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Comparison of Intravenous Dexmedetomidine and Fentanyl in Attenuating Hemodynamic Responses to Laryngoscopy and Endotracheal Intubation: A Randomized Controlled Study.

Dr. Harikrishna Gulipalli*[1], Dr. Haritha Gundeboyina[1]
[1]Assistant Professor, Department of Anaesthesiology, Visakha Institute of Medical Sciences, Visakhapatnam, Andhra Pradesh, India

Abstract

Background:

Laryngoscopy and endotracheal intubation trigger abrupt sympathetic stimulation, often resulting in tachycardia and hypertension. These responses may be well tolerated in healthy individuals but pose significant risks in patients with compromised cardiovascular reserve. Pharmacological agents such as dexmedetomidine and fentanyl are widely employed to blunt these pressor responses, though comparative evidence remains essential for clinical decision-making.

Aim:

To evaluate and compare the efficacy of intravenous dexmedetomidine and fentanyl in attenuating hemodynamic responses during laryngoscopy and intubation.

Methods:

This prospective, randomized, double-blind study included 60 ASA I–II patients scheduled for elective surgery under general anesthesia. Participants were allocated equally into two groups: Group D received dexmedetomidine infusion, and Group F received fentanyl infusion before laryngoscopy. Heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were recorded at baseline and at 1, 2, and 3 minutes after intubation. Adverse events were noted. Statistical comparisons were made using appropriate parametric tests, and $p < 0.05$ was considered significant.

Results:

Baseline characteristics were comparable across groups. Dexmedetomidine produced a consistent reduction in heart rate and blood pressure following intubation, while fentanyl resulted in noticeable increases across all hemodynamic parameters. At every post-intubation interval, Group D demonstrated significantly lower heart rate, systolic, diastolic, and mean arterial pressures ($p < 0.001$). Adverse events were minimal; transient bradycardia occurred in two patients receiving dexmedetomidine, whereas hypotension was observed in one patient from each group.

Conclusion:

Dexmedetomidine is more effective than fentanyl in suppressing the sympathetic surge associated with laryngoscopy and intubation, ensuring greater hemodynamic stability. Both agents were well tolerated, though clinical vigilance remains essential.

Recommendations:

Dexmedetomidine may be preferred in patients at risk of cardiovascular complications during airway manipulation. Further multicentric trials with larger sample sizes are recommended to reinforce these findings and explore dose-response relationships.

Keywords: ***Dexmedetomidine, Fentanyl, Laryngoscopy, Hemodynamic Response, Intubation Stress, Sympatholysis***
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Corresponding author: *Dr. Harikrishna Gulipalli.*
Email: *gharikrishna@yahoo.com*
Assistant Professor, Department of Anaesthesiology, Visakha Institute of Medical Sciences, Visakhapatnam, Andhra Pradesh, India.

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INTRODUCTION

Laryngoscopy and endotracheal intubation are integral steps in administering general anesthesia, yet they generate intense sympathetic stimulation that can rapidly elevate heart rate and blood pressure. This response is driven by mechanical stimulation of the oropharynx, larynx, and trachea, producing a cascade of hemodynamic changes such as tachycardia, hypertension, and increased myocardial oxygen demand. These alterations, though brief, may endanger individuals with limited cardiovascular reserve, including those with hypertension, ischemic heart disease, or cerebrovascular insufficiency [1–3]. Multiple pharmacological strategies have been evaluated to blunt this reflex response. Opioids, β-blockers, vasodilators, and local anesthetics have all demonstrated varying degrees of success. Fentanyl remains widely used for its rapid onset and potent analgesic actions, yet several studies indicate that it may not consistently suppress the full magnitude of the pressor response, particularly during vigorous laryngoscopic stimulation [1,2]. In contrast, dexmedetomidine, an α2-adrenergic agonist, has emerged as a valuable agent owing to its sympatholytic, sedative, and analgesic effects. Its ability to diminish catecholamine release contributes to more stable peri-intubation hemodynamics [3–5]. Comparative evaluation of these two drugs remains clinically relevant, especially in patients requiring stringent cardiovascular control during induction of anesthesia. Current evidence suggests potential advantages with dexmedetomidine; however, the extent of its superiority over fentanyl in routine clinical practice warrants further examination [1–5]. The present study was therefore designed to compare the efficacy of intravenous dexmedetomidine and fentanyl in attenuating the hemodynamic responses to laryngoscopy and intubation. By assessing their effects on heart rate, systolic and diastolic blood pressure, and mean arterial pressure, this investigation aims to generate evidence that may guide the selection of optimal pharmacological agents for safer airway management.

