Section: Anaesthesia

Original Research Article

A COMPARATIVE STUDY OF LOW- DOSE PROPOFOL AND FENTANYL FOR EARLY EMERGENCE IN PATIENTS UNDERGOING ELECTIVE CRANIOTOMY-PROSPECTIVE RANDOMIZED CONTROL STUDY

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ABSTRACT

Background: Smooth and early emergence with stable hemodynamics is essential in patients undergoing elective craniotomy to facilitate fast-tracking and early neurological assessment. This study compared low-dose propofol infusion with low-dose fentanyl infusion administered during dural closure under sevoflurane anesthesia.

Materials and Methods: Eighty patients aged 18–60 years, ASA physical status I–III, scheduled for elective craniotomy were randomized into two equal groups (n=40 each). At the start of dural closure, Group P received intravenous propofol (1 mg/kg bolus followed by 3 mg/kg/h infusion), and Group F received intravenous fentanyl (1 µg/kg bolus followed by 1.5 µg/kg/h infusion). The study period extended from dural closure to 1 hour after tracheal extubation. Hemodynamic parameters (heart rate, mean arterial pressure), emergence time, early emergence distribution, time to regain full consciousness (GCS), and postoperative respiratory complications were assessed.

Results: Demographic variables were comparable between groups. Mean emergence time was significantly shorter in Group P (5.1 ± 0.3 min) compared to Group F (6.2 ± 1.1 min) (p=0.04). Early emergence was observed in 76.7% of patients in Group P versus 60% in Group F (p=0.01). The propofol group demonstrated reduced post-extubation tachycardia ($p<0.05$). Mean arterial pressure and oxygen saturation were comparable between groups. Fewer patients required postoperative ventilatory support in Group P (3.3%) compared to Group F (10%) (p=0.05).

Conclusion: Low-dose propofol infusion during dural closure under sevoflurane anesthesia provides faster emergence, improved early recovery profile, and better attenuation of post-extubation tachycardia compared to fentanyl infusion, supporting its use in fast-tracking after elective craniotomy.

Keywords: Craniotomy; Propofol; Fentanyl; Emergence from Anesthesia; Hemodynamics.

INTRODUCTION

Early and predictable emergence from anesthesia remains a fundamental objective in patients undergoing neurosurgical procedures, particularly craniotomy for supratentorial lesions. Rapid awakening permits timely neurological assessment, early detection of complications, and prompt intervention. Postoperative intracranial hematoma, although relatively uncommon, occurs in approximately 0.8–2.2% of patients and may be catastrophic if diagnosis is delayed. Therefore, anesthetic techniques must balance rapid recovery with strict hemodynamic control to prevent secondary brain injury.[1]

Emergence from anesthesia is frequently associated with sympathetic stimulation leading to hypertension and tachycardia. It is estimated that more than 80–90% of neurosurgical patients experience hypertension during emergence if no preventive measures are instituted[1]. Acute elevation in systemic blood pressure during this vulnerable period may increase the risk of postoperative intracranial hemorrhage and cerebral edema. Although early extubation is desirable, fast-tracking may paradoxically predispose to hemodynamic instability. Various pharmacological agents including beta-blockers, combined alpha-beta blockers, calcium channel blockers, and lidocaine have been used to attenuate extubation responses, but these agents may cause bradycardia, hypotension, or delayed recovery. Hence, titration of short-acting anesthetic agents during craniotomy closure may offer a more practical and physiologically rational strategy.[1,6]

Cerebral physiology plays a central role in anesthetic management. Continuous cerebral blood flow (CBF) is maintained by autoregulation, neurovascular coupling, and vasomotor reactivity to carbon dioxide. Autoregulation ensures stable CBF across a range of mean arterial pressures by altering cerebrovascular resistance. Volatile anesthetics such as isoflurane and sevoflurane may impair autoregulation at higher concentrations and produce dose-dependent cerebral vasodilation.[2] In contrast, intravenous agents such as propofol reduce CBF and cerebral metabolic rate of oxygen ($CMRO_2$) proportionately, thereby preserving flow–metabolism coupling. Opioids are generally considered neutral with respect to CBF and $CMRO_2$ and maintain autoregulatory responses.[7]

