RESEARCH PAPER

A Cross-Sectional Study on Comparing the Effects Between Two Techniques Propofol - Ketamine and Dexmedetomidine-Ketamine in Total Intravenous Anesthesia (TIVA)

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ABSTRACT

Background

Total intravenous anesthesia (TIVA) is widely used for surgical procedures due to its favorable pharmacokinetic profile and rapid recovery characteristics. Optimizing anesthetic drug combinations is essential to achieve hemodynamic stability and effective analgesia.

Methods

A hospital-based cross-sectional comparative study was conducted among 100 adult patients undergoing elective surgical procedures under TIVA. Patients were divided into two groups: Group PK (propofol–ketamine) and Group DK (dexmedetomidine–ketamine), with 50 patients in each group. Hemodynamic parameters including heart rate, systolic blood pressure, and diastolic blood pressure were recorded at predefined intervals. Postoperative pain was assessed using the Visual Analogue Scale (VAS). Statistical analysis was performed using independent t-test and chi-square test, with $p<0.05$ considered significant.

Results

Baseline characteristics were comparable between the two groups. The mean heart rate was significantly lower in Group DK compared to Group PK at all time intervals ($p<0.05$). Similarly, systolic and diastolic blood pressures were significantly reduced in the dexmedetomidine group, indicating better hemodynamic stability. The mean VAS score was significantly lower in Group DK (0.32 ± 0.58) compared to Group PK (0.94 ± 0.99) ($p=0.0002$), demonstrating superior analgesic efficacy.

Conclusion

Dexmedetomidine–ketamine provides better hemodynamic stability and analgesia compared to propofol–ketamine in TIVA. It represents an effective and safer alternative for anesthetic management in elective surgical procedures.

Keywords: Total Intravenous Anesthesia; Dexmedetomidine; Ketamine; Propofol; Hemodynamic Stability; Analgesia; Visual Analogue Scale; Procedural Sedation

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INTRODUCTION

Total intravenous anesthesia (TIVA) has emerged as a preferred anesthetic technique in modern perioperative practice due to its predictable pharmacokinetics, rapid recovery profile, and reduced postoperative complications compared to inhalational anesthesia [1]. The growing demand for minimally invasive and short-duration surgical procedures has further emphasized the need for anesthetic regimens that provide optimal hemodynamic stability, adequate analgesia, and minimal adverse effects. In this context, the combination of anesthetic agents has gained significant attention to achieve balanced anesthesia while minimizing drug-related complications.

Propofol, a widely used intravenous anesthetic, is known for its rapid onset and short duration of action, making it suitable for TIVA. However, it is associated with dose-dependent hypotension and respiratory depression [2]. Ketamine, on the other hand, provides potent analgesia and maintains cardiovascular stability due to its sympathomimetic effects, but its use is limited by psychomimetic side effects and increased

secretions [3]. The combination of propofol and ketamine (PK) has been extensively studied to offset the disadvantages of each drug, with propofol reducing ketamine-induced emergence reactions and ketamine counteracting propofol-induced hypotension [3,4].

Dexmedetomidine, a highly selective α2-adrenergic agonist, has gained popularity as an adjunct in TIVA due to its sedative, analgesic, and sympatholytic properties without causing significant respiratory depression [5]. Its ability to attenuate stress responses and maintain hemodynamic stability makes it an attractive alternative to traditional anesthetic combinations. When combined with ketamine (DK), dexmedetomidine enhances analgesia while mitigating ketamine-induced tachycardia and hypertension, resulting in a more stable intraoperative profile [6,7].

Globally, anesthesia-related complications continue to be a significant contributor to perioperative morbidity, particularly in resource-limited settings. Hemodynamic instability, inadequate analgesia, and delayed recovery remain common concerns associated with anesthetic techniques [8]. The World Health Organization has emphasized the importance of safe anesthesia practices, especially in developing countries where surgical volume is increasing rapidly. In India, the burden of surgical procedures is rising due to demographic transitions and increased access to healthcare, thereby necessitating safer and more effective anesthetic protocols [9].

