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ORIGINAL ARTICLE

# A Comparative Study to Evaluate the Efficacy of Esmolol and Dexmedetomidine in Attenuation of Hemodynamic Response to Laryngoscopy in General Anesthesia

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## ABSTRACT

***Background:*** During general anesthesia procedure direct laryngoscopy along with endotracheal intubation has a transient sympathoadrenal response characterized by elevating heart rate(HR) and arterial BP. Although these physiological changes are usually tolerated by healthy individuals, there is a chance of precipitation of significant cerebrovascular and cardiovascular complications in patients with limited physiological reserve. Dexmedetomidine and esmolol are used because of rapid onset of action and good cardiovascular effects among the many agents used to blunt the pressor response.[1,2]

***Objectives:*** To compare and find out the effectivity of the Dexmedetomidine and Esmolol for reduction of stress response to laryngoscopy and endotracheal intubation by assessing changes in HR , SBP, and DBP during general anesthesia.

***Methodology:*** A comparative study was done in Department of Anesthesiology Department at Peerless Hospital, Kolkata, for 18 months. The study included 180 patients aged between 18 and 60 years with ASA physical status I and II who were scheduled for elective surgery under general anesthesia. Two groups were considered, Patients in Group D received dexmedetomidine at a dose of 1 µg/kg given intravenously over 10 minutes before induction, whereas those in Group E received intravenous esmolol 0.5 mg/kg 2 minutes prior to laryngoscopy. A standardized anesthetic protocol was followed for all patients. Hemodynamic variables, including HR, SBP, DBP, and MAP, were measured at baseline and

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at 1, 3, 5, 10, and 15 minutes after tracheal intubation. Data analysis was done using SPSS version 22, and a p-value of less than 0.05 was found to be statistically significant.

***Results:*** Patients receiving dexmedetomidine exhibited significantly better control of SBP at 1, 3, 5, and 10 minutes ($p<0.05$) after intubation, as well as significantly lower DBP across all post-intubation assessment points ($p<0.05$). MAP was also significantly lower in the dexmedetomidine group up to 10 minutes following intubation ($p<0.001$). Although heart rate values remained consistently lower among patients administered dexmedetomidine, the differences between the two groups did not reach statistical significance ($p>0.05$).

***Conclusion:*** Dexmedetomidine showed more effectiveness than esmolol in controlling the hemodynamic response during laryngoscopy and endotracheal intubation. It provided superior control of arterial blood pressure while maintaining comparable heart rate stability, making it a more suitable pharmacological option for achieving perioperative hemodynamic stability during induction of general anesthesia.

**KEYWORDS**

• Dexmedetomidine • Esmolol • Hemodynamic Stability • Laryngoscopy • Endotracheal Intubation • General Anesthesia

## INTRODUCTION

Laryngoscopy followed by endotracheal intubation is an integral step in the administration of general anesthesia and is regarded as the most reliable technique for securing the airway during the surgical procedures( both elective and emergency). Despite being routinely performed, direct laryngoscopy provokes a marked sympathetic nervous system response due to mechanical stimulation of the pharyngeal and laryngeal structures. This stimulation triggers the release of endogenous catecholamines, producing transient elevations in HR, SBP, DBP, and MAP.[1,2]

The hemodynamic response usually develops immediately after airway instrumentation, reaches its maximum intensity within one to two minutes followed by a slow returns toward baseline in a gap of 5 to 10 minutes. The accompanying tachycardia and hypertension increase myocardial oxygen consumption and may precipitate myocardial ischemia, dysrhythmias, acute left ventricular dysfunction, or myocardial infarction in high-risk patients. Likewise, abrupt increases in intracranial and intraocular pressure may adversely affect patients with intracranial pathology, cerebral aneurysms, traumatic brain injury, glaucoma, or other disorders associated with impaired autoregulation. Consequently, minimizing this sympathetic response has become a key objective during anesthetic induction to promote perioperative cardiovascular stability and reduce the likelihood of adverse events.[3,4]

Many pharmacological agents are already proposed to suppress the cardiovascular responses related with Endotracheal Intubation and Laryngoscopy. Opioids, local anesthetics, vasodilators, β-adrenergic antagonists, Calcium Channel Blocker(CCB) and $\alpha_2$-adrenergic agonists. Among these therapeutic options, dexmedetomidine and esmolol have attracted considerable clinical interest because of their fast onset of action, predictable pharmacokinetic properties, and high safety profile.[5]

