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Original Research Article

Comparative Study of Hemodynamic Responses to Propofol versus Etomidate during Induction of General Anaesthesia

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Abstract

Background: Induction of general anaesthesia is associated with significant hemodynamic alterations, including hypotension and tachycardia, which may adversely affect patient outcomes. Propofol, though widely used, is known for its cardiovascular depressant effects, whereas etomidate is considered to provide greater hemodynamic stability. This study was undertaken to compare the hemodynamic responses of these two agents during induction of general anaesthesia.

Aim: To compare the effects of propofol and etomidate on heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) during induction and following endotracheal intubation.

Materials and Methods: This prospective, randomized, comparative study included 100 patients (ASA I–II), aged 18–60 years, undergoing elective surgeries under general anaesthesia. Patients were randomly allocated into two groups: Group P (Propofol 2 mg/kg, n=50) and Group E (Etomidate 0.3 mg/kg, n=50). Hemodynamic parameters (HR, SBP, DBP, MAP) were recorded at baseline, post-induction, immediately after intubation, and at 1, 3, 5, and 10 minutes thereafter. Data were analyzed using Student's unpaired t-test and Chi-square test, with $p < 0.05$ considered statistically significant.

Results: Propofol induction resulted in a significant reduction in mean arterial pressure (13.6% decrease post-induction) compared to etomidate ($p < 0.05$). Heart rate increased significantly in the propofol group, with a 10.9% higher value at intubation compared to the etomidate group ($p = 0.001$). Etomidate demonstrated superior hemodynamic stability with minimal fluctuations in HR and MAP. The incidence of hypotension was significantly higher in Group P (28%) compared to Group E (10%) ($p = 0.02$). Myoclonus was observed only in the etomidate group (18%), whereas injection pain was more common with propofol (22%).

Conclusion: Etomidate provides significantly better hemodynamic stability than propofol during induction of general anaesthesia, with reduced incidence of hypotension and attenuated stress response to intubation. Despite a higher incidence of myoclonus, etomidate may be preferred in patients where cardiovascular stability is of paramount importance.

Keywords: Propofol, Etomidate, Hemodynamic Response, Mean Arterial Pressure, Induction, General Anaesthesia.

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Introduction

The induction of general anaesthesia is a critical phase characterized by significant physiological alterations, particularly in cardiovascular dynamics. The choice of induction agent plays a vital role in maintaining hemodynamic stability, especially in patients with limited cardiovascular reserve. Among the commonly used intravenous induction agents, propofol and etomidate have distinct pharmacodynamic profiles that influence their clinical use [1]. Propofol is one of the most widely used induction agents due to its rapid onset, short duration of action, and favorable recovery profile. It produces hypnosis by potentiating gamma-aminobutyric acid (GABA) receptor activity in the central nervous system [2]. However, propofol is associated with dose-dependent hypotension due to

systemic vasodilation, decreased myocardial contractility, and suppression of sympathetic activity [3]. These effects can be particularly detrimental in elderly patients, hypovolemic states, and those with compromised cardiac function [4].

Etomidate, on the other hand, is an imidazole derivative that provides rapid induction with minimal cardiovascular depression. It maintains hemodynamic stability by preserving sympathetic outflow and baroreceptor function [5]. Unlike propofol, etomidate has minimal effects on myocardial contractility and systemic vascular resistance, making it a preferred agent in high-risk patients [6]. However, its use is limited by side effects such as myoclonus and transient adrenal suppression [7].

Laryngoscopy and endotracheal intubation are additional stimuli that can provoke significant sympathetic responses, leading to tachycardia and hypertension. These responses may increase myocardial oxygen demand and precipitate adverse cardiac events in susceptible individuals [8]. Therefore, an ideal induction agent should not only provide adequate hypnosis but also attenuate the stress response associated with airway manipulation [9].

Several studies have compared the hemodynamic effects of propofol and etomidate, with most demonstrating superior cardiovascular stability with etomidate [10,11]. However, variations in study design, patient population, and outcome measures necessitate further research to establish definitive conclusions. In routine clinical practice, the choice between these agents is often influenced by patient characteristics, comorbidities, and the anticipated hemodynamic response [12].

Given the increasing emphasis on patient safety and individualized anaesthetic care, it is essential to evaluate the comparative efficacy and safety of commonly used induction agents. This study aims to assess and compare the hemodynamic responses to propofol and etomidate during induction of general anaesthesia in adult patients undergoing elective surgeries [13].

Materials and Methods

Study Design and Setting: This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology at a tertiary care hospital after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants.

Study Population: A total of 100 patients scheduled for elective surgeries under general anaesthesia were included in the study.

