European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: Applied Website:
https://farmclin.com/

A Comparative Study of Intravenous Magnesium Sulphate and Intravenous Esmolol for Attenuation of Hemodynamic Stress Response During Tracheal Extubation in Patients Undergoing Surgery Under General Anaesthesia

Dr. Dushyant Tomar[1]*, Dr. (Major) Abhishek Tiwari[2], Dr. Abhishek Srivastava[3]

[1*]Junior Resident, Department of Anaesthesiology, Faculty of Medicine & Health Sciences, Integral University, Lucknow, India.
[2]Professor, Department of Anaesthesiology, Faculty of Medicine & Health Sciences, Integral University, Lucknow, India.
[3]Associate Professor, Department of Anaesthesiology, Faculty of Medicine & Health Sciences, Integral University, Lucknow, India.

Corresponding Author: Dr. Dushyant Tomar
Email ID: dushyanttomar8@gmail.com

ABSTRACT

Background: Removal of the endotracheal tube is commonly linked to a sympathetic stress reaction manifested by increased heart rate, elevated blood pressure, coughing, and restlessness. These hemodynamic fluctuations may be detrimental, particularly in patients with limited cardiovascular reserve. Different pharmacological interventions have been explored to mitigate this physiological response. Among them, magnesium sulphate, owing to its calcium antagonistic and sympatholytic properties, and esmolol, a short-acting selective β1-adrenergic blocker, have shown promising results. However, comparative data regarding their efficacy during extubation remain limited.

Objectives: To compare the effectiveness of intravenous magnesium sulphate and intravenous esmolol in attenuating hemodynamic stress response during tracheal extubation in patients undergoing surgeries under general anaesthesia.

Materialsand Methods: This prospective, randomized controlled study was conducted in the Department of Anaesthesiology, Integral Institute of Medical Sciences and Research, Lucknow. “A total of 100 adult patients aged 18–65 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective surgeries under general anaesthesia were enrolled”. Group A was given 50 mg/kg magnesium sulphate intravenously, mixed with 100 mL normal saline and infused for 10 minutes before extubation. In contrast, Group B received intravenous esmolol at 0.6 mg/kg diluted similarly and administered over 10 minutes preceding extubation. Heart rate together with systolic, diastolic, and mean arterial pressures were documented at baseline (five minutes pre-extubation), at the moment of tube removal, and at intervals of 5, 10, and 15 minutes thereafter. "Pain and discomfort were assessed using the Visual Analogue Scale (VAS). Statistical analysis was performed using paired and unpaired Student’s t-tests, with a p-value <0.05 considered statistically significant".

Results: No significant differences were observed in age or gender distribution between the two groups. Magnesium sulphate was more effective in attenuating increases in systolic blood pressure, diastolic blood pressure, and mean arterial pressure at the time of extubation compared to esmolol. Esmolol demonstrated superior control of heart rate throughout the post-extubation period. Patients in the magnesium sulphate group had a consistent reduction in VAS scores at all recorded time points, indicating smoother extubation and better patient comfort. No significant adverse effects were observed in either group.

Conclusion: Administration of magnesium sulphate or esmolol intravenously can successfully moderate the hemodynamic disturbances associated with extubation. Magnesium sulphate provides better control of blood pressure and improves extubation quality, whereas esmolol is more effective in controlling heart rate. Magnesium sulphate may be considered a safer and more comprehensive agent for achieving smooth extubation in patients undergoing surgery under general anaesthesia.

KEYWORDS: Tracheal extubation; Hemodynamic response; Magnesium sulphate; Esmolol; General anaesthesia; Stress response.

How to Cite: Dr. Dushyant Tomar, Dr. (Major) Abhishek Tiwari, Dr. Abhishek Srivastava, (2026) A Comparative Study of Intravenous Magnesium Sulphate and Intravenous Esmolol for Attenuation of Hemodynamic Stress Response During Tracheal Extubation in Patients Undergoing Surgery Under General Anaesthesia, European Journal of Clinical Pharmacy, Vol.8, No.1, pp. 1293-1302

INTRODUCTION

Airway manipulation during general anaesthesia is well recognized as a potent stimulus for sympathetic nervous system activation. While the pressor response to laryngoscopy and endotracheal intubation has been extensively studied, the hemodynamic response during tracheal extubation has received comparatively less attention, despite being equally or sometimes more intense. Extubation is often associated with abrupt increases in heart rate, blood pressure, coughing, breath holding, agitation, and laryngospasm, all of which result from stimulation of the upper airway and emergence from anaesthesia [1,2].

The physiological stress response during extubation is primarily mediated through catecholamine release, leading to tachycardia and hypertension. This response may be transient in healthy individuals but can have serious consequences in susceptible patients, such as those with coronary artery disease, systemic hypertension, cerebrovascular disease, or raised intracranial pressure [3–5]. Sudden spikes in arterial pressure and heart rate at the time of extubation may trigger myocardial ischemia, cardiac rhythm disturbances, heart failure, intracranial hemorrhage, or disruption of surgical repairs, particularly following neurosurgical, ophthalmic, and head and neck procedures [6–8].

Extubation is also accompanied by airway reflexes such as coughing and straining, which further increase intrathoracic, intraocular, and intracranial pressures. These changes may compromise surgical outcomes, increase postoperative pain, and delay recovery [9,10]. Therefore, achieving a smooth and hemodynamically stable extubation is an important goal of modern anaesthetic practice.

Different pharmacological interventions have been examined to lessen the stress reaction occurring during extubation. These include opioids, lignocaine, calcium channel blockers, α2-agonists such as dexmedetomidine, β-adrenergic blockers, and magnesium sulphate [11–14]. Each of these drugs acts through different mechanisms and has variable efficacy and side effect profiles. No single agent has been universally accepted as ideal, and the choice often depends on patient characteristics, type of surgery, and anesthesiologist preference [15].