Esmolol is a cardioselective $\beta_1$-adrenergic receptor blocker characterized by an ultra-short duration of action along with elimination half-life of nine minutes approximately. By decreasing myocardial contractility and suppressing sympathetic activity, it effectively limits increases in heart rate and arterial BP during periods of acute stress. Since it is rapidly metabolized by plasma esterases, its hemodynamic effects are short-lasting, making it particularly suitable for transient stimuli such as laryngoscopy and endotracheal intubation.[6,7]

Dexmedetomidine is a selective $\alpha_2$-ADR receptor agonist possessing analgesic, sedative anxiolytic, and sympatholytic properties without causing clinically significant respiratory depression. Through inhibition of

central sympathetic outflow and suppression of norepinephrine release, it effectively blunts the cardiovascular responses associated with airway manipulation. Furthermore, dexmedetomidine decreases anesthetic and opioid requirements while promoting smooth perioperative hemodynamic control. Nevertheless, higher doses may predispose patients to bradycardia and hypotension, highlighting the importance of appropriate dose titration.[8,9]

Although both dexmedetomidine and esmolol are frequently employed to attenuate the pressor response to laryngoscopy and tracheal intubation, published evidence regarding their relative effectiveness remains inconsistent. A direct comparison between these agents is therefore warranted to determine the more effective and safer option for maintaining cardiovascular stability during anesthetic induction. Accordingly, the present study was designed to compare the efficacy of dexmedetomidine and esmolol in reducing changes in HR, SBP, and DBP following laryngoscopy and endotracheal intubation in patients undergoing surgery under general anesthesia.[10]

### Objectives

To compare the effectiveness of dexmedetomidine and esmolol in attenuating the hemodynamic response to laryngoscopy and endotracheal intubation by evaluating alterations in HR, SBP, and DBP during general anesthesia.

## MATERIALS AND METHODS

This hospital-based comparative observational study with cross-sectional design was done in the Anaesthesiology Department, Peerless Hospital, Kolkata, over a duration of eighteen months. The study population comprised adult patients of either gender, aged between 18 to 60 years, ASA physical status I or II, who were taken for elective procedures under general anesthesia. Patients declining participation, those with documented hypersensitivity to anesthetic agents or vasopressors, individuals with morbid obesity (BMI >35 kg/m$^2$), anticipated difficult airway, prolonged laryngoscopy, or multiple attempts at endotracheal intubation were excluded from the study.

### Sampling

Sample size was calculated on findings reported by Sharma *et al.* (2018)[11], who observed mean post-induction heart rates of 81.3 ± 9.92 beats/min in the Group D (Dexmedetomidine) and 85.3 ± 9.30 beats/min in the Group E (Esmolol). Assuming a pooled standard deviation of 9.6, a mean difference of 4 beats/min, 80% study power, and a 5% level of statistical significance, calculated minimum sample size was 90 participants per group. Therefore, a total of 180 eligible patients were recruited and allocated equally into two groups: Group D (Dexmedetomidine, n=90) and Group E (Esmolol, n=90).

### Tools and Techniques

Routine intraoperative monitoring consisted of continuous electrocardiography, pulse oximetry, Non-invasive BP monitoring, and Et-$CO_2$. Dexmedetomidine infusion was administered using a calibrated syringe infusion pump, while all anesthetic procedures were performed using a standard anesthesia workstation. After approval from Ethics Committee and taking informed consent (written), eligible participants were assigned to either study group using a computer-generated randomization sequence.

**Group D**: received i.v. dexmedetomidine at a dose of 1 µg/kg infused over ten minutes.

**Group E**: received i.v. esmolol at a dose of 0.5 mg/kg two minutes before laryngoscopy.

Standard anesthetic induction was achieved by midazolam, propfol, Fentanyl and rocuronium. ET - intubation - performed by the same anesthesiologist to minimize procedural variability. Hemodynamic variables were documented at baseline and subsequently at 1, 3, 5, 10, and 15 minutes after intubation. SPSS (v22) was used for statistical analysis with a p-value < 0.05 considered statistically significant.

