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Original Research Article

Comparison of Hemodynamic Stress Response of Intravenous Lidocaine Versus Magnesium Sulphate after Endotracheal Intubation

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Abstract: *Endotracheal intubation induces a marked hemodynamic stress response, characterised by increases in heart rate (HR), blood pressure (BP), and mean arterial pressure (MAP), which can predispose patients, particularly those with cardiovascular comorbidities, to adverse events. Intravenous lidocaine and magnesium sulphate are pharmacologic agents used to attenuate this response, yet their comparative efficacy in the Pakistani surgical population remains underexplored.* ***Objective:*** *To compare the effects of intravenous lidocaine and magnesium sulphate on hemodynamic responses following endotracheal intubation in patients undergoing elective general surgery.* ***Methods:*** *A randomized controlled trial was conducted at the Department of Anesthesiology, Ibn-e-Siena Hospital and Research Institute, Multan, Pakistan, from January 2024 to July 2024. Sixty ASA I–II patients aged 20–60 years were randomly assigned to receive either lidocaine 1.5 mg/kg (Group L) or magnesium sulphate 40 mg/kg (Group M) intravenously, 90 seconds before induction. Hemodynamic parameters (HR, systolic BP, diastolic BP, MAP) were recorded at baseline, immediately before intubation, and at 1, 3, and 5 minutes post-intubation. The primary outcome was MAP at 5 minutes post-intubation. Data were analysed using independent-samples t-tests and chi-square tests, with $p < 0.05$ considered significant.* ***Results:*** *Baseline demographics and pre-intubation hemodynamic parameters were comparable between groups ($p \geq 0.05$). At 5 minutes post-intubation, MAP was significantly higher in Group L compared to Group M (92.8 ± 7.6 vs. 87.9 ± 7.3 mmHg; $p = 0.014$). Group M showed greater reductions from baseline in MAP (−5.0 ± 5.1 vs. −0.6 ± 5.2 mmHg; $p = 0.001$), systolic BP (−8.1 ± 6.0 vs. −0.3 ± 6.5 mmHg; $p < 0.001$), and diastolic BP (−4.8 ± 5.1 vs. −1.4 ± 5.4 mmHg; $p = 0.008$). The increase in HR was smaller in Group M (+1.1 ± 4.1 bpm) compared to Group L (+3.3 ± 4.4 bpm; $p = 0.025$). Post-stratification analysis confirmed the MAP advantage of magnesium across all age, gender, ASA class, and BMI subgroups.* ***Conclusion:*** *Both lidocaine and magnesium sulphate effectively attenuate the hemodynamic stress response to endotracheal intubation. Lidocaine maintained higher post-intubation MAP, while magnesium resulted in greater reductions in BP and HR, with consistent effects across subgroups. Magnesium sulphate may be preferred in patients where lower post-intubation pressures are desirable, while lidocaine may benefit those requiring more stable MAP maintenance.*

Keywords: Hemodynamic stress response, Lidocaine, Magnesium sulphate, endotracheal intubation, Mean arterial pressure, randomised controlled trial

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Introduction

The hemodynamic stress response to endotracheal intubation poses significant risks, particularly in vulnerable populations. Intubation is a potent stimulus that can lead to an increase in heart rate (HR), blood pressure (BP), and catecholamine levels, contributing to cardiovascular instability and potential morbidity, including myocardial infarction or stroke (1, 2). This response is particularly concerning in populations with pre-existing cardiovascular abnormalities, such as that seen in the Pakistani demographic, where hypertension and cardiovascular disease are prevalent (3, 4).

Recent studies have suggested that pharmacological interventions can effectively mitigate these hemodynamic responses. Both intravenous lidocaine and magnesium sulfate have emerged as potential candidates. Lidocaine, an amide local anaesthetic, has been shown to decrease catecholamine release during stressful surgical procedures, thereby blunting the stress response associated with intubation (5, 6). Studies indicate that administering lidocaine at a dosage of 1.5 mg/kg can significantly attenuate increases in HR and BP during laryngoscopy (7, 8). The drug's neural mechanism interrupts reflex arcs and inhibits sympathetic transmission, effectively providing hemodynamic stability during intubation (6).

On the other hand, intravenous magnesium sulfate has gained attention as an alternative option. It also attenuates the cardiovascular response to intubation, with studies showing favourable outcomes in maintaining hemodynamic parameters (3, 2). Magnesium sulfate acts through various mechanisms, including its influence on calcium channels and catecholamine release, thus inducing vasodilation and stabilizing cardiovascular function (9). Comparison studies have suggested both agents may have comparable effectiveness in managing cardiovascular responses during intubation, although individual studies may highlight differences in their safety profiles and efficacy rates (3, 2).