METHODOLOGY

Study Design and Setting

This prospective, randomized, double-blind comparative trial was conducted at Visakha Hospitals and Diagnostics (Care Hospital), Visakhapatnam, a 200-bedded tertiary care centre providing comprehensive medical services. The study was carried out over a one-year period from October 2017 to September 2018. Patient recruitment occurred during this period. Participants were followed until completion of the immediate post-intubation observation phase, and primary outcome variables were recorded at baseline and at 1, 2, and 3 minutes following endotracheal intubation.

Study Population

A total of 60 patients, aged 18–55 years, classified as ASA physical status I or II, were included. All patients were scheduled for surgeries requiring laryngoscopy and endotracheal intubation.

Inclusion criteria

consisted of adults with normal airway assessment and no contraindications to the study drugs.

Exclusion criteria

were hypertension, ischemic heart disease, arrhythmias, an anticipated difficult airway, pregnancy, morbid obesity, autonomic dysfunction, hepatic or renal impairment, and a history of allergy to study medications.

Sample Size Calculation

The sample size was calculated based on previous studies comparing dexmedetomidine and fentanyl for attenuation of hemodynamic responses to laryngoscopy. Assuming a minimum expected difference of 10 beats/min in heart rate between groups at 1 minute post-intubation, with a standard deviation of 12, power of 80%, and alpha error of 0.05, the required sample size was estimated to be 27 patients per group. To compensate for possible dropouts, 30 patients were included in each group, resulting in a total sample size of 60 participants.

Randomization
Sequence Generation

Randomization was performed using a computer-generated random number table in a 1:1 allocation ratio. Block randomization with a fixed block size of four was employed to ensure balanced distribution of participants between the two groups throughout the study period. No stratification was applied.

Allocation Concealment and Implementation

Eligible participants were enrolled by the principal investigator after confirmation of inclusion and exclusion criteria. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes prepared by an independent anesthesiologist who was not involved in patient management or outcome assessment. The envelopes

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were opened immediately prior to preparation of the study drug.

Blinding

The independent anesthesiologist prepared the study drugs according to group allocation. Both study medications were prepared in identical syringes to maintain blinding. The anesthesiologist performing laryngoscopy and intubation, the investigator recording hemodynamic parameters, and the participants were blinded to group assignment throughout the study period.

Group D: Dexmedetomidine

Group F: Fentanyl

Both patients and investigators assessing outcomes were blinded to group assignments. Study drugs were prepared in identical syringes by an anesthesiologist not involved in further data collection.

The study drug was administered 10 minutes prior to the induction of anesthesia. In Group D, dexmedetomidine infusion (1 µg/kg) was completed over 10 minutes before laryngoscopy. In Group F, fentanyl (2 µg/kg) was administered intravenously over 2–3 minutes, timed to ensure peak effect at the time of laryngoscopy. Induction of anesthesia was initiated immediately after completion of the study drug infusion.

Intervention Protocol

Upon arrival in the operating room, standard monitoring—ECG, pulse oximetry, and non-invasive blood pressure—was instituted. Baseline parameters were recorded.

Group D received an intravenous infusion of dexmedetomidine (1 µg/kg over 10 minutes).

Group F received fentanyl (2 µg/kg intravenously) administered over the same duration.

After the infusion, anesthesia was induced with propofol and vecuronium. Laryngoscopy was performed by the same experienced anesthesiologist in all cases to minimize procedural variability.