Inclusion Criteria:

- Age between 18–60 years
- ASA physical status I and II
- Patients undergoing elective surgical procedures under general anaesthesia

Exclusion Criteria:

- Known allergy to propofol or etomidate
- ASA III and IV patients
- Patients with significant cardiac, hepatic, renal, or endocrine disorders
- Pregnant or lactating women
- Patients on beta-blockers or antihypertensive drugs affecting hemodynamics

Sample Size: Based on previous studies and assuming a clinically significant difference in mean arterial pressure of 10 mmHg between groups, with 80% power and 5% alpha error, the calculated sample size was 45 patients per group. To account for potential dropouts, a total of 100 patients (50 per group) were included.

Randomization and Group Allocation:

Patients were randomly divided into two groups using a computer-generated randomization table:

- **Group P (n=50):** Received propofol 2 mg/kg
- **Group E (n=50):** Received etomidate 0.3 mg/kg

Preoperative Preparation: All patients were kept nil per oral for 6–8 hours prior to surgery. Standard monitoring (ECG, non-invasive blood pressure, pulse oximetry) was instituted upon arrival in the operating room. Baseline hemodynamic parameters were recorded.

Anaesthetic Technique:

All patients received premedication with:

- Glycopyrrolate 0.2 mg IV
- Midazolam 0.02 mg/kg IV
- Fentanyl 2 µg/kg IV

Preoxygenation was done with 100% oxygen for 3 minutes. Induction was carried out using the assigned study drug:

- Group P: Propofol 2 mg/kg IV
- Group E: Etomidate 0.3 mg/kg IV

After loss of consciousness, vecuronium 0.1 mg/kg IV was administered to facilitate endotracheal intubation. Laryngoscopy and intubation were performed after 3 minutes.

Data Collection: Hemodynamic parameters recorded:

- Heart rate (HR)
- Systolic blood pressure (SBP)
- Diastolic blood pressure (DBP)
- Mean arterial pressure (MAP)

Measurements were taken at:

- Baseline
- Post-induction
- Immediately after intubation
- 1, 3, 5, and 10 minutes after intubation

Outcome Measures:

- Primary: Changes in MAP
- Secondary: Changes in HR, SBP, DBP

Statistical Analysis: Data were analyzed using SPSS software. Continuous variables were expressed as mean ± standard deviation. Intergroup comparisons were performed using Student's unpaired t-test, while categorical variables were analyzed using the Chi-square test. A p-value < 0.05 was considered statistically significant.

Results

A total of 100 patients were enrolled and completed the study. They were randomly allocated into two equal groups: Group P (Propofol, n=50) and Group E (Etomidate, n=50). All patients were included in the final analysis.

Baseline Characteristics: Both groups were comparable with respect to demographic variables such as age, gender distribution, body weight, and ASA physical status. There were no statistically significant differences between the groups (p > 0.05), confirming homogeneity and minimizing confounding bias.

Table 1: Comparison of Heart Rate (beats per minute)

Time Interval	Group P (Mean ± SD)	Group E (Mean ± SD)	% Change (P vs E)	p-value
Baseline	82 ± 8	81 ± 7	+1.2%	0.52
Post-induction	88 ± 9	83 ± 8	↑ 6.0% higher in P	0.03*
Intubation	102 ± 10	92 ± 9	↑ 10.9% higher in P	0.001*
1 min	98 ± 9	89 ± 8	↑ 10.1% higher in P	0.002*
3 min	94 ± 8	87 ± 7	↑ 8.0% higher in P	0.01*
5 min	90 ± 7	85 ± 6	↑ 5.9% higher in P	0.04*
10 min	85 ± 6	83 ± 6	↑ 2.4% higher in P	0.18

***Statistically significant**

- Heart rate increased in both groups following induction and intubation.
- Group P exhibited a 10.9% higher heart rate at intubation compared to Group E (p = 0.001).
- Significant differences persisted up to 5 minutes, after which values converged.
- Etomidate demonstrated better attenuation of tachycardic response.

Table 2: Comparison of Mean Arterial Pressure (mmHg)

Time Interval	Group P (Mean ± SD)	Group E (Mean ± SD)	% Change (P vs E)	p-value
Baseline	94 ± 6	95 ± 5	-1.0%	0.40
Post-induction	76 ± 7	88 ± 6	↓ 13.6% lower in P	0.001*
Intubation	82 ± 8	92 ± 7	↓ 10.9% lower in P	0.002*
1 min	80 ± 7	90 ± 6	↓ 11.1% lower in P	0.001*
3 min	84 ± 6	91 ± 6	↓ 7.7% lower in P	0.01*
5 min	88 ± 5	92 ± 5	↓ 4.3% lower in P	0.04*
10 min	92 ± 5	94 ± 5	↓ 2.1% lower in P	0.22

***Statistically significant**

- Propofol caused a marked reduction in MAP (13.6%) post-induction, which was highly significant.
- Etomidate maintained near-baseline MAP with minimal reduction.
- Significant differences persisted up to 5 minutes.
- Indicates superior hemodynamic stability with etomidate.

