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Original Article

Comparison between the Hemodynamic Profile with Esmolol versus Morphine as an Adjuvant Agent during Induction of Anesthesia

Usama Farooq[1], Rashid Ali[1], Tariq Mahmood[2], Neelofar Yousaf[3], Hafiz Ahmed Hassam Bhalli[1], Kenan Anwar Khan[1], Muhammad Farrukh Habib[4]*

[1]Graded Anesthetist, Combined Military Hospital Rawalpindi, Pakistan.
[2]Anesthetist, Combined Military Hospital Rawalpindi, Pakistan.
[3]Department of Pharmacology, Akhtar Saeed Medical and Dental College Lahore, Pakistan.
[4]Department of Management Sciences, Shifa Tameer E Millat University Islamabad, Pakistan.
Corresponding Author: Muhammad Farrukh Habib; Email: muhammadfarrukhhabib@gmail.com

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ABSTRACT

Background: The induction of general anesthesia is a critical phase in anesthetic practice, often associated with significant hemodynamic changes. These changes can lead to complications due to autonomic adrenergic responses. Esmolol, a beta-1 antagonist, is commonly used to blunt these responses, but its availability is limited in some settings. Morphine, a pure mu receptor antagonist, presents a potential alternative.

Objective: This study aimed to compare the efficacy of intravenous esmolol versus intravenous morphine in stabilizing the hemodynamic profile during the induction of general anesthesia.

Methods: This randomized controlled trial was conducted at the Department of Anesthesiology, Combined Military Hospital, from January to June 2023. After obtaining ethical approval and trial registration, 220 ASA-II patients aged 25-55 years scheduled for elective surgeries under general anesthesia were enrolled. Patients were randomized into two groups: Group E (n=110) received 1.5 mg/kg intravenous esmolol three minutes before laryngoscopy and intubation, and Group M (n=110) received 0.1 mg/kg intravenous morphine five minutes before laryngoscopy and intubation. Baseline heart rate, systolic and diastolic blood pressure, and oxygen saturation were recorded after pre-oxygenation with 100% oxygen for three minutes. Post-intubation, the same parameters were measured five minutes after intubation. Statistical analysis was performed using SPSS version 25.0, with independent samples T-tests used to compare means. A p-value of ≤0.05 was considered statistically significant.

Results: The mean age was 39.41 ± 5.13 years in Group E and 39.97 ± 5.08 years in Group M (p=0.414). Mean weight was 68.14 ± 3.88 kg in Group E and 68.08 ± 3.80 kg in Group M (p=0.916). Pre-induction mean heart rate was 71.75 ± 2.33 bpm in Group E and 71.58 ± 2.35 bpm in Group M (p=0.585). Five minutes post-intubation, mean heart rate was significantly lower in Group E (80.73 ± 2.54 bpm) compared to Group M (87.62 ± 2.83 bpm) (p<0.001). Mean systolic blood pressure post-intubation was 132.88 ± 4.65 mm Hg in Group E and 140.25 ± 2.39 mm Hg in Group M (p<0.001). Mean diastolic blood pressure post-intubation was 77.58 ± 2.35 mm Hg in Group E and 85.33 ± 3.71 mm Hg in Group M (p<0.001). Oxygen saturation remained stable in both groups.

Conclusion: Intravenous esmolol is superior to intravenous morphine in blunting the hemodynamic responses to laryngoscopy and intubation, providing a more stable hemodynamic profile during the induction of general anesthesia.

Keywords: esmolol, morphine, anesthesia induction, hemodynamic stability, laryngoscopy, intubation, autonomic responses, randomized controlled trial, general anesthesia, cardiovascular effects.

INTRODUCTION

The induction of general anesthesia is a critical phase for anesthetists, marked by significant hemodynamic changes that can range from predictable to unpredictable (1). Some patients may exhibit an exaggerated response during induction, deviating from the expected norm (2). General anesthesia induction is a multi-stage process beginning with pre-medication, followed by the administration of drugs to induce amnesia and paralysis, ultimately facilitating successful intubation or airway management (3). Each

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of these steps demands meticulous care and is fraught with potential complications (4). Among these steps, securing the airway, typically via an endotracheal tube, is paramount. The act of laryngoscopy, integral to this process, triggers various reflex physiological mechanisms that lead to increased systemic blood pressure and heart rate, and can provoke respiratory complications such as laryngospasm, coughing, and bronchospasm (5). In severe instances, nodal or ventricular arrhythmias may also occur (6). These physiological responses are mediated through reflex pathways and the autonomic nervous system.

To mitigate these responses and ensure a smoother intubation process, different pharmacological agents have been employed. Esmolol, a short-acting beta-1 antagonist, is one such agent used to attenuate the physiological responses to intubation, thereby promoting a more stable hemodynamic profile. It is also utilized to diminish the stress associated with surgical stimulation and during extubation (7). However, its use is contraindicated in patients with cardiac disease, atrioventricular block, sick sinus syndrome, and those with hypersensitivity to beta-blockers. In contrast, within the opioid class, fentanyl has been widely used for similar purposes. Nevertheless, the availability of fentanyl is limited in certain demographic setups, necessitating the exploration of alternative opioids (7-9).