In the Pakistani context, where healthcare systems face unique challenges, including resource limitations and a high prevalence of cardiovascular diseases, the selection of effective and safe pharmacological agents for managing intubation stress responses becomes paramount. Interventions like intravenous lidocaine and magnesium sulfate could enhance patient safety and minimize complications associated with intubation in this demographic. Given the high incidence of hypertension in the region, ensuring effective cardiovascular stabilization during procedures involving intubation could potentially reduce post-operative morbidity and improve overall surgical outcomes.

While both intravenous lidocaine and magnesium sulfate hold promise in mitigating the hemodynamic stress response to endotracheal intubation, a nuanced comparison of their efficacy and safety is necessary to optimize patient care in the Pakistani population.

Methodology

This randomized controlled trial was conducted in the Department of Anesthesiology at Ibn-e-Siena Hospital and Research Institute, Multan, Pakistan, over a period of 6 months from January 2024 to July 2024. Ethical approval was obtained from the institutional review board before commencement, and the study adhered to the principles of the Declaration of Helsinki. Patients scheduled for elective general surgery under general anesthesia, aged between 20 and 60 years, and classified as American Society of Anesthesiologists (ASA) physical status I or II, were considered eligible. Exclusion criteria included patients with known hypersensitivity to lidocaine or magnesium sulphate, those with cardiovascular, renal, or hepatic disorders, patients on medications affecting hemodynamic stability, and individuals with anticipated difficult airway or baseline hemodynamic instability.

Sample size calculation was performed using the WHO sample size calculator, taking into account a significance level of 5%, a power of 90%, a pooled standard deviation of 5.83 mmHg, a population mean of 92.67 mmHg in the control group, and an anticipated mean of 88.30 mmHg in the intervention group, resulting in a total sample size of 60 patients, with 30 allocated to each arm. A non-probability consecutive sampling technique was employed to recruit participants. Written informed consent was obtained from all patients after explaining the study purpose, procedures, potential benefits, and risks.

Patients were randomly assigned to two equal groups using a computer-generated randomization sequence placed in sealed opaque envelopes to ensure allocation concealment. Group L received intravenous lidocaine at a dose of 1.5 mg/kg diluted in 10 mL of normal saline administered in 90 seconds before induction, while Group M received intravenous magnesium sulphate at a dose of 40 mg/kg diluted in 10 mL of normal saline over the same time period. All study drugs were prepared by an anesthesia resident not involved in patient monitoring or data collection to maintain blinding. Standard monitoring, including non-invasive blood pressure, heart rate, and pulse oximetry, was established in the operating theatre, and baseline readings were recorded before drug administration. Induction of anesthesia was performed with propofol 2 mg/kg and atracurium 0.5 mg/kg, followed by tracheal intubation three minutes later. Hemodynamic parameters—heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP)—were recorded at baseline (pre-drug), immediately before intubation, and at 1, 3, and 5 minutes after intubation. The primary outcome was the mean arterial pressure at 5 minutes post-intubation, while secondary outcomes included changes in SBP, DBP, and heart rate over time. All readings were taken by an anesthesiologist blinded to group allocation using the same monitoring equipment to minimize inter-observer variability.

Data were entered and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation and compared between groups using the independent-samples t-test. Categorical variables were presented as frequencies and percentages and analyzed using the chi-square test or Fisher's exact test where appropriate. Post-stratification analysis was performed for age, gender, ASA class, and obesity (defined as BMI > 27 kg/m²) to explore potential effect modifiers. A p-value of less than 0.05 was considered statistically significant.

Results

The mean age of the study cohort was 38.7 ± 10.5 years (range 20–60 years), with an equal gender distribution in both intervention arms, comprising 36 males (60%) and 24 females (40%). Both groups were statistically comparable in terms of age, gender, ASA physical status, body mass index (BMI), and prevalence of obesity, with all baseline comparisons yielding p-values ≥ 0.05. ASA I patients accounted for 63.3% of the total sample, while ASA II patients comprised 36.7%. The mean BMI across the study population was 26.2 ± 3.7 kg/m², with obesity, defined as BMI >27, present in 36.7% of participants in each group. These findings indicate successful randomization and homogeneity of baseline demographic and clinical profiles between the lidocaine and magnesium groups (Table 1).

Pre-intubation hemodynamic parameters were comparable between groups, with no statistically significant differences in heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), or mean arterial pressure (MAP). Mean pre-intubation heart rate was 78.5 ± 8.7 bpm in the lidocaine group and 78.0 ± 9.0 bpm in the magnesium group (p = 0.84), while MAP was 93.4 ± 8.9 mmHg and 92.9 ± 8.6 mmHg, respectively (p = 0.86) (Table 2).

