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Original Research Article

Intravenous Esmolol in Different Doses to Attenuate Pressor Response to Laryngoscopy and Intubation in Patients Undergoing General Anaesthesia – A Prospective Randomised Comparative Study

Kiwi Mantan[1], Neha Aeron[2], Abhay Singh Rajpurohit[3], Anita Pareek[4], Utkarsh Singh Bais[5], Lakshmi Sravani Kagitha[6], Priyanka Kumari[7]

[1]MD Anaesthesia, IDCCM, Professor, Department of Anaesthesia, Sardar Patel Medical College, Bikaner, Rajasthan, India
[2]MD, DNB Anaesthesia, Associate Professor, Department of Anaesthesia, Sardar Patel Medical College, Bikaner, Rajasthan, India
[3]MBBS, Resident, Department of Anaesthesia, Sardar Patel Medical College, Bikaner, Rajasthan, India
[4]MD Anaesthesia, Senior Professor, Department of Anaesthesia, Sardar Patel Medical College, Bikaner
[5]MBBS, Resident, Department of Anaesthesia, Sardar Patel Medical College, Bikaner, Rajasthan, India
[6]MBBS, Resident, Department of Anaesthesia, Sardar Patel Medical College, Bikaner, Rajasthan, India
[7]MD Anaesthesia, Assistant Professor, Department of Anaesthesia, Sardar Patel Medical College, Bikaner, Rajasthan, India

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Corresponding Author: Dr. Abhay Singh Rajpurohit
Conflict of interest: Nil

Abstract:

Background: This study focused on evaluating the efficacy and safety of esmolol in attenuating the hemodynamic response associated with laryngoscopy and intubation. The study included the comparison between two different doses of esmolol given before intubation in general anaesthesia and evaluating which dose is better at attenuating the pressor response of laryngoscopy. It aimed to provide insights into optimal dosing strategies and comparative effectiveness amongst two different doses of esmolol.

Methods: This study is a prospective randomised comparative study which was conducted in the Department of Anaesthesiology, Sardar Patel Medical College and A.G of Hospitals, Bikaner after obtaining approval from Institute Ethical Committee and written informed consent from patients.

Results: In the present study using Esmolol, the overall incidence of complications was low across all groups. Bradycardia and hypotension were more frequent in Group B but were not statistically significant indicating a mild dose-related effect. Tachycardia and hypertension were significantly higher in the control group, demonstrating effective attenuation of the pressor response with esmolol. No cases of bronchospasm or arrhythmias were observed. Intervention was required in only two patients in Group B, which was not statistically significant. Overall, esmolol was effective and safe, with minimal, transient, and manageable complications.

Conclusion: Based on the observed hemodynamic profile, esmolol can be considered a safe and effective agent for attenuation of the pressor response to laryngoscopy and endotracheal intubation. Furthermore, the higher dose evaluated in this study appears to provide more pronounced hemodynamic stability and may be preferable in patients where exaggerated cardiovascular responses are undesirable.

Keywords: Esmolol, Laryngoscopy, Hemodynamic.

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Introduction

Endotracheal intubation is an integral component of general anaesthesia but is well known to provoke pronounced reflex cardiovascular responses. These responses typically manifest as tachycardia, acute elevation of arterial blood pressure, increased cardiac output, and a transient rise in central venous pressure. Although short-lived—usually persisting for only a few minutes—these changes represent a significant sympathetic surge with potential clinical implications. In patients with pre-existing cardiovascular disease, even brief episodes of hemodynamic instability may precipitate serious adverse events. [1]

Esmolol, an ultrashort-acting, cardioselective β_1-adrenergic antagonist, offers several advantages in this setting. Its rapid onset and brief elimination half-life of approximately nine minutes—attributable to metabolism by red blood cell

esterases—allow precise titration and rapid reversal of effects. [2-3] Esmolol is widely used in the management of supraventricular tachyarrhythmias, perioperative hypertension, and acute aortic syndromes. Its ability to effectively reduce heart rate and myocardial oxygen consumption makes it particularly suitable for blunting the intense sympathetic stimulation associated with laryngoscopy and endotracheal intubation.

