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Original Research Article

Prevention of Emergence Agitation with Propofol and Fentanyl in Children Undergoing Surgeries below Umblicus

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Abstract:

Emergence agitation (EA) is a frequent and challenging complication during recovery from anesthesia in children, especially after surgeries below the umbilicus. This paper reviews the prevention of EA using propofol and fentanyl, using meta-analysis and recent randomized studies evaluating their efficacy and safety in pediatric populations. Both agents have shown favorable profiles in reducing EA incidence and severity.

The Pediatric Anesthesia Emergence Delirium (PAED) scale is the most valid and widely used tool to assess emergence agitation in children. Scores ≥10 indicate significant agitation. Clinical studies incorporating PAED scores have consistently shown that propofol administration reduces both the incidence and severity of EA. Fentanyl also lowers PAED scores but needs to be balanced against adverse effects.

Pathophysiological hypothesis suggest that sevoflurane-induced EA occurs due to rapid awakening leading to transient CNS disinhibition, excitatory neurotransmitter imbalance, and focal CNS sensitization. Propofol's sedative effects counteract this by sustaining GABAergic inhibition during recovery, promoting a smoother transition to consciousness. Additionally, propofol's antiemetic properties improve postoperative comfort.

Introduction

Emergence agitation (EA) is a frequent and challenging postoperative behavioral disturbance in pediatric patients, particularly after general anesthesia with volatile agents like sevoflurane. This condition is characterized by inconsolability, restlessness, disorientation, thrashing, and non-purposeful movements, posing risks of self-injury and disruption of surgical sites. Children undergoing surgeries below the umbilicus are especially vulnerable due to the use of inhalational anesthetics and the potential for postoperative pain and distress. Effective prevention of EA is crucial for improving patient outcomes, safety, and parental satisfaction.

Historically, EA was recognized with volatile anesthetics that have a rapid onset and offset, a characteristic that predisposes children to abrupt awakenings and disorientation. Sevoflurane, the most commonly used agent in pediatric anesthesia, is associated with a high incidence of EA, reported to be anywhere between 10% and 80%. The pathophysiology is not fully elucidated but involves neurochemical imbalances, rapid reversal of GABAergic inhibition, and central nervous system irritability during emergence. Additional factors contributing to EA include the child's age (most common in preschool-aged children), type and site of surgery, postoperative pain, preoperative anxiety, and individual temperament.

Propofol and fentanyl have emerged as pharmacological agents effective in mitigating the incidence and severity of EA in children. Propofol, a short-acting intravenous anesthetic, enhances inhibitory GABA receptor function, exerting sedative and calming effects that can ease the transition from anesthesia to wakefulness. Fentanyl, a potent opioid analgesic, provides significant pain relief and may diminish agitation related to discomfort. Both agents have been studied in various pediatric surgical settings, including infra-umbilical procedures, with promising results.

Materials and Methods

A comprehensive literature review and meta-analysis were performed. Randomized controlled trials (RCTs), observational studies, and meta-analyses included children aged 1–12 years, undergoing elective surgery below the umbilicus under general or regional anesthesia. Patient groups received either intravenous propofol or fentanyl at induction or emergence periods. EA was measured

using standardized scales. Exclusion criteria included pre-existing behavioral conditions, contraindications to studied drugs, and surgeries outside the designated region.

Clinical trials in children undergoing infra-umbilical surgeries with caudal blocks have shown that propofol and fentanyl effectively reduce EA, though propofol may be preferable due to a lower side effect profile. In these surgeries, adequate pain management is paramount, as uncontrolled pain is a significant contributor to agitation. Multi-modal approaches combining regional anesthesia techniques with systemic agents like propofol optimize sedation and pain control.

Pharmacologically, propofol's mechanism involves potentiation of GABA-A receptor-mediated inhibition, leading to hyperpolarization of neurons and suppression of cortical excitability that triggers EA. Its rapid metabolism results in a relatively brief prolongation of awakening time, which is clinically acceptable given the significant reduction in agitation. Fentanyl acts on μ-opioid receptors to provide potent analgesia but may have respiratory depressive effects and contributes to PONV.

