ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 08 | August - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A COMPARATIVE STUDY OF HEMODYNAMIC RESPONSE WITH ESMOLOL, PROPOFOL AND LIGNOCAINE DURING EXTUBATION USING SUGAMMADEX AS REVERSAL AGENT IN ELECTIVE SURGERIES

Anaesthesiology

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ABSTRACT

Introduction: Extubation after general anaesthesia can produce tachycardia, hypertension and airway-related stimulation. Pharmacological attenuation is important when rapid reversal with sugammadex is used. This study compared esmolol, propofol and lignocaine for controlling post-extubation hemodynamic response in elective surgeries. **Objectives:** To evaluate and compare the effectiveness of intravenous esmolol, propofol and lignocaine in attenuating hemodynamic fluctuations during extubation, and to identify the most effective agent for achieving smooth extubation following sugammadex-based neuromuscular blockade reversal. **Methods:** This prospective randomized comparative study included 90 ASA I–II adult patients aged 18–65 years undergoing elective surgery under general anaesthesia. Patients received esmolol 1.5 mg/kg, propofol 0.5 mg/kg or lignocaine 1.5 mg/kg intravenously 2 minutes before extubation. **Results:** Baseline variables were comparable across groups. Esmolol maintained HR, SBP, DBP and MAP closest to baseline. Clinically significant >20% HR rise was lowest with esmolol 1 (3.3%) compared with propofol 6 (20.0%) and lignocaine 9 (30.0%) (p=0.01). **Conclusion:** Esmolol was the most effective agent for attenuating extubation-related hemodynamic response with sugammadex reversal. It provided superior cardiovascular stability and higher composite smooth extubation than propofol and lignocaine, without oxygen desaturation or major adverse events.

KEYWORDS

Esmolol, Propofol, Lignocaine, Sugammadex, Extubation Response, Hemodynamic Stability, Smooth Extubation, General Anaesthesia, Elective Surgery.

INTRODUCTION

Tracheal extubation is the planned removal of the endotracheal tube at the end of general anaesthesia, after the patient has regained adequate breathing, airway reflexes, and muscle power. Although it is a routine step, extubation is a critical period because stimulation of the larynx and trachea can produce coughing, bucking, tachycardia, hypertension, and other airway-related problems.[1] Smooth extubation is therefore important for patient safety, especially in elective surgeries where stable recovery from anaesthesia is expected.[2] The hemodynamic response during extubation mainly includes changes in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. These changes occur because airway stimulation activates the sympathetic nervous system. In many healthy patients, this response is temporary, but in patients with hypertension, ischemic heart disease, neurosurgical conditions, or eye-related procedures, sudden increases in heart rate and blood pressure may be harmful.[3,4] Different drugs have been used to reduce this extubation response. Esmolol is a short-acting beta-blocker that helps control tachycardia and hypertension by reducing sympathetic activity. Previous studies have shown that esmolol can reduce cardiovascular responses related to airway stimulation during anaesthesia and extubation.[5] Lignocaine is another commonly used drug that suppresses airway reflexes and helps reduce coughing, bucking, and cardiovascular stimulation during airway manipulation.[6] Propofol, an intravenous anaesthetic agent, may also help by producing smoother emergence and reducing airway reactivity when used carefully near the time of extubation.[7] Reversal of neuromuscular blockade is also important before extubation. Sugammadex is used to reverse rocuronium- or vecuronium-induced muscle relaxation and allows faster recovery of muscle power compared with traditional reversal methods.[8] Proper reversal with sugammadex may support safer extubation by improving breathing effort and reducing residual muscle weakness.[9]

MATERIAL & METHODS

Study Settings: The study was conducted in the Department of Anaesthesiology, BRD Medical College, Gorakhpur.

Study Type: Prospective Randomized Comparative study
Sample Size: 90
Study Duration: One year

Inclusion Criteria:

- Written informed consent was taken
- Adult patients (aged 18–65 years) undergoing elective surgeries under general anesthesia.
- ASA (American Society of Anesthesiologists) physical status I and II

Exclusion Criteria:

- Patient refusal
- Patients with known cardiovascular disease (e.g., ischemic heart disease, arrhythmias).
- History of allergic reactions to any of the study drugs (esmolol, propofol, lignocaine, or sugammadex).
- Patients with renal or hepatic impairment.
- Pregnant or lactating women.
- Emergency surgeries or those requiring extended mechanical ventilation.