Characterized by rapid onset and short duration, esmolol selectively inhibits β1-adrenergic receptors, has gained popularity for controlling peri-extubation tachycardia and hypertension. Its rapid onset, short duration of action, and minimal residual effects make it suitable for use during emergence from anaesthesia [16,17]. Esmolol attenuates sympathetic responses by reducing heart rate and myocardial contractility, thereby decreasing oxygen demand [18]. Several studies have demonstrated its efficacy in controlling heart rate during extubation; however, its effect on blood pressure control has been inconsistent, and hypotension or bradycardia may occur in some patients [19,20].

Magnesium sulphate is another agent that has been increasingly studied for attenuation of perioperative stress responses. By opposing calcium activity, magnesium inhibits the liberation of catecholamines from adrenergic nerve terminals and adrenal medullary tissue [21]. It also possesses vasodilatory, antiarrhythmic, and analgesic properties, making it an attractive option during emergence from anaesthesia [22,23]. Additionally, magnesium sulphate has been shown to reduce airway reflexes, coughing, and postoperative pain, contributing to smoother extubation [24].

“Previous studies have demonstrated that intravenous magnesium sulphate effectively attenuates increases in blood pressure and heart rate during laryngoscopy, intubation, and extubation” [25,26]. Unlike β-blockers, magnesium does not cause significant myocardial depression and is generally well tolerated when administered in appropriate doses [27]. However, concerns regarding delayed recovery, muscle weakness, and hypotension necessitate careful dosing and monitoring [28].

Although both magnesium sulphate and esmolol have been individually studied for attenuation of extubation response, comparative studies directly evaluating their relative efficacy during tracheal extubation are limited, particularly in the Indian population. Existing literature suggests that while esmolol is superior in heart rate control, magnesium sulphate may provide better attenuation of blood pressure and airway reflexes, leading to improved extubation quality [12,17,26].

In view of the clinical importance of maintaining hemodynamic stability during extubation and the need for an optimal pharmacological agent, the present study was designed to compare intravenous magnesium sulphate and intravenous esmolol inreducing the cardiovascular stress response. The study also aimed to evaluate extubation quality and patient comfort using objective hemodynamic parameters and subjective pain assessment.

MATERIALS AND METHODS

The study, designed as a prospective randomized controlled trial, was performed in the Anaesthesiology Department of Integral Institute of Medical Sciences and Research, India.The study spanned 24 months and commenced only after ethical authorization had been granted. Each subject gave documented informed consent before participation.

Study Population

The study included adult patients scheduled to undergo elective surgical procedures under general anaesthesia with planned tracheal extubation at the end of surgery.

Sample Size

A total of 100 patients were enrolled in the study, with 50 patients allocated to each group. Sample size was calculated based on a power of 80% and a confidence level of 95%, considering a standard deviation of 16 and an expected effect size of 9. The calculated sample size was 50 patients per group.

Randomization and Group Allocation
Patients were randomly allocated into two groups using the chit-pull method:
- Group A (Magnesium Sulphate Group): Received intravenous magnesium sulphate.
- Group B (Esmolol Group): Received intravenous esmolol.

Inclusion Criteria
1. Patients aged 18–65 years
2. American Society of Anesthesiologists (ASA) physical status I or II
3. Patients scheduled for elective surgery under general anaesthesia
4. Patients planned for tracheal extubation at the end of surgery
5. Mallampati classification Grade I or II
6. Patients who provided written informed consent

Exclusion Criteria
1. Patient refusal to participate
2. ASA physical status Grade III or higher
3. Patients requiring postoperative mechanical ventilation
4. Known hypersensitivity or allergy to magnesium sulphate or esmolol
5. Patients already receiving β-blocker therapy
6. Pregnant or lactating women
7. Patients with body mass index (BMI) >35 kg/m²
8. Emergency surgical procedures
9. Patients with significant cardiac conduction abnormalities, severe bradycardia, or heart block
10. Patients with renal insufficiency or neuromuscular disorders

Anaesthetic Technique
All patients were kept nil per oral as per standard fasting guidelines. “Upon arrival in the operating room, standard monitoring was instituted, including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography”. Baseline values for heart rate and arterial pressure were tested and documented.

General anaesthesia was induced using standard intravenous induction agents as per institutional protocol. Endotracheal intubation was performed after achieving adequate muscle relaxation. Anaesthesia was maintained using inhalational agents, oxygen, nitrous oxide, and intermittent doses of muscle relaxants as required. Ventilation was controlled to maintain normocapnia.

Intervention
Ten minutes prior to planned extubation, patients received the study drug according to group allocation:
- Group A: Intravenous magnesium sulphate 50 mg/kg, diluted in 100 mL of normal saline, administered as an infusion over 10 minutes.
- Group B: Intravenous esmolol 0.6 mg/kg, diluted in 100 mL of normal saline, administered as an infusion over 10 minutes.

After surgery ended, neuromuscular paralysis was reversed using conventional drugs, and tracheal extubation was undertaken when the patient met appropriate clinical criteria.

Data Collection
Hemodynamic parameters were recorded at the following time intervals:
- EB: 5 minutes before extubation (baseline)
- E0: At the time of extubation
- E5: 5 minutes after extubation
- E10: 10 minutes after extubation
- E15: 15 minutes after extubation

The following parameters were measured:
- Heart rate (HR)
- Systolic blood pressure (SBP)
- Diastolic blood pressure (DBP)
- Mean arterial pressure (MAP)

Pain and discomfort during emergence were assessed using the Visual Analogue Scale (VAS).

