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Original Research Article

Comparative Evaluation of Dexmedetomidine and Fentanyl for Attenuation of the Intubation Response

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Abstract

Background: Laryngoscopy and endotracheal intubation cause sympathetic stimulation resulting in tachycardia and hypertension. Dexmedetomidine and fentanyl are commonly used to attenuate these responses.

Methods: This prospective randomized comparative study included 100 ASA I–II patients undergoing elective surgery under general anesthesia. Patients were divided into Group D (n=50), receiving dexmedetomidine 1 µg/kg, and Group F (n=50), receiving fentanyl 2 µg/kg. Heart rate and mean arterial pressure were recorded at baseline and at predefined intervals before and after intubation.

Results: Immediately after intubation, mean heart rate was significantly lower in Group D than Group F (82.4 ± 8.2 vs. 94.7 ± 9.1 beats/min; $p<0.001$). Mean arterial pressure was also significantly lower (98.4 ± 7.7 vs. 110.8 ± 9.2 mmHg; $p<0.001$). Tachycardia and hypertension occurred significantly less frequently with dexmedetomidine. Bradycardia and hypotension were slightly more frequent with dexmedetomidine but did not differ significantly between groups.

Conclusion: Dexmedetomidine was more effective than fentanyl in attenuating the heart rate and blood pressure responses to laryngoscopy and endotracheal intubation, with acceptable hemodynamic safety.

Keywords: Dexmedetomidine; fentanyl; laryngoscopy; endotracheal intubation; hemodynamic response; stress response.

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Introduction

Direct laryngoscopy and endotracheal intubation produce significant sympathetic stimulation, resulting in transient increases in heart rate, arterial blood pressure, and circulating catecholamine concentrations. Shribman et al. demonstrated that both laryngoscopy and tracheal intubation provoke cardiovascular and catecholamine responses, with intubation producing a particularly prominent sympathetic response. [1] Various pharmacological approaches have therefore been investigated to attenuate these potentially undesirable hemodynamic changes, particularly in patients with cardiovascular or cerebrovascular disease. [2]

Dexmedetomidine is a highly selective α_2-adrenergic agonist possessing sedative, analgesic, sympatholytic, and anesthetic-sparing properties. Scheinin et al. demonstrated that dexmedetomidine attenuated sympathoadrenal responses to tracheal intubation while reducing anesthetic and perioperative opioid requirements. [3] Its cardiovascular effects are predominantly related to decrease central sympathetic outflow, resulting in reductions in heart rate and arterial pressure. [4] The pharmacological effects of dexmedetomidine are dose-dependent, with increasing plasma concentrations producing progressive sedation and characteristic cardiovascular responses. [5] Even at relatively low doses, dexmedetomidine provides clinically useful sedation and analgesia with minimal respiratory depression. [6]

Its anesthetic-sparing properties have also been demonstrated, with reduced requirements for anesthetic agents during surgical procedures. [7] These characteristics make dexmedetomidine particularly useful for controlling perioperative sympathetic stimulation. Keniya et al. further

demonstrated that preoperative dexmedetomidine effectively attenuated the hemodynamic response to laryngoscopy and endotracheal intubation while reducing perioperative anesthetic requirements. [8]

Fentanyl is a potent synthetic opioid routinely used during induction of general anesthesia because of its analgesic action and ability to suppress sympathetic responses associated with airway manipulation. However, dexmedetomidine and fentanyl act through different pharmacological mechanisms and may therefore differ in their ability to control the cardiovascular response to laryngoscopy and tracheal intubation.

Therefore, the present study was conducted to compare dexmedetomidine and fentanyl for attenuation of the hemodynamic response to laryngoscopy and endotracheal intubation in patients undergoing elective surgery under general anesthesia.

Materials and Methods

Study Design and Participants: The present study was designed as a prospective, randomized, comparative study involving 100 patients undergoing elective surgical procedures under general anesthesia with endotracheal intubation. Patients fulfilling the selection criteria were randomly allocated into two groups of 50 patients each.

Inclusion Criteria: Patients aged 18–60 years, of either sex, belonging to American Society of Anesthesiologists (ASA) physical status I or II, and scheduled for elective surgery requiring general anesthesia and endotracheal intubation were included.

Exclusion Criteria: Patients with anticipated difficult airway, uncontrolled hypertension, significant cardiovascular disease, cardiac conduction abnormalities, severe hepatic or renal dysfunction, known allergy to the study drugs, pregnancy or lactation, and patients receiving β-blockers, α_2-agonists, or other medications likely to significantly influence the cardiovascular response were excluded.

Group Allocation: The patients were randomly divided into two equal groups:

Group D (n=50): Patients received intravenous dexmedetomidine 1 µg/kg, diluted in normal saline and administered slowly over 10 minutes before induction.

Group F (n=50): Patients received intravenous fentanyl 2 µg/kg, administered before induction of anesthesia.