Propofol, a short-acting intravenous anesthetic, potentiates gamma-aminobutyric acid (GABA) receptor activity, producing sedation and hypnosis. It reduces systemic blood pressure through decreased systemic vascular resistance and myocardial depression. Importantly in neurosurgical practice, propofol decreases $CMRO_2$, CBF, and intracranial pressure (ICP), and facilitates rapid emergence due to its favorable pharmacokinetic profile. Its short context-sensitive half-time allows precise titration and predictable recovery, making it suitable for total intravenous anesthesia and controlled emergence.[4,5]

Fentanyl, a potent synthetic μ-opioid receptor agonist, provides profound analgesia and blunts sympathetic responses to laryngoscopy and extubation. It has minimal direct myocardial depressant effects but may cause vagally mediated bradycardia. By attenuating catecholamine release, fentanyl reduces hemodynamic fluctuations during emergence. However, excessive dosing may delay recovery or cause postoperative respiratory depression. Compared with remifentanil, fentanyl has a longer elimination half-life but remains widely used because of its hemodynamic stability and familiarity in neurosurgical anesthesia.[7-9]

Several studies have evaluated anesthetic techniques aimed at optimizing early recovery in craniotomy patients. Bhagat et al,[1] demonstrated that low-dose fentanyl infusion during craniotomy closure resulted in faster emergence and better control of postoperative hypertension compared with low-dose propofol or isoflurane. Todd et al,[2] reported comparable intracranial pressures among propofol–fentanyl, isoflurane–nitrous oxide, and fentanyl–nitrous oxide regimens, though recovery was faster with opioid-based techniques. Magni et al,[4] found no significant difference in emergence time between sevoflurane–fentanyl and propofol–remifentanil techniques, suggesting that balanced anesthesia with appropriate timing of drug discontinuation can achieve similar recovery profiles. Bruder et al,[6] further showed that delayed extubation did not attenuate metabolic or hemodynamic stress responses, reinforcing the importance of controlled but timely awakening.[6]

Despite available evidence, optimal pharmacological strategy during craniotomy closure remains debated. Low-dose propofol infusion may smooth emergence by reducing sympathetic outflow, while low-dose fentanyl may blunt extubation responses without significantly delaying recovery. Given the high incidence of emergence hypertension in neurosurgical patients at our center, evaluating these two strategies is clinically relevant.

The present study therefore aims to compare emergence duration between low-dose fentanyl and low-dose propofol administered during craniotomy closure under sevoflurane anesthesia. The primary objective is to compare mean emergence duration, while secondary objectives include assessment of hemodynamic responses and efficacy in preventing early postoperative hypertension.

MATERIALS AND METHODS

This randomized controlled trial was conducted at Tertiary care hospital in Tamilnadu over a period of 12 months in 2025. After obtaining approval from the Institutional Ethics Committee and written informed consent from all participants, 80 patients scheduled for elective neurosurgery under general anesthesia were enrolled in the study. All patients belonged to American Society of Anesthesiologists (ASA) physical status I–III and were aged between 18 and 60 years. Patients who did not meet inclusion criteria, refused consent, had known drug allergies, or had severe cardiovascular disease, hepatic or renal dysfunction, or chronic hypertension were excluded. The sample size of 80 (40 patients in each group) was calculated based on the expected difference between two means, assuming a 95% confidence interval, alpha error of 0.05, and power of 80%.[5]

All patients underwent detailed preoperative evaluation including hemoglobin, total and differential leukocyte count, platelet count, renal and liver function tests, coagulation profile, chest X-ray (PA view), electrocardiography, and echocardiography where indicated. In the operating room, standard monitoring with ECG, non-invasive blood pressure, pulse oximetry, end-tidal CO_2, and temperature probe was instituted and baseline values recorded. An 18G intravenous cannula was secured and crystalloid infusion started.

All patients were preoxygenated with 100% oxygen and premedicated with intramuscular glycopyrrolate 0.2 mg and intravenous midazolam 0.03 mg/kg. Patients were randomly allocated into two groups (n = 40 each) using sealed envelopes. Anesthesia was induced with fentanyl 2 µg/kg and thiopental 4–6 mg/kg, and intubation facilitated with atracurium 0.5 mg/kg. Maintenance was achieved with nitrous oxide and oxygen (2:1) along with 1–2% sevoflurane. Additional atracurium doses were given as required until skin suturing.