Outcome Measurements

Heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were documented at:

Baseline

1 minute after intubation

2 minutes after intubation

3 minutes after intubation

Any adverse events—including bradycardia, hypotension, arrhythmias, or oxygen desaturation—were recorded.

Statistical Analysis

Data were analyzed using appropriate parametric tests. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. A p-value < 0.05 was considered statistically significant.

RESULTS

Participant Flow

A total of 68 patients were assessed for eligibility during the study period. Eight patients were excluded due to failure to meet the inclusion criteria or refusal to participate. Sixty eligible participants were randomized in a 1:1 ratio to either Group D (dexmedetomidine, n = 30) or Group F (fentanyl, n = 30). All randomized participants received the allocated intervention and completed the study protocol. No participants were lost to follow-up or excluded from the final analysis. Consequently, data from all 60 patients were included in the primary outcome analysis.

Baseline Characteristics

Baseline demographic and clinical variables were comparable between the two groups. No statistically significant differences were observed with respect to age, sex distribution, body weight, ASA physical status, or Mallampati grading (Table 1). This ensured that subsequent hemodynamic variations were attributable to study medications rather than pre-existing disparities.

Table 1. Baseline Demographic and Clinical Characteristics of Participants

Variable	Group D (Dexmedetomidine) (n=30)	Group F (Fentanyl) (n=30)	p-value
Age (years), Mean ± SD	34.2 ± 7.8	33.6 ± 8.1	>0.05
Sex (M/F)	18 / 12	17 / 13	>0.05
Weight (kg), Mean ± SD	62.4 ± 9.3	63.7 ± 8.9	>0.05
ASA Physical Status (I/II)	20 / 10	19 / 11	>0.05
Mallampati Grade (I/II)	22 / 8	21 / 9	>0.05

No significant difference was observed between groups at baseline.

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Heart Rate Response

Heart rate trends revealed a consistent divergence between the two study groups. While baseline values were similar, participants in Group F demonstrated a marked rise in heart rate following laryngoscopy and intubation. In contrast, Group D exhibited a progressive decline during the same period. At 1, 2, and 3 minutes post-intubation, Group D maintained significantly lower heart rates than Group F ($p < 0.001$), underscoring the stronger sympatholytic effect of dexmedetomidine (Table 2, Figure 1).

Table 2. Heart Rate (beats/min) Before and After Laryngoscopy and Intubation

Time Interval	Group D Mean ± SD	Group F Mean ± SD	p-value
Baseline (0 min)	82.1 ± 8.4	83.3 ± 7.9	>0.05
1 minute	78.6 ± 7.5	91.2 ± 8.1	<0.001*
2 minutes	76.9 ± 7.3	88.6 ± 7.8	<0.001*
3 minutes	75.4 ± 6.9	86.3 ± 7.2	<0.001*

Dexmedetomidine significantly attenuated tachycardia compared with fentanyl.