Furthermore, esmolol lacks intrinsic sympathomimetic activity and demonstrates high β_1 selectivity, ensuring predictable cardiovascular effects without paradoxical tachycardia or bronchospasm. Its ultrashort duration minimizes the risk of prolonged bradycardia or hypotension and allows individualized dosing based on patient response. Despite evidence supporting its efficacy, variations in study methodology and dosing regimens have resulted in inconsistent findings across previous literature. Therefore, further evaluation of esmolol using standardized protocols and clearly defined hemodynamic endpoints is warranted to strengthen the evidence base and guide clinical practice. [4]

This study focused on evaluating the efficacy and safety of esmolol in attenuating the hemodynamic response associated with laryngoscopy and intubation. The study included the comparison between two different doses of esmolol given before intubation in general anaesthesia and evaluating which dose is better at attenuating the pressor response of laryngoscopy. It aimed to provide insights into optimal dosing strategies and comparative effectiveness amongst two different doses of esmolol.

Material And Methods

Study Design: A Prospective Randomised Comparative study (hospital-based study).

Study Setting: This study is a prospective randomised comparative study which was conducted in the Department of Anaesthesiology, Sardar Patel Medical College and A.G of Hospitals, Bikaner after obtaining approval from Institute Ethical Committee and written informed consent from patients.

Study Period: From July 2025 to December 2025.

Study Population: ASA I & II patients undergoing elective surgical procedure under general anaesthesia with endotracheal intubation during the study period were the study population.

Inclusion Criteria:

1. ASA I & II.
2. Weight upto 80 kg.
3. Age 18 – 60 years.
4. All elective cases requiring general anaesthesia.

Exclusion Criteria:

1. Patient Refusal.
2. Known allergy to drug used in the study.
3. Patients with ASA grade III and above.
4. Known difficult airway.
5. Any contraindication to esmolol (hypotension, bradycardia, heart blocks).
6. Patients on beta blockers.
7. Patients with full stomach.
8. Patients posted for Emergency surgery.
9. Pre-existing hypertension, diabetes, ischemic heart disease.

Sampling Technique: Simple randomised sample by computer generated randomisation.

Sample Size & Calculation: Patients who were eligible for inclusion in study as per inclusion criteria and reporting within the study duration were included in this study after obtaining written consent through simple randomised sampling. The sample size required in each arm of the study was calculated according to the given formula:

Minimum sample size is: $N = \frac{2 * (Z\alpha/2 + Z\beta)2SD2}{D2}$

Sample size calculation with 90% power

Where,

N = minimum required sample size in each of the groups D = difference in mean =13.08

SD2 = Squared pooled deviation=300.46

Z α/2=1.96 = conventional multiplier for alpha 0.05
Zβ=1.26= conventional multiplier for power 90%

Based on the formula given above, using the mentioned values, the sample size required is:

Minimum sample size is $N = \frac{2*(Z\alpha/2 + Z\beta)2SD2}{D2}$

N = 2∗(1.96+1.26)2SD2 D2

= 2(10.37) (300.46) = 37 in each group

$(13.08)^2$

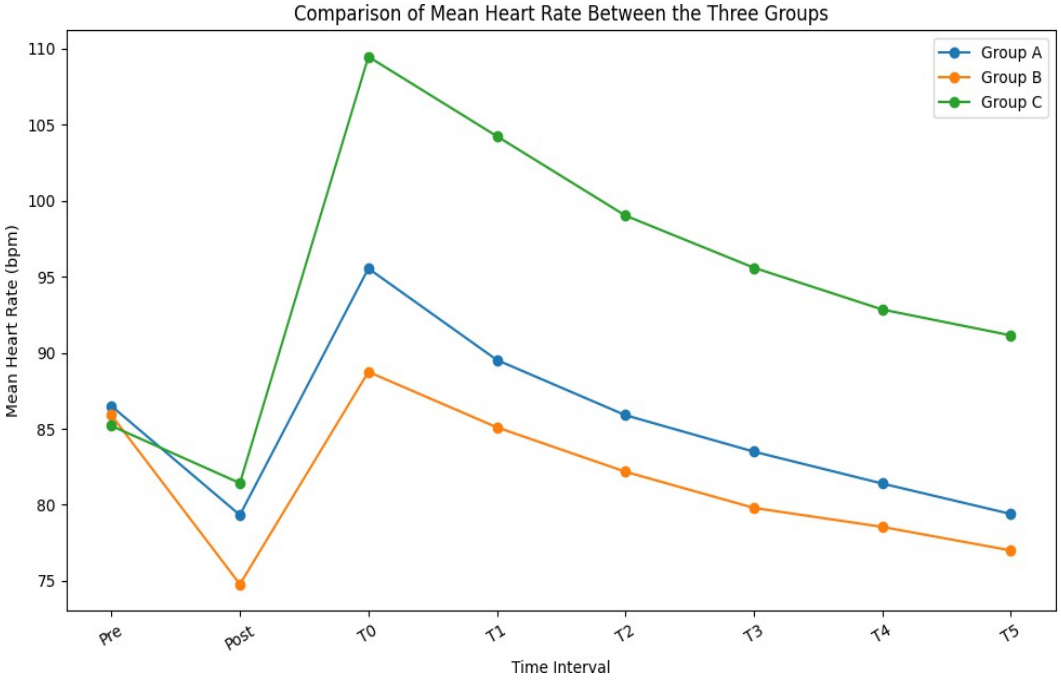
The minimum sample size required for the study in each group is 37. Given practical considerations and potential dropouts, enrolling 40 patients per group, as done in the study, ensures robust and reliable results. Thus, sample size of 40 patients in each group was taken in this study.

Allocation: The patients were divided in three groups by lottery system (simple random sampling). The first patient who fulfilled the inclusion criteria was allotted group A, then every other patient who fulfilled inclusion criteria was placed in group B and then group C then again in group A. Thus, all the patients were equally divided in three groups.

Group	Drugs	No. of Patients	Total Drug Volume
Group A	GA + i.v. Esmolol Hydrochloride(1.5mg/kg) + 0.9%NS	40	25 ml
Group B	GA + i.v. Esmolol Hydrochloride(3.0mg/kg) + 0.9%NS	40	25 ml
Group C	GA + 0.9% NS	40	25 ml

Results

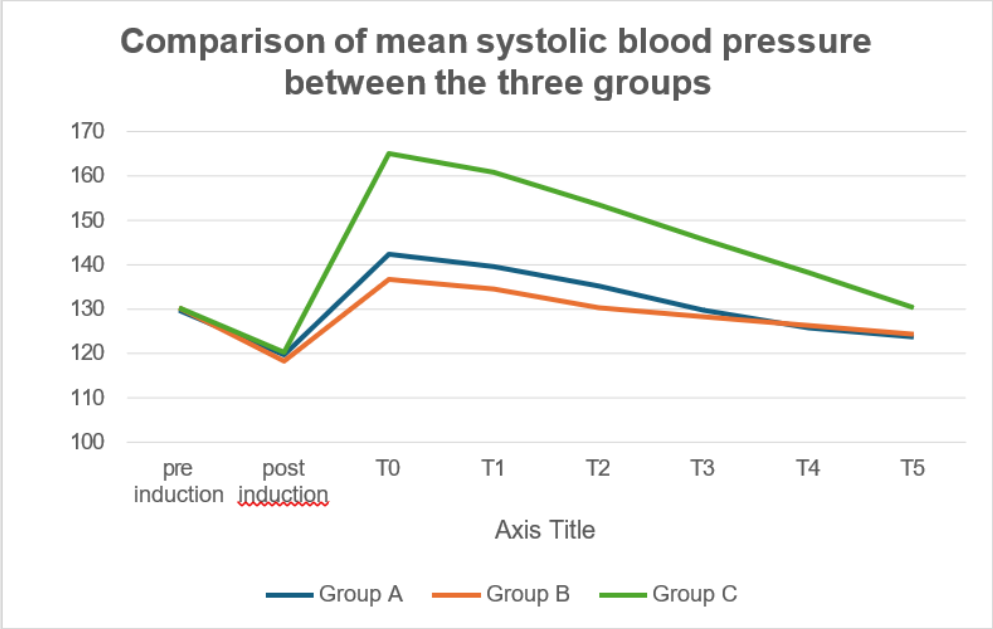
Overall comparison of mean age across the three groups demonstrated no statistically significant difference. Statistical analysis demonstrated a significant difference in sex distribution among the three groups ($p = 0.045$). This indicates that the proportion of male and female participants was not comparable across groups, with Group B showing a higher predominance of male patients relative to Groups A and C. Statistical analysis revealed no significant difference in ASA grade distribution among the three groups ($p = 0.560$). This suggests that the baseline physical status of patients, as assessed by ASA classification, was comparable across all groups



