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Original Research Article

A Comparative Study Between Intravenous Esmolol and Intravenous Labetalol for Attenuation of Haemodynamic Response During Laryngoscopy and Tracheal Intubation

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Conflict of interest: Nil

Abstract:

Background: Laryngoscopy and tracheal intubation trigger sympathetic responses, causing transient elevations in heart rate and blood pressure, which may be hazardous in patients with cardiovascular risk. Beta-blockers such as esmolol and labetalol are commonly used to attenuate these hemodynamic responses.

Aim: To compare the efficacy of intravenous esmolol and labetalol in blunting the hemodynamic response during laryngoscopy and tracheal intubation in adult patients undergoing elective surgery.

Methodology: A prospective, hospital-based, comparative observational study was conducted on 90 ASA I–II adult patients, randomized to receive esmolol (0.5 mg/kg, n=45) or labetalol (0.25 mg/kg, n=45) before intubation. Hemodynamic parameters—heart rate, diastolic blood pressure, and rate pressure product—were recorded at baseline, post-induction, intubation, and at 1, 3-, 5-, 10-, and 15-minutes post-intubation.

Results: Baseline parameters were comparable between groups. Labetalol produced significantly lower heart rates, diastolic pressures, and rate pressure product than esmolol at most time points, indicating superior attenuation of cardiovascular stress. A transient 3–5-minute window showed comparable efficacy.

Conclusion: Intravenous labetalol (0.25 mg/kg) provides more sustained hemodynamic stability than esmolol (0.5 mg/kg) during laryngoscopy and intubation, making it the preferred agent for peri-intubation cardiovascular protection.

Keywords: Laryngoscopy, Intubation, Hemodynamic response, Esmolol, Labetalol, Beta-blocker.

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Introduction

The use of laryngoscopy and tracheal intubation are vital in the practice of anesthesia especially in taking care of the airway and proper ventilation in the operating room [1]. Nevertheless, these protocols have been thoroughly reported to cause pronounced hemodynamics changes which entail temporary increases in heart rate, arterial blood pressure and vascular resistance in the body. These are responses that are mostly mediated by sympathetic nervous system and are activated by mechanical stimulation of the oropharynx, larynx, and trachea. Though these physiological reactions are generally highly tolerated in healthy people, they may be life-threatening in patients with cardiovascular comorbidities, i.e. hypertension, ischemic heart disease or intracranial pathology. A rapid increase in blood pressure or heart rate during the laryngoscopy can trigger myocardial ischemia, arrhythmias, or cerebrovascular accidents and the inhibition of this hemodynamic reaction is a key measure of anesthetic care [2].

Different pharmacological measures have been used to counter these sympathetic reactions with beta-adrenergic blockers forming one of the foundational measures [3]. The effects of beta-blockers are based on antagonizing the activity of the catecholamines on the 8-receptors of adrenaline, which in turn slows the heart rate, cardiac contractility, and the blood pressure (systemic). Esmol and labetalol are the most frequently used intravenous drugs that have various pharmacokinetic and pharmacodynamic characteristics as the agents of the latter. Esmol is a cardioselective, ultra-short acting, ultra-fast acting, 01-adrenergic antagonist, with a short acting duration, which is specifically applicable to short term procedures or hemodynamic management [4]. Its high rate of red blood cell esterases metabolism permits accurate titration and there is low chance of long-term hypotension or bradycardia. Labetalol, on the other hand, is not selective 1- adrenergic or beta blocker with some 1- adrenergic antagonism effects, giving negative chronotropic/ inotropic and vasodilatory effects. This two-fold process helps labetalol to reduce heart rate and blood pressure in a more efficient manner, and with a marginally longer effect duration than esmol with an advantageous effect in

patients needing hemodynamic control over an extended period of" time [5].