## RESULTS AND ANALYSIS

### Socio-demographic Characteristics of the Study Population

The baseline demographic profile of participants was well balanced between the dexmedetomidine and esmolol groups.

Most patients belonged to the 41–55-year age category (88; 48.9%), followed by those aged 24–40 years (59; 32.8%), over 55 years (27; 15.0%), and below 24 years (6; 3.3%). Age distribution was not significant between the two treatment groups (p=0.972), giving a comparable baseline characteristics.

Male participants predominated in the study population, representing 132 (73.3%) of the total sample, while females accounted for 48 (26.7%). Among patients receiving dexmedetomidine, male were 65 and female were 25 , whereas the esmolol group comprised 67 males and 23 females. Statistical analysis demonstrated no significant difference in gender distribution between the groups (p=0.433).

Based on the ASA Physical Status classification, the majority of participants were categorized as ASA Grade I (144; 80.0%), while the remaining 36 (20.0%) belonged to ASA Grade II. Group D included 69 patients with ASA Grade I and 21 with Grade II, whereas Group E consisted of 75 Grade I and 15 Grade II patients. The distribution of ASA grades was comparable between the two groups, with no statistically significant difference observed (p=0.176).

Body mass index (BMI) categories were also similarly distributed across both treatment groups.(BMI 25–29.9 kg/m²) the overweight category was observed in majority, accounting for 108 (60.0%) patients, followed by individuals with normal BMI (60; 33.3%). Only a small proportion of participants were underweight (4; 2.2%) or obese (8; 4.5%). The BMI distribution was not statistically significant between the dexmedetomidine and esmolol groups (p=0.785), indicating that the study groups were comparable with respect to anthropometric characteristics.

**Table 1:** Socio-demographic and distribution of study subjects (n=180)

| Variable | Category | Dexmedetomidine (n=90) | Esmolol (n=90) | Total (n=180) | p-value |
|---|---|---|---|---|---|
| Age in years | <24 | 3 | 3 | 6 | 0.972 |
| | 24–40 | 31 | 28 | 59 | |
| | 41–55 | 43 | 45 | 88 | |
| | >55 | 13 | 14 | 27 | |
| Gender | Male | 65 | 67 | 132 | 0.433 |
| | Female | 25 | 23 | 48 | |
| ASA Physical Status | Grade I | 69 | 75 | 144 | 0.176 |
| | Grade II | 21 | 15 | 36 | |
| BMI Category (kg/m²) | <18.5 | 3 | 1 | 4 | 0.785 |
| | 18.5–24.9 | 29 | 31 | 60 | |
| | 25.0–29.9 | 54 | 54 | 108 | |
| | 30.0–34.9 | 4 | 4 | 8 | |

## Haemodynamic Parameters and their comparison

### *Systolic Blood Pressure (SBP)*

Baseline SBP was comparable between the Esmolol and Dexmedetomidine groups (122.02 ± 7.13 vs. 122.56 ± 6.90 mmHg; p=0.618). Following laryngoscopy, the Dexmedetomidine group demonstrated significantly lower Systolic BP at 1, 3, 5, and 10 minutes compared with the Esmolol group (p<0.05). By 15 minutes, statistically significance was not present (p=0.28).

### *Diastolic Blood Pressure (DBP)*

Baseline DBP was similar in both groups (72.84 ± 6.14 vs. 72.71 ± 6.90 mmHg; p=0.758). The Dexmedetomidine group showed significantly lower DBP than the Esmolol group at all post-intubation time points, including 1, 3, 5, 10, and 15 minutes (all p<0.05), indicating superior attenuation of the diastolic pressor response.

### *Mean Arterial Pressure (MAP)*

MAP was comparable at baseline (89.2 ± 5.83 vs. 87.3 ± 4.80 mmHg; p=0.068). After intubation, MAP remained lower in the Dexmedetomidine group at 1, 3, 5, and 10 minutes compared with the Esmolol group (p<0.001). However, by 15 minutes,

the difference between the groups was not statistically significant (p=0.215).