Statistical Analysis
Data were entered into Microsoft Excel and analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation. Comparisons between the two groups were performed using Student’s t-test. A p-value less than 0.05 was considered statistically significant. Graphs and tables were generated using Microsoft Excel and Microsoft Word.

RESULTS

The present study was conducted on a total of 100 patients undergoing elective surgical procedures under general anaesthesia, with 50 patients allocated to the Magnesium Sulphate group (Group A) and 50 patients to the Esmolol group (Group B). All enrolled patients completed the study, and data from all participants were included in the final analysis.

The demographic characteristics of patients in both groups were comparable. The majority of patients in Group A belonged to the 26–35 year age group (36%), while in Group B, 40% of patients were in the same age range. The mean age in Group A was 34.16 ± 9.23 years, compared to 30.84 ± 8.99 years in Group B. Gender distribution was also similar between the groups, with females constituting 74% in Group A and 66% in Group B. No statistically significant difference was observed in gender distribution between the two groups.

Baseline hemodynamic parameters recorded five minutes before extubation were comparable between the two groups. No meaningful statistical differences were observed in baseline systolic pressure, diastolic pressure, mean arterial pressure, or heart rate, confirming that the two groups were similar before the intervention.

At the time of extubation, significant differences in hemodynamic responses were observed between the two groups. The systolic blood pressure was significantly lower in the Magnesium Sulphate group compared to the Esmolol group, indicating better attenuation of the pressor response in Group A. These findings suggest that magnesium sulphate was more effective than esmolol in controlling blood pressure surges during extubation.

Heart rate responses differed notably between the two groups following extubation. Although baseline heart rates were similar, patients in the Esmolol group consistently exhibited lower heart rates at the time of extubation and during the post-extubation period at 5, 10, and 15 minutes. The differences in heart rate between the two groups at these time points were statistically significant, indicating superior heart rate control with esmolol compared to magnesium sulphate.

"During the post-extubation period, systolic, diastolic, and mean arterial pressures at 5, 10, and 15 minutes after extubation were comparable between the two groups, with no statistically significant differences at most time points". This indicates that both drugs were effective in restoring hemodynamic stability in the early recovery phase.

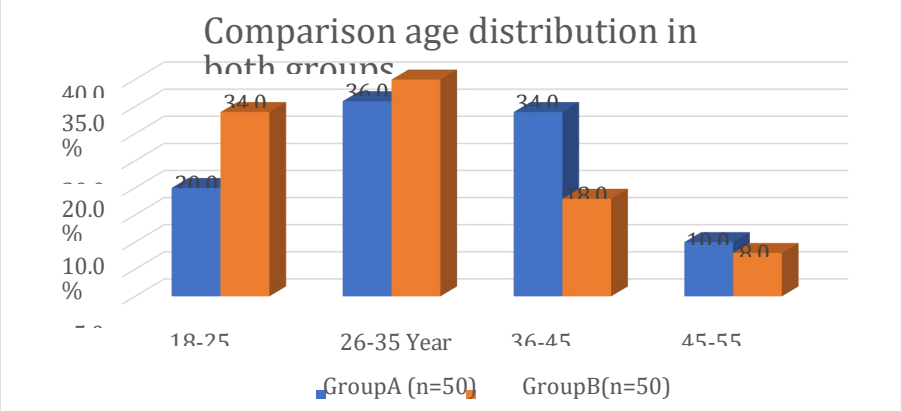
Assessment of extubation quality using the Visual Analogue Scale revealed significantly lower scores in the Magnesium Sulphate group at baseline and at all post-extubation intervals. Patients receiving magnesium sulphate experienced less discomfort and smoother emergence compared to those receiving esmolol. The difference in VAS scores between the two groups was statistically significant at all measured time points.

During the course of the study, no participants in either group developed serious side effects like profound hypotension, bradycardia, rhythm abnormalities, delayed recovery, or respiratory problems. Both magnesium sulphate and esmolol were well tolerated, and no patient required additional pharmacological intervention to manage hemodynamic instability.

Overall, the results of the present study demonstrate that intravenous magnesium sulphate provides superior control of blood pressure and improves extubation quality, while intravenous esmolol offers better control of heart rate under same circumstances.

Table1:Distribution of the studied patients based on age in both groups

Age group	GroupA(n=50)	GroupB(n=50)	Value#
18-25 Year	10 (20.0%)	17 (34.0%)	χ^2=4.493 p-value=0.213
26-35 Year	18 (36.0%)	20 (40.0%)	
36-45 Year	17 (34.0%)	9 (18.0%)	
45-55 Year	5 (10.0%)	4 (8.0%)	
MEAN±SD*	34.16±9.23	30.84±8.99	0.072