Anesthetic Technique: On arrival in the operating room, standard monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry, and end-tidal carbon dioxide monitoring was instituted. Baseline heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and oxygen saturation were recorded.

An intravenous line was secured, and the assigned study drug was administered according to group allocation. Patients were preoxygenated with 100% oxygen for 3 minutes. General anesthesia was induced using intravenous propofol 2 mg/kg. After confirming adequate mask ventilation, neuromuscular blockade was achieved using intravenous vecuronium 0.1 mg/kg. Patients were ventilated with oxygen for approximately 3 minutes before laryngoscopy.

Direct laryngoscopy was performed using a Macintosh laryngoscope, followed by endotracheal intubation with an appropriately sized cuffed endotracheal tube. To minimize variability, laryngoscopy and intubation were performed by an experienced anesthesiologist, and patients requiring more than one attempt or prolonged laryngoscopy were excluded from final analysis.

Anesthesia was maintained using oxygen, nitrous oxide and an inhalational anesthetic with intermittent doses of neuromuscular blocking agent as required.

Hemodynamic Assessment

Heart rate, SBP, DBP, and MAP were recorded at the following time points:

- **T0:** Baseline before administration of the study drug
- **T1:** After administration of the study drug
- **T2:** Immediately before laryngoscopy
- **T3:** Immediately after intubation
- **T4:** 1 minute after intubation
- **T5:** 3 minutes after intubation
- **T6:** 5 minutes after intubation
- **T7:** 10 minutes after intubation

The primary outcome was the difference between the two groups in the change in HR and MAP following laryngoscopy and endotracheal intubation.

Secondary outcomes included changes in SBP and DBP and the incidence of adverse effects such as hypotension, bradycardia, hypertension, and tachycardia.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Demographic and baseline continuous variables were compared using the independent Student's t-test. Serial hemodynamic changes were

evaluated using repeated-measures analysis of variance, with appropriate post-hoc comparisons. Categorical variables were compared using the Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

A total of 100 patients undergoing elective surgery under general anesthesia were included in the study. Patients were randomly allocated into Group D (dexmedetomidine, n=50) and Group F (fentanyl, n=50).

Both groups were comparable with respect to demographic characteristics and baseline hemodynamic parameters.

Table 1: Demographic and baseline characteristics of the study groups

Parameter	Group D (n=50)	Group F (n=50)	p-value
Age (years), mean ± SD	39.8 ± 10.2	40.6 ± 9.8	0.690
Male, n (%)	28 (56.0%)	27 (54.0%)	0.841
Female, n (%)	22 (44.0%)	23 (46.0%)	
Weight (kg), mean ± SD	65.4 ± 8.6	66.1 ± 8.9	0.690
ASA I, n (%)	31 (62.0%)	30 (60.0%)	0.838
ASA II, n (%)	19 (38.0%)	20 (40.0%)	
Baseline HR (beats/min)	78.6 ± 7.8	79.1 ± 8.1	0.754
Baseline MAP (mmHg)	93.8 ± 6.9	94.2 ± 7.1	0.776

There were no statistically significant differences between the two groups regarding age, sex, body weight, ASA status, baseline heart rate, or mean arterial pressure (p>0.05). Thus, the groups were comparable before administration of the study drugs.

Table 2: Comparison of heart rate between the two groups at different time intervals

Time point	Group D (beats/min), mean ± SD	Group F (beats/min), mean ± SD	p-value
T0 – Baseline	78.6 ± 7.8	79.1 ± 8.1	0.754
T1 – After study drug	72.8 ± 7.1	76.9 ± 7.6	0.006*
T2 – Before laryngoscopy	70.9 ± 6.8	75.8 ± 7.2	0.001*
T3 – Immediately after intubation	82.4 ± 8.2	94.7 ± 9.1	<0.001*
T4 – 1 min after intubation	80.1 ± 7.9	91.2 ± 8.8	<0.001*
T5 – 3 min after intubation	76.4 ± 7.3	85.3 ± 8.1	<0.001*
T6 – 5 min after intubation	74.2 ± 7.0	81.6 ± 7.7	<0.001*
T7 – 10 min after intubation	75.6 ± 7.2	78.9 ± 7.5	0.027*

***Statistically significant at p<0.05.**

Both drugs attenuated the increase in heart rate following laryngoscopy and intubation; however, the rise was significantly smaller in Group D. Immediately after intubation, mean HR was 82.4 ± 8.2 beats/min in Group D compared with 94.7 ± 9.1 beats/min in Group F (p<0.001). The difference gradually decreased over the subsequent 10 minutes.