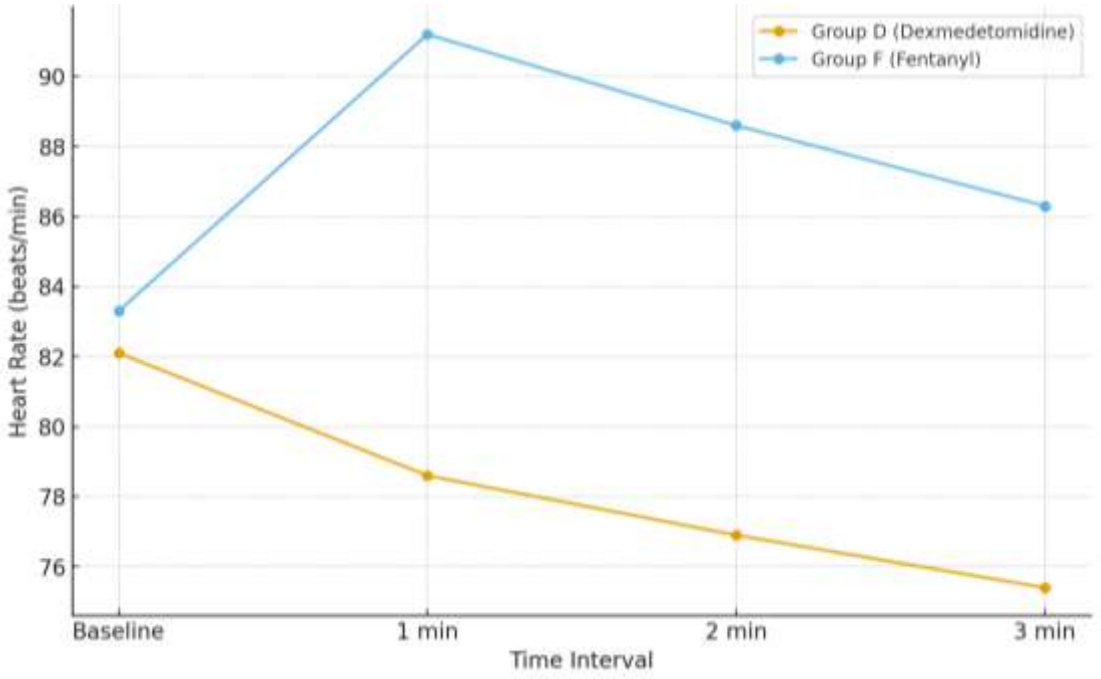

Figure 1: Heart Rate Changes Before and After Laryngoscopy and Intubation

Systolic and Diastolic Blood Pressure

Systolic blood pressure (SBP) remained stable at baseline in both groups. However, Group F showed an appreciable increase in SBP immediately after intubation, whereas Group D demonstrated a steady reduction across the same interval. These differences were statistically significant at all post-intubation time points ($p < 0.001$).

A similar pattern emerged in diastolic blood pressure (DBP), where Group F experienced an acute rise, while Group D maintained controlled values throughout. All comparisons beyond baseline yielded significant differences ($p < 0.001$), demonstrating superior attenuation of pressor responses with dexmedetomidine (Table 3).

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Table 3. Systolic and Diastolic Blood Pressure (mmHg) at Various Time Points

A.Systolic Blood Pressure

Time Interval	Group D Mean ± SD	Group F Mean ± SD	p-value
Baseline	124.6 ± 10.2	123.9 ± 11.1	>0.05
1 minute	118.2 ± 9.7	134.6 ± 10.4	<0.001*
2 minutes	116.4 ± 9.1	131.8 ± 9.9	<0.001*
3 minutes	115.1 ± 8.8	129.2 ± 9.4	<0.001*

B.Diastolic Blood Pressure

Time Interval	Group D Mean ± SD	Group F Mean ± SD	p-value
Baseline	79.1 ± 6.4	80.3 ± 6.7	>0.05
1 minute	76.8 ± 5.9	86.7 ± 6.3	<0.001*
2 minutes	75.4 ± 5.8	84.9 ± 6.1	<0.001*
3 minutes	74.6 ± 5.7	83.8 ± 6.0	<0.001*

Mean Arterial Pressure

Mean arterial pressure (MAP) followed the expected hemodynamic pattern observed in SBP and DBP. Group F exhibited a marked elevation at 1, 2, and 3 minutes following intubation, whereas Group D displayed a modest fall, maintaining more stable readings. The intergroup differences were significant at each interval ($p < 0.001$), indicating more effective suppression of sympathetic activation in the dexmedetomidine cohort (Table 4A).

Table 4. Mean Arterial Pressure (MAP) and Adverse Events

A. Mean Arterial Pressure (MAP)

Time Interval	Group D Mean ± SD	Group F Mean ± SD	p-value
Baseline	94.2 ± 6.1	94.8 ± 6.4	>0.05
1 minute	89.7 ± 5.8	102.6 ± 6.1	<0.001*
2 minutes	88.1 ± 5.6	100.9 ± 5.7	<0.001*
3 minutes	87.2 ± 5.4	98.4 ± 5.6	<0.001*

Adverse Events

Adverse events were minimal across the study sample. Mild bradycardia occurred in two patients receiving dexmedetomidine, requiring no intervention. Hypotension was observed in one patient from each group but resolved spontaneously. No arrhythmias or oxygen desaturation episodes were noted. Overall, both drugs demonstrated favorable safety profiles within the studied dose range (Table 4B).