The "relative effectiveness of intravenous esmol and labetalol has been evaluated in several studies to compare the effects of the two drugs in reducing the pressor response to laryngoscopy and intubation, but due to varying study designs, dosage schedules, and patient samples, generalization of these results is limited [6]. Certain researchers have indicated that esmol offers a dose-dependent and fast heart rate reduction with a relative lack of hypotension when compared to labetalol which has a stronger blood pressure decrease but slower onset. In addition, patient-specific parameters like baseline cardiovascular status, comorbidities and the expected length of sympathetic stimulation may influence the decision between these agents. The clinicians should strike a balance between the targeted hemodynamic control and any side effects that may result as a result of this like bradycardia, hypotension, or bronchospasm especially in high-risk patients [7].

The hemodynamic response to laryngoscopy and intubation results from multiple factors which include the choice of anesthetic method and the level of anesthesia and the use of additional drugs [8]. The sympathetic response which occurs during airway procedures persists as a major clinical issue in spite of improvements in anesthesia methods through the development of short-acting opioids and inhalational agents and local anesthetic techniques. Researchers continue to investigate which pharmacological agent will effectively and safely reduce this physiological reaction. The study of esmolol and labetalol through comparative research shows which drug provides better treatment results and faster effects and fewer side effects which will assist in managing anesthesia for regular surgical cases and complex surgical situations.

Since the pharmacological characteristics of esmol and labetalol are distinct, a controlled clinical comparison, which is possible in a systematic study, can offer useful evidence to maximize patient outcomes. The knowledge of the peculiarities of their cardiovascular effects, the time during which they start, and the time during which they act will allow the anesthesiologists to adjust therapy to the unique needs of a particular patient, reducing the risk of hemodynamic instability during peri-intubation. The proposed research challenges to assess and compare the efficacy of intravenous esmol and labetalol in the prevention of the hemodynamic response during laryngoscopy and tracheal intubation as a positive contribution to safer anesthetic practice and enhanced cardiovascular stability during perioperative" changes.

Methodology

Study Design: This study was designed as a prospective, hospital-based, comparative, observational study. It aimed to evaluate and compare the efficacy of intravenous esmolol and intravenous labetalol in attenuating the haemodynamic response associated with laryngoscopy and tracheal intubation in adult patients undergoing elective surgery under general anaesthesia.

Study Area: The study was conducted at Burdwan Medical College and Hospital, a tertiary care hospital located in the semi-urban region of Eastern India, which caters to a diverse patient population.

Study Duration: The total study period was approximately one and a half years, from April 2019 to September 2020. One year was dedicated to data collection, three months were allocated for data compilation, statistical analysis, and tabulation, and the final three months were used for thesis writing.

Study Participants

Inclusion Criteria

1. Patients providing informed consent to participate in the study.
2. Age between 18 and 45 years.
3. American Society of Anesthesiologists (ASA) physical status I–II.
4. Normotensive individuals.
5. Body weight ranging from 40 to 75 kg.
6. Patients receiving standardized preanaesthetic medications:
    - Glycopyrrolate 4 µg/kg i.v.
    - Fentanyl 1.5 µg/kg i.v.
    - Ondansetron 4 mg i.v.
    - Midazolam 1 mg i.v.
    - Propofol 2 mg/kg i.v. as induction agent
    - Rocuronium 0.7 mg/kg for muscle relaxation
7. Patients scheduled for intubation using a Macintosh laryngoscope.

Exclusion Criteria

1. Patients with bronchial asthma, diabetes mellitus, heart block, chronic obstructive pulmonary disease (COPD), or hypertension.
2. Known hypersensitivity to either esmolol or labetalol.
3. Patients unwilling to participate.
4. Patients with anticipated difficult intubation.
5. ASA physical status III or higher.
6. Body" weight <40 kg or >75 kg.

