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COMPARISON OF PROPOFOL AND KETAMINE ON HEMODYNAMIC STABILITY DURING INDUCTION OF GENERAL ANESTHESIA: A PROSPECTIVE COMPARATIVE OBSERVATIONAL STUDY

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Abstract

Background: *Hemodynamic stability during induction of general anesthesia is a critical determinant of perioperative safety. The choice of induction agent significantly influences cardiovascular parameters including heart rate and blood pressure. Propofol and Ketamine represent two pharmacologically distinct induction agents with opposing hemodynamic profiles, yet comprehensive comparative data from resource-limited clinical settings remain limited.*

Objective: *To compare the hemodynamic effects of Propofol and Ketamine on heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) during induction of general anesthesia and following endotracheal intubation in patients undergoing elective surgical procedures.*

Methods: *A prospective comparative observational study was conducted at PHQ Teaching Hospital Gilgit from March 2026 to July 2026. A total of 120 patients undergoing elective surgery under general anesthesia were enrolled and divided into two groups: Group P (Propofol 2 mg/kg IV, n=63) and Group K (Ketamine 2 mg/kg IV, n=57). Hemodynamic parameters including HR, SBP, and DBP were recorded at baseline, after induction, and after endotracheal intubation. Data were analyzed using SPSS v25.0, employing Chi-square tests and independent samples t-tests, with $p \leq 0.05$ considered statistically significant.*

Results: *Baseline demographic and clinical characteristics including age ($p=0.299$), gender ($p=0.632$), and ASA classification ($p=0.570$) were comparable between groups. Following induction, the Propofol group demonstrated significantly lower heart rates (61–70 bpm: 60.3%) compared to the Ketamine group (81–90 bpm: 43.9%; 91–100 bpm: 36.8%) ($\chi^2=64.934$, $p<0.001$). After intubation, Ketamine recipients showed markedly elevated HR (91–110 bpm: 70.2% vs. 7.9% in Propofol, $\chi^2=66.363$, $p=0.001$). Post-induction SBP was significantly higher in the*

Ketamine group (131–150 mmHg: 38.6%) compared to Propofol (90–110 mmHg: 44.4%) (χ^2=39.437, p=0.001). Post-intubation DBP was also markedly elevated in the Ketamine group (81–120 mmHg: 91.2%) versus Propofol (41.3%) (χ^2=37.941, p=0.001).

Conclusion: *Propofol provided significantly superior hemodynamic stability during induction of general anesthesia and endotracheal intubation compared to Ketamine. Ketamine's sympathomimetic properties resulted in clinically significant elevations in heart rate and blood pressure, particularly following intubation. Propofol should be considered the preferred induction agent when hemodynamic stability is a primary clinical concern, while Ketamine may be reserved for patients with pre-existing cardiovascular depression or hemodynamic instability.*

INTRODUCTION

General anesthesia is an indispensable component of modern surgical practice, enabling complex operative procedures while ensuring patient comfort and unconsciousness. The induction phase — the transition from the conscious to the anesthetized state — represents one of the most hemodynamically critical periods of the perioperative continuum. During this phase, the interplay between the pharmacological actions of induction agents, the physiological response to laryngoscopy and endotracheal intubation, and the patient's baseline cardiovascular reserve can produce profound hemodynamic perturbations. Maintaining cardiovascular stability during induction is therefore a primary objective of modern anesthetic management.[1,2]

Intravenous induction agents are favored in contemporary anesthesia practice for their rapid onset, predictable pharmacokinetics, and ease of titration. Among the most widely used are Propofol and Ketamine, two pharmacologically distinct agents that exert opposing effects on the cardiovascular system. Propofol, a short-acting phenolic compound, acts primarily through potentiation of $GABA_2$ receptors in the central nervous system. It is highly lipophilic, crosses the blood-brain barrier rapidly, and produces smooth, reliable induction with rapid recovery. These properties have established Propofol as the most commonly used induction agent worldwide. However, its well-documented vasodilatory and negative inotropic effects can produce clinically significant reductions in blood pressure, particularly in elderly patients, hypovolemic individuals, and those with pre-existing cardiovascular compromise.[3,4]

