

## Comparative Study of Esmolol, Fentanyl, and Dexmedetomidine on Hemodynamic Response to Laryngoscopy and Intubation

Santosh Kumar<sup>1</sup>, Akhilesh Kumar Singh<sup>2</sup>, Rajat Kumar<sup>3</sup><sup>1</sup>PG Student 3rd Year, Department of Anaesthesiology, Nalanda Medical College & Hospital, Patna, Bihar, India<sup>2</sup>Assistant Professor, Department of Anaesthesiology, Nalanda Medical College & Hospital, Patna, Bihar, India<sup>3</sup>Senior Resident, Department of Anaesthesiology, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

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Corresponding Author: Santosh Kumar

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### Abstract:

**Background:** Endotracheal intubation after laryngoscopy is associated with significant sympathetic stimulation leading to tachycardia and hypertension. Various pharmacological agents are used to attenuate this response, including Esmolol, Fentanyl, and Dexmedetomidine.**Objective:** To compare the effects of Dexmedetomidine, Esmolol, and Fentanyl on cardiovascular changes associated with airway manipulation.**Methods:** This study was carried out at NMCH Hospital from November 2024 to November 2025. Ninety patients were enrolled and evenly assigned into three groups of thirty each: Group E (Esmolol), Group F (Fentanyl), and Group D (Dexmedetomidine). Statistical analysis was performed using ANOVA and post hoc tests.**Results:** Dexmedetomidine showed the most stable hemodynamic profile with significantly lower blood pressure fluctuations and heart rate compared to Esmolol and Fentanyl ( $p < 0.001$ ). Esmolol effectively controlled heart rate but was less effective for blood pressure. Fentanyl showed moderate attenuation.**Conclusion:** Dexmedetomidine demonstrated greater stability of hemodynamic parameters during laryngoscopy followed by tracheal intubation.**Keywords:** Esmolol, Fentanyl, Dexmedetomidine, Laryngoscopy, Intubation, Hemodynamic Response.

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### Introduction

Airway manipulation during general anesthesia, particularly laryngoscopy followed by tracheal intubation, is an essential step but is known to provoke a strong sympathetic response, which may lead to hypertension, tachycardia, and cardiac arrhythmias [1]. These responses are usually transient but can be hazardous in patients with cardiovascular or cerebrovascular diseases [2].

The hemodynamic response is primarily mediated by catecholamine release triggered by stimulation of the larynx and trachea [3]. The magnitude of this response depends on patient factors, depth of anesthesia, and duration of laryngoscopy [4].

Various pharmacological agents have been used to attenuate this response, including opioids, beta-blockers, vasodilators, and alpha-2 agonists [5]. Among these, Esmolol, Fentanyl, and Dexmedetomidine are commonly studied due to their rapid onset and favorable safety profile [6].

Esmolol is an ultra-short-acting beta-1 selective blocker that effectively blunts tachycardia [7]. Fentanyl, a potent opioid analgesic, reduces sympathetic response by central action [8]. Dexmedetomidine, a highly selective alpha-2 agonist, provides sedation, analgesia, and sympatholysis [9].

Despite numerous studies, there is still debate regarding the most effective agent with minimal side effects [10]. Therefore, this study aims to compare these three drugs in a controlled clinical setting.

### Materials and Methods

**Study Setting:** Prospective randomized comparative study conducted at NMCH Hospital from November 2024 to November 2025.**Sample Size:** 90 patients were enrolled and evenly distributed into three groups (30 each).

**Exclusion Criteria**

- Cardiovascular disease
- Hypertension
- Pregnancy
- Known drug allergy

**Group Allocation:** Patients were randomly assigned into three equal groups based on the study drug administered. Participants in Group E received intravenous esmolol at 1 mg/kg. Group F was administered fentanyl intravenously at 2 µg/kg. Patients in Group D received dexmedetomidine at 1 µg/kg given as an intravenous infusion prior to laryngoscopy.

**Statistical Analysis:** Data analyzed using SPSS v25. ANOVA with post hoc Tukey test applied. p<0.05 considered significant.

**Results**

90 patients were enrolled and equally distributed into three groups: Group E (Esmolol), Group F (Fentanyl), and Group D (Dexmedetomidine), with 30 patients in each group.

**Demographic Profile:** The mean age, gender distribution, and ASA status were similar across all three groups, indicating uniformity among study participants (Table 1).

**Table 1: Demographic Characteristics of Study Population**

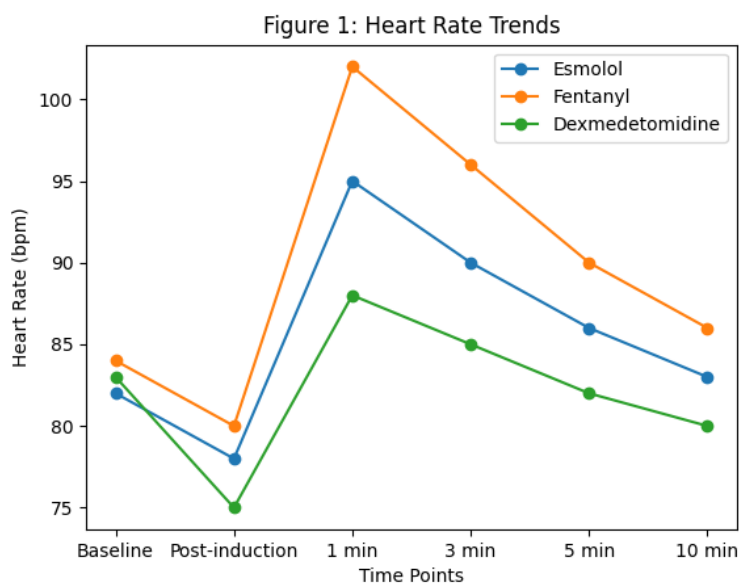
Parameter	Group E (n=30)	Group F (n=30)	Group D (n=30)	p-value
Age (years)	38.2 ± 10.1	36.9 ± 9.8	37.5 ± 10.5	0.82
Gender (M/F)	18/12	17/13	16/14	0.91
ASA I/II	19/11	18/12	20/10	0.88

**Heart Rate Changes:** Baseline heart rate was comparable among the three groups (p = 0.76). Following laryngoscopy and intubation, a significant rise in heart rate was noted in all groups at 1 minute.