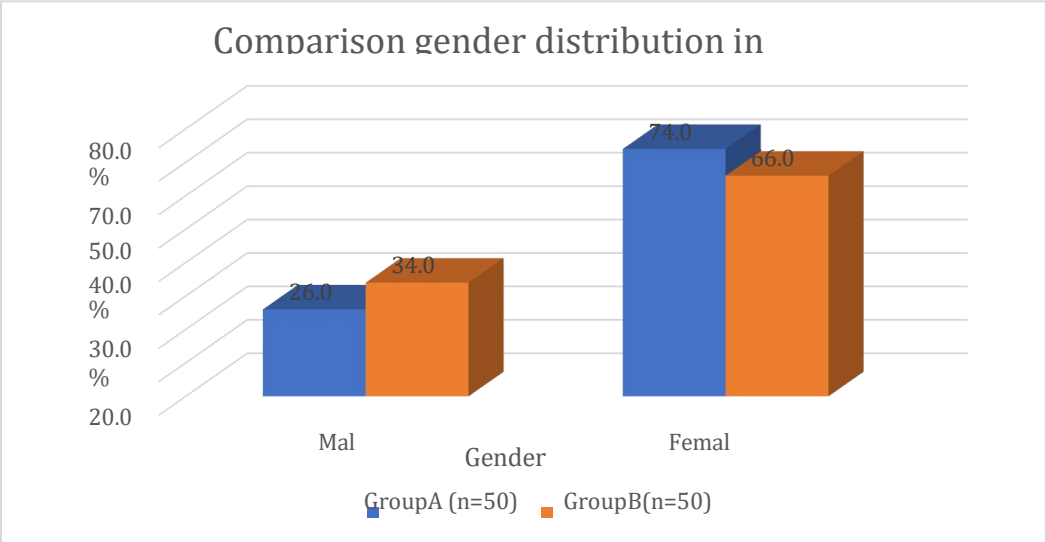
Graph1:Comparison age distribution in both groups

The patients In GroupA and GroupB were compared in terms of gender distribution.In Group A, 13 (26.0%) were male and 37 (74.0%) were female, while in Group B, 17 (34.0%) were male and 33(66.0%)werefemale.

Table2:Distribution of the studied patients based on gender both groups

Gender	GroupA(n=50)	GroupB(n=50)	Value#
Male	13 (26.0%)	17 (34.0%)	χ^2=0.762
Female	37 (74.0%)	33 (66.0%)	p-value=0.383

#Chi-Squaretest



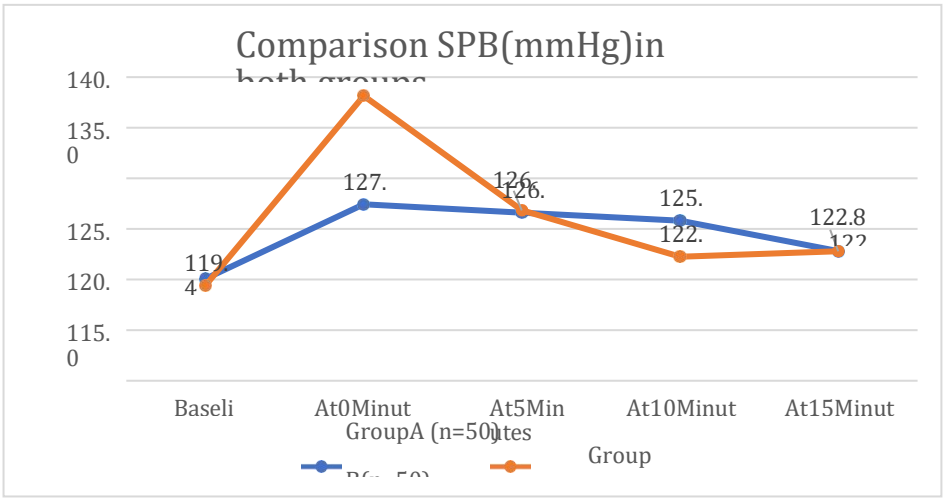
Graph2:Comparis on genderdistribution in both groups

At baseline, the SBP was similar between the two groups, with a mean of 120.08±8.8 mmHg in Group A and 119.42±8.3 mmHg in Group B. However, at 0 minutes, Group B had a significantly higher SBP (138.16±4.4 mmHg) compared to Group A (127.44±9.0 mmHg).At 5 minutes, the SBP was similar between the groups.At 10 minutes, GroupAhad a slightly higher SBP compared to Group B, while at 15 minutes, the SBP was almost identical between the two groups. The differences were statistically significant at 0 minutes and 10 minutes, with p-values <0.001 and 0.006, respectively.

Table3:Comparison of the studied patients based on systolic blood pressure in both groups

SBP(mmHg)	GroupA(n=50)	GroupB(n=50)	t-value	p-value
Baseline	120.08±8.8	119.42±8.3	0.384	0.702
At0Minutes	127.44±9.0	138.16±4.4	7.526	**<0.001**
At5Minutes	126.60±9.1	126.84±4.0	0.170	0.865
At10Minutes	125.82±7.3	122.28±4.8	2.824	**0.006**
At15Minutes	122.82±6.7	122.80±4.9	0.017	0.987

*Studentt-test;P<0.05=statisticallysignificant;P>0.05=statisticallynon-significant



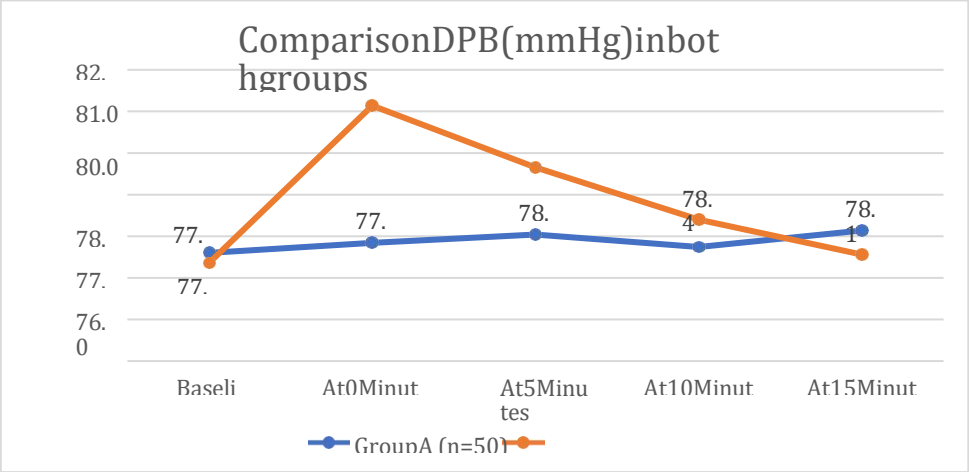
Graph3:ComparisonSPB(mmHg)inbothgroups

Thediastolicblood pressure(DBP)was compared between GroupAand GroupB at different timepoints.At baseline, theDBPwas similarbetween thetwo groups.At 0 minutes,GroupB adaslightlyhigherDBP(81.14±5.9mmHg)comparedtoGroupA(78.40±5.6mmHg),with astatisticallysignificantdifference(p=0.021).However,at5,10,and15minutes,theDBPwas comparable between the two groups, with no statistically significant differences, as indicated by p-values of 0.092, 0.503, and 0.508, respectively