Ketamine, a phencyclidine derivative, produces dissociative anesthesia through antagonism of N-Methyl-D-aspartate (NMDA) receptors. Unlike most induction agents, Ketamine exerts a sympathomimetic effect through stimulation of the central sympathetic nervous system and inhibition of catecholamine reuptake, resulting in increases in heart rate, blood pressure, and cardiac output via endogenous catecholamine release. These cardiovascular-stimulating properties make Ketamine particularly advantageous in hemodynamically unstable patients, including those in trauma, hypovolemia, or sepsis. Additionally, Ketamine preserves airway reflexes and spontaneous respiration, offering further safety advantages in certain clinical contexts. However, its sympathomimetic effects may be deleterious in patients with hypertension, ischemic heart disease, or conditions where elevated heart rate and blood pressure increase myocardial oxygen demand.[5,6]

The laryngoscopy-intubation sequence provokes a profound sympathoadrenal response characterized by sharp increases in heart rate and arterial blood pressure, potentially elevating myocardial oxygen consumption and predisposing susceptible patients to myocardial ischemia, arrhythmias, or cerebrovascular complications. The choice of induction agent critically modulates the magnitude of this pressor response. Propofol's cardiovascular depressant effects may attenuate the intubation response, albeit at the risk of pre-induction hypotension. Conversely, Ketamine's

sympathomimetic activity may maintain blood pressure but potentially exacerbate the cardiovascular response to airway manipulation.[78] Despite the extensive use of both agents and a growing body of comparative literature, conflicting evidence persists regarding which induction agent provides optimal hemodynamic profiles in different patient populations. Variations in study design, dosage protocols, patient demographics, surgical contexts, and monitoring methodologies have contributed to inconsistent conclusions. Moreover, comparative data from resource-constrained healthcare settings in South Asia, where patient demographics and clinical contexts may differ substantially from those in high-income countries, remain limited. This prospective comparative observational study was therefore conducted to provide locally relevant, clinically applicable evidence comparing the hemodynamic effects of Propofol and Ketamine during induction of general anesthesia at a tertiary care facility in Gilgit, Pakistan.

METHODOLOGY

A prospective comparative observational study was conducted at the PHQ Teaching Hospital Gilgit, Khyber Pakhtunkhwa, Pakistan, from March 2026 to July 2026. Ethical approval was obtained from the Departmental Research/Ethical Committee of the University of Haripur prior to commencement of data collection. All participants provided written informed consent prior to enrollment in the study. A total of 120 patients undergoing elective surgery under general anesthesia were enrolled and allocated into two study groups based on the induction agent administered: Group P (Propofol 2 mg/kg IV, n=63) and Group K (Ketamine 2 mg/kg IV, n=57). Patients aged 18–70 years undergoing elective surgery under general anesthesia, ASA physical status I, II, or III, Patients providing written informed consent were included and Known significant cardiovascular disease or uncontrolled hypertension, Severe hepatic or renal disease, Pregnant or lactating females, ASA physical status IV, Known allergy to Propofol or Ketamine.

All patients were maintained nil per oral (NPO) for a minimum of 6–8 hours prior to surgery. Standard intraoperative monitoring was applied prior to induction, including continuous electrocardiography (ECG), pulse oximetry (SpO_2), and non-invasive blood pressure monitoring (NIBP). Patients received their assigned induction agent intravenously: Group P received Propofol 2 mg/kg and Group K received Ketamine 2 mg/kg. Following induction, endotracheal intubation was performed according to standard anesthetic practice by an experienced anesthesiologist. Data were collected using a predesigned, validated structured proforma. Demographic variables including age, gender, weight, and ASA physical status were recorded for all participants. Hemodynamic parameters — heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and oxygen saturation (SpO_2) — were recorded at three time points: (i) baseline before induction, (ii) after induction of anesthesia, and (iii) after endotracheal intubation. All collected data were entered and analyzed using SPSS version 25.0. Quantitative variables were expressed as mean ± standard deviation (SD). Qualitative variables including gender and ASA status were expressed as frequencies and percentages. The independent samples t-test was used to compare continuous hemodynamic parameters between groups. The Pearson Chi-square test was applied for categorical variable comparisons. A p-value of ≤0.05 was considered statistically significant.