At 3 and 5 minutes post-intubation, Group D continued to demonstrate better control of heart rate, while Group F showed the highest values. By 10 minutes, heart rate values approached baseline in all groups but remained comparatively lower in the Dexmedetomidine group (Table 2, Figure 1).

**Table 2: Comparison of Heart Rate (beats per minute)**

Time Point	Group E	Group F	Group D	p-value
Baseline	82 ± 8	84 ± 7	83 ± 9	0.76
Post-induction	78 ± 7	80 ± 6	75 ± 6	0.04
1 min	95 ± 10	102 ± 11	88 ± 7	<0.001
3 min	90 ± 9	96 ± 10	85 ± 6	<0.001
5 min	86 ± 8	90 ± 9	82 ± 5	0.002
10 min	83 ± 7	86 ± 8	80 ± 5	0.01



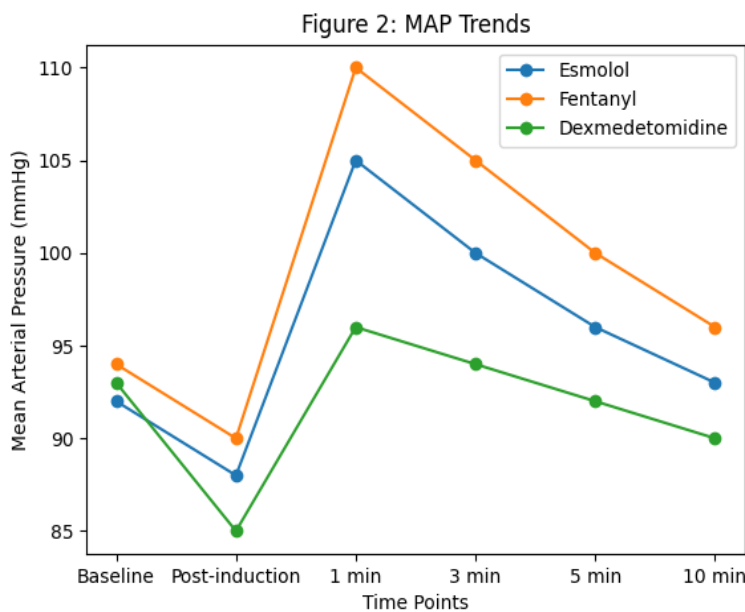
**Figure 1: Trend of Heart Rate Changes Across Study Groups**

**Mean Arterial Pressure (MAP):** Baseline MAP values were statistically comparable ( $p = 0.69$ ). Following intubation, a significant increase in MAP was observed in all groups at 1 minute, with the highest rise in Group F. Group D exhibited the least variation, indicating superior attenuation of pressor response.

At subsequent intervals (3, 5, and 10 minutes), MAP values gradually declined toward baseline, with Group D maintaining more stable readings compared to Groups E and F. These differences were statistically significant ( $p < 0.001$  at early intervals) (Table 3, Figure 2).

**Table 3: Comparison of Mean Arterial Pressure (mmHg)**

Time Point	Group E	Group F	Group D	p-value
Baseline	92 ± 6	94 ± 7	93 ± 6	0.69
Post-induction	88 ± 5	90 ± 6	85 ± 5	0.03
1 min	105 ± 8	110 ± 9	96 ± 6	<0.001
3 min	100 ± 7	105 ± 8	94 ± 5	<0.001
5 min	96 ± 6	100 ± 7	92 ± 5	0.001
10 min	93 ± 5	96 ± 6	90 ± 4	0.02



**Figure 2: Trend of Mean Arterial Pressure Changes Across Groups**

**Summary of Findings:** Dexmedetomidine (Group D) consistently demonstrated superior attenuation of both heart rate and blood pressure responses compared to Esmolol and Fentanyl. The differences observed at key time intervals were statistically significant, particularly within the first 5 minutes following intubation ( $p < 0.001$ ).

**Discussion**

The present study demonstrates that Dexmedetomidine provides superior attenuation of hemodynamic responses compared to Esmolol and Fentanyl. This finding aligns with previous studies emphasizing its sympatholytic effects [11].

Esmolol effectively controlled tachycardia but was less effective in controlling blood pressure, consistent with earlier findings [12]. Fentanyl showed moderate efficacy but was insufficient alone to blunt the full response [13].

Dexmedetomidine acts centrally by reducing norepinephrine release, thereby stabilizing cardiovascular parameters [14]. Several studies have confirmed its superiority over opioids and beta-blockers [15-18].

The findings are consistent with randomized trials that demonstrated better control of HR and MAP with Dexmedetomidine [19-22].

**Conclusion**

Dexmedetomidine is more effective than Esmolol and Fentanyl in attenuating hemodynamic responses to laryngoscopy and intubation. It provides better stability in heart rate and blood pressure.

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