Methods

Eligible consenting patients were randomized into three groups: Group E received esmolol 1.5 mg/kg, Group P received propofol 0.5 mg/kg, and Group L received lignocaine 1.5 mg/kg, each intravenously 2 minutes before extubation, following standard anesthesia protocol and monitoring.

Statistical Analysis

SPSS version 24th was used for data analysis, using descriptive statistics to summarize demographic and baseline characteristics, and ANOVA to compare hemodynamic and postoperative recovery parameters across the three groups, with a p-value of <0.05 indicating statistical significance.

RESULTS

The three study groups were comparable at baseline. Mean age was similar in the Esmolol, Propofol, and Lignocaine groups (41.0 ± 10.0,

43.0 ± 12.0, and 42.0 ± 11.0 years; p=0.71). Height, weight, and BMI were also comparable, with BMI values of 24.9 ± 3.1, 25.8 ± 3.7, and 25.2 ± 3.4 kg/m², respectively (p=0.59). Gender distribution was similar, with males comprising 60.0%, 60.0%, and 53.3% in the three groups (p=0.84). ASA status was also balanced, with ASA I patients being 63.3%, 66.7%, and 56.7% (p=0.62). Baseline HR (78 ± 8, 79 ± 9, 77 ± 8 bpm; p=0.63), SBP (121 ± 10, 123 ± 12, 123 ± 11 mmHg; p=0.52), DBP (76 ± 7, 76 ± 8, 76 ± 7 mmHg; p=0.98), MAP (91 ± 7, 93 ± 9, 92 ± 8 mmHg; p=0.57), and SpO_2 (99 ± 1% in all groups; p=0.85) showed no significant difference, indicating that all groups were well matched before extubation.

Table 1: Comparison of Heart Rate at Different Time Points After Extubation

Time point	Esmolol (n=30)	Propofol (n=30)	Lignocaine (n=30)	p-value
Baseline / pre-extubation	78 ± 8	79 ± 9	77 ± 8	0.63
T0 Immediate	80 ± 9	92 ± 11	95 ± 12	<0.001
T1 1 min	76 ± 7	88 ± 10	94 ± 12	<0.001
T3 3 min	75 ± 6	82 ± 9	88 ± 11	<0.001
T5 5 min	76 ± 7	80 ± 9	83 ± 10	0.01
T10 10 min	76 ± 7	78 ± 9	80 ± 9	0.17

In Table 1, baseline heart rate was comparable among the Esmolol, Propofol, and Lignocaine groups (78 ± 8, 79 ± 9, and 77 ± 8 bpm; p=0.63). Immediately after extubation, heart rate increased minimally in the Esmolol group (80 ± 9 bpm), while higher rises were seen in the Propofol (92 ± 11 bpm) and Lignocaine groups (95 ± 12 bpm; p<0.001). At 1 minute, heart rate remained lower with Esmolol (76 ± 7 bpm) compared with Propofol (88 ± 10 bpm) and Lignocaine (94 ± 12 bpm; p<0.001). Similar significant differences were observed at 3 minutes (75 ± 6, 82 ± 9, and 88 ± 11 bpm; p<0.001) and 5 minutes (76 ± 7, 80 ± 9, and 83 ± 10 bpm; p=0.01). By 10 minutes, heart rate became comparable again (76 ± 7, 78 ± 9, and 80 ± 9 bpm; p=0.17), indicating better early heart rate control with Esm

