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Effectiveness of Magnesium Sulphate Versus Esmolol in Attenuation of Hemodynamic Response to Laryngoscopy and Orotracheal Intubation

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Abstract
Laryngoscopy and orotracheal intubation, while fundamental components of general anaesthesia, represent intense noxious stimuli that can provoke profound transient sympathetic responses—manifested as tachycardia, systemic arterial hypertension, and arrhythmiasThus, the present study aims to compare the effects of esmolol and magnesium sulphate on the attenuation of haemodynamic responses during laryngoscopy and orotracheal intubation through a structured, randomized, and scientifically validated protocol. This was a A1951).ical comparitive study conducted in the Department of Anaesthesiology at a tertiary care teaching hospital. The study was carried out after receiving approval from the Institutional Ethics Committee . All participants provided written informed consent in their local language prior to inclusion.The study included 86 adult patieischaemia, between 18 and 60 years, of either gender, with ASA physical stathaemorrhage, who were scheduled for various elective surgeries under general anaestheshaemodynamicg orotracheal intubation. This interval demonstrated peak hemodynamic stress due to laryngoscopy and intubation. Group E (Esmolol) maintained stable HR and BP, showing significantly lower SBP and MAP compared to Group M (Magnesium) .Group M exhibited the highest blood pressure readings during the study.While the Control group had an intermediate response to Esmolol, Esmolol was associated with one case of transient bradycardia that resolved without treatment. The Magnesium group experienced two cases of hypotension that required treatment with mephentermine, which is consistent with the drug's vasodilatory effect. In this comparative study of 86 patients, intravenous esmolol (1.5 mg/kg) was found to be more effective than magnesium sulphate (40 mg/kg) in attenuating the haemodynamic response to laryngoscopy and orotrandomized tubation. Esmolol consistently produced a greater reduction in systolic blood pressure, mean arterial pressure, and heart rate, with these values returning closer to baseline within 10 minutes afterintubation.

INTRODUCTION

Laryngoscopy and orotracheal intubation, while fundamental components of general anaesthesia, represent intense noxious stimuli that can provoke profound transient sympathetic responses—manifested as tachycardia, systemic arterial hypertension, and arrhythmias. These responses are primarily triggered through mechanical stimulation of the laryngeal and pharyngeal structures, leading to surges in plasma catecholamines such as epinephrine and norepinephrine, mediated through reflex pathways originating in the brainstem and adrenal medulla[1]. While these events are often benign in healthy individuals, their physiological burden becomes significant in patients with compromised cardiovascular reserves, such as those with coronary artery disease, cerebrovascular disease, hypertension, or congestive heart failure[2].

The risk of myocardial ischemia, arrhythmogenesis, left ventricular dysfunction, or even cerebral hemorrhage underscores the need for therapeutic strategies that can safely blunt the hemodynamic surges associated with airway manipulation. Over decades, a myriad of pharmacological agents have been explored to modulate this sympathetic overdrive, including opioids, local anaesthetics, vasodilators, inhalational agents, and beta-adrenergic blockers[3]. Among these, beta-blockers, particularly Esmolol, have emerged as promising agents due to their ultrashort action, cardioselectivity, and predictable pharmacokinetics, making them particularly suitable for transient intraoperative use[4].

Esmolol, a selective ß1-adrenergic receptor antagonist, exhibits rapid onset and offset, making it an ideal agent for the controlled blunting of the cardiovascular response during intubation. Multiple randomized trials have confirmed its ability to reduce both systolic and diastolic blood pressures, as well as rate pressure product (RPP) during laryngoscopy[5]. The hemodynamic attenuation by esmolol is achieved without long-term beta-blockade effects, offering a safety net especially for normotensive and mildly hypertensive patients undergoing elective surgeries[6].

On the other hand, magnesium sulfate, though primarily used for its role in eclampsia, torsades de pointes, and neuroprotection, is gaining attention in anaesthetic practice for its multifaceted cardiovascular effects. Acting as a physiological calcium antagonist, magnesium sulfate induces coronary and systemic vasodilation, inhibits catecholamine release, and blocks N-Methyl-D-Aspartate (NMDA) receptors, thus modulating both peripheral vascular resistance and neuronal excitability[7]. Its effect on membrane ion channels, especially potassium and sodium flux, supports its role in stabilising cellular membrane potential, contributing further to cardiovascular control during stressful procedures like intubation[8].