### Heart Rate (HR)

Baseline HR was similar in the Esmolol and Dexmedetomidine groups (84.31 ± 4.82 vs. 85.24 ± 4.50 beats/min; p=0.187). Although the Group(D) demonstrated numerically lower heart rates following intubation at all measured intervals, the differences between the two groups at 1, 3, 5, 10, and 15 minutes were not statistically significant (all p>0.05).

**Table 2:** Haemodynamic Parameters and their comparison (n=180)

| Parameter | Time | Dexmedetomidine (Mean ± SD) | Esmolol (Mean ± SD) | p-value |
|---|---|---|---|---|
| Systolic Blood Pressure (mmHg) | Baseline | 122.56 ± 6.90 | 122.02 ± 7.13 | 0.618 |
| | 1 min | 132.22 ± 7.01 | 142.09 ± 6.82 | <0.001 |
| | 3 min | 130.22 ± 7.29 | 140.17 ± 7.29 | <0.001 |
| | 5 min | 126.49 ± 7.20 | 135.07 ± 7.84 | 0.002 |
| | 10 min | 122.90 ± 7.30 | 130.90 ± 8.42 | <0.001 |
| | 15 min | 124.68 ± 11.35 | 128.02 ± 9.15 | 0.280 |
| Diastolic Blood Pressure (mmHg) | Baseline | 72.71 ± 6.90 | 72.84 ± 6.14 | 0.758 |
| | 1 min | 75.50 ± 5.36 | 81.07 ± 6.19 | <0.001 |
| | 3 min | 72.69 ± 5.47 | 78.76 ± 5.90 | <0.001 |
| | 5 min | 69.42 ± 4.90 | 74.11 ± 5.73 | <0.001 |
| | 10 min | 70.70 ± 5.20 | 73.29 ± 5.73 | <0.001 |
| | 15 min | 71.56 ± 5.76 | 74.93 ± 5.71 | 0.006 |
| Mean Arterial Pressure (mmHg) | Baseline | 87.30 ± 4.80 | 89.20 ± 5.83 | 0.068 |
| | 1 min | 94.40 ± 5.84 | 101.40 ± 6.17 | <0.001 |
| | 3 min | 91.90 ± 5.91 | 99.20 ± 6.09 | <0.001 |
| | 5 min | 88.40 ± 5.40 | 94.40 ± 5.54 | <0.001 |
| | 10 min | 88.10 ± 5.42 | 92.20 ± 5.75 | <0.001 |
| | 15 min | 89.30 ± 5.83 | 92.60 ± 5.24 | 0.215 |
| Heart Rate (beats/min) | Baseline | 85.24 ± 4.50 | 84.31 ± 4.82 | 0.187 |
| | 1 min | 89.52 ± 4.18 | 92.79 ± 5.07 | 0.701 |
| | 3 min | 82.96 ± 4.47 | 89.41 ± 6.09 | 0.379 |
| | 5 min | 80.24 ± 3.48 | 85.47 ± 3.72 | 0.153 |
| | 10 min | 82.80 ± 3.60 | 83.20 ± 3.53 | 0.242 |
| | 15 min | 83.18 ± 4.06 | 85.12 ± 4.32 | 0.129 |