Sample Size: Based on "statistical considerations, assuming a significance level of $p < 0.05$, a power of 80% (Z_1-$\beta = 0.84$), and an effect size of 5 in the mean arterial pressure (MAP) difference between groups, the minimum required sample size was calculated using the formula:

$n>2(Z\alpha+Z1-\beta)2\times SD2/d2$

This yielded n = 40 patients per group. To account for potential dropouts, 45 patients were enrolled in each group, resulting in a total sample size of 90.

Procedure: Eligible patients were screened during pre-anaesthetic evaluation and those meeting the inclusion criteria were informed about the study verbally and in writing. Written consent was obtained prior to enrollment. Participants were randomly assigned to either Group E (receiving esmolol) or Group L (receiving labetalol). All patients received the same premedication regimen, induction protocol, and intubation technique using a Macintosh laryngoscope. Esmolol (0.5 mg/kg i.v.) was administered 2 minutes prior to laryngoscopy, whereas labetalol (0.25 mg/kg i.v.) was given 5 minutes before laryngoscopy. Hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and rate pressure product (RPP), were recorded at baseline, post-induction, at intubation, and at 1, 3-, 5-, 10-, and 15-minutes post-intubation. Data were meticulously recorded in a standardized case record form.

Statistical Analysis: Categorical variables were expressed as frequencies and percentages, and comparisons between groups were made using Pearson's Chi-square test or Fisher's exact test as appropriate. Continuous variables were presented as mean ± standard deviation (SD) or median, and compared using the Mann–Whitney U test. Statistical analysis was performed using SPSS version 20, and an alpha level of 5% was set for significance, with $p < 0.05$ considered statistically significant. The study aimed to determine whether intravenous esmolol or labetalol provided superior attenuation of haemodynamic stress responses during laryngoscopy" and intubation.

Result

Table 1 presents "the distribution of age among the two groups, E and L. The mean age of group E was 39.64 years with a median of 40 years and a standard deviation of 4.11, while group L had a slightly higher mean age of 40.29 years, a median of 40 years, and a standard deviation of 3.29. The p-value for the age comparison between the two groups was 0.727, indicating that the difference in age was not statistically significant. This suggests that both groups were comparable in terms of age, and age is unlikely to have influenced the study outcomes.

Table 1: Distribution of Age (In Years) Among Two Groups

Group	Mean Age (years)	Median Age (years)	Std. Deviation	p-Value	Significance
E	39.64	40	4.11	0.727	Not Significant
L	40.29	40	3.29		

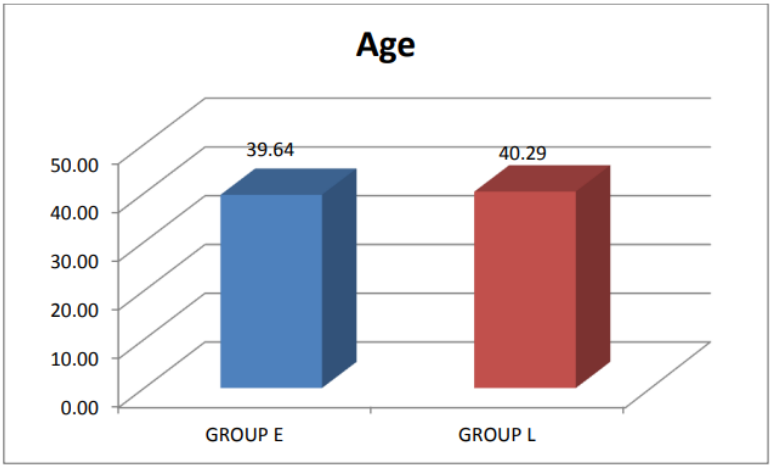

Figure 1: Distribution of Age (In Years) Among Two Groups

Table 2 presents the distribution of age (in years) between Group E and Group L. The majority of participants in both groups fell within the 31–40 years age range, with 23 (51.11%) in Group E and 26 (57.78%) in Group L, accounting for 54.44% of the total sample. Participants aged 41–50 years comprised 20 (44.44%) in Group E and 19 (42.22%) in Group L, representing 43.33% overall. Only 2 participants (4.44%) in Group E were aged 21–30 years, while there were none in Group L in this age category. The difference in age distribution between the two groups was not statistically significant ($p = 0.331$), indicating a comparable age profile across the study groups.