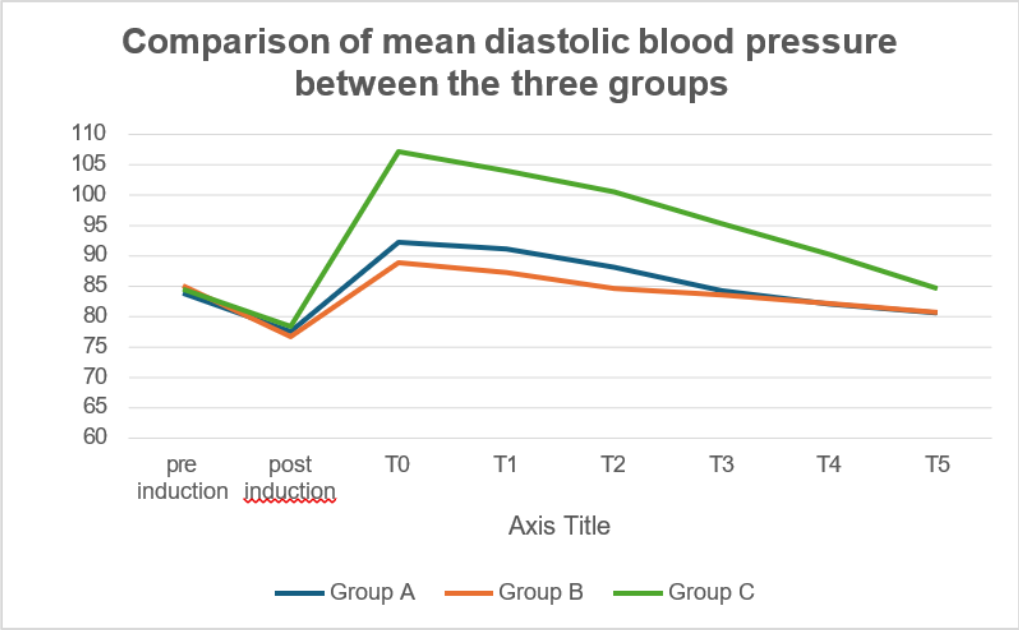
Baseline heart rates were comparable across all groups. After induction, heart rate decreased in all groups, with a significant difference observed only between Groups B and C. At Intubation (T0), all groups differed significantly from each other, with maximum increase in heart rate seen in group C.

From T1 to T5, Group C consistently showed higher heart rates than Groups A and B, with significant differences observed for A vs C and B vs C, while Groups A and B remained comparable.

Overall, Group C exhibited higher intraoperative heart rates, whereas Groups A and B showed similar trends (lowest HR seen in Group B).



Baseline SBP was comparable across all groups, with no pairwise differences. Following induction, SBP decreased in all groups, with a significant difference observed only between Groups B and C. At T0, T1, and T2, all groups differed significantly from each other. From T3 to T5, overall differences remained significant, with Groups A and B showing no difference, while both differed significantly from Group C. Group C consistently maintained higher SBP values across intraoperative time points. In contrast, Groups A and B followed a similar and relatively stable trend. Overall, Group C demonstrated higher intraoperative SBP, whereas Groups A and B remained largely comparable.