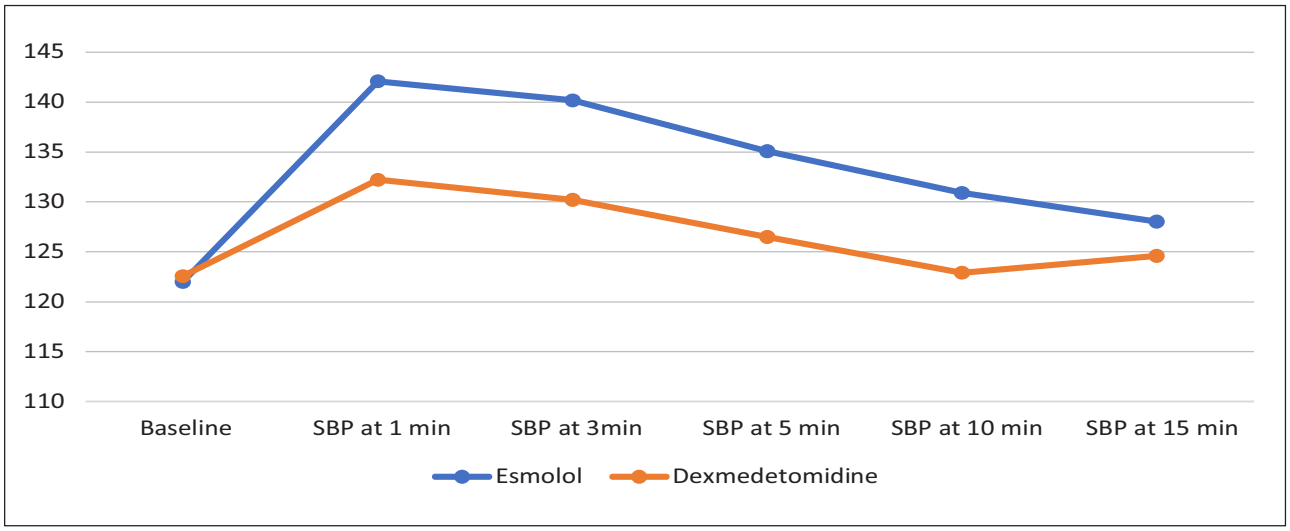



**Figure 1:** Comparison of mean Systolic Blood Pressure among the patients receiving Esmolol and Dexmedetomidine (n=180)

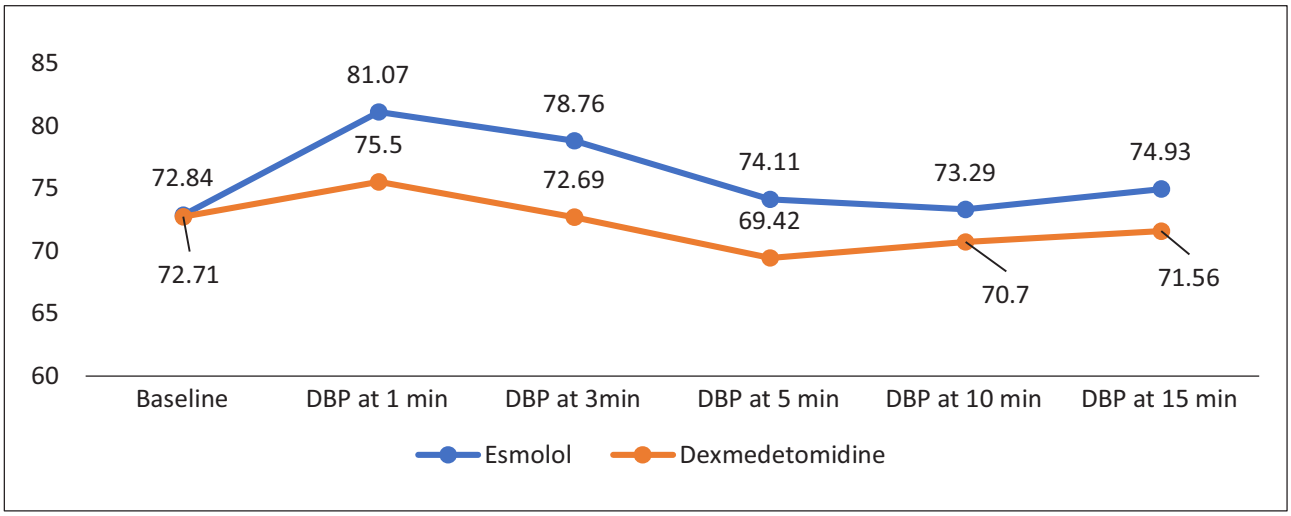



**Figure 2:** Comparison of mean Diastolic Blood Pressure among the patients receiving Esmolol and Dexmedetomidine (n=180)