Table 2: Distribution of Age (In Years) Between Two Groups					
Age (years)	**Group E n (%)**	**Group L n (%)**	**Total n (%)**	**p-Value**	**Significance**
21–30	2 (4.44)	0 (0.00)	2 (2.22)	0.331	Not Significant
31–40	23 (51.11)	26 (57.78)	49 (54.44)		
41–50	20 (44.44)	19 (42.22)	39 (43.33)		
Total	45 (100.00)	45 (100.00)	90 (100.00)		

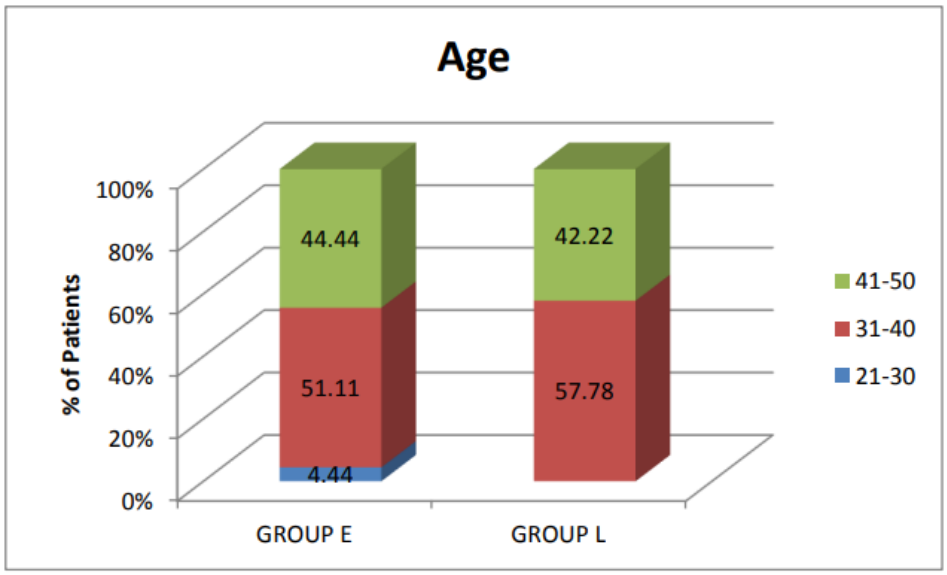

Figure 2: Distribution of Age (In Years) Between Two Groups

Table 3 compares the pulse rate (beats per minute) between the experimental (E) and control (L) groups at various perioperative time points. At baseline, both groups had similar mean pulse rates (E: 99.8 ± 9.8; L: 100.04 ± 13.59) with no significant difference ($p = 0.862$). However, after induction, the experimental group showed a significantly higher pulse rate (86.82 ± 9.75) than the control group (73.33 ± 8.08, $p < 0.001$). This trend of higher pulse rates in the experimental group persisted through intubation and at all measured intervals up to 15 minutes post-intubation, with mean values gradually decreasing in both groups over time. The differences at each subsequent time point—intubation, 1, 3, 5, 10, and 15 minutes—were all statistically significant ($p < 0.001$), indicating a consistent and significant elevation of pulse rate in the experimental group compared to the control group throughout the monitored period.