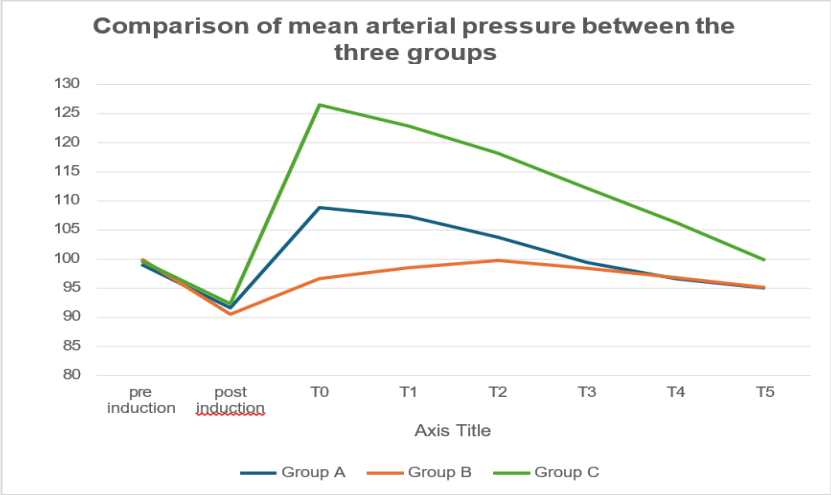
Baseline DBP was comparable across all groups, with no pairwise differences. Following induction, DBP decreased in all groups, with a difference observed only between Groups B and C.

At T0, T1, and T2, all groups differed significantly from each other. From T3 to T5, overall differences persisted, with Groups A and B showing no difference, while both differed significantly from Group C.

Group C consistently maintained higher DBP values throughout the intraoperative period. Groups A and B followed a similar trend with relatively stable and lower values.

In contrast, the overlap between Groups A and B suggests comparable hemodynamic responses.

Overall, Group C demonstrated higher intraoperative DBP, whereas Groups A and B remained largely comparable.



Baseline MAP was comparable across all groups, with no pairwise differences. Following induction, MAP decreased in all groups, with a difference observed only between Groups B and C.

At T0, T1, and T2, all groups differed significantly from each other. From T3 to T5, overall differences persisted, with Groups A and B showing no difference, while both differed significantly from Group C.

Group C consistently showed higher MAP throughout the intraoperative period, while Groups A and B followed similar trends with relatively lower values.

Overall, Group C demonstrated higher intraoperative MAP, whereas Groups A and B remained largely comparable.

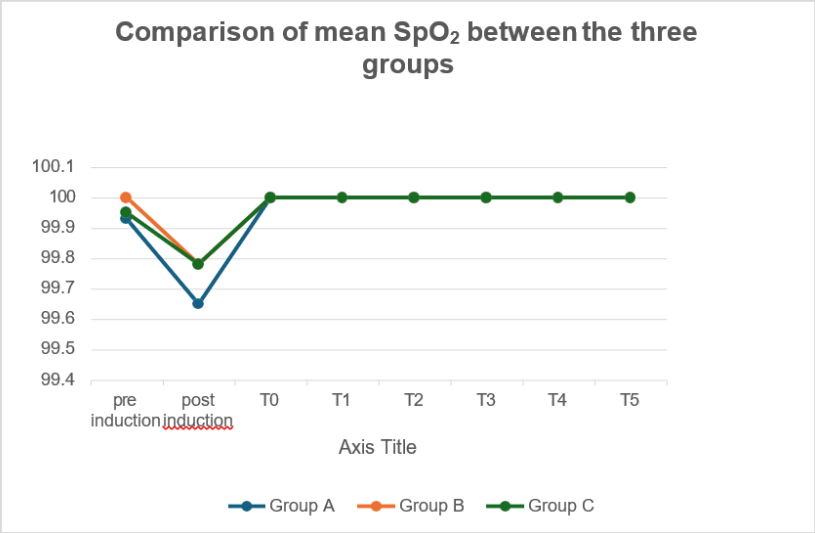


Table 1: Comparison of complications observed in three groups. (N = 120)

