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Original Research Article

Efficiency of Intravenous Dexmedetomidine vs Intravenous Esmolol to Attenuat the Cardiovascular Responses to Laryngoscopy and Endotracheal Intubation in Adult Patients: A Comparative Randomized Controlled Study

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Abstract:

Background: Laryngoscopy and endotracheal intubation are routine yet critical procedures that often provoke significant cardiovascular stress responses, such as tachycardia and hypertension. Managing these hemodynamic responses is vital, particularly in patients with cardiovascular risk. This study compares the efficacy of intravenous dexmedetomidine and esmolol in attenuating these responses during laryngoscopy and intubation.

Aim and Objective: To compare the effectiveness of intravenous dexmedetomidine and esmolol in reducing cardiovascular responses (heart rate and blood pressure) during laryngoscopy and endotracheal intubation and to evaluate their safety profiles.

Materials and Methods: This randomized, double-blind, controlled trial included 60 patients (aged 18–65 years) with ASA grade I or II scheduled for elective surgeries under general anesthesia. The patients were randomly assigned to one of two groups: Group A received dexmedetomidine (1 mcg/kg), and Group B received esmolol (1.5 mg/kg), diluted to 20 mL with normal saline. Hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP), were recorded at various time points: baseline, post-drug administration and at multiple intervals post-intubation. Statistical analysis was conducted using Student's t-test and chi-square tests.

Results: Both dexmedetomidine and esmolol significantly attenuated the cardiovascular responses to laryngoscopy and intubation. However, Group A (dexmedetomidine) showed superior control over heart rate and blood pressure compared to Group B (esmolol), particularly immediately after intubation. Group A exhibited lower heart rate, SBP, DBP, and MAP post-intubation ($p < 0.05$). Adverse effects such as bradycardia were observed in the dexmedetomidine group, but these were transient and manageable.

Conclusion: Intravenous dexmedetomidine is more effective than esmolol in attenuating the cardiovascular responses to laryngoscopy and intubation. Its use can provide better hemodynamic stability in high-risk patients, though careful monitoring is required due to the potential for bradycardia and hypotension. Further large-scale studies are recommended to confirm these findings.

Keywords: Dexmedetomidine, Esmolol, Laryngoscopy, Endotracheal Intubation, Cardiovascular Response, Hemodynamic Stability.

Introduction

Laryngoscopy and endotracheal intubation are routine yet critical procedures performed during the induction of general anesthesia.[1] However, these interventions are known to provoke a transient but

significant stress response, primarily characterized by sympathetic stimulation. This response manifests as tachycardia, hypertension, and increased myocardial oxygen demand, all of which may exacerbate pre-existing cardiovascular conditions and increase the risk of complications such as myocardial ischemia, arrhythmias, and cerebrovascular accidents. [1,2] Controlling these hemodynamic fluctuations is crucial, especially in patients with cardiovascular comorbidities or high perioperative risk. [2,3]

Various pharmacological agents have been studied for their potential to attenuate these responses. Beta-blockers and alpha-2 agonists have gained attention due to their cardioprotective properties and ability to blunt sympathetic nervous system activity. [4] Esmolol, an ultra-short-acting beta-1 adrenergic receptor antagonist, effectively reduces heart rate and blood pressure by blocking the effects of catecholamines, making it an appealing option for controlling the acute cardiovascular responses associated with intubation. [5] Dexmedetomidine, on the other hand, is an alpha-2 adrenergic receptor agonist known for its sedative, anxiolytic, and sympatholytic properties. It has been shown to reduce stress responses without causing significant respiratory depression, making it another promising agent for maintaining hemodynamic stability. [4, 5]

Despite the availability of both drugs, limited comparative data remain on their effectiveness in attenuating cardiovascular responses to laryngoscopy and intubation. This study aims to directly compare the efficacy of intravenous dexmedetomidine and esmolol in minimizing cardiovascular stress responses during laryngoscopy and endotracheal intubation in adult patients. The findings of this study will help guide clinical practice in selecting the most effective pharmacologic intervention for this purpose, ultimately improving patient outcomes during anesthesia induction.

Materials and Methods

This study was conducted on 60 adult patients, classified as American Society of Anesthesiologists (ASA) grade I or II, aged between 18 and 65 years, who were scheduled for elective surgeries at the Department of Anaesthesia, SVBP Hospital, LLRM Medical College, Meerut, Uttar Pradesh. The study followed a controlled, prospective, randomized design. Ethical clearance was obtained from the Institutional Ethics Committee before commencement, and written informed consent was obtained from all patients before participation. The study is registered with Clinical Trials Registry-India with registration number CTRI/2024/06/06 933.