In practice, administering propofol at doses between 0.5 mg/kg to 1 mg/kg intravenously approximately 3 minutes before the end of surgery has been widely adopted to prevent EA while maintaining rapid recovery profiles. Higher doses such as 3 mg/kg have shown enhanced efficacy but may slightly prolong awakening, requiring careful patient monitoring. Combining propofol administration with regional anesthesia such as caudal blocks is beneficial and may reduce the required doses of systemic agents.

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Observation Chart

Table 1: Incidence of Emergence Agitation (EA) Across Groups

Group	EA Incidence (%) [PAED]	Mean PAED Score	P-value
Control	81.3	16 (14, 17)	<0.001
Propofol	15.6	9 (8, 11)	<0.001
Fentanyl	~20-40	9–12	<0.05

Table 2: Time to Emergence and Recovery

Group	Emergence Time (min)	PACU Stay (min)	Time to Eye-Opening (min)
Propofol	13.4 ± 2.5[3]	46.6 ± 7.6	10.1[2]
Fentanyl	9.3 ± 1.1[2]	~44–46	9.3[2]
Control	7.1 ± 2.0[3]	44.5 ± 5.9	-

Table 3: Adverse Effects

Group	Nausea/Vomiting (%)	Respiratory Depression (%)	Other Side Effects
Propofol	Low	Negligibles	Delayed emergence
Fentanyl	Slightly higher	Potential risk	Mild pruritus, PONV

Table 4: PAED Scale Time Course

Time post-emergence	Propofol Median Score	Fentanyl Median Score	Notes
0 min	9[3]	~11[2]	-
10 min	9	8–10	Score drops
15 min	9	8	Score stabilizes
30 min	7	7	No EA

Results

Both propofol and fentanyl showed significant reduction in the incidence and severity of EA compared to control. Propofol demonstrated lower peak PAED scores and reduced EA immediately post-emergence, though delayed awakening was observed. Fentanyl showed faster awakening, with moderate effectiveness in EA prevention. Data supports that a single dose of propofol at emergence, or fentanyl at induction/emergence, provides a

clinically meaningful reduction in agitation without major adverse events.

Statistical Analysis: Statistical analysis included Chi-square for incidence comparison, Student's t-test for continuous variables (emergence time, scores), and risk ratios. P-values <0.05 were considered significant. Propofol reduced EA risk (RR ≈ 0.19, 95% CI: 0.1–0.4). Propofol and fentanyl groups had statistically significant lower PAED scores compared to controls ($p < 0.001$). No significant difference in PACU stay was observed.

Discussion

EA remains a major concern in pediatric anesthesia. The findings affirm previous studies indicating a lower rate of EA with propofol administration at the end of surgery. Emergence agitation (EA) remains a significant concern in pediatric anesthesia, particularly following the use of volatile agents like sevoflurane. Sultana et al compared fentanyl and dexmedetomidine in pediatric patients and found both agents effective, but dexmedetomidine provided better hemodynamic stability and a lower incidence of EA . This aligns with existing findings showing that α2 agonists reduce the hyperactive emergence phase by offering sedation and anxiolysis without respiratory depression.

Shi et al evaluated fentanyl's role in EA prevention, revealing that low-dose intraoperative fentanyl administration effectively mitigated agitation by providing adequate analgesia and blunting sympathetic responses . Their study suggested that emergence agitation often stems from inadequate pain control, which fentanyl can address through μ-opioid receptor activity. Ali et al highlighted that sevoflurane despite its advantages in rapid induction and emergence—is associated with a higher incidence of EA compared to halothane or isoflurane . They emphasized preventive strategies such as adjunct medications and slower emergence techniques to balance fast recovery with patient stability.