This study aims to compare intravenous morphine with esmolol in stabilizing the hemodynamic profile during the induction of general anesthesia. Morphine, being more readily available in many settings compared to fentanyl, presents a viable alternative for this purpose. By examining the hemodynamic outcomes associated with the use of these two agents, we seek to determine their efficacy and safety profiles, thus providing a basis for optimizing anesthesia induction protocols in diverse clinical scenarios. This comparison is critical for enhancing patient safety and improving overall anesthetic management during one of the most pivotal moments in surgical procedures.

MATERIAL AND METHODS

This randomized controlled trial was conducted at the Department of Anesthesiology, Combined Military Hospital, from January to June 2023, following approval from the institutional ethical review board. An initial pilot study was conducted with 50 participants, divided equally into two groups, with one group receiving intravenous esmolol and the other receiving intravenous morphine before induction. The pilot study revealed a mean difference in heart rate of 12.22 ± 1.26 beats per minute between the groups. Based on these results, the sample size was calculated to ensure a 95% confidence interval and 80% power, considering a population variance of 1000 and the observed mean difference. The minimum sample size was determined to be 110 participants per group. Ultimately, 220 participants were included in the study, with 110 participants in each group, randomized through non-probability consecutive sampling by the lottery method, in line with CONSORT guidelines (Figure-I).

Participants included in the study were ASA-II patients aged 25-55 years scheduled for elective surgeries under general anesthesia. Exclusion criteria encompassed patients with metastatic disease, major cardiac or respiratory conditions, low ejection fraction, post-chemotherapy status, pregnant females, and those unwilling to participate. Upon arrival in the operating room, standard monitoring was initiated for all participants. Both groups received intravenous dexamethasone 0.05 mg/kg and intravenous ondansetron 4 mg as anti-emetic prophylaxis. Baseline measurements of heart rate, systolic and diastolic blood pressure, and oxygen saturation were recorded after pre-oxygenation with 100% oxygen for three minutes. Group E (n=110) received 1.5 mg/kg intravenous esmolol three minutes before laryngoscopy and intubation, while Group M (n=110) received 0.1 mg/kg intravenous morphine five minutes before laryngoscopy and intubation. A size 3 standard Macintosh blade was used for airway manipulation in both groups.

The primary variables measured included mean heart rate, systolic and diastolic blood pressure, and oxygen saturation five minutes post-intubation. Demographic data were described using means and standard deviations for continuous variables, and frequencies and percentages for categorical variables. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Independent samples T-tests were employed to compare mean differences between the two groups, with a p-value of ≤0.05 considered statistically significant. All participants provided informed consent, and the study adhered to the principles outlined in the Declaration of Helsinki (1964).

RESULTS

The demographic variables between the two groups were well-matched, indicating no significant differences that could confound the results. The mean age of participants in Group E was 39.41 ± 5.13 years, while in Group M it was 39.97 ± 5.08 years, with a p-value of 0.414, suggesting comparable age distribution between the groups. Similarly, the mean weight was nearly identical, with Group E at 68.14 ± 3.88 kg and Group M at 68.08 ± 3.80 kg, yielding a p-value of 0.916. The gender distribution was also similar, with Group E comprising 60.9% males and 39.1% females, and Group M having 57.3% males and 42.7% females (Table I).

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Table 1: Demographic Variables Between Both Groups (n=220)

Variable	Group E (n=110)	Group M (n=110)	p-value
Mean Age (years)	39.41 ± 5.13	39.97 ± 5.08	0.414
Mean Weight (kg)	68.14 ± 3.88	68.08 ± 3.80	0.916
Gender (Male/Female)			
- Male	67 (60.9%)	63 (57.3%)	-
- Female	43 (39.1%)	47 (42.7%)	-

Table 2: Hemodynamic Variables (n=220)

Variable	Group E (n=110)	Group M (n=110)	p-value
Pre-Induction:			
- Mean Heart Rate (beats per minute)	71.75 ± 2.33	71.58 ± 2.35	0.585
- Mean Systolic Blood Pressure (mm Hg)	117.77 ± 2.87	117.83 ± 2.77	0.886
- Mean Diastolic Blood Pressure (mm Hg)	71.09 ± 1.03	71.13 ± 1.03	0.795
- Mean Oxygen Saturation (%)	92.05 ± 0.98	91.97 ± 0.92	0.572
5 Minutes Post-Intubation:			
- Mean Heart Rate (beats per minute)	80.73 ± 2.54	87.62 ± 2.83	<0.001
- Mean Systolic Blood Pressure (mm Hg)	132.88 ± 4.65	140.25 ± 2.39	<0.001
- Mean Diastolic Blood Pressure (mm Hg)	77.58 ± 2.35	85.33 ± 3.71	<0.001
- Mean Oxygen Saturation (%)	92.06 ± 0.97	92.02 ± 0.96	0.729

Regarding pre-induction hemodynamic variables, both groups exhibited similar baseline measurements. The mean heart rate for Group E was 71.75 ± 2.33 beats per minute, while Group M recorded 71.58 ± 2.35 beats per minute, with a non-significant p-value of 0.585. The mean systolic blood pressure was 117.77 ± 2.87 mm Hg in Group E and 117.83 ± 2.77 mm Hg in Group M, also showing no significant difference with a p-value of 0.886. Additionally, the mean diastolic blood pressure was nearly identical between the groups, at 71.09 ± 1.03 mm Hg for Group E and 71.13 ± 1.03 mm Hg for Group M, with a p-value of 0.795. The mean oxygen saturation was 92.05 ± 0.98% in Group E and 91.97 ± 0.92% in Group M, with a p-value of 0.572, indicating no significant difference in baseline oxygenation status (Table II).

