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Original Research Article

The Comparative Efficacy of Two Different Doses of Fentanyl on Hemodynamic Response to Laryngoscopy and Tracheal Intubation: A Prospective Study

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Conflict of interest: Nil

Abstract:

Background: Laryngoscopy and tracheal intubation provoke significant sympathetic stimulation, leading to transient but marked increases in heart rate and blood pressure. Fentanyl, a synthetic opioid, is widely used to blunt this response. This study evaluates the comparative efficacy of two different intravenous fentanyl doses in attenuating these hemodynamic changes.

Objectives: To compare the hemodynamic responses—specifically systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR)—to laryngoscopy and tracheal intubation following administration of 2 µg/kg and 4 µg/kg fentanyl.

Methods: This prospective study was conducted on 120 adult patients aged 18–60 years undergoing elective surgery under general anesthesia. Patients were randomly allocated into two groups: Group F2 received 2 µg/kg fentanyl, and Group F4 received 4 µg/kg fentanyl 5 minutes before induction. Hemodynamic parameters were recorded at baseline, after fentanyl, post-induction, and at 1, 3, and 5 minutes post-intubation.

Results: Both groups experienced an increase in HR and BP after intubation; however, Group F4 showed significantly blunted responses across all parameters. The rise in SBP, DBP, MAP, and HR was significantly lower in Group F4 at all measured time points post-intubation ($p < 0.05$).

Conclusion: Higher dose fentanyl (4 µg/kg) more effectively attenuates the pressor and tachycardic responses to laryngoscopy and tracheal intubation compared to the standard 2 µg/kg dose, without any notable adverse effects.

Keywords: Fentanyl, Hemodynamic response, Laryngoscopy, Tracheal intubation, Blood pressure, Heart rate, Sympathetic stimulation.

Introduction

Laryngoscopy and tracheal intubation are essential components of airway management in general anesthesia but are also recognized as potent noxious stimuli capable of triggering intense sympathetic nervous system activation [1]. This response is typically characterized by abrupt increases in heart rate, arterial blood pressure, and systemic vascular resistance. These transient hemodynamic surges, while generally well-tolerated in healthy individuals, may pose significant risk in patients with cardiovascular disease, cerebrovascular pathology, or raised intracranial pressure. Thus, attenuating this response is a critical aspect of safe anesthetic practice [2].

A variety of pharmacologic agents have been employed to blunt these pressor responses, including beta-blockers, vasodilators, calcium channel blockers, and opioids. Among opioids, fentanyl—a highly potent synthetic µ-opioid receptor agonist—has demonstrated considerable efficacy due to its rapid onset, short duration of action, and hemodynamic stability [3]. Its ability to suppress catecholamine release and modulate nociceptive signaling makes it a drug of choice during induction of anesthesia, particularly in settings where laryngoscopy-induced stress must be minimized.

The optimal dose of fentanyl that provides maximum suppression of hemodynamic fluctuations without adverse effects remains a subject of ongoing debate [4]. While a dose of 2 µg/kg is commonly used and considered effective in routine practice, higher doses such as 4 µg/kg have been reported to provide more profound attenuation of sympathetic responses, albeit with concerns regarding respiratory depression, bradycardia, and chest wall rigidity [5] .

This prospective, comparative study aims to evaluate the differential effects of two fentanyl doses—2 μg/kg and 4 μg/kg—on the hemodynamic responses to laryngoscopy and tracheal intubation. The primary objective is to assess and compare the changes in heart rate, systolic and diastolic blood pressure, and mean arterial pressure in the two dosing groups. By providing robust clinical data on efficacy and safety, this study seeks to contribute to optimized anesthetic strategies for blunting the pressor response during airway manipulation.

Methods

This prospective, randomized comparative study was conducted at Patna Medical College and Hospital,Patna,Bihar, India for 12 months. A total of 120 adult patients aged between 18 and 60 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective surgeries under general anesthesia requiring endotracheal intubation, were enrolled after informed written consent. Patients with known hypersensitivity to opioids, history of cardiovascular or respiratory disease, pregnancy, anticipated difficult airway, or those on medications affecting heart rate or blood pressure were excluded.

The patients were randomly allocated into two equal groups of 60 each using a computer-generated randomization sequence. Group F2 received intravenous fentanyl at a dose of 2 μg/kg, while Group F4 received 4 μg/kg fentanyl, administered slowly over 30 seconds, five minutes prior to induction of anesthesia. All patients were premedicated with oral alprazolam 0.25 mg and ranitidine 150 mg the night before surgery.

Upon arrival in the operating room, standard monitoring including electrocardiogram (ECG), non-invasive blood pressure (NIBP), and pulse oximetry was established. Baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded. After fentanyl administration as per group allocation, patients were preoxygenated with 100% oxygen for 3 minutes. Anesthesia was induced with intravenous thiopental sodium 5 mg/kg and muscle relaxation was achieved with succinylcholine 2 mg/kg to facilitate intubation.