Table 2: Comparison of Blood Pressure Parameters After Extubation

Parameter/Time point	Esmolol	Propofol	Lignocaine	p-value
SBP Baseline	121 ± 10	123 ± 12	123 ± 11	0.52
SBP T0	120 ± 11	132 ± 13	138 ± 14	<0.001
SBP T1	118 ± 9	135 ± 12	140 ± 14	<0.001
SBP T3	116 ± 8	128 ± 11	134 ± 13	<0.001
SBP T5	117 ± 8	124 ± 10	129 ± 11	0.002
SBP T10	116 ± 8	122 ± 10	125 ± 11	0.01
DBP Baseline	76 ± 7	76 ± 8	76 ± 7	0.98
DBP T0	74 ± 7	82 ± 8	84 ± 9	<0.001
DBP T1	73 ± 6	83 ± 8	85 ± 9	<0.001
DBP T3	72 ± 6	79 ± 7	82 ± 8	<0.001
DBP T5	73 ± 6	77 ± 7	79 ± 8	0.004
DBP T10	73 ± 6	76 ± 7	77 ± 7	0.08
MAP Baseline	91 ± 7	93 ± 9	92 ± 8	0.57
MAP T0	90 ± 7	102 ± 10	106 ± 11	<0.001
MAP T1	89 ± 7	104 ± 10	108 ± 11	<0.001
MAP T3	88 ± 6	99 ± 9	103 ± 10	<0.001
MAP T5	88 ± 6	96 ± 8	99 ± 9	0.002
MAP T10	88 ± 6	94 ± 8	96 ± 9	0.01

In Table 2, Baseline blood pressure parameters were comparable among the Esmolol, Propofol, and Lignocaine groups, with SBP 121 ± 10, 123 ± 12, and 123 ± 11 mmHg (p=0.52), DBP 76 ± 7, 76 ± 8, and 76 ± 7 mmHg (p=0.98), and MAP 91 ± 7, 93 ± 9, and 92 ± 8 mmHg (p=0.57). After extubation, Esmolol maintained better blood pressure stability, while Propofol and Lignocaine showed higher rises. SBP remained lower with Esmolol from T0 to T10 (120 ± 11 to 116 ± 8 mmHg) compared with Propofol (132 ± 13 to 122 ± 10 mmHg) and Lignocaine (138 ± 14 to 125 ± 11 mmHg). Similar trends were seen for DBP, with Esmolol 74 ± 7 to 73 ± 6 mmHg, Propofol 82 ± 8 to 76 ± 7 mmHg, and Lignocaine 84 ± 9 to 77 ± 7 mmHg. MAP also stayed lowest with Esmolol 90 ± 7 to 88 ± 6 mmHg, compared with Propofol 102 ± 10 to 94 ± 8 mmHg and Lignocaine 106 ± 11 to 96 ± 9 mmHg. Significant intergroup differences were seen up to T10 for SBP and MAP, and up to T5 for DBP, indicating better blood pressure control with Esmolol.

Table 3: Peak Post-extubation Hemodynamic Response Among Study Groups

Parameter	Group	Baseline mean ± SD	Peak Post-extubation mean ± SD	Peak time point	Absolute Change from Baseline	Percentage Change from Baseline
HR (bpm)	Esmolol	78 ± 8	80 ± 9	T0	2	0.026
HR (bpm)	Propofol	79 ± 9	92 ± 11	T0	13	0.165
HR (bpm)	Lignocaine	77 ± 8	95 ± 12	T0	18	0.234
SBP (mmHg)	Esmolol	121 ± 10	120 ± 11	T0	-1	-0.80%
SBP (mmHg)	Propofol	123 ± 12	135 ± 12	T1	12	0.098
SBP (mmHg)	Lignocaine	123 ± 11	140 ± 14	T1	17	0.138
DBP (mmHg)	Esmolol	76 ± 7	74 ± 7	T0	-2	-2.60%
DBP (mmHg)	Propofol	76 ± 8	83 ± 8	T1	7	0.092
DBP (mmHg)	Lignocaine	76 ± 7	85 ± 9	T1	9	0.118
MAP (mmHg)	Esmolol	91 ± 7	90 ± 7	T0	-1	-1.10%
MAP (mmHg)	Propofol	93 ± 9	104 ± 10	T1	11	0.118
MAP (mmHg)	Lignocaine	92 ± 8	108 ± 11	T1	16	0.174