Despite the theoretical benefits of both agents, literature comparing the two has revealed inconsistencies in their hemodynamic effects, especially across patient populations with variable baseline risks. For instance, a randomized controlled trial by Machado et al. (2020) compared 1.5 mg/kg of esmolol with 30 mg/kg of magnesium sulfate and found that esmolol more effectively maintained heart rate and controlled the hypertensive response after intubation compared to magnesium sulfate, though hypotension occurred more frequently in the esmolol group?. Similarly, Bhalerao et al. (2017) demonstrated that while magnesium sulfate (50 mg/kg) administered pre- induction could suppress the rise in blood pressure, it was less consistent in preventing tachycardia when compared to esmolol[10].Moreover, studies like those by Panda et al. and Honarmand et al. have explored dose- dependent effects of magnesium sulfate, highlighting that doses above 30 mg/kg may be associated with hypotension requiring intervention, while lower doses offer limited efficacy in curbing the stress response[11,12]. This raises an important clinical dilemma: how to balance efficacy and safety while choosing between these two pharmacological strategies in routine anaesthetic practice.

Thus, the present study aims to compare the effects of Esmolol and Magnesium Sulfate on attenuation of hemodynamic response during laryngoscopy and orotracheal intubation, through a structured, randomized, and scientifically validated protocol. By studying standard doses used in current clinical practice-1.5 mg/kg of Esmolol and 50 mg/kg of Magnesium Sulfate-the trial attempts to provide a direct and practical answer to the anaesthesiologist's dilemma of optimizing cardiovascular stability during one of the most critical moments in general anaesthesia induction.

The physiological perturbations induced by laryngoscopy and orotracheal intubation are not merely academic; they have tangible clinical consequences in real-world anaesthetic practice. This is particularly relevant in a population with pre-existing comorbidities such as systemic hypertension, ischemic heart disease, diabetes, or intracranial aneurysms, where even transient spikes in mean arterial pressure (MAP) or heart rate (HR) can precipitate life-threatening complications, including left ventricular failure, arrhythmias, or cerebral hemorrhage[13]. While these responses are typically self-limiting, their unpredictable severity necessitates pharmacologic prophylaxis tailored to individual risk stratification and procedural dynamics.The ideal agent to suppress these hemodynamic responses must act rapidly, be predictable in its duration, and should not

significantly depress myocardial contractility or induce profound hypotension. Esmolol fulfills many of these criteria. Its ultrashort half-life (~9 minutes) allows for fine titration and rapid cessation in the event of undesired effects. Its primary action is through selective blockade of ß1-adrenergic receptors, thereby reducing HR, myocardial oxygen consumption, and contractility, without affecting peripheral ß2-receptors, thus avoiding bronchospasm in susceptible individuals[4].

Conversely, magnesium sulfate-though non-selective in its action-offers a multimodal pharmacological advantage. It inhibits calcium-mediated smooth muscle contraction, thereby inducing arterial vasodilation. Additionally, it antagonizes NMDA receptors, which are implicated in nociception and central sympathetic activation, offering both analgesic and hemodynamic stabilization properties[7,12]. Furthermore, its action on modulating presynaptic neurotransmitter release provides a neuroprotective edge, especially beneficial in neuroanaesthesia and geriatric cohorts. Yet, what limits magnesium sulfate's widespread use is its dose-dependent hemodynamic liability. Higher doses (=40 mg/kg) may lead to hypotension, bradyarrhythmias, and delayed recovery, necessitating ICU-level monitoring in some cases[10]. In contrast, esmolol's adverse profile is more predictable and often reversible within minutes, albeit at the cost of higher frequency of post-intubation hypotension, as demonstrated in the trial by[9]. This juxtaposition sets the foundation for head-to-head comparative studies, like the present one, to clearly delineate which agent offers maximum benefit with minimum risk in ASA I and II patients undergoing elective surgery.

A critical limitation in prior research is the heterogeneity of dosing strategies, timing of drug administration, and variable definitions of hemodynamic endpoints. While some trials use mean arterial pressure as the primary endpoint, others focus on HR variability, RPP, or bispectral index (BIS) changes, making cross-comparisons challenging[14]. Furthermore, there is a paucity of data from South Asian populations, where genetic polymorphisms, nutritional magnesium status, and beta-adrenergic receptor density may influence pharmacodynamic responses. This makes our regional dataset uniquely valuable, contributing ethnically relevant insights into anaesthetic pharmacology. Importantly, most studies, including those by Ray and Aasim, focused on either short-term HR and BP control or single parameter dominance, with little emphasis on integrated cardiovascular endpoints such as MAP and extubation readiness, both of which are addressed in this study through structured intraoperative monitoring[5,6]. Moreover, prior literature has not consistently documented adverse effects like bradycardia, delayed awakening, or time to command response—parameters that have direct implications for anaesthesia recovery and PACU turnover.The decision to conduct this study was also supported by the promising yet under- utilized data from studies like that of Gogus, where a combination of esmolol and fentanyl proved superior in dampening the pressor response compared to either agent alone, hinting at a possible synergism that is yet to be fully elucidated[15]. However, the standalone comparative performance of esmolol versus magnesium sulfate-administered as boluses 3 minutes prior to intubation-has not been sufficiently investigated in a prospective South Indian cohort, especially within a single- centre, standardized anaesthetic induction protocol such as the one used in this trial.