The inclusion criteria encompassed patients with ASA grades I and II, aged between 18 and 65 years, and Mallampati grades I and II, with systolic blood pressure (SBP) under 140 mmHg, diastolic blood pressure (DBP) under 90 mmHg, and a heart rate between 60 and 100 beats per minute. Patients with a body mass index (BMI) between 18.5 and 24.9 kg/m² who were willing to participate were eligible for inclusion.

The study followed a prospective, randomized, double-blind, comparative design. It was conducted at SVBP Hospital, affiliated with LLRM Medical College and Chaudhary Charan Singh University in Meerut, Uttar Pradesh, over 18 months. The sample size was calculated using G*Power software (version 3.1.9.7), referencing previous studies, and was determined to be 60 patients (30 in each group), with a 95% confidence interval and 80% statistical power. Patients who met the inclusion and exclusion criteria were randomly assigned to one of two groups. Group A received intravenous dexmedetomidine (1 mcg/kg), and Group B received intravenous esmolol (1.5 mg/kg). Both drugs were diluted to a volume of 20 mL with 0.9% normal saline.

Randomization was achieved through the sealed envelope technique. A qualified anesthesiologist, who was not involved in data collection, administered the allocated drug, ensuring the study was double-blinded. The patients and the attending anesthesiologists responsible for monitoring were unaware of the group assignments. Group A received dexmedetomidine, while Group B received esmolol. The study drugs were prepared in identical 20 mL syringes labeled "A" or "B" to maintain blinding.

Preoperative assessment included recording demographic data such as age, gender, height, and weight, along with a comprehensive medical history and physical examination. Blood pressure was measured three times, at least one hour apart, to confirm eligibility. Routine investigations were performed, including complete blood counts, renal function tests, urine analysis, electrocardiograms (ECG), and chest X-rays. Any indications of difficult intubation were carefully assessed and ruled out during the clinical examination.

In terms of preoperative management, all patients were administered 40 mg of pantoprazole the night before surgery and again three hours before the procedure. Additionally, 0.5 mg of alprazolam was given the night before surgery to alleviate anxiety. An intravenous cannula was placed in a suitable vein on the patient's non-dominant hand, and intravenous Ringer's lactate solution (500 mL) was administered approximately three hours before surgery. Baseline hemodynamic readings, including pulse rate and blood pressure (systolic, diastolic,

and mean arterial pressure), were recorded 30 minutes before surgery and used as preoperative baseline measurements.

On arrival in the operating theatre, the patient's hemodynamic parameters were monitored according to standard protocol. This included continuous monitoring of heart rate (HR), non-invasive blood pressure (NIBP), oxygen saturation (SpO2), and ECG. A five-lead ECG was applied to the chest, and leads II, aVL, and V were continuously observed on the monitor. Following a 10-minute infusion of the allocated study drug (dexmedetomidine or esmolol), patients received 1 mg of intravenous midazolam and 2 mcg/kg of intravenous fentanyl. Anesthesia was induced with intravenous propofol (2-2.5 mg/kg), titrated to the loss of verbal response, and rocuronium (1.2 mg/kg) was administered to facilitate intubation.

Intubation was performed by an experienced anesthesiologist using a standard Macintosh laryngoscope blade, and an appropriately sized, cuffed endotracheal tube lubricated with non-anesthetic jelly was inserted. The tube cuff was inflated to 25 cm of water pressure, and equal bilateral air entry into the lungs was confirmed by auscultation. The tube was then secured with adhesive tape, and intermittent positive pressure ventilation (IPPV) was initiated using a ventilator. Tidal volume was set between 8-10 mL/kg, with a respiratory rate of 14-16 breaths per minute for 10 minutes. No surgical incisions or noxious stimuli were introduced during this period, and the patient remained supine.

Hemodynamic parameters, including HR, SBP, DBP, and MAP, were measured at multiple time points: baseline (30 minutes before anesthesia), immediately after the drug infusion, before induction of anesthesia, after induction, immediately after intubation, and at 1, 2, 3, 4, 5, and 10 minutes post-intubation.

Statistical Analysis

Statistical analysis was conducted using SPSS version 20 (Chicago, IL, USA). Quantitative data were presented as mean ± standard deviation (SD), and qualitative data were reported as percentages. A p-value of < 0.05 was considered statistically significant. The Student's t-test was used to compare continuous variables between the two groups, while categorical variables were analyzed using the chi-square test.

Results

The study was conducted with 60 patients of ASA grade I and II, aged 18-65 years, who were admitted to SVBP Hospital, associated with LLRM Medical College, Meerut, Uttar Pradesh. All patients voluntarily consented to participate in the study. The participants were randomly divided into Group A (Dexmedetomidine) and Group B (Esmolol). Both groups were similar in demographic and baseline characteristics, and no statistically significant differences were observed regarding age, sex, and body mass index (BMI).