In Table 3, Peak post-extubation hemodynamic response was lowest in the Esmolol group. Heart rate increased only from 78 ± 8 to 80 ± 9 bpm at T0, compared with Propofol 79 ± 9 to 92 ± 11 bpm and Lignocaine 77 ± 8 to 95 ± 12 bpm. For SBP, Esmolol showed a slight fall from 121 ± 10 to 120 ± 11 mmHg, while Propofol increased from 123 ± 12 to 135 ± 12 mmHg and Lignocaine from 123 ± 11 to 140 ± 14 mmHg. Similar findings were seen for DBP and MAP, where Esmolol showed slight reductions (76 ± 7 to 74 ± 7 mmHg; 91 ± 7 to 90 ± 7 mmHg), while Propofol and Lignocaine showed clear rises. Overall, Lignocaine showed the highest peak response, followed by Propofol, whereas Esmolol provided the best attenuation of post-extubation hemodynamic changes.

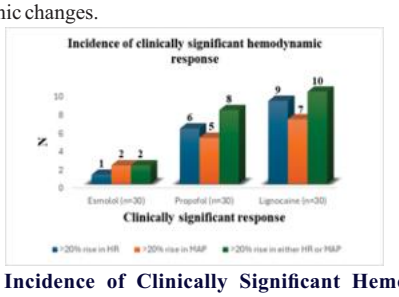

Figure 1: Incidence of Clinically Significant Hemodynamic Response

Figure 1, Clinically significant hemodynamic response was least common in the Esmolol group. A >20% rise in heart rate was seen in only 1 patient (3.3%) in the Esmolol group, compared with 6 patients (20.0%) in the Propofol group and 9 patients (30.0%) in the Lignocaine group, which was statistically significant (p=0.01). A >20% rise in MAP was also lower with Esmolol 2 (6.7%), compared with Propofol 5 (16.7%) and Lignocaine 7 (23.3%), though this was not statistically significant (p=0.11). Overall, a >20% rise in either HR or MAP occurred in 2 patients (6.7%) with Esmolol, 8 patients (26.7%) with Propofol, and 10 patients (33.3%) with Lignocaine (p=0.03), showing better hemodynamic stability with E.

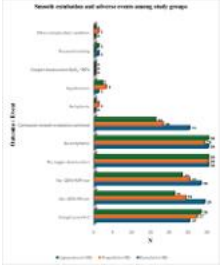

Figure 2: Smooth Extubation and Adverse Events Among Study Groups

In Figure 2, Smooth extubation was achieved most commonly in the Esmolol group. Although cough score 0–1 was highest in the Lignocaine group 28 (93.3%), followed by Propofol 27 (90.0%) and Esmolol 25 (83.3%), this difference was not statistically significant (p=0.36). Esmolol showed better hemodynamic stability, with no >20% HR rise in 29 (96.7%) patients compared with Propofol 24 (80.0%) and Lignocaine 21 (70.0%) (p=0.01). No >20% MAP rise was also highest with Esmolol 28 (93.3%), followed by Propofol 25 (83.3%) and Lignocaine 23 (76.7%) (p=0.18). No oxygen desaturation was seen in all groups 30 (100.0%), and no arrhythmia was seen in 30 (100.0%), 29 (96.7%), and 30 (100.0%) patients, respectively. Composite smooth extubation was significantly higher with Esmolol 25 (83.3%) than Propofol 18 (60.0%) and Lignocaine 16 (53.3%) (p=0.01). Adverse events were infrequent and comparable, including arrhythmia 0%, 3.3%, 0%, hypotension 3.3%, 10.0%, 6.7%, nausea/vomiting 3.3%, 0%, 3.3%, and sedation 0%, 3.3%, 0% in Esmolol, Propofol, and Lignocaine groups, respectively.