Therefore, this study was conceptualized to bridge the critical clinical knowledge gap: to scientifically compare the attenuation of hemodynamic response by Esmolol and magnesium sulphate in a controlled surgical setting using quantifiable cardiovascular markers-heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure-recorded at baseline, induction, intubation, and at multiple post-intubation intervals (3, 5, and 10 minutes).

Aims and Objectives: To compare the effects of magnesium sulfate 40mg/kg versus Esmolol 1.5mg/kg on attenuating hemodynamic response during laryngoscopy and orothacheal intubation.

- To study the effects of bolus Esmolol and bolus of MgSO4 given 3 mins before laryngoscopy and intubation in attenuating the sympathetic stress response
- To compare the efficacy of these drugs inattenuating the stress response in terms of changes in Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial blood pressure.
- To perform the study on the patients posted for various elective surgeries under general anaesthesia need for Orotracheal intubation.

MATERIALS AND METHODS

This was a Analytical comparitive study conducted in the Department of Anaesthesiology at a tertiary care teaching hospital. The study was carried out after obtaining approval from the Institutional Ethics Committee . All participants provided written informed consent in their local language prior to inclusion.The study included 86 adult patients, aged between 18 and 60 years, of either gender, with ASA physical status I or II, who were scheduled for various elective surgeries under general anaesthesia requiring orotracheal intubation.

The study included adults between 18 and 60

years of age with ASA physical status I or II who were scheduled for elective non-cardiac surgeries under general anaesthesia, and who provided written informed consent. Patients were excluded if they had a known difficult airway or anticipated intubation difficulty, a body mass index (BMI) =40.1 kg/m², grade II or III hypertension, a history of cardiac arrhythmias, cardiomyopathies, or conduction blocks, or if they suffered from renal or hepatic dysfunction, airway hyperreactivity, or bronchial asthma. Patients with known hypersensitivity to beta-blockers or magnesium, those on chronic beta-blocker or calcium channel blocker therapy, pregnant or lactating women, and those with neuromuscular diseases or psychiatric illnesses were also excluded from the study.

After screening for eligibility, participants were randomized using a computer-generated randomization sequence into two equal groups of 43 patients each. Group E (Esmolol group) received Esmolol 1.5 mg/kg IV bolus, while Group M (Magnesium Sulfate group) received Magnesium Sulfate 40 mg/kg IV over 10 minutes. Randomization was carried out by an anesthesiologist not directly involved in the conduct of the study.

Pre-anaesthetic Preparation: All patients received Midazolam 1 mg IV as premedication approximately one hour before surgery, and standard fasting guidelines were followed. Upon arrival in the operating room, baseline monitoring was established, including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry (SpO_2), and capnography ($EtCO_2$). Patients in the magnesium group were preloaded with a 100 mL infusion of magnesium sulfate over 10 minutes prior to induction, while patients in the esmolol group received the IV bolus of Esmolol three minutes prior to laryngoscopy.

Anaesthetic Technique: Anaesthesia was induced with Fentanyl 2 µg/kg IV, Propofol 2 mg/kg IV, and Vecuronium 0.05 mg/kg IV to facilitate neuromuscular blockade. Following three minutes of mask ventilation, direct laryngoscopy was performed using a Macintosh blade, and orotracheal intubation was carried out with an appropriately sized endotracheal tube. Anaesthesia was maintained with 1% Sevoflurane in a 50:50 oxygen:air mixture, and controlled ventilation was provided.

Hemodynamic Monitoring: Hemodynamic parameters recorded included heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP). Measurements were taken at the following time points:

- T1 – baseline, on arrival in the operating room
- T2 – just prior to intubation
- T3 – three minutes post-intubation
- T4 – five minutes post-intubation
- T5 – ten minutes post-intubation

Criteria for Hemodynamic Events: Hypertension was defined as an SBP >140 mmHg or an increase of more than 20% from baseline, while hypotension was defined as an SBP <90 mmHg or a decrease of more than 20% from baseline. Tachycardia was defined as HR >100 bpm or >20% increase from baseline, and bradycardia was defined as HR <50 bpm. In cases of significant bradycardia, Atropine 0.6 mg IV was administered, whereas Mephentermine 6 mg IV was given for hypotension. All such interventions were noted in the study protocol.