Table 3: Comparison of Pulse Rate (Beats Per Minute) Between Two Groups								
Time Point	**Mean (E)**	**Median (E)**	**SD (E)**	**Mean (L)**	**Median (L)**	**SD (L)**	**p-Value**	**Significance**
Baseline	99.8	98	9.8	100.04	97	13.59	0.862	Not Significant
After Induction	86.82	87	9.75	73.33	71	8.08	<0.001	Significant
At Intubation	96.27	96	9.43	85.36	83	7.58	<0.001	Significant
1 Minute	95.07	95	8.77	86.2	85	7.89	<0.001	Significant
3 Minutes	93.8	92	8.31	83.71	82	6.84	<0.001	Significant
5 Minutes	92.8	91	7.83	81.49	80	6.87	<0.001	Significant
10 Minutes	89.36	90	7.99	77.73	75	7.2	<0.001	Significant
15 Minutes	85.47	85	7.9	75.47	74	7.07	<0.001	Significant

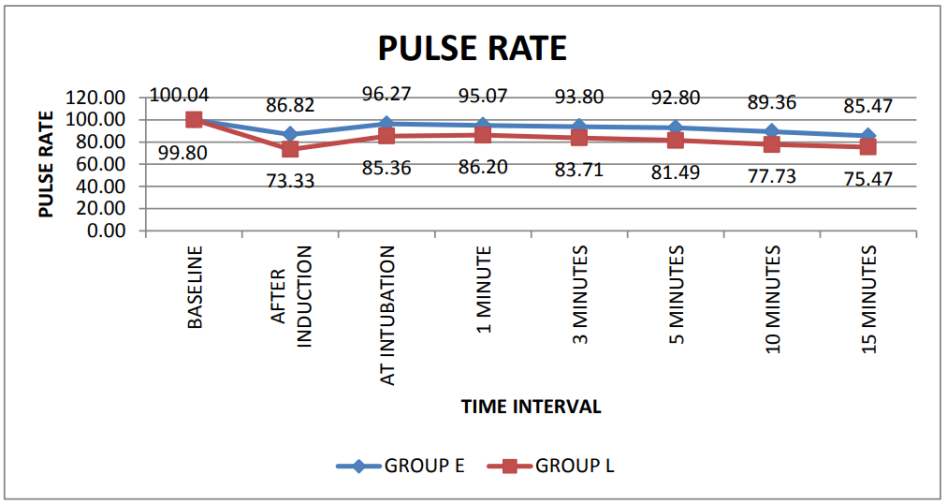

Figure 3: Comparison of" Pulse Rate (Beats Per Minute) Between Two Groups

Table 4 compares "the diastolic blood pressure (DBP, in mm Hg) between the experimental (E) and control (L) groups at various perioperative time points. At baseline, the mean DBP was similar between the groups (E: 77.84, L: 78.27; $p = 0.961$), indicating no significant difference. After induction, the DBP slightly decreased in both groups (E: 67.4, L: 66.02; $p = 0.254$), remaining statistically non-significant. However, during intubation and at 1 minute post-intubation, the experimental group showed a marked rise in DBP (E: 96.96 and 95.2 vs L: 80.07 and 79.13; $p < 0.001$), which was statistically significant. At 3 and 5 minutes, the DBP differences between groups were minimal and not significant ($p = 0.875$ and 0.518). Interestingly, at 10 and 15 minutes, the experimental group again demonstrated significantly higher DBP (E: 78.24 and 80 vs L: 66.02 and 64.02; $p < 0.001$), reflecting persistent hemodynamic differences at these later time points. Overall, significant DBP elevations in the experimental group occurred specifically at intubation, 1 minute, and 10–15 minutes post-procedure.

