IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 8 Ser.2 (August 2025), PP 81-86
www.iosrjournals.org

A Comparative Study to Evaluate the Effects of Nitroglycerin and Esmolol on Haemodynamic Parameters in Controlled Hypertensive Patients During Emergence From Anaesthesia and Extubation

Dr.Muthyapwar Shiva[1], Dr.Ruchira sarkar[2], Dr Manu Tripathi[3], Dr.Romitha Goyal[4]

[1]*Junior resident in Anesthesiology, kmmch mathura*
[2]*Assistant professor in Anesthesiology , kmmch , mathura*
[3]*Junior resident in Anesthesiology, kmmch, mathura*
[4]*Junior resident in Anesthesiology, kmmch, mathura*
Corresponding author - Dr.Muthyapwar Shiva , junior resident in Anesthesiology, kmmch mathura

ABSTRACT
Background: *Emergence from anaesthesia and extubation are associated with significant haemodynamic fluctuations, which may be detrimental in hypertensive patients. Esmolol, a short-acting β_1-blocker, and Nitroglycerin, a vasodilator, are commonly used to attenuate these responses, but their comparative efficacy in controlled hypertensive patients remains unclear.*
Aim: *To compare the effects of Esmolol and Nitroglycerin on haemodynamic parameters during emergence and extubation in controlled hypertensive patients undergoing elective surgery under general anaesthesia.*
Methods: *This prospective, randomized, controlled clinical trial included 60 ASA I–II patients aged 20–60 years with controlled hypertension. Patients were allocated into two equal groups: Group E received Esmolol infusion (100 µg/kg/min) and Group N received Nitroglycerin infusion (0.5 µg/kg/min) during emergence and up to three minutes post-extubation. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and rate pressure product (RPP) were recorded at predefined time points. Data were analyzed using the unpaired Student's t-test and Chi-square test, with $p < 0.05$ considered significant.*
Results: *Demographic and baseline parameters were comparable between groups ($p > 0.05$). Esmolol significantly attenuated increases in HR, SBP, DBP, MAP, and RPP at all peri-extubation time points compared to Nitroglycerin ($p < 0.05$). Nitroglycerin was associated with reflex tachycardia and greater BP variability, with three cases (10%) of mild hypotension. No bradycardia occurred in either group.*
Conclusion: *Esmolol provides superior haemodynamic stability compared to Nitroglycerin during emergence and extubation in controlled hypertensive patients, effectively controlling HR and BP without significant adverse effects. Its rapid onset and short duration make it an ideal agent for peri-extubation haemodynamic management in this patient population.*
Keywords: *Esmolol, Nitroglycerin, Hypertension, Extubation, Haemodynamic stability, Rate pressure product*

I. INTRODUCTION

Emergence from general anaesthesia and tracheal extubation are critical phases in the perioperative period, often accompanied by significant haemodynamic responses such as tachycardia and hypertension. These changes result from a complex interplay of airway stimulation, sympathetic nervous system activation, and circulating catecholamine release, which may lead to increased myocardial oxygen demand and potential cardiovascular complications, particularly in susceptible individuals such as those with hypertension[1,2].

In patients with controlled hypertension, even transient surges in heart rate (HR) and blood pressure (BP) during extubation can precipitate myocardial ischaemia, arrhythmias, or cerebrovascular events[3]. Therefore, attenuation of these responses is a key anaesthetic goal to ensure haemodynamic stability and prevent adverse events. Several pharmacological strategies, including the use of opioids, calcium channel blockers, α_2-agonists, vasodilators, and β-adrenergic blockers, have been evaluated for this purpose[4,5].

Esmolol, an ultra-short-acting, cardioselective β_1-adrenergic blocker, has been shown to effectively blunt sympathetic responses by reducing HR and myocardial contractility, thereby lowering myocardial oxygen consumption[6]. Its rapid onset (within 1–2 minutes) and short elimination half-life (approximately 9 minutes) allow precise titration and minimal residual effects in the postoperative period[7]. Conversely, nitroglycerin, a potent vasodilator with predominant venodilation and modest arterial dilation, decreases preload and afterload,

thereby reducing myocardial oxygen demand[8]. However, its use may be associated with reflex tachycardia due to baroreceptor-mediated sympathetic activation, potentially counteracting its haemodynamic benefits[9].

Comparative data on the efficacy of Esmolol versus Nitroglycerin in controlling haemodynamic responses during emergence and extubation in controlled hypertensive patients remain limited. Understanding their relative effects on HR, BP, and myocardial workload (as measured by rate pressure product, RPP) is essential to guide optimal peri-extubation management in this high-risk group[10].