Table4:Comparison of the studied patients based on diastolic blood pressure in bothgroups

DBP(mmHg)	GroupA(n=50)	GroupB(n=50)	t-value	p-value
Baseline	77.60±5.6	77.36±6.2	0.202	0.840
At0Minutes	78.40±5.6	81.14±5.9	2.351	**0.021**
At5Minutes	78.04±4.3	79.66±5.1	1.702	0.092
At10Minutes	77.74±5.1	78.40±4.6	0.672	0.503
At15Minutes	78.14±4.3	77.56±4.4	0.664	0.508

*Studentt-test



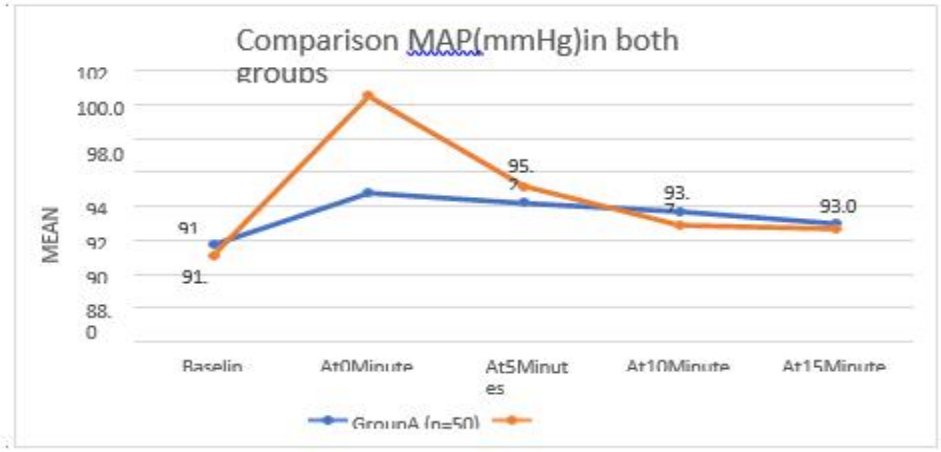
Graph4:Comparison DPB(mmHg)in both groups

The mean arterial pressure (MAP) was compared between GroupAand Group B at different timepoints.Atbaseline,theMAPwassimilarbetweenthetwogroups.At0minutes,GroupB had a significantly higher MAP(100.5±3.8 mmHg) compared to GroupA(94.8±5.8 mmHg), withahighlystatisticallysignificantdifference(p<0.001).However,at5,10,and15minutes, theMAPwascomparablebetweenthetwogroups,withnostatisticallysignificantdifferences, as indicated by p-values of 0.264, 0.411, and 0.676, respectively.

Table5:Comparison of the studied patients based on meanarterial pressure in both groups

MAP(mmHg)	GroupA(n=50)	GroupB(n=50)	t-value	p-value
Baseline	91.8±5.4	91.1±6.2	0.530	0.598
At0Minutes	94.8±5.8	100.5±3.8	5.815	**<0.001**
At5Minutes	94.2±4.6	95.2±4.4	1.123	0.264
At10Minutes	93.7±4.6	92.9±4.3	0.826	0.411
At15Minutes	93.0±4.0	92.7±3.9	0.419	0.676

*Student t-test



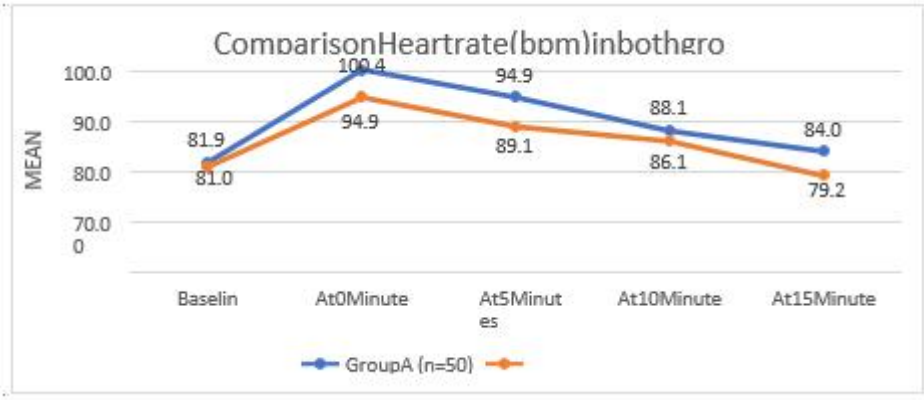
Graph5:Comparison MAP (mmHg)in both groups

The heart rates of the patients studied in both groups were compared. At baseline, the mean heart rates were similar in GroupA(81.94±7.1bpm)andGroupB(81.06±8.0bpm,p=0.564). However, at all subsequent time points (0, 5, 10, and 15 minutes), GroupAhad significantly higher heart rates compared to Group B, with p-values indicating statistical significance (<0.001 at 0, 5, and 15 minutes, and 0.035 at 10 minutes)