Table 4: Comparison of DBP (In Mm of Hg) Between Two Groups

Time Point	Group	Mean	Median	Std. Deviation	P-Value	Significance
DBP: Baseline	E	77.84	78	5.25	0.961	Not Significant
	L	78.27	76	8.68		
DBP After Induction	E	67.4	67	5.46	0.254	Not Significant
	L	66.02	65	7.24		
DBP at Intubation	E	96.96	98	4.71	<0.001	Significant
	L	80.07	78	6.65		
DBP: 1 Minute	E	95.2	95	5.16	<0.001	Significant
	L	79.13	78	6.66		
DBP: 3 Minutes	E	73.93	73	6.48	0.875	Not Significant
	L	74.13	74	6.62		
DBP: 5 Minutes	E	71.69	70	6.68	0.518	Not Significant
	L	71.02	70	6.67		
DBP: 10 Minutes	E	78.24	79	4.07	<0.001	Significant
	L	66.02	65	6.19		
DBP: 15 Minutes	E	80	80	3.43	<0.001	Significant
	L	64.02	63	6.44		

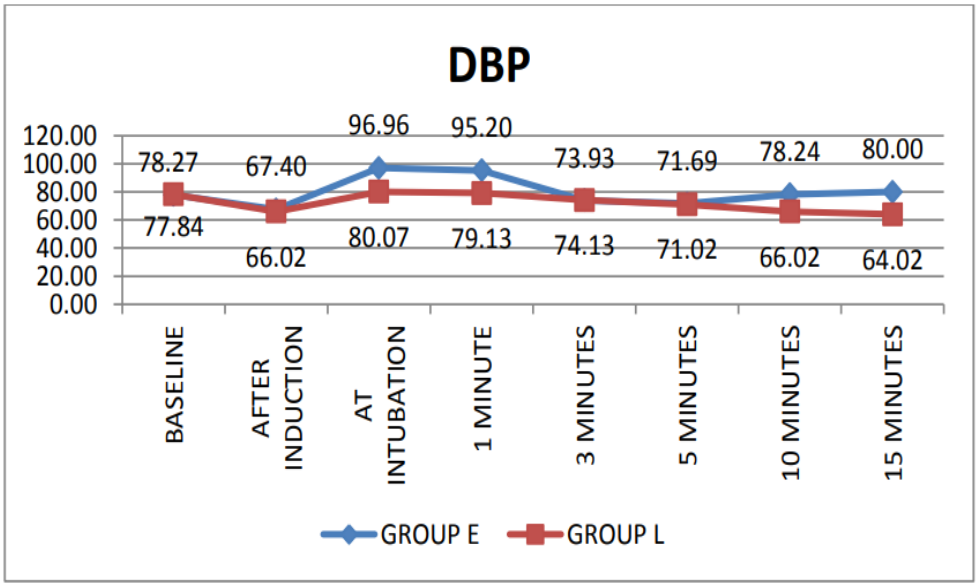

Figure 4: Comparison of DBP (In Mm of Hg) Between Two Groups

Table 5 presents the comparison of Rate Pressure Product (RPP) between Group E and Group L at various perioperative time points. At baseline, both groups had similar RPP values, with Group E showing a mean of 12,476.69 and Group L 12,378.29, and the difference was not statistically significant ($p = 0.513$). However, after induction, Group E exhibited a markedly higher RPP (mean 9,943.07) compared to Group L (mean 7,533.27), and this difference was statistically significant ($p < 0.001$). This trend of significantly higher RPP in Group E continued at intubation (13,388.64 vs. 10,657.4), 1 minute (13,125.11 vs. 10,554.33), 3 minutes (10,576.6 vs. 9,505.22), 5 minutes (10,109.96 vs. 8,913.27), 10 minutes (10,004.67 vs. 8,227.44), and 15 minutes (9,789.89 vs. 8,242.84), all showing p-values < 0.001. Overall, the data indicate that Group E consistently maintained significantly higher RPP than Group L throughout the intraoperative period following induction.