The present prospective, randomized, controlled clinical trial was designed to compare the effects of Esmolol and Nitroglycerin on haemodynamic parameters in controlled hypertensive patients during emergence from anaesthesia and extubation. The primary objective was to evaluate HR control, while secondary objectives included assessing blood pressure stability, RPP changes, and incidence of adverse events.

II. MATERIAL AND METHODS

Study Design and Setting

This prospective, randomized, controlled clinical trial was conducted in the Department of Anaesthesiology at Krishna Mohan Medical College and Hospital, Mathura, over 12 months from April 2023 to March 2024. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants before enrollment.

Study Population

A total of 60 patients, aged between 20 and 60 years, belonging to the American Society of Anesthesiologists (ASA) physical status I or II, with a documented history of **controlled hypertension** and scheduled for elective surgical procedures under general anaesthesia, were included in the study.

Inclusion Criteria

- Age 20–60 years
- ASA physical status I–II
- Controlled hypertensive patients on regular antihypertensive therapy
- Scheduled for elective surgery under general anaesthesia

Exclusion Criteria

- Uncontrolled hypertension
- History of ischemic heart disease, arrhythmias, heart block, or heart failure
- Chronic obstructive pulmonary disease (COPD) or bronchial asthma
- Known hypersensitivity to Esmolol or Nitroglycerin
- Pregnant or lactating women
- Patients requiring postoperative ventilation or having anticipated difficult airway

Sample Size and Randomization

Sixty patients fulfilling the eligibility criteria were enrolled and randomly allocated into two equal groups (n = 30 each) using a computer-generated randomization table. Group allocation was concealed in sealed opaque envelopes, which were opened just before drug administration.

- **Group E (Esmolol group)** – Received Esmolol infusion at 100 µg/kg/min during emergence and extubation.
- **Group N (Nitroglycerin group)** – Received Nitroglycerin infusion at 0.5 µg/kg/min during emergence and extubation.

Anaesthetic Technique

All patients fasted overnight and received oral antihypertensive medication on the morning of surgery with a sip of water. In the operating room, standard ASA monitoring was initiated, including electrocardiography (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2). An intravenous (IV) line was secured, and baseline hemodynamic parameters—heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and rate pressure product (RPP)—were recorded.

Anaesthesia was induced with intravenous fentanyl (2 µg/kg) and propofol (2 mg/kg) followed by vecuronium (0.1 mg/kg) to facilitate tracheal intubation. Anaesthesia was maintained with isoflurane in a mixture of oxygen and nitrous oxide (50:50) and intermittent boluses of vecuronium.

Study Intervention

At the end of surgery, the study drug infusion (Esmolol or Nitroglycerin) was initiated when the surgeon began skin closure and continued until three minutes after extubation. Neuromuscular blockade was reversed with

neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg) administered intravenously. Extubation was performed once the patient was awake, following standard extubation criteria.

Data Collection

Hemodynamic parameters—HR, SBP, DBP, MAP, and RPP—were recorded at the following time points:

1. **Baseline** (pre-induction)
2. **Pre-reversal** (before administration of reversal agents)
3. **Post-reversal** (after administration of reversal agents but before extubation)
4. **At extubation**
5. **1 minute post-extubation**
6. **3 minutes post-extubation**

Outcome Measures

- **Primary outcome:** Control of heart rate during emergence and extubation.
- **Secondary outcomes:** Stability of blood pressure (SBP, DBP, MAP), changes in RPP, and incidence of adverse events (bradycardia, hypotension).

Statistical Analysis

Data were compiled and analyzed using **SPSS version 26.0** (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using the unpaired Student's t-test. Categorical variables were expressed as percentages and analyzed using the Chi-square test or Fisher's exact test, as appropriate. A **p-value < 0.05** was considered statistically significant.

III. RESULTS AND OBSERVATIONS

Demographic and Baseline Characteristics

The two groups were comparable concerning age, gender distribution, weight, ASA physical status, and duration of surgery, with no statistically significant differences ($p > 0.05$) (Table 1).

Table 1. Demographic and Baseline Characteristics of Patients

Parameter	Group E (n = 30)	Group N (n = 30)	p-value
Age (years, mean ± SD)	46.1 ± 8.2	45.3 ± 7.9	0.72
Gender (M/F)	18 / 12	17 / 13	0.79
Weight (kg, mean ± SD)	68.4 ± 9.1	67.9 ± 8.8	0.84
ASA Physical Status I / II	12 / 18	11 / 19	0.79
Duration of surgery (min ± SD)	92.3 ± 14.8	90.6 ± 15.2	0.63

Heart Rate Trends

Heart rate was significantly lower in the Esmolol group at all peri-extubation time points compared to the Nitroglycerin group, with near-baseline values maintained without bradycardia. Nitroglycerin caused reflex tachycardia, especially at extubation and in the immediate post-extubation period (Table 2).