RESULTS

A total of 120 patients were included in the final analysis: 63 in the Propofol group and 57 in the Ketamine group. Baseline demographic and clinical characteristics were comparable between both groups, confirming successful group allocation.

Table 1: Baseline Demographic and Clinical Characteristics (n=120)

Variable	Category	Propofol n(%) n=63	Ketamine n(%) n=57	Total n(%) n=120	χ^2	p-value
Age Group (Years)	18–30	21 (33.3)	18 (31.6)	39 (32.5)	3.677	0.299 NS
	31–40	20 (31.7)	11 (19.3)	31 (25.8)		
	41–50	9 (14.3)	14 (24.6)	23 (19.2)		
	51–60	13 (20.6)	14 (24.6)	27 (22.5)		
Gender	Male	37 (58.7)	31 (54.4)	68 (56.7)	0.230	0.632 NS
	Female	26 (41.3)	26 (45.6)	52 (43.3)		
ASA Class	I	8 (12.7)	9 (15.8)	17 (14.2)	1.125	0.570 NS
	II	43 (68.3)	41 (71.9)	84 (70.0)		
	III	12 (19.0)	7 (12.3)	19 (15.8)		

NS = Not Significant ($p > 0.05$). Groups were well-matched at baseline with no statistically significant differences in age, gender, or ASA classification.

Table 2: Comparison of Heart Rate (HR) After Induction and After Intubation Between Groups (n=120)

Variable	Category (bpm)	Propofol n(%) n=63	Ketamine n(%) n=57	χ^2	p-value
HR After Induction	50–60	1 (1.6)	0 (0.0)	64.934	<0.001 **
	61–70	38 (60.3)	0 (0.0)		
	71–80	14 (22.2)	11 (19.3)		
	81–90	9 (14.3)	25 (43.9)		
	91–100	1 (1.6)	21 (36.8)		
HR After Intubation	60–70	12 (19.0)	0 (0.0)	66.363	0.001 **
	71–80	29 (46.0)	1 (1.8)		
	81–90	17 (27.0)	16 (28.1)		
	91–100	5 (7.9)	25 (43.9)		
	101–110	0 (0.0)	15 (26.3)		

*** Highly Significant ($p \leq 0.001$). bpm = beats per minute. Propofol maintained significantly lower heart rates at both time points compared to Ketamine.*

Table 3: Comparison of Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) Between Groups (n=120)

Variable	Category (mmHg)	Propofol n(%) n=63	Ketamine n(%) n=57	χ^2	p-value
SBP After Induction	90–110	28 (44.4)	1 (1.8)	39.437	0.001 **
	111–130	32 (50.8)	34 (59.6)		
	131–150	3 (4.8)	22 (38.6)		
SBP After Intubation	100–120	21 (33.3)	0 (0.0)	40.009	0.001 **
	121–140	38 (60.3)	29 (50.9)		
	141–161	4 (6.3)	28 (49.1)		
DBP After Induction	55–80	48 (76.2)	29 (50.9)	8.339	0.004 *
	81–100	15 (23.8)	28 (49.1)		
DBP After Intubation	60–80	37 (58.7)	5 (8.8)	37.941	0.001 **
	81–100	26 (41.3)	42 (73.7)		
	101–120	0 (0.0)	10 (17.5)		