4 B.Adverse Events

Adverse Event	Group D (n, %)	Group F (n, %)
Bradycardia	2 (6.6%)	0 (0%)
Hypotension	1 (3.3%)	1 (3.3%)
Arrhythmias	0	0
Oxygen desaturation	0	0

DISCUSSION

The present randomized, double-blind comparative study assessed the ability of intravenous dexmedetomidine and fentanyl to attenuate the hemodynamic responses triggered by laryngoscopy and endotracheal intubation. Airway manipulation produces intense sympathetic discharge, often resulting in abrupt elevations in heart rate and blood pressure. Such fluctuations can be particularly harmful in patients with limited cardiovascular reserve, making effective blunting of this response clinically important. In the current study, dexmedetomidine demonstrated superior suppression of these changes when compared with fentanyl.

Dexmedetomidine produced a gradual reduction in heart rate following intubation, while fentanyl was associated with a noticeable rise. This pattern reflects dexmedetomidine's α2-agonist–mediated sympatholytic action, which reduces norepinephrine

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release and stabilizes autonomic activity. Similar findings have been reported by Hussain et al., who observed that dexmedetomidine attenuated tachycardia more effectively than clonidine in controlled settings [6]. Likewise, Niyogi et al. demonstrated that both intravenous and intranasal dexmedetomidine significantly reduced heart rate responses compared with baseline values, confirming its reliable modulation of sympathetic outflow [7].

Blood pressure responses in this study paralleled the heart rate trends. Dexmedetomidine maintained systolic, diastolic, and mean arterial pressures closer to baseline, whereas fentanyl permitted marked elevations across all intervals. This outcome is consistent with the work of Jarineshin et al., who showed that dexmedetomidine in different doses consistently blunted cardiovascular responses during laryngoscopy [8]. Additional support comes from Sriramka et al., who reported that adding dexmedetomidine to nebulized lidocaine yielded better hemodynamic control than lidocaine alone [9]. Several comparative studies further strengthen these observations. Vaswani et al. found dexmedetomidine more effective than fentanyl in limiting peri-intubation blood pressure surges in patients undergoing laparoscopic surgery [10]. Similarly, Gunalan et al. demonstrated that dexmedetomidine provided steadier heart rate and blood pressure profiles than fentanyl when both drugs were given as pre-intubation boluses [11]. A recent bispectral index-guided trial by Choudhary et al. also confirmed that dexmedetomidine offers greater cardiovascular stability than fentanyl when used alongside propofol for induction [12].

The safety profile of both drugs in the present study was satisfactory. Mild bradycardia noted in the dexmedetomidine group resolved spontaneously, echoing the findings of earlier clinical trials [6–12]. No serious adverse events were encountered, supporting the feasibility of dexmedetomidine use with appropriate monitoring, particularly in patients predisposed to bradyarrhythmias.

Collectively, the evidence from this study and prior literature indicates that dexmedetomidine provides more reliable attenuation of the sympathetic surge associated with laryngoscopy and intubation. Its potent sympatholytic action ensures smoother cardiovascular transitions, whereas fentanyl, although beneficial, does not consistently prevent the rapid hemodynamic elevations induced by airway manipulation.

Generalizability

The findings of this study offer useful insights into hemodynamic control during laryngoscopy; however, their generalizability is limited by the single-center design and the relatively small sample size. All participants were ASA I–II and underwent elective surgery, which restricts applicability to high-risk or emergency populations. Although the results strongly support dexmedetomidine's superiority over fentanyl, broader conclusions require validation through larger, multicentric studies involving diverse patient groups and varied clinical settings.