Table 2. Comparison of Heart Rate (beats/min) at Different Time Points

Time Point	Group E (mean ± SD)	Group N (mean ± SD)	p-value
Baseline	78.2 ± 6.5	77.9 ± 6.3	0.85
Pre-reversal	80.1 ± 6.7	84.5 ± 6.8	0.01*
Post-reversal	82.3 ± 6.4	88.7 ± 7.1	0.001*
At extubation	85.6 ± 6.9	96.8 ± 7.4	<0.001*
1 min post-extubation	83.2 ± 6.2	94.1 ± 7.0	<0.001*
3 min post-extubation	80.4 ± 6.0	90.5 ± 6.6	<0.001*

Blood Pressure Parameters

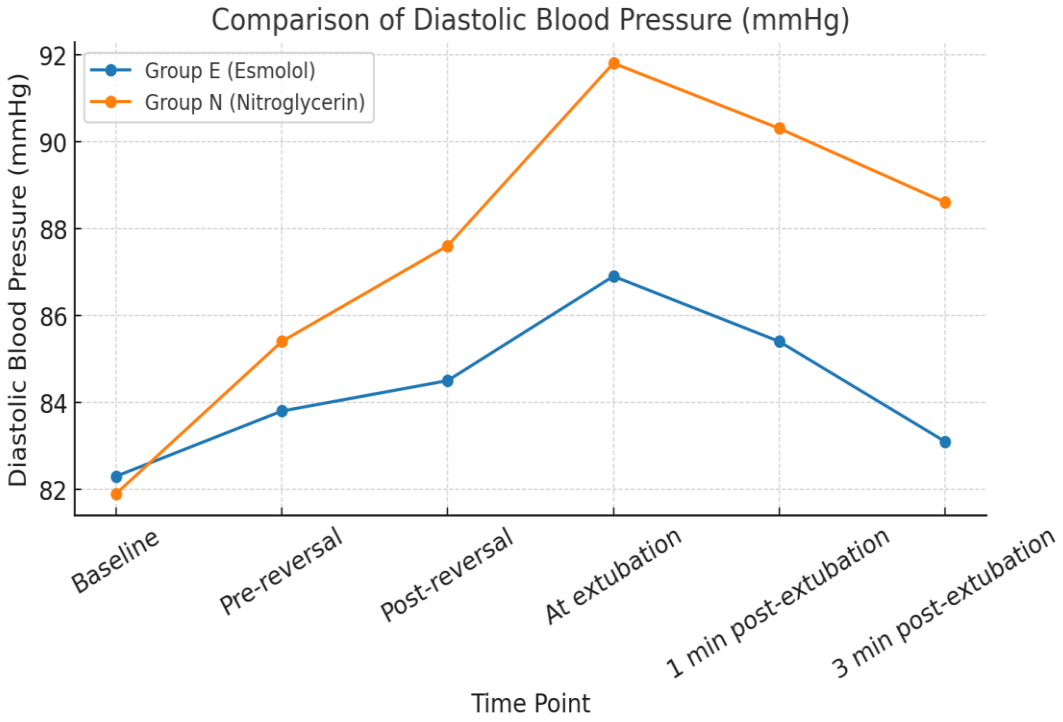
Both groups showed an increase in blood pressure during extubation; however, Esmolol maintained more stable SBP, DBP, and MAP with fewer fluctuations compared to Nitroglycerin, which caused greater variability and occasional hypotension (Tables 3 & 4).

Table 3. Comparison of Systolic Blood Pressure (mmHg)

Time Point	Group E (mean ± SD)	Group N (mean ± SD)	p-value
Baseline	128.4 ± 8.2	127.9 ± 8.4	0.81
Pre-reversal	130.2 ± 8.5	132.5 ± 8.7	0.28
Post-reversal	132.1 ± 8.8	135.8 ± 8.9	0.08
At extubation	136.5 ± 8.6	142.8 ± 9.1	0.003*
1 min post-extubation	134.2 ± 8.4	140.6 ± 8.7	0.002*
3 min post-extubation	130.8 ± 8.1	137.2 ± 8.5	0.001*

Table 4. Comparison of Diastolic Blood Pressure (mmHg)

Time Point	Group E (mean ± SD)	Group N (mean ± SD)	p-value
Baseline	82.3 ± 6.2	81.9 ± 6.4	0.79
Pre-reversal	83.8 ± 6.5	85.4 ± 6.6	0.28
Post-reversal	84.5 ± 6.3	87.6 ± 6.5	0.05
At extubation	86.9 ± 6.4	91.8 ± 6.7	0.002*
1 min post-extubation	85.4 ± 6.2	90.3 ± 6.5	0.002*
3 min post-extubation	83.1 ± 6.0	88.6 ± 6.4	<0.001*



Rate Pressure Product (RPP)

Esmolol consistently showed significantly lower RPP values compared to Nitroglycerin, indicating reduced myocardial oxygen demand and better cardiac workload control (Table 5).