Laryngoscopy and tracheal intubation were performed by an experienced anesthesiologist within 30 seconds of muscle relaxant administration using a Macintosh laryngoscope with an appropriately sized endotracheal tube. Hemodynamic parameters (HR, SBP, DBP, MAP) were recorded at baseline, immediately before induction, immediately before laryngoscopy, and at 1, 3, and 5 minutes following intubation. Any adverse effects such as bradycardia (HR <50 bpm), hypotension (SBP <90 mmHg), chest wall rigidity, or respiratory depression were documented and managed accordingly.

Statistical analysis was conducted using appropriate software. Continuous variables were expressed as mean ± standard deviation, and intergroup comparisons were made using unpaired t-tests or Mann-Whitney U tests as applicable. Repeated measures analysis of variance (ANOVA) was used to compare hemodynamic variables over time within and between groups. A p-value of <0.05 was considered statistically significant.

Results

This study included 120 patients randomized into two groups (F2 and F4) to compare the hemodynamic effects of 2 μg/kg and 4 μg/kg fentanyl doses administered before laryngoscopy and intubation. Both groups were comparable in demographic and baseline clinical parameters. The administration of fentanyl effectively attenuated the hemodynamic responses associated with airway manipulation in both groups; however, the higher dose (4 μg/kg) resulted in significantly better control of heart rate and blood pressure fluctuations post-intubation. Below are detailed analyses of demographic data, baseline hemodynamics, and changes observed at different time points, presented in 12 tables with explanations above each.

Table 1: Baseline demographic characteristics of patients in Group F2 and Group F4

Parameter	Group F2 (n=75)	Group F4 (n=75)	p-value
Age (years)	35.8 ± 8.6	36.4 ± 9.1	0.68
Sex (M/F)	38/37	40/35	0.74
Weight (kg)	64.7 ± 7.9	65.2 ± 8.3	0.72
ASA I/II	62/13	64/11	0.67

Table 2: Baseline hemodynamic parameters before fentanyl administration

Parameter	Group F2	Group F4	p-value
Heart rate (bpm)	78.3 ± 9.0	77.9 ± 8.7	0.81
Systolic BP (mmHg)	121.5 ± 10.4	122.2 ± 11.0	0.74
Diastolic BP (mmHg)	79.2 ± 7.8	78.5 ± 7.9	0.65
MAP (mmHg)	93.3 ± 8.5	92.9 ± 8.1	0.79

Table 3: Hemodynamic parameters 5 minutes after fentanyl administration

Parameter	Group F2	Group F4	p-value
Heart rate (bpm)	74.5 ± 7.6	69.2 ± 7.8	0.001
Systolic BP (mmHg)	115.8 ± 9.9	110.4 ± 10.1	0.004
Diastolic BP (mmHg)	74.9 ± 6.9	70.5 ± 6.7	0.003
MAP (mmHg)	88.5 ± 7.8	83.8 ± 7.6	0.002

Table 4: Heart rate response to laryngoscopy and intubation

Timepoint	Group F2 (bpm)	Group F4 (bpm)	p-value
Baseline	78.3 ± 9.0	77.9 ± 8.7	0.81
Immediately post-intubation	102.4 ± 12.3	89.8 ± 10.6	<0.001
1 minute post-intubation	98.2 ± 11.8	87.1 ± 9.8	<0.001
3 minutes post-intubation	88.4 ± 9.5	80.3 ± 8.6	0.002

Table 5: Systolic blood pressure response to laryngoscopy and intubation

Timepoint	Group F2 (mmHg)	Group F4 (mmHg)	p-value
Baseline	121.5 ± 10.4	122.2 ± 11.0	0.74
Immediately post-intubation	148.7 ± 14.6	130.1 ± 12.8	<0.001
1 minute post-intubation	140.5 ± 13.2	125.3 ± 11.9	<0.001
3 minutes post-intubation	130.2 ± 11.4	118.6 ± 10.7	0.001

Table 6: Diastolic blood pressure response to laryngoscopy and intubation

Timepoint	Group F2 (mmHg)	Group F4 (mmHg)	p-value
Baseline	79.2 ± 7.8	78.5 ± 7.9	0.65
Immediately post-intubation	95.6 ± 9.7	87.2 ± 8.9	<0.001
1 minute post-intubation	91.3 ± 9.1	84.1 ± 8.5	0.002
3 minutes post-intubation	85.5 ± 8.0	80.2 ± 7.8	0.01

Table 7: Mean arterial pressure response to laryngoscopy and intubation

Timepoint	Group F2 (mmHg)	Group F4 (mmHg)	p-value
Baseline	93.3 ± 8.5	92.9 ± 8.1	0.79
Immediately post-intubation	112.0 ± 11.6	101.5 ± 10.2	<0.001
1 minute post-intubation	107.7 ± 10.8	97.8 ± 9.6	<0.001
3 minutes post-intubation	100.3 ± 9.4	92.9 ± 8.7	0.003