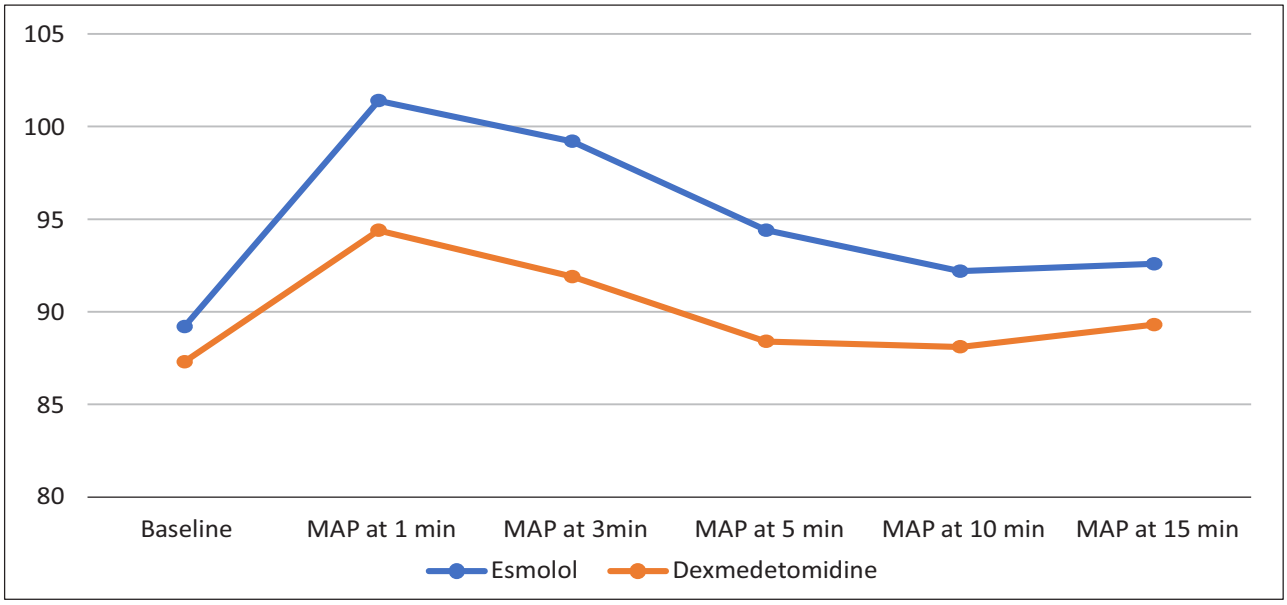



**Figure 3:** Comparison of mean of Mean Arterial Pressure among the patients receiving Esmolol and Dexmedetomidine (n=180)