Table 5. Comparison of Rate Pressure Product (RPP)

Time Point	Group E (mean ± SD)	Group N (mean ± SD)	p-value
Baseline	10,030 ± 920	9,940 ± 910	0.72
Pre-reversal	10,416 ± 940	11,187 ± 950	0.004*
Post-reversal	10,872 ± 960	12,025 ± 980	<0.001*
At extubation	11,661 ± 980	13,796 ± 1,010	<0.001*
1 min post-extubation	11,168 ± 950	13,224 ± 990	<0.001*
3 min post-extubation	10,490 ± 930	12,393 ± 960	<0.001*

Table 6. Comparison of Mean Arterial Pressure (MAP) (mmHg)

Time Point	Group E (mean ± SD)	Group N (mean ± SD)	p-value
Baseline	97.7 ± 6.0	97.2 ± 6.1	0.78
Pre-reversal	99.3 ± 6.2	101.1 ± 6.3	0.21
Post-reversal	100.4 ± 6.4	103.7 ± 6.5	0.03*
At extubation	103.4 ± 6.6	108.8 ± 6.8	0.001*
1 min post-extubation	101.7 ± 6.3	107.0 ± 6.6	0.001*
3 min post-extubation	99.0 ± 6.2	104.8 ± 6.4	<0.001*

Table 7. Incidence of Adverse Events

Adverse Event	Group E (n = 30)	Group N (n = 30)	p-value
Bradycardia (<50 bpm)	0	0	—
Hypotension (SBP <90)	0	3 (10%)	0.07
Nausea/Vomiting	2 (6.7%)	3 (10%)	0.64
Headache	1 (3.3%)	2 (6.7%)	0.55
Any adverse event	3 (10%)	6 (20%)	0.28

Table 8. Intra-group Comparison of Heart Rate Changes from Baseline

Time Point	Group E: ΔHR (bpm) ± SD	p-value vs baseline	Group N: ΔHR (bpm) ± SD	p-value vs baseline
Pre-reversal	+1.9 ± 1.0	0.04*	+6.6 ± 1.4	<0.001*
Post-reversal	+4.1 ± 1.2	<0.001*	+10.8 ± 1.6	<0.001*
At extubation	+7.4 ± 1.5	<0.001*	+18.9 ± 1.8	<0.001*
1 min post-extubation	+5.0 ± 1.3	<0.001*	+16.2 ± 1.7	<0.001*
3 min post-extubation	+2.2 ± 1.1	0.03*	+12.6 ± 1.5	<0.001*

IV. DISCUSSION

The present study compared the effects of Esmolol and Nitroglycerin on haemodynamic parameters during emergence from anaesthesia and extubation in controlled hypertensive patients. The findings demonstrate that Esmolol was more effective than Nitroglycerin in attenuating the rise in heart rate, systolic and diastolic blood pressure, mean arterial pressure, and rate-pressure product, thereby providing superior haemodynamic stability in the peri-extubation period.

Extubation is associated with increased sympathetic activity, resulting in tachycardia, hypertension, and increased myocardial oxygen demand[1,2]. These effects are particularly significant in hypertensive patients, where the risk of myocardial ischaemia or cerebrovascular events is elevated[3]. In our study, Esmolol maintained HR close to baseline at all measured time points, whereas Nitroglycerin produced significantly higher HR values, particularly at extubation and during the immediate post-extubation period. This reflex tachycardia observed with Nitroglycerin is consistent with previous findings attributing it to baroreceptor-mediated sympathetic activation secondary to vasodilation[4,5].

The efficacy of Esmolol in controlling HR and BP during airway manipulation has been reported in multiple studies. Helfman et al. demonstrated that Esmolol at 100 μg/kg/min effectively attenuates the haemodynamic response to laryngoscopy and intubation without significant bradycardia or hypotension[6]. Similarly, Kumar et al. reported that Esmolol provided better HR control compared to dexmedetomidine during extubation[7]. Our results align with these observations, indicating that Esmolol is also superior to Nitroglycerin in the emergence phase in hypertensive patients.