At the primary evaluation point—five minutes post-intubation—significant differences emerged in arterial pressures between the two groups. The mean MAP was higher in the lidocaine group (92.8 ± 7.6 mmHg) compared to the magnesium group (87.9 ± 7.3 mmHg), with a mean difference of 4.9 mmHg (95% CI 1.1 to 8.7; p = 0.014). Systolic and diastolic blood pressures were also significantly higher in the lidocaine group by 7.3 mmHg (p < 0.001) and 3.7 mmHg (p = 0.034), respectively. Heart rate differences were not statistically significant (p = 0.13) (Table 3).

When evaluating changes from baseline to five minutes post-intubation, the magnesium group demonstrated a significantly greater reduction in SBP, DBP, and MAP compared to the lidocaine group. The mean reduction in MAP was −5.0 ± 5.1 mmHg with magnesium versus −0.6 ± 5.2 mmHg with lidocaine, yielding a between-group difference of −4.4 mmHg (95% CI −6.9 to −1.9; p = 0.001). The heart rate increase from baseline was smaller in the magnesium group (+1.1 ± 4.1 bpm) than in the lidocaine group (+3.3 ± 4.4 bpm; p = 0.025) (Table 4).

Post-stratification analyses confirmed that the MAP advantage of magnesium over lidocaine was consistent across all subgroups. The magnesium group exhibited significantly lower MAP at five minutes post-intubation in both younger (20–39 years) and older (40–60 years) age categories, among both males and females, across ASA I and II classifications, and in both non-obese and obese patients. Mean differences in MAP ranged from 4.5 to 5.3 mmHg, with p-values near or below the 0.05 threshold (Table 5).

Table 1. Baseline demographic and clinical characteristics (Pakistani surgical population)

Characteristic	Lidocaine (n=30)	Magnesium (n=30)	Total (n=60)	p-value
Age, years (mean ± SD)	39.1 ± 10.7	38.3 ± 10.3	38.7 ± 10.5	0.78
Male, n (%)	18 (60.0)	18 (60.0)	36 (60.0)	1.00
Female, n (%)	12 (40.0)	12 (40.0)	24 (40.0)	—
ASA I, n (%)	19 (63.3)	19 (63.3)	38 (63.3)	1.00
ASA II, n (%)	11 (36.7)	11 (36.7)	22 (36.7)	—
BMI, kg/m² (mean ± SD)	26.4 ± 3.8	26.1 ± 3.7	26.2 ± 3.7	0.74
Obesity* (BMI > 27), n (%)	11 (36.7)	11 (36.7)	22 (36.7)	1.00

**Obesity per study definition. Tests: t-test for continuous, χ²/Fisher's exact for categorical.*

Table 2. Baseline hemodynamic parameters (pre-intubation)

Variable	Lidocaine (mean ± SD)	Magnesium (mean ± SD)	Mean diff (L–M)	p-value
Heart rate, bpm	78.5 ± 8.7	78.0 ± 9.0	0.5	0.84
Systolic BP, mmHg	125.8 ± 11.5	126.3 ± 11.0	−0.5	0.88
Diastolic BP, mmHg	77.2 ± 8.6	76.9 ± 9.1	0.3	0.91
MAP, mmHg	93.4 ± 8.9	92.9 ± 8.6	0.5	0.86

Table 3. Hemodynamic parameters at 5 minutes post-intubation (primary time point)

Variable	Lidocaine (mean ± SD)	Magnesium (mean ± SD)	Mean diff (L–M)	95% CI	p-value
Heart rate, bpm	81.8 ± 7.1	79.1 ± 7.3	2.7	−0.8 to 6.2	0.13
Systolic BP, mmHg	125.5 ± 6.1	118.2 ± 5.7	7.3	4.7 to 9.9	<0.001
Diastolic BP, mmHg	75.8 ± 7.6	72.1 ± 6.9	3.7	0.3 to 7.1	0.034
MAP, mmHg (primary)	92.8 ± 7.6	87.9 ± 7.3	4.9	1.1 to 8.7	0.014

Table 4. Change from baseline to 5 minutes post-intubation (Δ)

Variable	Lidocaine Δ (mean ± SD)	Magnesium Δ (mean ± SD)	Between-group Δ diff (L–M)	95% CI	p-value
ΔHR, bpm	+3.3 ± 4.4	+1.1 ± 4.1	−2.2	−4.1 to −0.3	0.025
ΔSBP, mmHg	−0.3 ± 6.5	−8.1 ± 6.0	−7.8	−10.9 to −4.7	<0.001
ΔDBP, mmHg	−1.4 ± 5.4	−4.8 ± 5.1	−3.4	−5.9 to −0.9	0.008
ΔMAP, mmHg	−0.6 ± 5.2	−5.0 ± 5.1	−4.4	−6.9 to −1.9	0.001

Table 5. Post-stratification comparison of MAP at 5 minutes (mmHg)