Table6:Comparison of the studied patients based on heartrate in bothgroups

Heartrate (bpm)	GroupA(n=50)	GroupB(n=50)	t-value	p-value
Baseline	81.94±7.1	81.06±8.0	0.578	0.564
At0Minutes	100.46±3.9	94.94±8.2	4.266	**<0.001**
At5Minutes	94.94±4.9	89.12±6.8	4.902	**<0.001**
At10Minutes	88.18±2.3	86.16±6.2	2.136	**0.035**
At15Minutes	84.08±6.1	79.24±3.9	4.687	**<0.001**

*Studentt-test



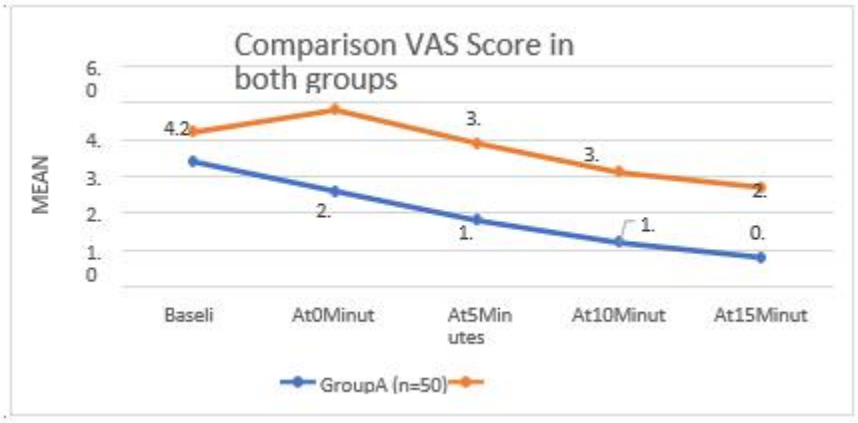
Graph6:Comparison Heartrate (bpm)in both groups

The VAS scores of the studied patients in both groups were compared.At baseline, GroupA had a mean VAS score of 3.4±1.6, which was significantly lower than Group B (4.2±1.8, p=0.020).At all subsequent time points (0, 5, 10, and 15 minutes), GroupAhad significantly lower VAS scores compared to Group B (p<0.001)

Table7:Comparison of the studied patients based onVAS Score in bothgroups

VASScore	GroupA(n=50)	GroupB(n=50)	t-value	p-value
Baseline	3.4±1.6	4.2±1.8	2.348	**0.020**
At0Minutes	2.6±1.5	4.8±1.6	7.093	**<0.001**
At5Minutes	1.8±1.7	3.9±1.5	6.549	**<0.001**
At10Minutes	1.2±1.2	3.1±1.4	7.286	**<0.001**
At15Minutes	0.8±1.1	2.7±1.2	8.253	**<0.001**

*Studentt-test



Graph7:Comparison VAS Score in bothgroups

DISCUSSION

Tracheal extubation is a critical phase of general anaesthesia and is frequently associated with marked sympathetic stimulation. Unlike laryngoscopy and intubation, which occur under deep anaesthesia, extubation takes place during emergence when airway reflexes return and cortical awareness increases. This results in tachycardia, hypertension, coughing, agitation, and increased airway reflex activity due to catecholamine release and activation of the sympathetic nervous system [1,2]. “Although

these responses are usually transient, they may have serious consequences in patients with limited cardiovascular or cerebrovascular reserve" [3,4].

Several studies have demonstrated that the magnitude of hemodynamic changes during extubation may be equal to or even greater than those observed during intubation [5,6]. Sudden increases in heart rate and blood pressure during extubation can precipitate myocardial ischemia, arrhythmias, left ventricular failure, intracranial hemorrhage, increased intraocular pressure, and disruption of surgical sutures, particularly in neurosurgical, ophthalmic, and head and neck surgeries [7–9]. Therefore, attenuation of the extubation response has become an important goal of balanced anaesthesia.

In the present study, demographic variables and baseline hemodynamic parameters were comparable between the magnesium sulphate group and the esmolol group, ensuring uniformity and allowing valid comparison of the pharmacological effects of both drugs. The differences observed during extubation and the post-extubation period can therefore be attributed to the distinct mechanisms of action of magnesium sulphate and esmolol.

Effect of Magnesium Sulphate on Blood Pressure

Compared with esmolol, intravenous magnesium sulphate demonstrated superior efficacy in moderating systolic, diastolic, and mean arterial blood pressures at extubation. As a physiological antagonist of calcium, magnesium sulphate reduces calcium movement into vascular smooth muscle cells, causing vasodilation and a decline in systemic vascular resistance[10]. Additionally, magnesium inhibits catecholamine release from the adrenal medulla and peripheral adrenergic nerve terminals, thereby reducing sympathetic tone [11,12].

These findings are in agreement with Elsharnouby and Elsharnouby, who demonstrated significant attenuation of blood pressure responses during airway manipulation with magnesium sulphate [13]. Reddy et al. also reported effective control of peri-extubation hypertension using magnesium sulphate [14]. Bansal et al. observed that magnesium sulphate provided better blood pressure stability during emergence and extubation compared to other agents [15].

Effect of Esmolol on Blood Pressure

Esmolol is an ultra–short-acting selective β1-adrenergic blocker that primarily reduces heart rate and myocardial contractility. Its effect on peripheral vascular resistance is limited, which may explain the comparatively higher blood pressure values observed in the esmolol group at the time of extubation [16]. Previous studies have also reported variable efficacy of esmolol in controlling blood pressure during extubation [17,18]. Gupta et al. found that while esmolol was effective in attenuating tachycardia, its effect on blood pressure was inconsistent [19]. These observations are consistent with the findings of the present study.