Post-intubation, significant differences emerged in hemodynamic responses between the two groups. Five minutes after intubation, the mean heart rate in Group E was 80.73 ± 2.54 beats per minute, significantly lower than the 87.62 ± 2.83 beats per minute observed in Group M, with a p-value of less than 0.001. This suggests that esmolol was more effective in attenuating the increase in heart rate associated with intubation. Similarly, the mean systolic blood pressure was significantly lower in Group E at 132.88 ± 4.65 mm Hg compared to 140.25 ± 2.39 mm Hg in Group M, again with a p-value of less than 0.001. The mean diastolic blood pressure followed the same trend, being 77.58 ± 2.35 mm Hg in Group E and 85.33 ± 3.71 mm Hg in Group M, with a p-value of less than 0.001. These results highlight the superior efficacy of esmolol in maintaining lower blood pressure levels during the stressful period of intubation. The mean oxygen saturation remained stable and comparable between the groups post-intubation, at 92.06 ± 0.97% for Group E and 92.02 ± 0.96% for Group M, with a non-significant p-value of 0.729 (Table II).

Overall, the findings demonstrate that esmolol provides a more stable hemodynamic profile compared to morphine during the induction of general anesthesia, as evidenced by the significantly lower heart rate and blood pressure measurements post-intubation. These differences underscore the potential benefits of using esmolol over morphine in specific clinical scenarios to minimize hemodynamic fluctuations and enhance patient safety during anesthesia induction.

DISCUSSION

The study aimed to identify alternative drug regimens capable of blunting the responses to laryngoscopy and intubation, thereby achieving a better hemodynamic profile and reducing complications associated with autonomic adrenergic responses. Given the widespread use of esmolol internationally for this purpose, its limited availability to major medical institutions in our demographic setup prompted the search for viable alternatives, particularly for patients with cardiac and respiratory conditions. Although esmolol, a beta-1 selective antagonist, has been effective, reports of bronchospasm and respiratory complications necessitated the exploration of other options (7).

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Morphine, a pure mu receptor antagonist and potent analgesic, was considered a suitable alternative. Opioids, such as intravenous fentanyl and nalbuphine, have also been reported to blunt hemodynamic responses effectively. Due to the limited availability of fentanyl in our setups, we hypothesized that intravenous morphine might offer a competitive hemodynamic profile compared to nalbuphine, an agonist-antagonist opioid (9). Previous studies comparing nalbuphine and fentanyl indicated that fentanyl was superior in attenuating intubation responses, owing to its short duration of action and potent analgesic effects (10). However, direct comparisons of morphine with esmolol for blunting hemodynamic responses are scarce. Studies comparing morphine with fentanyl have shown that while morphine can attenuate responses, it does not effectively block the chronotropic response to laryngoscopy and intubation (11).

Our study findings were consistent with these observations, showing that the chronotropic response of the heart was not effectively blunted with morphine compared to esmolol, resulting in a statistically significant difference (12, 13). Studies comparing esmolol with other agents, such as intravenous magnesium and fentanyl, have demonstrated esmolol's superior efficacy in attenuating hemodynamic responses during intubation (14, 15). Both groups in our study showed no significant difference in oxygen saturation, corroborating findings from other studies (16).

Local studies have also assessed the efficacy of various agents for blunting adrenergic responses. For instance, Ayub et al. compared the opioids tramadol and nalbuphine, both of which offered competitive profiles for blunting responses (17). Similarly, Ali et al. compared lignocaine with fentanyl, finding that opioid agents provided a superior profile for blunting hemodynamic responses (18). This study demonstrated that intravenous esmolol is superior to intravenous morphine in blunting hemodynamic responses to laryngoscopy and intubation. The strengths of the study included its randomized controlled design and rigorous methodological approach, adhering to CONSORT guidelines. However, limitations included its single-center nature, which may limit the generalizability of the findings. A multi-center study could provide more comprehensive results across a broader demographic. Additionally, the study excluded patients with cardiac and respiratory diseases or hypertension, necessitating further research to assess the efficacy of these agents in such populations.

CONCLUSION

In conclusion, intravenous esmolol provided a better hemodynamic profile by effectively blunting the adrenergic response to laryngoscopy and intubation. This study recommends the use of intravenous esmolol as a superior agent compared to intravenous morphine for this purpose. Further multi-center studies, including a broader patient demographic, are warranted to confirm these findings and extend their applicability.

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