, particularly in relation to perioperative hemodynamic events and adverse drug reactions. TIVA was consistently associated with reduced sympathetic activation, leading to more stable intraoperative hemodynamics in normotensive patients, though dose-dependent hypotension with propofol remains a consideration. In contrast, inhalational agents were more likely to cause vasodilation-related hypotension in high-risk patients but could be rapidly adjusted via inspired concentration, offering responsive control [3].

The incidence of intraoperative awareness was notably lower in patients under TIVA, possibly due to more consistent delivery and monitoring through target-controlled infusion systems. Several studies also highlighted the neuroprotective potential of propofol-based TIVA in neurosurgical and cardiac surgeries, where reduction in cerebral metabolic demand is desired. However, in patients with poor peripheral access or metabolic abnormalities, intravenous agents may be less predictable in pharmacokinetics, favoring inhalational routes. Respiratory effects were also differentiated: inhalational agents were more likely to induce bronchodilation, an advantage in patients with reactive airway diseases. In contrast, TIVA avoided airway irritation and was preferred in cases requiring laryngeal mask airway insertion or where airway reflexes needed minimal stimulation. Regarding immunologic effects, TIVA was found to reduce the incidence of perioperative immune suppression, which may impact infection rates and cancer recurrence, though evidence remains inconclusive. The reviewed data suggest a lower incidence of emergence delirium in TIVA patients, particularly in pediatric populations. Cardioprotective properties of volatile agents, especially sevoflurane and isoflurane, were observed in myocardial ischemia models, though their clinical relevance remains debated. In balancing these findings, the anesthetic choice must consider specific organ system risks and procedure-related priorities. Ultimately, understanding the nuanced differences between these two approaches allows for safer, more tailored anesthetic management across diverse patient populations [4].

Despite growing interest in TIVA, widespread implementation faces several challenges, including provider familiarity, equipment availability and institutional protocols. The need for specialized infusion pumps, target-controlled infusion (TCI) software and real-time monitoring technologies may hinder adoption in under-resourced settings. In contrast, inhalational techniques require less training and infrastructure, making them more accessible in routine practice. Concerns also persist regarding inter-patient variability in TIVA pharmacokinetics, particularly in populations with altered drug metabolism such as obese, elderly, or critically ill patients. Ongoing education and simulation-based training are essential to ensure anesthesiologists are equipped to deliver TIVA safely and effectively. Moreover, protocols for anesthesia emergence, airway management and postoperative care must be adapted to suit TIVA's pharmacodynamic profile. Intraoperative documentation and vigilance for delayed emergence or propofol infusion syndrome—though rare—are necessary components of safe practice [5].

Conclusion

Future research should focus on refining algorithms for TCI, integrating AI to anticipate drug response patterns and establishing clear outcome benchmarks across surgery types. Comparative effectiveness studies involving diverse surgical populations and long-term follow-up will help validate existing meta-analytic conclusions. Furthermore, global anesthesia societies are encouraged to develop guidelines that support evidence-based anesthetic selection and highlight the environmental advantages of TIVA. Patient education also plays a vital role, as informed individuals may express preferences for one anesthetic technique over another based on previous experiences or recovery goals. As anesthesia continues to evolve into a more data-driven, outcome-focused discipline, the TIVA versus inhalational debate highlights the necessity for individualized, context-sensitive decision-making. This meta-analysis affirms that both modalities have valuable roles and that the future lies in their thoughtful integration rather than competition.

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Conflict of Interest

None.

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