Effect on Heart Rate

Heart rate control during extubation is particularly important because tachycardia increases myocardial oxygen consumption and may precipitate ischemia in susceptible patients. In the present study, esmolol provided significantly better control of heart rate at the time of extubation and throughout the post-extubation period compared to magnesium sulphate. This is consistent with the pharmacological profile of esmolol as a rapid-onset, short-duration β1-selective blocker [16].

Several studies support the superiority of esmolol in controlling heart rate during extubation. Kaur et al. demonstrated significantly lower heart rates with esmolol compared to magnesium sulphate during emergence from anaesthesia [20]. Singh et al. also reported effective attenuation of extubation-induced tachycardia with esmolol [21]. Miller et al. emphasized the usefulness of esmolol in controlling perioperative tachycardia due to its short half-life and predictable pharmacokinetics [22].

Magnesium sulphate, although it exhibits sympatholytic properties and may reduce heart rate indirectly, does not provide the same degree of β-adrenergic blockade as esmolol [23]. This explains the relatively higher heart rates observed in the magnesium sulphate group during the post-extubation period.

Extubation Quality and Patient Comfort

An important observation in the present study was the significantly lower Visual Analogue Scale (VAS) scores in the magnesium sulphate group at all measured time points. Lower VAS scores indicate smoother extubation, reduced discomfort, and decreased airway irritation. Magnesium sulphate possesses analgesic properties mediated through antagonism of N-methyl-D-aspartate (NMDA) receptors and modulation of calcium channels involved in nociceptive transmission [24].

Tramer et al. reported that magnesium sulphate reduced postoperative pain and analgesic requirements, contributing to improved patient comfort [25]. Hassan et al. also demonstrated smoother recovery and improved hemodynamic stability during emergence with magnesium administration [26]. The findings of the present study are consistent with these reports and indicate that magnesium sulphate improves both hemodynamic stability and extubation quality.

Esmolol, although effective in controlling heart rate, lacks intrinsic analgesic or sedative properties. Consequently, it does not significantly suppress airway reflexes or reduce postoperative discomfort, which may explain the higher VAS scores observed in the esmolol group [19,21].

Safety and Tolerability

Both magnesium sulphate and esmolol were well tolerated in the present study, with no significant adverse events such as severe hypotension, bradycardia, delayed recovery, or respiratory depression. Previous studies have similarly reported favorable safety profiles for both drugs when used in appropriate doses and with adequate monitoring [27,28]. This supports their safe use during the peri-extubation period.

Comparison with Existing Literature and Clinical Implications

The findings of the present study are consistent with existing literature suggesting that no single pharmacological agent is ideal for attenuating all components of the extubation response. Magnesium sulphate provides superior control of blood pressure and improves extubation quality, whereas esmolol offers better control of heart rate. Patel et al. and Sharma et al. emphasized the importance of individualized drug selection based on patient comorbidities and surgical requirements [29]. Recent studies have also demonstrated comparable findings, supporting the complementary roles of magnesium sulphate and esmolol in extubation management [30].

In a study Mehta et al. (2025) conducted a randomized controlled trial comparing intravenous magnesium sulphate and esmolol for attenuation of hemodynamic responses during tracheal extubation in adult patients undergoing general anaesthesia. The authors reported that magnesium sulphate provided superior control of systolic and mean arterial pressure and resulted in smoother extubation with reduced coughing and discomfort, while esmolol was more effective in controlling heart rate. These findings closely parallel the results of the present study, where magnesium sulphate showed better blood pressure control and improved extubation quality, whereas esmolol demonstrated superior heart rate attenuation [31].

A study by Sharma et al. (2025) evaluated the efficacy of intravenous magnesium sulphate in attenuating peri-extubation stress responses in patients undergoing elective surgeries. The study demonstrated significant reductions in systolic blood pressure, diastolic blood pressure, and coughing during extubation in the magnesium group compared to controls. The authors concluded that magnesium sulphate improves hemodynamic stability and patient comfort during emergence from anaesthesia. These observations support the present study's findings regarding improved extubation quality and better blood pressure control with magnesium sulphate [32].

A study by Kumar et al. (2025) performed a comparative study assessing beta-blockers and magnesium sulphate for controlling extubation-induced hemodynamic fluctuations. The authors found that esmolol was superior in limiting tachycardia, whereas magnesium sulphate provided better control of blood pressure and reduced airway reflexes. The study emphasized that no single agent is ideal for all components of the extubation response and recommended individualized drug selection. This conclusion is consistent with the findings of the present study [33].

Standard anaesthesia textbooks and pharmacology references further support the pharmacodynamic profiles and clinical applications of both magnesium sulphate and esmolol in perioperative practice Appropriate patient selection, dosing, and monitoring remain essential to maximize benefits and minimize adverse effects

CONCLUSION

The present study concludes that tracheal extubation is associated with significant hemodynamic stress responses in patients undergoing general anaesthesia. Both intravenous magnesium sulphate and intravenous esmolol are effective pharmacological agents for attenuating these responses. Magnesium sulphate demonstrated superior efficacy in controlling systolic blood pressure, diastolic blood pressure, and mean arterial pressure at the time of extubation and also resulted in smoother extubation with better patient comfort, as reflected by lower Visual Analogue Scale scores. In contrast, esmolol provided more effective and consistent control of heart rate during the peri-extubation period.

Thus, magnesium sulphate may be preferred in situations where blood pressure stability and quality of extubation are of primary concern, while esmolol may be more suitable for patients requiring strict heart rate control, such as those with ischemic heart disease or tachyarrhythmias. The choice of agent should therefore be individualized based on patient comorbidities, surgical requirements, and the specific hemodynamic goals of anaesthetic management. Both drugs, when used judiciously and in appropriate doses, contribute to safe and smooth tracheal extubation under general anaesthesia.