Conclusion

This randomized comparative study demonstrates that dexmedetomidine provides significantly better attenuation of the hemodynamic responses associated with laryngoscopy and endotracheal intubation when compared with fentanyl. Dexmedetomidine consistently stabilized heart rate, systolic pressure, diastolic pressure, and mean arterial pressure at all post-intubation intervals, reflecting its strong sympatholytic profile. Fentanyl, although effective to some extent, was unable to prevent the characteristic cardiovascular surges triggered by airway manipulation. Both drugs were well tolerated, with minimal and manageable adverse effects. Overall, dexmedetomidine emerges as a more reliable agent for achieving peri-intubation hemodynamic control, especially in patients who require enhanced cardiovascular stability during the induction of anesthesia.

Limitations

This study was limited by its single-center design and relatively small sample size, which may reduce the strength of broader clinical inferences. Only ASA I–II patients undergoing elective surgery were included, restricting applicability to higher-risk groups or emergency settings. Drug doses were standardized, and variations in anesthetic or analgesic requirements were not evaluated. Hemodynamic responses beyond the immediate post-intubation period were not assessed, limiting understanding of longer-term cardiovascular effects.

Recommendations

Based on the study findings, dexmedetomidine may be preferred over fentanyl for attenuating the hemodynamic responses associated with laryngoscopy and intubation, particularly in patients who require enhanced cardiovascular stability during induction. Clinicians should exercise careful monitoring when administering dexmedetomidine,

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especially in individuals prone to bradycardia. Future research should include larger, multicentric trials to improve external validity and explore optimal dosing strategies. Studies involving high-risk and emergency populations are also needed to determine the broader applicability of these findings. Evaluation of long-term hemodynamic effects and recovery profiles would further strengthen clinical recommendations.

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Abbreviations
ASA – American Society of Anesthesiologists
BP – Blood Pressure
DBP – Diastolic Blood Pressure
HR – Heart Rate
IV – Intravenous
MAP – Mean Arterial Pressure
SBP – Systolic Blood Pressure
SD – Standard Deviation
µg/kg – Micrograms per Kilogram

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The authors declare no conflict of interest.

Author contributions:
HG-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **HG**-Concept and design of the study, results interpretation, review of literature, preparing the first draft of the manuscript, and revision of the manuscript.

Author Biography
Dr.Harikrishna Gulipalli is an experienced anaesthesiologist with more than 18 years of experience in cardiac anaesthesia and critical care. He earned his MBBS from Andhra Medical College, Visakhapatnam (2000) and Diploma in Anaesthesia (2006), followed by DNB Anaesthesia (2019) and an MBA in Health Care Services (2017). He has worked extensively in tertiary care hospitals, including Manipal Hospitals, My Cure Hospital, Care Hospitals, and ANU Institute of Neuro and Cardiac Sciences, Visakhapatnam. Currently, he is an Assistant Professor of Anaesthesiology at Visakha Institute of Medical Sciences and Consultant Anaesthesiologist at Vrindaa Super Specialty Hospital, Visakhapatnam. His expertise covers cardiac, thoracic, vascular, paediatric, and transplant anaesthesia, as well as advanced airway management, invasive procedures, and perioperative critical care. **ORCID ID**: https://orcid.org/0009-0001-3533-951X

Dr. Haritha Gundeboyina completed her MBBS from Narayana Medical College, Nellore (2003–2009) and DNB in Anaesthesiology from CARE Hospitals, Visakhapatnam (2012–2015). She has served as Senior Resident in the Department of Anaesthesiology at Andhra Medical College (2015–2016) and Consultant Anaesthesiologist at CARE Hospitals, Visakhapatnam (2016–2018). Subsequently, she worked as a Senior Resident and later as an Assistant Professor in Anaesthesiology at GITAM Medical College (2018–2022). Since January 2022, she has been serving as an Assistant Professor in the Department of Anaesthesiology at Visakha Institute of Medical Sciences, Visakhapatnam. Her clinical expertise spans advanced trauma, cardiac, neonatal, and transplant anaesthesia, with significant experience in managing multi-specialty and super-specialty cases. **ORCID ID**: https://orcid.org/0009-0006-7643-1300

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