** Significant ($p<0.05$); ** Highly Significant ($p\leq0.001$). SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure. Ketamine was associated with consistently higher blood pressure values at both post-induction and post-intubation time points.*

The Propofol group demonstrated clearly superior hemodynamic stability across all measured parameters. Following induction, 60.3% of Propofol patients maintained heart rates in the 61–70 bpm range, while 80.7% of Ketamine patients had heart rates exceeding 80 bpm. After intubation, 70.2% of Ketamine recipients had heart rates above 91 bpm compared to only 7.9% in the Propofol group, a highly statistically significant difference (χ^2=66.363, p=0.001). Post-induction SBP of 131–150 mmHg was recorded in 38.6% of Ketamine patients compared to only 4.8% of Propofol patients. After intubation, 49.1% of the Ketamine group had SBP in the 141–161 mmHg range, versus only 6.3% in the Propofol group. These findings collectively confirm that Propofol maintained hemodynamic parameters within clinically acceptable ranges, while Ketamine produced consistent and significant cardiovascular stimulation throughout the induction and intubation sequence.

DISCUSSION

This prospective comparative observational study evaluated the hemodynamic effects of Propofol and Ketamine during induction of general anesthesia and endotracheal intubation in 120 adult surgical patients at a tertiary care hospital in Gilgit, Pakistan. The principal finding was that Propofol provided significantly superior hemodynamic stability compared to Ketamine across all measured cardiovascular parameters, including heart rate, systolic blood pressure, and diastolic blood pressure, following both induction and intubation.

The two groups were well-matched at baseline, with no statistically significant differences in age (p=0.299), gender (p=0.632), or ASA physical status (p=0.570), thereby ensuring that observed hemodynamic differences could be attributed to the pharmacological properties of the induction agents rather than pre-existing patient characteristics. This confirms the internal validity of the comparative analysis.

The heart rate findings in the present study are consistent with the established pharmacological profiles of both agents. Propofol inhibits the baroreceptor reflex and reduces sympathetic tone, resulting in a modest decrease in heart rate, particularly during the period immediately following induction. In contrast, Ketamine stimulates the central sympathetic nervous system and inhibits catecholamine reuptake, producing a well-recognized increase in heart rate. Our finding that 60.3% of Propofol patients maintained heart rates in the 61–70 bpm range post-induction, compared to the marked tachycardia observed in the Ketamine group (80.7% exceeding 80 bpm), aligns with the findings of Hossain et al. (2025), who similarly demonstrated that Ketamine induction was associated with significantly greater heart rate elevation compared to Propofol during general anesthesia.[12]

The significantly higher post-intubation heart rates in the Ketamine group (70.2% of patients exceeding 91 bpm) compared to the Propofol group (7.9%) reflect Ketamine's propensity to potentiate rather than attenuate the sympathoadrenal response to laryngoscopy and intubation. This finding is consistent with multiple prior comparative studies. Smischney et al. (2012) demonstrated in a randomized controlled trial that Ketamine-containing regimens were associated with improved blood pressure stability but noted the risk of tachycardia with higher-dose Ketamine protocols.[11] Similarly, Gandhi (2024), in a retrospective observational study at Gandhi Surgical Hospital, India, found that both Propofol and Ketofol maintained adequate hemodynamic stability, but noted that Ketamine's cardiovascular stimulant properties required careful monitoring, particularly during airway manipulation.[13]

The blood pressure findings further underscore the hemodynamic divergence between the two agents. Post-induction SBP values in the 131–150 mmHg range were observed in 38.6% of Ketamine patients but only 4.8% of Propofol patients (χ^2=39.437, p=0.001). After intubation, nearly half (49.1%) of the Ketamine group had SBP values between 141 and 161 mmHg, compared to only 6.3% of the Propofol group. These findings are pharmacologically coherent: Propofol's vasodilatory mechanism reduces systemic vascular resistance and cardiac output, resulting in moderate blood pressure reduction, while Ketamine's sympathomimetic action elevates blood pressure through catecholamine-mediated vasoconstriction and positive chronotropy. Gupta et al. (2024) corroborated these findings in a randomized trial comparing hemodynamic responses to laryngoscopy with different induction agents, concluding that Propofol-based induction provided a more attenuated pressor response than Ketamine-based protocols.[2]