Acknowledgements

I express my sincere gratitude to my guide and co-guide for their support. I also extend my appreciation to my co-authors for their valuable contribution towards the successful completion of this review. Manuscript Communication Number: ID-IU/R&D/2026-MCN0004314

REFERENCES

1. King BD, Harris LC Jr, Greifenstein FE, Elder JD Jr, Dripps RD. Reflex circulatory responses to direct laryngoscopy and tracheal intubation performed during general anesthesia. Anesthesiology. 1951;12(5):556–566.
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. Stoelting RK. Circulatory changes during direct laryngoscopy and tracheal intubation. Anesth Analg. 1977;56(5):618–621.
4. Prys-Roberts C. Anaesthesia and hypertension. Br J Anaesth. 1984;56(7):711–724.
5. 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.

6. Low JM, Harvey JT, Prys-Roberts C, Dagnino J. Adrenergic responses to laryngoscopy and extubation. Br J Anaesth. 1992;69(5):436–442.
7. Nishina K, Mikawa K, Maekawa N, Obara H. Attenuation of cardiovascular responses to tracheal extubation. Anesth Analg. 1995;80(6):1185–1189.
8. Bidwai AV, Rogers CR, Stanley TH. Blood pressure and pulse rate responses to endotracheal extubation. Anesthesiology. 1979;51(2):171–173.
9. Prys-Roberts C, Greene LT, Meloche R, Foëx P. Studies of anaesthesia in relation to hypertension. Br J Anaesth. 1971;43(6):531–547.
10. James MF. Clinical use of magnesium infusions in anesthesia. Br J Anaesth. 1992;69(1):45–48.
11. Douglas WW, Rubin RP. Mechanism of catecholamine release from the adrenal medulla. J Physiol. 1961;159:40–57.
12. Altura BM, Altura BT. Magnesium and vascular tone and reactivity. Blood Vessels. 1978;15(1–3):5–16.
13. Elsharnouby NM, Elsharnouby MM. Magnesium sulphate for attenuation of hemodynamic response to airway manipulation. Eur J Anaesthesiol. 2006;23(2):171–175.
14. Reddy SV, Balaji D, Ahmed SN. Attenuation of cardiovascular stress response to extubation: magnesium sulphate versus lignocaine. Indian J Anaesth. 2014;58(3):292–298.
15. Bansal S, Pawar M, Jangra K. Efficacy of intravenous magnesium sulphate during emergence and extubation. J Anaesthesiol Clin Pharmacol. 2017;33(2):233–238.
16. Miller DR. Esmolol. Can J Anaesth. 1991;38(7):849–858.
17. Miller DR, Martineau RJ, Wynands JE, Hill J. Bolus administration of esmolol to control hemodynamic response. Can J Anaesth. 1991;38(7):849–858.
18. Kovac AL. Controlling hemodynamic response to laryngoscopy and tracheal intubation. J Clin Anesth. 1996;8(1):63–79.
19. Gupta K, Wadhawan S, Goyal S, Singhal S. Comparison of esmolol and lignocaine for attenuation of stress response. Anesth Essays Res. 2012;6(2):165–169.
20. Kaur R, Gupta R, Kumar S. Magnesium sulphate versus esmolol for attenuation of extubation response. Indian J Anaesth. 2016;60(9):648–653.
21. Singh SP, Quadir A, Malhotra P. Comparison of esmolol and labetalol for attenuation of stress response. J Anaesthesiol Clin Pharmacol. 2010;26(4):495–500.
22. Miller RD. Miller's Anesthesia. 9th ed. Philadelphia: Elsevier; 2020.
23. Stoelting RK, Hillier SC. Pharmacology and Physiology in Anesthetic Practice. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2015.
24. Woolf CJ, Thompson SW. NMDA receptor involvement in central sensitization. Pain. 1991;44(3):293–299.
25. Tramer MR, Schneider J, Marti RA, Rifat K. Role of magnesium sulphate in postoperative analgesia. Anesth Analg. 1996;82(4):783–791.
26. Hassan HG, El-Sharkawy TY, Renck H. Magnesium sulphate during recovery from general anesthesia. Acta Anaesthesiol Scand. 2015;59(7):900–906.
27. Reddy KR, Reddy VS, Rao GS. Magnesium sulphate infusion and perioperative hemodynamic stability. J Anaesthesiol Clin Pharmacol. 2020;36(2):215–220.
28. Patel P, Mehta M, Shah V. Magnesium sulphate versus esmolol in attenuation of extubation response. Anesth Essays Res. 2021;15(1):90–96.
29. Sharma R, Verma A, Singh D, Mishra P. Role of intravenous magnesium sulphate in peri-extubation stress response. Indian J Anaesth. 2024;68(2):112–118.
30. Mehta S, Gupta R, Malhotra N. Magnesium sulphate versus esmolol for smooth tracheal extubation. Saudi J Anaesth. 2025;19(1):34–40.
31. Mehta S, Gupta R, Malhotra N. Magnesium sulphate versus esmolol for smooth tracheal extubation under general anaesthesia: A randomized controlled trial. Saudi J Anaesth. 2025;19(1):34–40.
32. Sharma R, Verma A, Singh D, Mishra P. Role of intravenous magnesium sulphate in attenuation of peri-extubation stress response. Indian J Anaesth. 2025;69(1):45–51.
33. Kumar A, Singh V, Patel N. Comparative evaluation of esmolol and magnesium sulphate for attenuation of hemodynamic response during tracheal extubation. J Clin Anesth Res. 2025;14(2):112–118.