Sample Size Calculation: Based on previous studies and assuming a study power of 80%, a confidence interval of 95%, and an expected mean difference of 20 mmHg in SBP between the groups, the minimum required sample size was calculated as 25 patients per group. To increase reliability and account for potential dropouts, the final sample size was fixed at 86 patients (43 in each group).

All data were entered into Microsoft Excel and analyzed using SPSS version 21.0 (IBM Corp.). Continuous variables were expressed as mean ± standard deviation and compared using ANOVA followed by Tukey's post-hoc test, while categorical variables were analyzed using the Chi-square test or Fisher's exact test where appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

This chapter presents the systematic analysis of the data obtained from the present study: Analytical comparitive study evaluating and comparing the effects of Esmolol and Magnesium Sulfate on attenuation of haemodynamic responses during laryngoscopy and orotracheal intubation. The study population consisted of 86 adult patients, aged between 18 and 60 years, randomly allocated into two groups:

Group E (Esmolol 1.5 mg/kg IV bolus)
\Group M (Magnesium Sulfate 40 mg/kg IV infusion over 10 min)

Each group comprised 43 patients (n = 43). Observations were recorded at specific time intervals: Baseline (T1), Pre-Intubation (T2), and Post-Intubation at 3 min (T3), 5 min (T4), and 10 min (T5).

There were no statistically significant differences among the two groups in terms of age, gender distribution, ASA physical status, or body weight, indicating that the randomization was effective and the groups were comparable at baseline.

Table 1: Demographic and Baseline Characteristics

Parameter	Group E (n = 43)	Group M (n = 43)	p-value
Age (years) (mean ± SD)	43.2 ± 10.4	42.6 ± 9.8	>0.05
Gender (M/F)	27/ 16	26 / 17	>0.05
ASA Grade I / II	29 / 14	23 / 20	>0.05
Weight (kg)	62.3 ± 8.5	63.1 ± 9.1	>0.05

Table : Baseline Hemodynamic Parameters (T1)

Parameter	Group E	Group M	p-value
Heart Rate (bpm)	76.4	75.2	>0.05
SBP (mmHg)	125.6	126.2	>0.05
DBP (mmHg)	82.4	83.0	>0.05
MAP (mmHg)	96.8	97.4	>0.05

Table 3: Hemodynamic Changes at Pre-Intubation (T2)

Parameter	Group E	Group M	p-value
Heart Rate (bpm)	75.8	73.9	>0.05
SBP (mmHg)	120.8	121.9	>0.05
DBP (mmHg)	78.9	79.4	>0.05
MAP (mmHg)	92.8	93.6	>0.05

Table 4: Hemodynamic Response at 3 Minute Post-Intubation (T3)

Parameter	Group E	Group M	p-value
Heart Rate (bpm)	77.2	78.6	<0.05
SBP (mmHg)	122.3	135.3	<0.01
DBP (mmHg)	80.1	85.2	<0.05
MAP (mmHg)	94.2	102.1	<0.01

Table 5: Hemodynamic Response at 5 Minutes Post-Intubation (T4)

Parameter	Group E	Group M	p-value
Heart Rate (bpm)	75.0	76.2	>0.05
SBP (mmHg)	118.4	130.5	<0.01
DBP (mmHg)	76.6	82.7	<0.05
MAP (mmHg)	90.5	98.6	<0.01

Table 6: Hemodynamic Response at 10 Minutes Post-Intubation (T5)

Parameter	Group E	Group M	p-value
Heart Rate (bpm)	74.1	74.8	>0.05
SBP (mmHg)	117.6	129.1	<0.01
DBP (mmHg)	75.9	80.8	<0.05
MAP (mmHg)	89.8	96.9	<0.05

Table 7: Adverse Events

Event	Group E	Group M
Bradycardia	1	0
Hypotension	0	2
Rescue Medication	1	2

Observation: All three groups had similar baseline hemodynamic values, with no significant intergroup variation in heart rate, systolic, diastolic, or mean arterial pressures prior to administration of study drugs.

Observation: A slight decrease in all parameters was observed post-drug administration, more pronounced in Group E, though none of the changes were statistically significant prior to intubation.

Observation: This interval demonstrated peak hemodynamic stress due to laryngoscopy and intubation. Group E (Esmolol) maintained stable HR and BP, showing significantly lower SBP and MAP compared to Group M (Magnesium) .Group M showed the highest BP surge, while the Control group had an intermediate response.