The diastolic blood pressure results similarly favored Propofol. After intubation, 73.7% of Ketamine recipients had DBP values between 81–100 mmHg and an additional 17.5% exceeded 101 mmHg, compared to only 41.3% of Propofol patients exceeding 80 mmHg and none exceeding 100 mmHg (χ^2=37.941, p=0.001). These elevated diastolic pressures in the Ketamine group reflect increased peripheral vascular resistance secondary to catecholamine release, which, while hemodynamically stabilizing in hypovolemic patients, may represent a significant risk in patients with underlying cardiovascular disease, ischemic heart disease, or pre-existing hypertension.

A systematic review and meta-analysis by Loughnan et al. (2026), evaluating ketamine versus alternate agents during emergency tracheal intubation in critically ill adults, found that ketamine was associated with a higher risk of post-induction hemodynamic instability compared to etomidate, though it outperformed midazolam-sufentanil combinations. These findings, taken together with the present study, suggest that while Ketamine may be advantageous in specific hemodynamically unstable contexts, its routine

use in elective surgical patients with intact cardiovascular reserve may produce unnecessary cardiovascular stress.[14]

It is important to acknowledge that Ketamine's sympathomimetic properties can be clinically beneficial in patients with pre-existing hemodynamic instability, hypovolemia, or cardiovascular depression. In such patients, Propofol's vasodilatory effects may precipitate dangerous hypotension. The clinical utility of a "Ketofol" combination — mixing Propofol and Ketamine — has been explored as a strategy to balance the opposing hemodynamic effects of both agents, with several studies demonstrating improved cardiovascular stability compared to either agent alone.[1113] Future research exploring optimal Propofol-Ketamine dosing ratios in the local patient population may provide additional clinically actionable data.

The present study has several limitations warranting acknowledgment. As a single-center observational study, the findings may not be fully generalizable to other clinical settings with different patient demographics or anesthetic practices. The relatively small sample size may have limited the ability to detect differences in less frequent outcomes. Continuous invasive arterial pressure monitoring, which would have provided more precise hemodynamic measurements, was not employed. The study did not include a Ketofol group, limiting comparative analysis of combination regimens. Additionally, the observational nature of the study, with group allocation based on clinical practice rather than randomization, may introduce selection bias. Future multicenter randomized controlled trials with larger sample sizes, more comprehensive hemodynamic monitoring, and extended perioperative follow-up are warranted to confirm these findings.

CONCLUSION

This prospective comparative observational study demonstrates that Propofol provides significantly superior hemodynamic stability during induction of general anesthesia and endotracheal intubation compared to Ketamine in patients undergoing elective surgical procedures. Propofol maintained heart rate, systolic blood pressure, and diastolic blood pressure within clinically acceptable ranges throughout the induction and intubation sequence. Ketamine, by contrast, produced consistent and statistically significant elevations in all measured cardiovascular parameters, reflecting its well-established sympathomimetic mechanism of action. These cardiovascular stimulant effects, while potentially beneficial in hemodynamically depressed patients, represent a clinical liability in elective surgical patients with intact cardiovascular function, particularly those with pre-existing hypertension, ischemic heart disease, or conditions where elevated myocardial oxygen demand is undesirable. Propofol should therefore be considered the preferred induction agent when hemodynamic stability is a primary perioperative concern. Ketamine remains a valuable alternative in hemodynamically unstable patients, trauma cases, or patients at risk of Propofol-induced hypotension. The individualization of induction agent selection based on patient clinical status and cardiovascular risk profile remains the cornerstone of safe anesthetic practice. Multicenter randomized trials are recommended to further validate these findings across diverse patient populations.

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