Complications	Group A	Group B	Group C	P value
Bradycardia (<60 bpm)	2	5	1	0.18
Hypotension (MAP ↓ >20%)	3	6	2	0.21
Tachycardia (>100 bpm)	3	1	11	<0.001
Hypertension (>20% rise)	4	2	13	<0.001
Bronchospasm	0	0	0	NA
Arrhythmias	0	0	0	NA
Need for Intervention	0	2	0	0.36

In the present study using Esmolol, the overall incidence of complications was low across all groups. Bradycardia and hypotension were more frequent in Group B but were not statistically significant indicating a mild dose-related effect.

Tachycardia and hypertension were significantly higher in the control group, demonstrating effective attenuation of the pressor response with esmolol. No cases of bronchospasm or arrhythmias were observed.

Intervention was required in only two patients in Group B, which was not statistically significant.

Overall, esmolol was effective and safe, with minimal, transient, and manageable complications.

Discussion

The incidence of complications in the present study was low, indicating that esmolol is a safe drug when used in appropriate doses.

Bradycardia and hypotension were observed more frequently in group B, suggesting a dose-dependent trend. Although these differences were not statistically significant, they are clinically relevant, as excessive β-blockade may lead to undesirable haemodynamic depression. Krishna et al., (2015)5 identified 1.5 mg/kg as optimal, while Cheeran et al., (2017)6 observed increased efficacy with higher doses but with risk of hypotension, aligning with the trends seen in the present study.

On the other hand, tachycardia and hypertension were significantly more common in group C, emphasizing the importance of pharmacological attenuation of the pressor response.

No cases of bronchospasm or arrhythmias were observed, which is consistent with the β1 selectivity of esmolol. Only minimal intervention was required, further supporting its safety profile.

These findings are in agreement with recent literature, including Cheeran et al. (2017)5 and Mulimani et al. (2019)7, which reported that higher doses of esmolol may be associated with increased incidence of hypotension without significant additional benefit.

Various pharmacological agents have been used to attenuate the pressor response, including opioids, α2-agonists, calcium channel blockers, and lignocaine. Among these, esmolol offers distinct advantages due to its rapid onset, short duration, and predictable pharmacodynamics.

Recent studies such as Sharma et al. (2024)8 have shown that esmolol provides more consistent haemodynamic control compared to lignocaine. While agents like dexmedetomidine may offer superior stability, they are associated with prolonged sedation and hypotension, limiting their routine use.

Thus, esmolol remains a practical and effective choice, especially in situations requiring rapid and transient control of haemodynamic response.

The findings of the present study have important clinical implications. The results of the present study suggest that:

- Esmolol is highly effective in attenuating the haemodynamic response to laryngoscopy and intubation
- A dose-dependent effect is evident, with 3 mg/kg providing superior control.
- The 1.5 mg/kg dose provides adequate attenuation with a slightly better safety margin
- Dose selection should be individualized based on patient profile and requirement.

Conclusions

The present study demonstrated the use of two different doses of esmolol (3mg/kg and 1.5 mg/kg) to attenuate pressor response to laryngoscopy and intubation compared to a control group.

Baseline demographic characteristics including age, weight, and ASA physical status were comparable among the three groups, indicating homogeneity of the study population.

Both esmolol groups effectively blunted the sympathetic hemodynamic response, with higher dose (3mg/kg) demonstrating superior attenuation compared to lower dose (1.5mg/kg) at different time intervals, particularly immediately after intubation and during the early intraoperative period suggesting that esmolol provides effective control of tachycardia and hypertension associated with airway manipulation. Pressor response was significantly higher in the control group.

Based on the observed hemodynamic profile, esmolol can be considered a safe and effective agent for attenuation of the pressor response to laryngoscopy and endotracheal intubation. Furthermore, the higher dose evaluated in this study appears to provide more pronounced hemodynamic stability and may be preferable in patients where exaggerated cardiovascular responses are undesirable.

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