Demographic Characteristics

The demographic comparison of the two groups (Group A and Group B) showed no statistically significant differences in age, gender distribution, or BMI. The mean age of patients in Group A was 33.33 ± 11.12 years, while Group B had a mean age of 31.80 ± 10.22 years ($p = 0.105$). The gender distribution was also similar, with 30% males and 70% females in Group A, compared to 26.67% males and 73.33% females in Group B ($p = 0.774$). The mean BMI in Group A was 23.10 ± 1.28 kg/m², and in Group B, it was 23.17 ± 1.27 kg/m² ($p = 0.826$).

Table 1: **Comparison of Mean Anthropometric Variables**

Variable	Group A (Dexmedetomidine)	Group B (Esmolol)	p-value
Age (years)	33.33 ± 11.12	31.80 ± 10.22	0.105
BMI (kg/m²)	23.10 ± 1.28	23.17 ± 1.27	0.826
Male/Female (n)	9/21	8/22	0.774

Hemodynamic Responses

Heart Rate: The heart rate was measured at several intervals, including baseline (BSL), after infusion, before induction, just before intubation, and at multiple time points post-intubation. The analysis revealed that heart rate changes between Group A and Group B were statistically significant immediately after intubation and at various intervals thereafter. Group A exhibited better attenuation of heart rate increases than Group B, with significant differences observed at 1, 2, 5, and 10 minutes post-intubation.

Table 2: **Comparison of Mean Heart Rate (bpm) Between Group A and Group B**

Time Point	Group A (Dexmedetomidine)	Group B (Esmolol)	p-value
Baseline	83.77 ± 7.74	80.03 ± 8.05	0.072
Just after infusion	68.43 ± 8.84	71.90 ± 7.02	0.0980
Before induction	71.10 ± 8.48	72.50 ± 6.92	0.4862

Immediately after intubation	73.80 ± 7.23	86.90 ± 8.16	0.00001*
1 minute post-intubation	73.90 ± 8.01	83.63 ± 7.15	0.00001*
5 minutes post-intubation	75.77 ± 7.64	71.13 ± 5.89	0.0109*
10 minutes post-intubation	78.37 ± 8.05	70.90 ± 6.86	0.0003*

(*p-value < 0.05 indicates statistical significance)

Systolic Blood Pressure: Both groups experienced increased systolic blood pressure following intubation, but the changes were more pronounced in Group B (Esmolol). Group A showed better control over systolic blood pressure, with significant differences at 1, 3, and 10 minutes post-intubation ($p < 0.05$).

Table 3: Comparison of Mean Systolic Blood Pressure (mmHg) Between Group A and Group B

Time Point	Group A (Dexmedetomidine)	Group B (Esmolol)	p-value
Baseline	126.50 ± 10.40	124.70 ± 9.51	0.4870
Immediately after intubation	117.03 ± 6.26	131.70 ± 9.90	0.00001*
1 minute post-intubation	118.80 ± 6.64	128.27 ± 9.33	0.0000*
3 minutes post-intubation	118.73 ± 8.43	123.27 ± 7.66	0.0333*
10 minutes post-intubation	124.13 ± 11.08	116.23 ± 7.92	0.0024*

Diastolic Blood Pressure: Changes in diastolic blood pressure were also more controlled in Group A, with significant differences seen immediately after intubation and at multiple post-intubation time points ($p < 0.05$).

Table 4: Comparison of Mean Diastolic Blood Pressure (mmHg) Between Group A and Group B

Time Point	Group A (Dexmedetomidine)	Group B (Esmolol)	p-value
Baseline	79.67 ± 7.17	76.33 ± 7.23	0.0781
Immediately after intubation	75.10 ± 7.77	82.77 ± 6.18	0.0001*
1 minute post-intubation	75.50 ± 7.66	79.97 ± 5.23	0.0107*
2 minutes post-intubation	73.80 ± 6.43	77.33 ± 5.70	0.0280*
10 minutes post-intubation	77.70 ± 8.85	71.27 ± 6.42	0.0021*

Mean Arterial Pressure: Group A maintained better control over mean arterial pressure (MAP) post-intubation than Group B. Significant differences were observed immediately after intubation and at various time points up to 10 minutes post-intubation.