Table 3: Comparison of mean arterial pressure and adverse events

Parameter/Time point	Group D (n=50)	Group F (n=50)	p-value
Baseline MAP (mmHg)	93.8 ± 6.9	94.2 ± 7.1	0.776
MAP after study drug (mmHg)	87.6 ± 6.5	91.8 ± 6.8	0.002*
MAP immediately after intubation (mmHg)	98.4 ± 7.7	110.8 ± 9.2	<0.001*
MAP at 1 min (mmHg)	95.7 ± 7.3	106.2 ± 8.6	<0.001*
MAP at 3 min (mmHg)	91.2 ± 6.9	100.4 ± 7.8	<0.001*
MAP at 5 min (mmHg)	89.6 ± 6.7	96.8 ± 7.2	<0.001*
MAP at 10 min (mmHg)	91.1 ± 6.8	93.7 ± 7.0	0.061
Bradycardia, n (%)	4 (8.0%)	1 (2.0%)	0.362
Hypotension, n (%)	3 (6.0%)	1 (2.0%)	0.617
Tachycardia after intubation, n (%)	2 (4.0%)	9 (18.0%)	0.025*
Hypertension after intubation, n (%)	2 (4.0%)	8 (16.0%)	0.046*

***Statistically significant at p<0.05.**

The increase in MAP following intubation was significantly attenuated in the dexmedetomidine group. Immediately after intubation, MAP was 98.4 ± 7.7 mmHg in Group D compared with 110.8 ±

9.2 mmHg in Group F ($p<0.001$). The difference remained significant up to 5 minutes and became non-significant by 10 minutes. Bradycardia and hypotension occurred somewhat more frequently with dexmedetomidine, although these differences were not statistically significant. Conversely, post-intubation tachycardia and hypertension were significantly more frequent in the fentanyl group.

Discussion

Laryngoscopy and endotracheal intubation produce sympathetic stimulation that may result in transient tachycardia and hypertension. The present study compared dexmedetomidine and fentanyl for attenuation of this response and demonstrated that dexmedetomidine provided better control of both heart rate and mean arterial pressure following intubation.

Immediately after intubation, mean heart rate was significantly lower in the dexmedetomidine group than in the fentanyl group (82.4 ± 8.2 vs. 94.7 ± 9.1 beats/min; $p<0.001$). The difference remained significant during subsequent observations. These findings are consistent with Menda et al., who demonstrated that dexmedetomidine administered during anesthetic induction attenuated the hemodynamic response to endotracheal intubation. [9] Similarly, Sulaiman et al. reported effective suppression of the stress response to intubation with dexmedetomidine in patients undergoing cardiac surgery. [10]

Gunalan et al. directly compared dexmedetomidine and fentanyl and observed better attenuation of the stress response with dexmedetomidine, supporting the findings of the present study. [11] Sebastian et al. also demonstrated effective attenuation of the hemodynamic response with intravenous dexmedetomidine, although its effects were influenced by the administered dose. [12] The sympatholytic action of dexmedetomidine, mediated through central α_2-adrenoceptor activation and reduction of sympathetic outflow, probably explains its greater control of post-intubation tachycardia.

Mean arterial pressure immediately after intubation was 98.4 ± 7.7 mmHg in the dexmedetomidine group compared with 110.8 ± 9.2 mmHg in the fentanyl group ($p<0.001$). The difference remained significant up to 5 minutes. Previous studies have similarly demonstrated effective suppression of the pressor response with dexmedetomidine and other sympatholytic agents. [13,14] Mahiswar et al., in a randomized double-blind comparison of dexmedetomidine and fentanyl, also demonstrated favorable attenuation of the stress response with dexmedetomidine. [15]

The ability of α_2-adrenergic agonists to improve perioperative hemodynamic stability has been supported by earlier investigations of sympatholytic agents such as clonidine. [16,17] Comparative evidence between dexmedetomidine and fentanyl further indicates that dexmedetomidine can provide more consistent control of cardiovascular responses during airway manipulation. [18]

Bradycardia and hypotension occurred somewhat more frequently in the dexmedetomidine group, although the differences were not statistically significant. In contrast, tachycardia and hypertension following intubation were significantly more frequent with fentanyl. These findings indicate that dexmedetomidine provides effective sympatholysis, although careful monitoring for excessive reductions in heart rate and blood pressure remains necessary.

The study was limited by its single-center design, relatively short period of hemodynamic observation, and inclusion of predominantly ASA I–II patients. Further studies involving high-risk cardiovascular patients and different doses of dexmedetomidine and fentanyl may provide additional evidence regarding their comparative efficacy and safety.

Conclusion

Both dexmedetomidine and fentanyl attenuated the hemodynamic response to laryngoscopy and endotracheal intubation. However, dexmedetomidine provided significantly better control of heart rate and mean arterial pressure and reduced the incidence of post-intubation tachycardia and hypertension. Although mild bradycardia and hypotension occurred more frequently with dexmedetomidine, these differences were not significant. Thus, intravenous dexmedetomidine 1 µg/kg was more effective than fentanyl 2 µg/kg for attenuation of the intubation response in patients undergoing elective surgery under general anesthesia.

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