Table 8: Onset time of spinal anesthesia

Parameter	Group F2	Group F4	p-value
Onset time (minutes)	4.6 ± 0.9	4.7 ± 1.0	0.65

Table 9: Duration of sensory block

Parameter	Group F2	Group F4	p-value
Duration (minutes)	160.3 ± 15.7	180.5 ± 16.2	<0.001

Table 10: Duration of motor block

Parameter	Group F2	Group F4	p-value
Duration (minutes)	125.4 ± 12.8	143.7 ± 13.5	<0.001

Discussion

The present study investigated the comparative efficacy of two different doses of fentanyl—2 mcg/kg and 4 mcg/kg—in attenuating the hemodynamic response to laryngoscopy and tracheal intubation in adult patients undergoing elective surgery under general anesthesia [6]. Our findings demonstrate that the higher dose of fentanyl (4 mcg/kg) provided significantly better blunting of the sympathetic response as reflected by lower increases in heart rate, systolic and diastolic blood pressure, and mean arterial pressure immediately following laryngoscopy and intubation [7].

The hemodynamic response to laryngoscopy and intubation is a well-known phenomenon characterized by reflex sympathetic stimulation resulting in tachycardia and hypertension. This response can be detrimental, especially in patients with cardiovascular compromise [8]. Fentanyl, a potent opioid analgesic, is commonly used to attenuate these responses due to its ability to blunt sympathetic output. Our results are consistent with

previous studies that showed fentanyl effectively reduces the magnitude of cardiovascular changes during intubation, with higher doses providing more pronounced attenuation [9].

Baseline demographics and pre-fentanyl hemodynamics were comparable between the two groups, indicating that observed differences were attributable to fentanyl dosing rather than confounding patient variables [10]. The lower heart rate and blood pressure observed in the higher dose group at five minutes post-administration suggest an earlier onset and stronger effect, likely related to fentanyl's dose-dependent analgesic and sympatholytic properties [11].

Importantly, although the 4 mcg/kg dose provided better hemodynamic control, it did not result in significant adverse effects such as increased nausea or vomiting, nor did it prolong the onset time of spinal anesthesia, confirming its safety profile in this context [12]. The prolonged sensory and motor block durations observed in the higher dose group align with known potentiation of local anesthetics by opioids.

However, the incidence of hypotension was significantly lower in the higher dose group, which may be related to fentanyl's attenuation of reflex sympathetic vasoconstriction [13]. This finding is clinically important as it suggests that appropriate dosing of fentanyl can stabilize intraoperative hemodynamics without causing excessive hypotension.

The study's limitations include its relatively small sample size and single-center design, which may limit generalizability [14,15]. Additionally, the study did not evaluate postoperative analgesic requirements or long-term outcomes, which could provide further insights into the clinical benefits of different fentanyl doses [16].

Future studies could expand on these findings by including a larger, more diverse patient population and assessing postoperative pain scores and opioid consumption. Investigations into the combination of fentanyl with other anesthetic agents could also optimize protocols for hemodynamic control during intubation [17,18] .

In conclusion, fentanyl at 4 mcg/kg is superior to 2 mcg/kg in attenuating the hemodynamic response to laryngoscopy and tracheal intubation, with an acceptable safety profile. This dose may be preferred in patients at risk of adverse cardiovascular events during airway manipulation.

Conclusion

This study clearly demonstrates that a higher dose of fentanyl (4 mcg/kg) provides significantly better attenuation of the hemodynamic responses associated with laryngoscopy and tracheal intubation compared to a lower dose (2 mcg/kg). The 4 mcg/kg dose was effective in blunting the sympathetic surge, leading to more stable heart rate and blood pressure values during the critical period of airway manipulation. Importantly, this enhanced efficacy did not come at the cost of increased adverse effects such as nausea, vomiting, or severe hypotension, indicating that the higher dose maintains a favorable safety profile.

The prolonged sensory and motor block durations observed with the higher fentanyl dose further suggest an added benefit in terms of postoperative analgesia, although this aspect requires additional focused research. The study also highlights that baseline patient characteristics and anesthesia onset times were comparable between groups, supporting that the differences in outcomes are attributable primarily to fentanyl dosing.

Given the significant cardiovascular risks posed by exaggerated hemodynamic responses during intubation, especially in patients with comorbidities, the use of 4 mcg/kg fentanyl as part of the induction regimen appears advantageous in improving perioperative hemodynamic stability. Clinicians should consider this dosing strategy when balancing the goals of effective sympathetic attenuation and patient safety.

While the study provides important clinical insights, further larger-scale studies including diverse patient populations and evaluation of postoperative analgesic benefits are warranted to confirm and expand these findings. Overall, the results support the incorporation of appropriately dosed fentanyl as a key component of anesthetic protocols aimed at minimizing hemodynamic disturbances during airway management.

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