At dural closure, patients received the study drug according to allocation. Group P received propofol 1 mg/kg bolus followed by 3 mg/kg/h infusion, while Group F received fentanyl 1 µg/kg bolus followed by 1.5 µg/kg/h infusion. The study period extended from dural closure to one hour after extubation.

Heart rate and mean arterial pressure were recorded at baseline and throughout the study. Observations were divided into pre-extubation (every 5 minutes), extubation (1 minute before to 1 minute after), and post-extubation phases (every minute for 5 minutes, then every 15 minutes up to 1 hour). After head dressing, nitrous oxide was discontinued and neuromuscular blockade reversed with neostigmine and glycopyrrolate. Extubation was performed once adequate reversal, spontaneous respiration, oxygen saturation, and command following were achieved.

Emergence time was defined as the interval from completion of head dressing to extubation. Early emergence was defined as extubation within 15 minutes. Glasgow Coma Scale and respiratory parameters were assessed at 5, 15, 30, 45, and 60 minutes post-extubation. Hemodynamic responses and postoperative hypertension were compared between groups.

The data were analysed with epiinfo 7. The categorical variables were compared using chi square test and continuous variable using t test.

RESULTS

Table 1: Baseline data

Variable	**Group P**	**Group F**	**P Value**
Age (years)	39.3 ± 0.81	36.8 ± 0.61	0.83
Gender			
Male	17 (56.6%)	14 (46.7%)	0.078
Female	13 (43.4%)	16 (53.3%)	
Weight (kg)	63.4 ± 4.8	65.9 ± 9.4	0.34

The mean age, gender and weight distribution is similar in both group with p non significant.

Table 2: Intraop variables

Variable	**Group P**	**Group F**	**P Value**
Duration of Anaesthesia (min)	235.1 ± 66.3	247.09 ± 41.05	0.05
Duration of Surgery (min)	187.02 ± 21.1	198.01 ± 14.1	0.046
Interval Between Start of Study and Dressing (min)	78.03 ± 11.3	86.91 ± 8.03	0.017
Temperature During Extubation (°C)	36.3 ± 0.6	36.4 ± 0.4	0.777

The mean interval between start of study and head dressing is significantly lower in propofol group and results were significant with p value of 0.017. Similarly duration of surgery was less in propofol group. Though duration of anaesthesia was lower in propofol group the significance is in border line.

Table 3: Emergence time and Postop outcome

Variable	**Group P**	**Group F**	**P Value**
Mean Time of Emergence (min)	5.1 ± 0.3	6.2 ± 1.1	0.04
Early Emergence n (%)	23(76.7%)	18 (60%)	0.01
Time to Gain Full Consciousness			
< 5 min	3 (10%)	1 (3.3%)	0.048
15 min	7 (23.3%)	5 (16.6%)	0.032
30 min	8 (26.6%)	6 (20%)	0.892
45 min	5 (16.6%)	9 (30%)	0.05
60 min	7 (23.3%)	8 (26.6%)	0.778
Post-operative Complications n (%)			
Nausea/Vomiting	2 (6.6%)	5 (16.6%)	0.041
Shivering	1 (3.3%)	4 (13.3%)	0.032
Hypotension	1 (3.3%)	3 (10%)	0.217
Bradycardia	0 (0%)	2 (6.6%)	0.148

The table 3 presents emergence characteristics, recovery profile, and post-operative complications for Groups P and F. Group P showed faster emergence, earlier recovery of consciousness, and fewer post-operative complications compared to Group F, with statistically significant differences.