Table 5: Comparison of RPP Between Two Groups

RPP Measurement	Group E Mean	Group E Median	Group E Std. Deviation	Group L Mean	Group L Median	Group L Std. Deviation	p-Value	Significance
Baseline	12476.69	12152	1833.69	12378.29	11640	2795.79	0.513	Not Significant
After Induction	9943.07	9652	1638.6	7533.27	7100	1570.58	<0.001	Significant
At Intubation	13388.64	13152	2167.33	10657.4	10285	1684.49	<0.001	Significant
1 Minute	13125.11	12865	1827.48	10554.33	9996	1713.97	<0.001	Significant
3 Minutes	10576.6	10584	1119.8	9505.22	9130	1386.57	<0.001	Significant
5 Minutes	10109.96	10080	1124.48	8913.27	8400	1390.46	<0.001	Significant
10 Minutes	10004.67	9933	1408.14	8227.44	7725	1342.08	<0.001	Significant
15 Minutes	9789.89	9570	1361.7	8242.84	7696	1437.15	<0.001	Significant

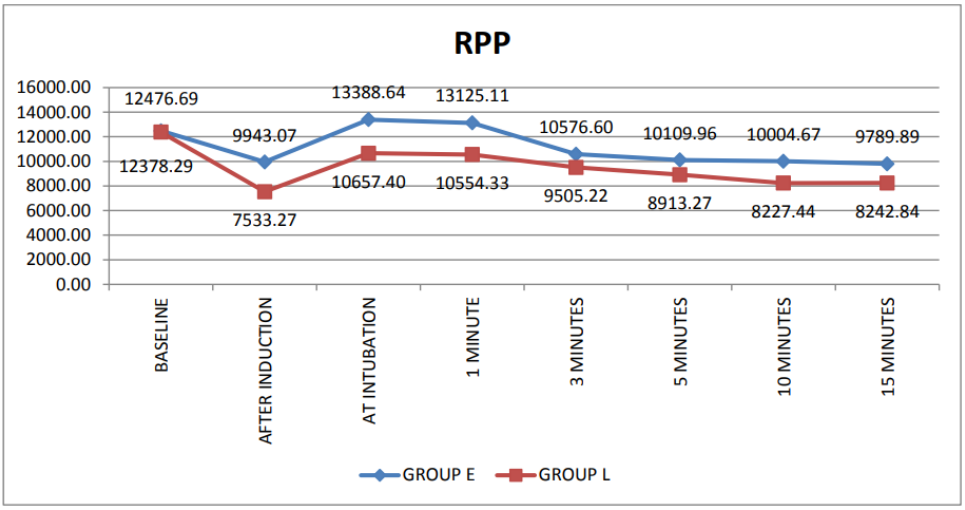

Figure 5: Comparison of" RPP Between Two Groups

Discussion

The study "results show that intravenous Labetalol at 0.25 mg/kg confers better hemodynamic control during laryngoscopy and tracheal intubation than intravenous Esmolol at 0.5 mg/kg. The two groups shared identical baseline characteristics which included age, so the differences in pulse rate and diastolic blood pressure and rate pressure product must have stemmed from the therapeutic treatments instead of demographic differences. The Esmolol group maintained elevated pulse rates throughout the entire study period both after induction and intubation, which resulted in statistically significant differences that lasted until 15 minutes after intubation. The Esmolol group experienced greater cardiovascular stress because their diastolic blood pressure and myocardial workload showed higher values according to rate pressure product measurements.

The results of the study show agreement with the research findings of Lakshmi and Sree (2014) [9], who conducted a comparison between intravenous Esmolol (1 mg/kg) and Labetalol (0.5 mg/kg), which established Labetalol as the more effective treatment for laryngoscopy and intubation-related pressor response reduction. The study results showed Labetalol (0.25 mg/kg) and Esmolol (0.5 mg/kg) at half their Labetalol dose, but the findings supported Lakshmi and Sree (2014) who showed Labetalol as the more effective treatment for hemodynamic control during peri-intubation. The studies found peak attenuation to occur after intubation, which demonstrated Labetalol's capacity to deliver both immediate and long-lasting cardiovascular stability.