DISCUSSION

In the present study, all three groups were baseline comparable, with no significant difference in age, height, weight, BMI, sex distribution, ASA grade, baseline HR, SBP, DBP, MAP and SpO_2, as age was 41.0 ± 10.0, 43.0 ± 12.0 and 42.0 ± 11.0 years in esmolol, propofol and lignocaine groups respectively (p=0.71), while baseline HR was 78 ± 8, 79 ± 9 and 77 ± 8 bpm (p=0.63), SBP 121 ± 10, 123 ± 12 and 123 ± 11 mmHg (p=0.52), DBP 76 ± 7 in all groups (p=0.98), MAP 91 ± 7, 93 ± 9 and 92 ± 8 mmHg (p=0.57), and SpO_2 99 ± 1% in all groups (p=0.85). After extubation, esmolol produced the most stable response, with HR remaining 80 ± 9 at T0, 76 ± 7 at T1 and 75 ± 6 at T3 compared with higher values in propofol and lignocaine groups, with significant intergroup differences from T0 to T5 (p<0.001 to p=0.01), becoming non-significant at T10 (p=0.17). Similarly, SBP, DBP and MAP were lowest and most stable in the esmolol group, with SBP T1 118 ± 9 versus 135 ± 12 and 140 ± 14 mmHg, and MAP T1 89 ± 7 versus 104 ± 10 and 108 ± 11 mmHg (p<0.001). This pattern is similar to Mendonça et al. (2023).[5], who reported lower tachycardia with esmolol than placebo (2.2% vs 48.9%, p=0.002) and lower hypertension (4.4% vs 31.1%, p=0.004). Paudel et al. (2022).[10] also found significantly lower HR, SBP, DBP and MAP with esmolol than lignocaine after airway stimulation. Dolinaj et al. (2025).[11] supports the clinical relevance of controlling coughing and temporary hypertension during extubation, although it was a narrative review and not directly comparable to this three-drug randomized design. peak post-extubation rise was least with esmolol, where HR increased only from 78 ± 8 to 80 ± 9 bpm at T0, SBP decreased from 121 ± 10 to 120 ± 11 mmHg, DBP from 76 ± 7 to 74 ± 7 mmHg and MAP from 91 ± 7 to 90 ± 7 mmHg. In contrast, propofol showed higher peak HR rise from 79 ± 9 to 92 ± 11 bpm and lignocaine from 77 ± 8 to 95 ± 12 bpm, while peak MAP increased to 104 ± 10 and 108 ± 11 mmHg respectively. Clinically significant >20% HR rise was lowest with esmolol 1 (3.3%) compared with propofol 6 (20.0%) and lignocaine 9 (30.0%) (p=0.01), and >20% rise in either HR or MAP was also lower with esmolol 2 (6.7%) than propofol 8 (26.7%) and lignocaine 10 (33.3%) (p=0.03). Composite smooth extubation was highest with esmolol 25 (83.3%), followed by propofol 18 (60.0%) and lignocaine 16 (53.3%) (p=0.01), with no desaturation in any group. This agrees with Mendonça et al. (2023).[5], where esmolol reduced tachycardia (2.2% vs 48.9%, p=0.002), hypertension (4.4% vs 31.1%, p=0.004), bucking (8.9% vs 44.5%, p=0.002) and improved extubation quality (p<0.001). Paudel et al. (2022).[10] similarly found esmolol superior to lignocaine for HR, SBP, DBP and MAP control after airway stimulation. Dolinaj et al. (2025).[11] supports the clinical importance of preventing temporary hypertension and coughing during extubation, although it did not compare these three drugs directly.

CONCLUSION

The present prospective randomized comparative study showed that esmolol 1.5 mg/kg administered 2 minutes before extubation provided the most effective attenuation of hemodynamic response when sugammadex was used for reversal in elective surgeries. Baseline demographic and hemodynamic variables were comparable among esmolol, propofol and lignocaine groups, ensuring valid intergroup comparison. Esmolol maintained heart rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure closest to baseline, with the lowest peak post-extubation rise and significantly fewer patients developing >20% rise in HR or combined HR/MAP response. Composite smooth extubation was also highest with esmolol, without oxygen desaturation or major adverse events. Propofol showed intermediate efficacy, while lignocaine was least effective for hemodynamic stability.

Conflict of Interest: *None.*
Funding: *None.*
Ethical Approval: *Obtained.*
Consent: *Written consent secured.*

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