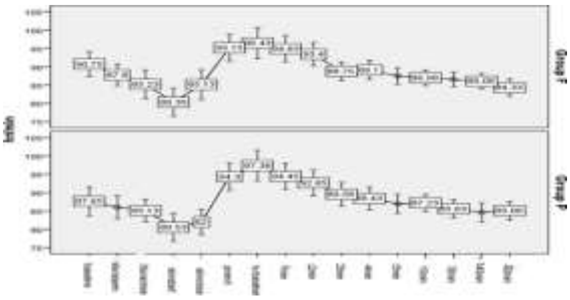

Figure 1: Change in Heart Rate

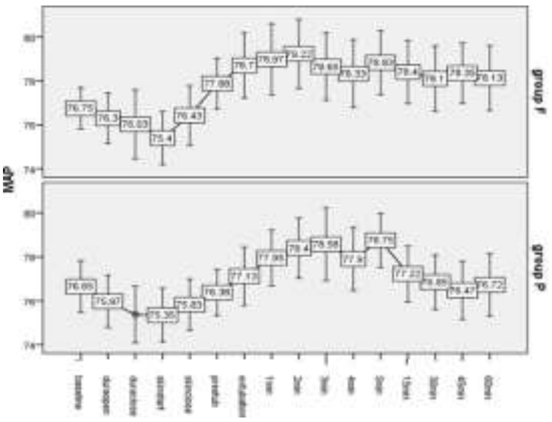

Figure 2: MAP Changes

DISCUSSION

Fast-tracking in neurosurgical patients requires smooth and early emergence while avoiding adverse hemodynamic responses that may precipitate cerebral edema, intracranial hemorrhage, or postoperative delirium. The present study compared low-dose propofol infusion with low-dose fentanyl infusion administered during dural closure under sevoflurane anesthesia and evaluated emergence characteristics, hemodynamic responses, and recovery profile.

Demographic variables including age, gender, and weight were comparable between groups, similar to observations by Talke et al,[5] who reported no significant baseline differences while comparing anesthetic techniques for supratentorial craniotomy. This ensured homogeneity and minimized confounding factors.

The duration of anesthesia and surgery was significantly lower in the propofol group. Comparable findings have been reported by Talke et al,[5] Gerlach et al,[8] and Prabhakar et al,[11] who observed shorter surgical duration and improved intraoperative conditions with propofol-based techniques compared to opioid- or inhalational-based anesthesia. However, Bhagat et al,[1] reported no significant difference in surgical duration among groups, highlighting variability across studies.

Hemodynamically, heart rate and mean arterial blood pressure were largely comparable between groups. However, the propofol group demonstrated significantly less tachycardia in the immediate post-extubation period. Bhagat et al,[1] similarly reported better attenuation of extubation response with propofol compared to fentanyl and isoflurane. Although MAP changes were not statistically significant in our study, previous studies have shown variable incidence of postoperative hypertension: Bilotta et al,[16] reported hypertension in 14% of patients receiving sufentanil with propofol, whereas Talke et al. 5 and Magni et al,[4] reported higher incidences (50% and 29%, respectively). These findings suggest that while early emergence is desirable, optimal hemodynamic control remains challenging.

Emergence was significantly faster in the propofol group (mean 5.1 min vs 6.2 min; p=0.04), with a higher proportion of early emergence (76.7% vs 60%; p=0.01). Todd et al. 2 demonstrated rapid emergence (5 min) but reported a high incidence of hypertension (87–98%). Conversely, Gauthier et al. 12 observed longer emergence times (~15 min) but fewer hypertensive episodes (25%). These studies indicate the difficulty in achieving both rapid awakening and stable hemodynamics simultaneously. In contrast, Bhagat et al,[1] reported earlier emergence with fentanyl but noted higher rates of hypertension in that group.

Postoperative ventilatory complications were comparable; however, fewer patients in the propofol group required ventilatory support (3.3% vs 10%; p=0.05). Similar findings were reported by Bhagat et al.1, who observed lower postoperative complication rates with propofol-based anesthesia.

Overall, low-dose propofol infusion during dural closure provided faster emergence, improved early recovery profile, and better attenuation of post-extubation tachycardia compared to fentanyl, without increasing adverse respiratory events. These findings support the role of propofol as a favorable agent for fast-tracking in elective craniotomy patients while maintaining acceptable hemodynamic stability.

CONCLUSION

From this study it can be concluded that low dose propofol during craniotomy closure has clear benefits over fentanyl in terms of quick awakening and limiting emergence response in patients undergoing elective craniotomy. Both low dose propofol and fentanyl used during craniotomy closure were beneficial in preventing early emergence hypertension.

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