Meftahuzzaman et al. (2014) [10] conducted a study which showed that Labetalol (0.25 mg/kg) provides superior control over reflex hemodynamic responses compared to Fentanyl (2 µg/kg) during intubation because it better regulates pulse rate and blood pressure. The present study results support the current study which showed that Labetalol effectively prevented diastolic blood pressure and pulse rate increases more than Esmolol which demonstrated the clinical importance of adrenergic blockade during stressful airway procedures. Singh et al. (2015) [11] described research results which showed that Labetalol provides superior hemodynamic management to Fentanyl during laryngoscopy among different patient groups.

The study revealed that Labetalol and Esmolol showed similar therapeutic results at 3 to 5 minutes after intubation. The blood pressure measurements which included systolic and diastolic values together with mean arterial pressure showed no significant differences between the two groups at these time points. The temporary matching of hemodynamic measurements happened because Labetalol was administered five minutes before intubation while Esmolol was given two minutes before which led to their pharmacokinetic profiles matching for a brief period (Singh SP et al., 2010) [12]. The short half-life of Esmolol which lasts about 9 minutes together with the extended effects of Labetalol explain why Labetalol provided better control of hemodynamic responses until15 minutes after intubation.

Kumar et al. (2016) [13] studied two different Labetalol doses (0.15 mg/kg and 0.3 mg/kg) for treating hypertension and found that patients showed different hemodynamic responses based on their predetermined dosage. The study used 0.25 mg/kg as its intermediate dose, which effectively decreased pulse rate and diastolic blood pressure and rate pressure product while demonstrating better performance than Esmolol. The research shows that even small Labetalol doses can produce meaningful hemodynamic effects, which supports the finding that El-Shmaa (2016) [14] showed Labetalol produced stronger blood pressure reduction than Lidocaine during" intubation.

Previous "research conducted by Figueredo and Garcia-Fuentes (2001) [15] and Ghause et al. (2002)

[16] demonstrated that Esmolol effectively reduces the sympathetic response during intubation yet its effects lasted for a shorter duration compared to Labetalol. The Esmolol group experienced elevated rate pressure product levels because the measurement showed ongoing cardiovascular stress. Labetalol demonstrated extended rate pressure product suppression which created a therapeutic benefit for patients who faced potential myocardial ischemia.

The unique contribution of our study lies in its demonstration of the specific time window (3–5 minutes post-intubation) during which Esmolol and Labetalol exhibit comparable efficacy. The results of this study support the findings of Singh SP et al. (2010) by demonstrating that Labetalol maintains better hemodynamic stability after this time period. The practical implication is that timing of administration is critical, and early administration of Labetalol ensures optimal attenuation of pressor responses during both intubation and the immediate postoperative period.

The study demonstrates that intravenous Labetalol provides better hemodynamic control during laryngoscopy and tracheal intubation than Esmolol based on existing research which shows this advantage at all dose levels. The study results reveal two findings: first, they establish the temporary period of equivalence, and second, they demonstrate that Labetalol maintains its effectiveness for more than five minutes following intubation. The research shows that Labetalol should be used primarily for patients who face high risk of extreme cardiovascular reactions because it provides safe anesthesia control during airway" procedures.

Conclusion

The research shows that intravenous Labetalol at 0.25 mg/kg provides better results than intravenous Esmolol at 0.5 mg/kg for reducing hemodynamic changes which occur during laryngoscopy and tracheal intubation. The study participants exhibited similar baseline characteristics which enabled researchers to attribute the observed differences in pulse rate and diastolic blood pressure and rate pressure product to the effects of their medications. Labetalol delivered better cardiovascular stress reduction results throughout the entire peri-intubation period by keeping his pulse rates and diastolic pressures and myocardial workload at lower levels while Esmolol produced effects that lasted for a shorter duration. The study found that both medications showed equivalent effectiveness during a 3-to-5-minute period because their effects depended on the timing and how the body processed them. Labetalol provides better hemodynamic control because it delivers extended hemodynamic stability, which makes it the better choice for secure anesthetic management during procedures that require airway control.

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