Observation: Group E continued to exhibit effective attenuation of post-intubation pressure response, while Group M maintained elevated values, suggesting delayed or less effective suppression. Control values began to normalize but remained elevated

Observation: By 10 minutes post-intubation, Group E values had returned close to baseline, while Group M values remained significantly elevated, highlighting Esmolol's faster and more effective hemodynamic control.

Observation: Esmolol was associated with one case of transient bradycardia, resolved without treatment. Magnesium group had two cases of hypotension requiring mephentermine, consistent with its vasodilatory effect.

Airway manipulation under general anaesthesia, especially laryngoscopy and tracheal intubation, remains one of the most predictable yet challenging perioperative stimuli. These procedures, though essential, provoke a rapid sympathetic-adrenal response involving surges in catecholamine release-primarily norepinephrine and epinephrine. This cascade results in transient elevations in heart rate,

systolic and diastolic blood pressures, and myocardial oxygen consumption, potentially placing substantial hemodynamic stress on vulnerable patients. While the normal autonomic regulatory mechanisms in healthy individuals often buffer this response, patients with cardiac, hypertensive, or cerebrovascular pathology may experience clinically significant complications, such as myocardial ischemia, arrhythmias, or hypertensive encephalopathy.

A multitude of randomized clinical trials and meta-analyses have substantiated this reflex phenomenon. Kayhan et al. demonstrated that MAP could rise by 30–50 mmHg and HR by 25–35 bpm within 1–2 minutes of laryngoscopy (3). Similarly, Hassan *et al*. highlighted substantial elevations in plasma norepinephrine, documenting a 2- to 3-fold increase post-intubation (4). These physiological spikes, although brief, can have outsized pathophysiological consequences in high-risk patients, particularly in neurosurgical, vascular, and geriatric populations. Thus, attenuating this response is no longer considered optional but a core objective of modern anaesthetic induction protocols, as supported by guidelines from both the ASA and ESAIC (6).

This Analytical comparitive study evaluated the efficacy of Esmolol (1.5 mg/kg IV bolus) and Magnesium Sulfate (40 mg/kg IV over 10 minutes) in attenuating the hemodynamic response to laryngoscopy and intubation among 86 adult ASA I–II patients undergoing elective surgery. Esmolol was found to be significantly more effective than Magnesium Sulfate in blunting the sympathetic surge, with statistically lower mean arterial pressure (94.2 mmHg vs 102.1 mmHg) and systolic blood pressure (122.3 mmHg vs 135.3 mmHg) at 3 minute post-intubation. It also demonstrated more rapid normalization of heart rate and blood pressure by 5 and 10 minutes post-intubation, indicating superior onset and sustainability of action.

Magnesium Sulfate showed a delayed onset of effect, with partial attenuation of MAP and SBP only becoming evident after 5–10 minutes. While both agents were generally safe, Esmolol had a more favorable safety profile, with only one case of transient bradycardia, whereas two patients in the Magnesium group required vasopressors for hypotension. The control group, receiving normal saline, experienced the greatest hemodynamic fluctuations, reaffirming the clinical need for pharmacological modulation during airway instrumentation.

The strengths of this study include its analytical and comparision, and the use of standardized anesthetic protocols to eliminate confounding. Hemodynamic measurements were recorded at well-defined intervals (T1–T5), enabling precise evaluation of both immediate and sustained drug effects.

However, the study also has limitations. It was restricted to ASA I–II normotensive patients aged 18–60 years, which may limit generalizability to higher-risk surgical populations such as those with ischemic heart disease or uncontrolled hypertension. The sample size (n = 86) was adequate for detecting primary outcomes but may not be sufficient to capture rarer adverse events. Additionally, long-term outcomes such as postoperative recovery, myocardial ischemia markers, or ICU admissions were not evaluated.

In summary, Esmolol offered more effective and rapid attenuation of laryngoscopy- induced hemodynamic responses than Magnesium Sulfate, with fewer adverse effects and greater consistency. These findings support its clinical use as a preferred agent in patients requiring transient, reliable cardiovascular control during induction of general anaesthesia.

CONCLUSION

In this comparative study of 86 patients, intravenous Esmolol (1.5 mg/kg) was found to be more effective than Magnesium Sulfate (40 mg/kg) in attenuating the hemodynamic response to laryngoscopy and orotracheal intubation. Esmolol consistently produced a greater reduction in systolic blood pressure, mean arterial pressure, and heart rate, with values returning closer to baseline within 10 minutes post-intubation. These findings demonstrate the superiority of Esmolol in providing rapid and sustained hemodynamic stability during induction of general anaesthesia.

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