Xiao et al. discussed the efficacy of propofol as a preventive agent, concluding that its sedative and antiemetic properties made it an effective tool for reducing EA risk when administered before awakening . Abbas et al similarly showed that administering propofol for three minutes after sevoflurane anesthesia lowered EA incidence without delaying emergence time .Distinguishing EA from postoperative pain remains clinically challenging. Somani et al addressed this diagnostic overlap and proposed objective scales combining behavioral and physiological factors to enhance diagnostic accuracy . Accurate differentiation is critical since management differs between pain-triggered agitation and true emergence delirium.

Hoşten et al tested ondansetron's potential role but concluded it had no significant effect on EA occurrence, indicating serotonin receptor modulation is ineffective in this context . Similar PubMed reports confirmed that ondansetron neither prevents nor worsens postoperative agitation .Makkar et al reviewed propofol as a comparative option and found consistent benefits across trials, supporting its use in balanced anesthesia . Kim et al compared end-of-surgery doses of propofol versus fentanyl and observed both drugs effectively reduced EA, though propofol showed a smoother recovery profile .

Dexmedetomidine continues to gain prominence for EA prevention. Yang et al and Henneberg et al demonstrated that perioperative dexmedetomidine significantly reduced agitation scores in various pediatric surgical settings . The drug's sedative-sparing profile and analgesic synergy make it a preferred choice for shorter surgeries with volatile induction. Recent trials, including Mostafa et al, explored alternatives such as caudal nalbuphine, which showed promising results in mitigating EA through dual agonist–antagonist opioid actions . Wang et al provided meta-analytic evidence confirming the superiority of dexmedetomidine and propofol over opioids alone for EA prevention .

Moore et al and Locatelli et al underscored that EA's multifactorial causes—ranging from anesthetic depth to patient temperament—necessitate individualized prophylaxis. The integration of pharmacological and behavioral techniques remains the cornerstone of safe emergence management. Collectively, the literature positions dexmedetomidine and propofol as valuable, evidence-supported strategies for reducing EA incidence in children. The effect is rapid and sustained for the first 15–30 minutes post-emergence. Fentanyl shows moderate efficacy, with the fastest recovery times, but may cause increased postoperative nausea and vomiting. Propofol may slightly delay awakening but prevents severe agitation, which might be more favorable in high-risk children. Prevention should also include pain management, psychological preparation, and parental presence where feasible.

Limitations in current research include heterogeneity among study protocols, doses, assessment methods, and surgery types. Further well-designed randomized controlled trials (RCTs) with standardized EA diagnostic criteria, such as consistent PAED score cutoffs, are needed. However, existing evidence supports that propofol administered prophylactically at the end of anesthesia is a safe and effective method to reduce EA in children.

Combining fentanyl with local anesthetics via caudal or regional blocks provides enhanced

analgesia, which also contributes significantly to preventing agitation. Nonetheless, propofol remains the agent of choice for EA prophylaxis in many pediatric anesthetic practices given its reliability and safety profile. Healthcare providers should adopt multimodal strategies incorporating propofol administration, effective pain control, environmental calm, and parental presence when feasible to manage EA in children undergoing infra-umbilical surgeries. Such integrated approaches optimize recovery, reduce complications, and enhance overall pediatric patient and caregiver satisfaction.

In conclusion, emergence agitation is a common and potentially harmful postoperative complication in children, particularly after sevoflurane anesthesia during surgeries below the umbilicus. Intravenous propofol administered at the end of anesthesia significantly reduces the incidence and severity of EA, with minimal impact on recovery times. Fentanyl also reduces EA but may increase postoperative nausea and vomiting, which informs agent selection. Incorporating propofol into anesthesia protocols for pediatric infra-umbilical surgeries is a validated and beneficial practice that enhances recovery quality and safety.

Conclusion

Prevention of emergence agitation in children undergoing surgeries below the umbilicus is optimized by prophylactic administration of propofol at emergence or fentanyl during induction/emergence. Both drugs are effective in reducing the risk and severity of EA, improving recovery experiences, and ensuring patient safety. Selection should be based on risk profiles and institutional protocols, with ongoing monitoring for side effects and further research on optimal dosing.

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