Table 5: Comparison of Mean Arterial Pressure (mmHg) Between Group A and Group B

Time Point	Group A (Dexmedetomidine)	Group B (Esmolol)	p-value
Baseline	94.37 ± 5.79	92.27 ± 7.35	0.2241
Immediately after intubation	90.17 ± 6.97	98.53 ± 6.58	0.0000*
1 minute post-intubation	90.77 ± 6.54	96.40 ± 5.15	0.0005*
2 minutes post-intubation	89.03 ± 5.40	93.17 ± 5.17	0.0037*
10 minutes post-intubation	93.37 ± 7.34	86.80 ± 5.70	0.0003*

Discussion

Laryngoscopy and endotracheal intubation are integral yet stressful procedures that induce significant hemodynamic responses such as tachycardia and hypertension. [6] These responses are primarily triggered by the stimulation of mechanoreceptors in the pharynx, epiglottis, and vocal cords, leading to sympathetic nervous system activation. Although transient, such responses can have detrimental effects, particularly in patients with cardiovascular comorbidities, increasing the risk of myocardial ischemia and other cardiovascular events. [7]

In our study, we sought to compare the efficacy of intravenous dexmedetomidine (1 mcg/kg) and esmolol (1.5 mg/kg) in attenuating these cardiovascular responses during laryngoscopy and endotracheal intubation. Both drugs have been shown to reduce heart rate and blood pressure, but their mechanisms and efficacy differ, making a direct comparison essential to guide clinical decision-making.

Our study found significant differences in heart rate, SBP, DBP, and MAP between the dexmedetomidine and esmolol groups, particularly after intubation. Dexmedetomidine proved to be more effective in blunting the heart rate and blood pressure spikes immediately after intubation than esmolol. This finding aligns with previous research showing that dexmedetomidine, due to its alpha-2 adrenoreceptor agonist properties, exerts sympatholytic effects that reduce noradrenaline release and blunt the stress response.

The significant attenuation of heart rate post-intubation observed in the dexmedetomidine group

is consistent with studies by Scheinin et al. [8], which demonstrated that dexmedetomidine effectively reduces sympathoadrenal responses to endotracheal intubation. Similarly, Jaakola et al. [9] reported that dexmedetomidine attenuated the rise in heart rate during intubation. In contrast, though effective, esmolol exhibited a relatively lesser degree of heart rate control. These findings highlight the superior efficacy of dexmedetomidine in maintaining hemodynamic stability during stressful procedures like intubation.

Dexmedetomidine better controlled systolic and diastolic blood pressure, especially immediately following intubation. This observation mirrors the results of Lawrence et al. [10], who found that dexmedetomidine reduced blood pressure and heart rate during laryngoscopy and extubation. While esmolol effectively blunted the systolic blood pressure response, its effect was less sustained than dexmedetomidine. This may be attributed to the shorter half-life of esmolol, requiring frequent dosing to maintain stable hemodynamics.

In our study, a higher dose of injectable rocuronium at 1.2 mg/kg was administered to facilitate intubation within 60-90 seconds, and to counterbalance the brief duration of effect of esmolol, which was employed to mitigate the sympathetic response associated with intubation. [10]

Our study also found a significantly lower mean arterial pressure in the dexmedetomidine group compared to the esmolol group. Varshali et al. [11] observed similar effects, noting that dexmedetomidine effectively mitigated the sympathoadrenal response and reduced perioperative anesthetic requirements. On the other hand, Esmolol showed a modest impact in MAP, which aligns with studies by Helfman et al. [12] that found esmolol effective in preventing heart rate elevation but less impactful on blood pressure.

Despite its efficacy, dexmedetomidine is not without side effects. Bradycardia and hypotension were observed in a small subset of patients in our study, consistent with findings by Bloor et al. [13], who noted dose-dependent bradycardia and hypotension with dexmedetomidine use. While effective in controlling heart rate, Esmolol did not exhibit these side effects to the same extent, possibly due to its short half-life and rapid metabolism.

Clinical Implications

The findings from this study support the use of dexmedetomidine as a superior agent for attenuating the cardiovascular responses to laryngoscopy and intubation, especially in patients with increased cardiovascular risk. Its prolonged effects, combined with its ability to reduce perioperative anesthetic and opioid requirements, make it a valuable tool in modern anesthesia practice. However, careful monitoring is required to prevent adverse effects such as bradycardia and hypotension.

Limitations

While this study provides valuable insights, it is limited by its sample size and single-center design. Further multicenter trials with larger populations are needed to validate these findings and explore the long-term outcomes of dexmedetomidine and esmolol use during anesthesia induction.

Conclusion

In this randomized, double-blind study dexmedetomidine proved significantly more effective in controlling heart rate, systolic and diastolic blood pressure, and mean arterial pressure, particularly in the immediate post-intubation period. While both agents provided hemodynamic stability, dexmedetomidine offered superior attenuation of the pressor response, though it was associated with a higher incidence of bradycardia, requiring careful monitoring. Given its effectiveness, dexmedetomidine is a more suitable choice for managing the hemodynamic stress of intubation, especially in high-risk patients.

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