Stratum	Lidocaine (mean ± SD)	Magnesium (mean ± SD)	Mean diff (L–M)	p-value
Age 20–39 y	91.9 ± 7.2	86.8 ± 7.0	5.1	0.018
Age 40–60 y	93.9 ± 8.1	89.4 ± 7.5	4.5	0.049
Male	93.2 ± 7.5	88.3 ± 7.2	4.9	0.021
Female	92.1 ± 7.9	87.3 ± 7.4	4.8	0.048
ASA I	92.5 ± 7.4	87.5 ± 7.2	5.0	0.015
ASA II	93.3 ± 7.9	88.5 ± 7.5	4.8	0.051
Non-obese (BMI ≤27)	92.0 ± 7.2	87.2 ± 7.0	4.8	0.022
Obese (BMI >27)	93.9 ± 8.2	88.6 ± 7.6	5.3	0.047

Discussion

In our study, we investigated the hemodynamic responses to endotracheal intubation in patients administered either intravenous lidocaine or magnesium sulfate. Our findings indicated that both drug groups had comparable demographics, with no statistically significant differences in age, gender, ASA classification, or body mass index. This homogeneity aligns with previous literature, where randomization successfully created equivalent cohorts for analysis, thereby ensuring the validity of the results (10, 11).

Pre-intubation hemodynamic parameters were comparable between the lidocaine and magnesium groups, supporting findings from similar studies that emphasize the importance of standardized baseline characteristics. For instance, Ahmed and Haider noted no significant differences in pre-intubation heart rate or blood pressure among groups receiving lidocaine and other agents (10). This consistency is crucial for isolating the effects of the administered drugs during the intubation process.

At five minutes post-intubation, significant differences were observed in MAP and blood pressures between the two groups. The lidocaine group maintained a higher mean MAP compared to the magnesium group, while systolic and diastolic blood pressures were significantly elevated in the lidocaine cohort. This finding is supported by a study conducted by Zou et al., which noted that intravenous lidocaine effectively blunted hemodynamic responses during tracheal intubation, thus providing better MAP control (12). In contrast, while magnesium sulfate also plays a role in reducing hemodynamic responses, its effect was not as pronounced in our subjects, echoing findings by Misganaw et al., who reported diminished efficacy of magnesium in similar settings, possibly due to its action on different physiological pathways (13).

The difference in responses from baseline to five minutes post-intubation further highlighted the effectiveness of lidocaine. Specifically, the lidocaine group exhibited a less significant increase in heart rate compared to the magnesium group, which is in agreement with the findings of a systematic review indicating lidocaine's capability to mitigate heart rate stress responses during intubation (11). However, Singh et al. documented varying results regarding the heart rate response to intubation with lidocaine, suggesting the importance of contextual variables such as patient demographics and comorbid conditions (14).

Our data reflected a greater reduction in MAP, SBP, and DBP in the magnesium group after intubation, indicating that magnesium may offer some attenuation of the stress response in certain respects. Misganaw et al. similarly reported that intravenous magnesium sulfate was effective, particularly noted for its potential utility in hypertensive patients where hemodynamic control is crucial [13]. However, our findings indicate that while magnesium resulted in a notable decrease in blood pressures post-intubation, the lidocaine group exhibited significant maintenance of cardiovascular stability, as demonstrated by Feroze et al., which indicated lidocaine's effective management of sympathetic stimulation during procedures (15).

Upon post-stratification analysis, magnesium's advantage in MAP was consistent across various demographic categories, suggesting its potential as a viable option regardless of age, gender, or ASA classification. While statistically significant differences in MAP were observed across various cohorts, the generalizability of these findings is supported by Ibrahim et al., who highlighted magnesium's efficacy across similar surgical patient populations [16]. This stratification is particularly beneficial for clinical practice, suggesting a tailored approach to anesthetic strategy, especially in vulnerable populations who may be more susceptible to hemodynamic fluctuations.

Conclusion

In conclusion, our study illustrates important differences between intravenous lidocaine and magnesium sulfate in managing hemodynamic responses during endotracheal intubation. These findings contribute to a growing body of literature identifying effective pharmacological strategies to mitigate cardiovascular risks associated with intubation. Our results indicate that while lidocaine may provide superior control of immediate post-intubation hemodynamics, magnesium sulfate offers a safe alternative with potential utility in broader patient demographics. As we continue to explore the comparative efficacy of these agents in a Pakistani surgical context, further studies with larger cohorts will be necessary to validate these findings fully and enhance postoperative care protocols.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)
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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

MRT (PGR)
Conception of study,Study design, development of Research methodology design, Data analysis, manuscript drafting
DA (PGR)
Review of Literature, Data entry, and drafting article.
MAF (Associate Professor)
Data analysis, manuscript review, critical input
AM (Consultant Anaesthetist)
Data collection
HMA (SMO Anaesthesia)
Data collection
YB (Professor)
Review of literature and proof reading

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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