With regard to blood pressure control, both agents reduced the magnitude of BP surges compared to baseline, but Esmolol maintained more consistent values and prevented large fluctuations. Nitroglycerin, while effective in lowering afterload, was associated with occasional hypotension and greater variability in SBP, DBP, and MAP. This is in agreement with Abrams' review of nitroglycerin's haemodynamic effects, which highlighted its potential to cause abrupt BP drops and reflex tachycardia[8].

The rate pressure product (RPP), an indirect measure of myocardial oxygen consumption[9], was significantly lower in the Esmolol group at all time points post-reversal, at extubation, and post-extubation. Lower RPP values indicate reduced cardiac workload and oxygen demand, which is especially important in hypertensive patients with possible underlying subclinical coronary artery disease. Our findings are consistent with those of Dhasmana et al., who also reported that Esmolol significantly reduced RPP compared to vasodilators during airway instrumentation[10].

Adverse events were minimal in both groups, with no incidence of bradycardia in the Esmolol group and only three cases of mild hypotension in the Nitroglycerin group, which resolved spontaneously. The absence of severe complications suggests that both agents are safe when used within the studied dosage range. However, Esmolol offers the added advantage of predictable control without reflex sympathetic activation.

Overall, the results of this study support the preferential use of Esmolol over Nitroglycerin for haemodynamic stability during emergence and extubation in controlled hypertensive patients. The ultra-short-acting β-blocker profile of Esmolol, combined with its lack of reflex tachycardia, makes it an ideal agent for such high-risk scenarios. Future studies with larger sample sizes and inclusion of high-risk cardiac patients could further validate these findings and help refine peri-extubation haemodynamic management protocols.

V. CONCLUSION

In controlled hypertensive patients undergoing elective surgery, Esmolol infusion at 100 μg/kg/min during emergence from anaesthesia and extubation provided superior haemodynamic stability compared to Nitroglycerin infusion at 0.5 μg/kg/min. Esmolol effectively attenuated the rise in heart rate, systolic and diastolic blood pressure, mean arterial pressure, and rate-pressure product without causing bradycardia or significant hypotension. Nitroglycerin, while reducing afterload, was associated with reflex tachycardia and greater variability in blood pressure. Given its predictable profile, rapid onset, and ultra-short duration of action, Esmolol appears to be the preferred agent for peri-extubation haemodynamic control in hypertensive patients.

REFERENCES

[1]. Kovac AL. Controlling the haemodynamic response to laryngoscopy and endotracheal intubation. *J Clin Anesth*. 1996;8(1):63-79.
[2]. Derbyshire DR, Chmielewski A, Fell D, Vater M, Achola K, Smith G. Plasma catecholamine responses to tracheal intubation. *Br J Anaesth*. 1983;55(9):855-860.
[3]. Fox EJ, Sklar GS, Hill CH, Villanueva R, King BD. Complications related to the pressor response to endotracheal intubation. *Anesthesiology*. 1977;47(6):524-525.
[4]. Chatterjee K, Parmley WW, Ganz W, et al. Hemodynamic and metabolic responses to vasodilator therapy in acute myocardial infarction. *Circulation*. 1973;48(6):1183-1193.
[5]. Gibbons RJ, Abrams J, Chatterjee K, et al. ACC/AHA 2002 guideline update for the management of patients with chronic stable angina. *Circulation*. 2003;107(1):149-158.
[6]. Helfman SM, Gold MI, DeLisser EA, Herrington CA. Which drug prevents tachycardia and hypertension after laryngoscopy and tracheal intubation: lidocaine, fentanyl, or esmolol? *Anesth Analg*. 1991;72(4):482-486.
[7]. Kumar A, Sinha C, Kumar A, Kumari P. Comparative study of esmolol and dexmedetomidine for attenuation of extubation response. *J Clin Diagn Res*. 2017;11(9):UC01-UC05.
[8]. Abrams J. Hemodynamic effects of nitroglycerin and long-acting nitrates. *Am Heart J*. 1985;110(1 Pt 2):216-224.
[9]. Gobel FL, Norstrom LA, Nelson RR, Jorgensen CR, Wang Y. The rate-pressure product as an index of myocardial oxygen consumption during exercise in patients with angina pectoris. *Circulation*. 1978;57(3):549-556.
[10]. Dhasmana S, Singh A, Sharma P, Srivastava D. Comparative study of esmolol and nitroglycerin on cardiovascular response during laryngoscopy and intubation. *Int J Res Med Sci*. 2017;5(9):3856-3861.