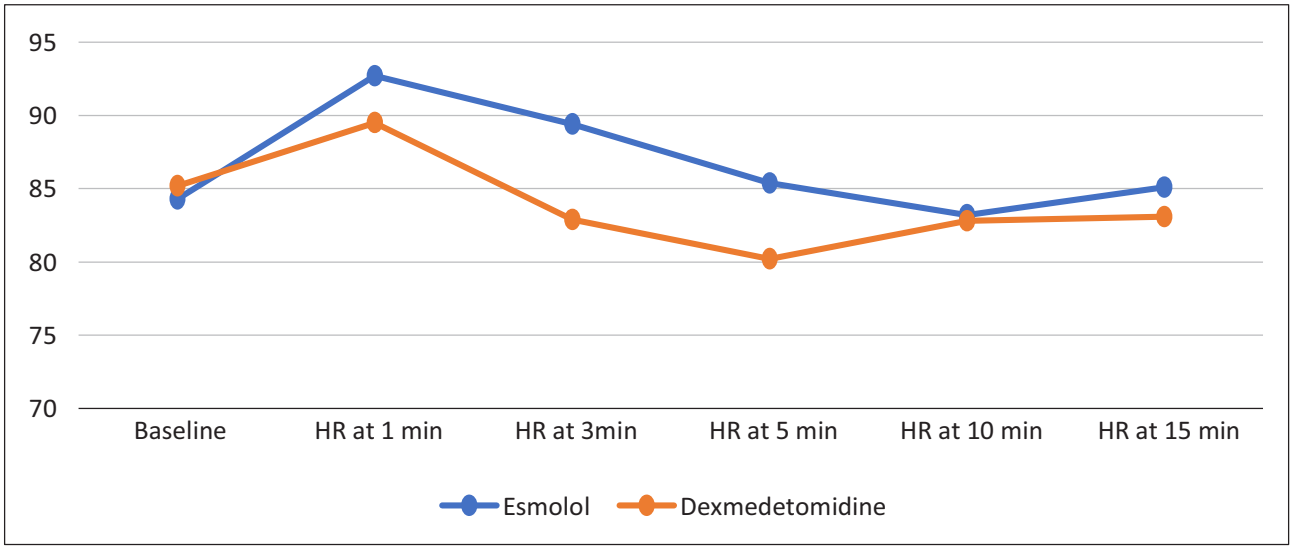



**Figure 4:** Comparison of mean of Heart Rate among the patients receiving Esmolol and Dexmedetomidine (n=180)

## DISCUSSION

Dexmedetomidine and esmolol both were effective in the present study in minimizing the hemodynamic changes with laryngoscopy and endotracheal intubation during general anesthesia. Both study groups were comparable with respect to baseline characteristics indicating that the observed differences in cardiovascular responses were primarily due to the pharmacological effects of the medications rather than baseline demographic or clinical variations.

The findings of this study found that dexmedetomidine was more effective than esmolol in attenuating the pressor response following laryngoscopy and tracheal intubation. Patients who received dexmedetomidine exhibited significantly lower systolic blood pressure at 1, 3, 5, and 10 minutes after intubation, while DBP remained significantly reduced throughout the entire post-intubation observation period. Mean arterial pressure also remained significantly lower up to 10 minutes after intubation in the dexmedetomidine group, reflecting superior maintenance of perioperative hemodynamic stability. Although heart rate values tended to be lower in patients receiving dexmedetomidine, the difference between the two treatment groups did not reach statistical significance.

The observations of the this study are aligning with the findings of **Srivastava *et al.,*** who found that dexmedetomidine provided more sustained suppression of the cardiovascular response to laryngoscopy than esmolol. In their study, patients receiving dexmedetomidine had lower HR and arterial BP throughout the observation period, whereas those administered esmolol experienced a transient reduction followed by a rise in hemodynamic parameters during the early post-intubation phase. Comparable results were also documented by **Gupta HB *et al.,*** who demonstrated that dexmedetomidine maintained greater cardiovascular stability, while esmolol was associated with significant increases in heart rate and blood pressure for up to ten minutes after tracheal intubation.[13,14]

The present findings are further corroborated by the work of **Sen B *et al.,*** who observed significantly lower systolic blood pressure, diastolic blood pressure, mean arterial pressure, and rate-pressure product among patients receiving dexmedetomidine compared with those treated with esmolol from the first minute through twenty minutes following intubation. Similar conclusions were reached by **Selvaraj *et al.,*** who found dexmedetomidine to be more effective in attenuating the overall sympathetic response, particularly with respect to diastolic blood pressure. Likewise, the randomized controlled trial conducted by **Sharma S *et al.*** demonstrated significantly lower HR, SBP, DBP, MAP, and rate-pressure product in patients receiving dexmedetomidine compared with those receiving esmolol or placebo throughout the peri-intubation period.[11,15,16]

The results of the present investigation also correspond with those reported by **Reddy SV *et al.,*** who concluded that dexmedetomidine was superior to esmolol in suppressing the sympathetic cardiovascular responses induced by laryngoscopy and endotracheal intubation. The enhanced efficacy of dexmedetomidine can be attributed to its highly selective $\alpha_2$-adrenergic agonist activity, which suppresses central sympathetic outflow and inhibits catecholamine release, thereby providing sustained cardiovascular stability. Conversely, esmolol acts primarily through selective $\beta_1$-adrenergic receptor blockade, effectively limiting tachycardia but offering comparatively less protection against increases in arterial blood pressure. Collectively, these findings strengthen the existing evidence that dexmedetomidine offers more comprehensive attenuation of the hemodynamic stress response associated with airway instrumentation than esmolol.[17]

## CONCLUSION

The present study demonstrated that dexmedetomidine was more effective than esmolol in blunting the cardiovascular responses associated with laryngoscopy and endotracheal intubation. Compared with esmolol, dexmedetomidine achieved superior control of systolic blood pressure, diastolic blood pressure, and mean arterial pressure while maintaining comparable heart rate stability throughout the peri-intubation period. These findings suggest that dexmedetomidine is a better pharmacological option for maintaining perioperative hemodynamic stability during induction of general anesthesia and may be preferred in patients where

attenuation of the sympathetic stress response is of particular clinical importance.

**Conflict of Interest:** None declared.

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**Ethical Approval:** Approved by Institutional Ethics committee, Peerless Hospital, Kolkata.

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