Table 3: Incidence of Hypotension and Adverse Effects

Parameter	Group P (%)	Group E (%)	% Difference	p-value
Hypotension	14 (28%)	5 (10%)	↑ 18% in P	0.02*
Bradycardia	6 (12%)	4 (8%)	↑ 4% in P	0.51
Myoclonus	0 (0%)	9 (18%)	↑ 18% in E	0.001*
Injection pain	11 (22%)	2 (4%)	↑ 18% in P	0.004*

***Statistically significant**

- Hypotension was 18% more frequent in Group P (p = 0.02).
- Myoclonus was seen exclusively with etomidate (18%, p = 0.001).

- Injection pain was significantly higher with propofol.
- Overall, etomidate had better cardiovascular stability, while propofol had fewer neuromuscular side effects.

Discussion

The present study was designed to compare the hemodynamic responses to propofol and etomidate during induction of general anaesthesia. The findings clearly demonstrate that etomidate provides superior cardiovascular stability compared to propofol, particularly during the critical phases of induction and intubation.

Hemodynamic stability during induction is essential to prevent adverse cardiovascular events, especially in patients with limited physiological reserve. Propofol, despite its favorable pharmacokinetic profile, is known to cause significant hypotension due to systemic vasodilation and myocardial depression [2]. This was evident in our study, where mean arterial pressure decreased by approximately 13.6% immediately after induction in the propofol group. Similar findings have been reported by multiple investigators, who observed a reduction in blood pressure ranging from 15–30% following propofol administration [4].

In contrast, etomidate demonstrated remarkable hemodynamic stability, with minimal changes in mean arterial pressure. This can be attributed to its unique mechanism of action, which preserves sympathetic tone and maintains baroreceptor reflexes. Previous studies have consistently shown that etomidate causes minimal cardiovascular depression, making it an ideal induction agent in high-risk patients [7]. Our findings align with those of Kumar A et al., who reported significantly lesser reductions in blood pressure with etomidate compared to propofol [8].

The heart rate response observed in our study further supports the hemodynamic advantages of etomidate. Patients receiving propofol exhibited a significantly higher increase in heart rate during intubation (10.9% higher than etomidate group). This exaggerated tachycardic response may be a compensatory mechanism for the hypotension induced by propofol. In contrast, etomidate attenuated the sympathetic response to laryngoscopy more effectively, resulting in a more stable heart rate profile. Similar observations have been documented in studies by Ebert TJ et al. and Fragen RJ et al. [10,11]. Laryngoscopy and intubation are known to trigger a surge in catecholamine release, leading to transient hypertension and tachycardia. An ideal induction agent should blunt this response without causing significant hypotension. In our study, etomidate was more effective in maintaining a balance between these opposing effects. Although both groups exhibited hemodynamic fluctuations during intubation, the magnitude was significantly lower in the etomidate group [12].

The incidence of hypotension was significantly higher in the propofol group (28%) compared to the etomidate group (10%). This finding is clinically relevant, as intraoperative hypotension is associated with increased risk of organ hypoperfusion and postoperative complications [13]. The reduced incidence of hypotension with etomidate reinforces its role as a safer alternative in patients where hemodynamic stability is paramount.

However, etomidate is not without drawbacks. In our study, myoclonus was observed in 18% of patients receiving etomidate, which is consistent with previous reports [14]. Myoclonus, although transient and self-limiting, can be distressing and may interfere with monitoring. Propofol, on the other hand, was associated with a higher incidence of injection pain (22%), a well-documented side effect attributed to its formulation [15].

Bradycardia incidence was comparable between the groups, suggesting that both agents have minimal direct effect on vagal tone. The overall safety profile of both drugs was acceptable, with no serious adverse events reported.

The findings of this study have important clinical implications. While propofol remains a popular induction agent due to its rapid onset and smooth recovery, its hemodynamic effects limit its use in certain patient populations. Etomidate, with its superior cardiovascular stability, is particularly advantageous in elderly patients, those with cardiac disease, or patients with hemodynamic instability.

Nevertheless, the choice of induction agent should be individualized based on patient characteristics, surgical requirements, and clinician expertise. The benefits of etomidate must be weighed against its potential side effects, including myoclonus and adrenal suppression, although the latter is usually transient and clinically insignificant after a single induction dose [16].

Conclusion

Etomidate provides significantly better hemodynamic stability compared to propofol during induction of general anaesthesia. While propofol is associated with hypotension and tachycardia, etomidate maintains near-baseline cardiovascular parameters. However, etomidate is associated with a higher incidence of myoclonus. Therefore, etomidate may be preferred in patients where cardiovascular stability is crucial.

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