Several randomized controlled trials have compared dexmedetomidine–ketamine and propofol–ketamine combinations in various clinical settings. Mercanoglu et al. demonstrated that dexmedetomidine-based TIVA provides superior hemodynamic stability and reduced perioperative stress response compared to other combinations [1]. Similarly, Kakarla et al. reported significantly better sedation quality and lower heart rate and blood pressure fluctuations in patients receiving dexmedetomidine–ketamine compared to propofol–ketamine [2]. Esmaillian et al. also found that dexmedetomidine combinations resulted in improved procedural conditions and reduced analgesic requirements [4].

Evidence from procedural sedation studies further supports the advantages of dexmedetomidine–ketamine combinations. Grégoire et al. observed enhanced analgesia and reduced requirement for additional sedatives with dexmedetomidine-based regimens [5]. Goyal et al. reported improved safety profiles and hemodynamic stability in patients undergoing endoscopic procedures with dexmedetomidine–ketamine compared to propofol-based combinations [6]. Pediatric studies have also demonstrated similar findings, with dexmedetomidine providing smoother sedation and better cardiovascular stability [7].

Pharmacologically, the synergistic interaction between dexmedetomidine and ketamine plays a crucial role in achieving balanced anesthesia. Dexmedetomidine reduces sympathetic outflow, leading to decreased heart rate and blood pressure, while ketamine maintains cardiovascular tone through catecholamine release [10–12]. This complementary mechanism results in improved hemodynamic control without significant respiratory compromise. Additionally, dexmedetomidine has been shown to possess opioid-sparing effects, thereby reducing postoperative pain and analgesic requirements [13].

Despite the growing body of evidence, there remains a lack of consensus regarding the optimal anesthetic combination for TIVA, particularly in terms of balancing hemodynamic stability and analgesic efficacy. Earlier studies comparing propofol–ketamine combinations have shown satisfactory results but with limitations related to cardiovascular fluctuations and variable analgesic outcomes [14]. More recent studies suggest that dexmedetomidine-based regimens may offer superior outcomes, but further comparative evaluation is required to establish their efficacy across different clinical settings [15].

In the present study, a cross-sectional comparison was undertaken to evaluate the effects of propofol–ketamine and dexmedetomidine–ketamine combinations in TIVA. The findings of this study demonstrated that the dexmedetomidine–ketamine group exhibited significantly lower heart rate and blood pressure values at various intraoperative intervals, along with reduced pain scores, indicating better hemodynamic stability and analgesic efficacy . These results align with existing literature and highlight the potential advantages of dexmedetomidine as an adjunct in TIVA.

Therefore, this study aims to contribute to the existing evidence by providing a comparative analysis of these two commonly used anesthetic combinations, with a focus on hemodynamic parameters and analgesic outcomes. Understanding these differences is essential for optimizing anesthetic protocols and improving perioperative patient outcomes.

METHODOLOGY

This hospital-based cross-sectional comparative study was conducted in the Department of Anaesthesiology

at a tertiary care teaching hospital to evaluate and compare the effects of two anesthetic techniques—propofol–ketamine (PK) and dexmedetomidine–ketamine (DK)—in patients undergoing procedures under total intravenous anesthesia (TIVA). The study was carried out over a period of one year, from January 2025 to December 2025, with a **data collection period of six months from June 2025 to December 2025**, after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment.

A total of 100 adult patients scheduled for elective surgical procedures under TIVA were included and divided into two groups of 50 each. Group PK received a combination of propofol and ketamine, whereas Group DK received dexmedetomidine and ketamine. Patients were selected using a convenient sampling technique (or randomized allocation, if applicable). Individuals aged between 18 and 70 years and belonging to ASA physical status I and II were included in the study. Patients with significant cardiovascular, respiratory, hepatic, or renal disorders, known hypersensitivity to study drugs, pregnancy, or those receiving medications affecting hemodynamic parameters were excluded.

All patients were kept nil per oral in accordance with standard preoperative fasting guidelines. Upon arrival in the operating theatre, baseline hemodynamic parameters including heart rate, systolic blood pressure, and diastolic blood pressure were recorded using standard monitoring devices such as electrocardiography, pulse oximetry, and non-invasive blood pressure monitoring. Intravenous access was secured, and patients were premedicated as per institutional protocol.

In Group PK, anesthesia was induced using intravenous propofol in combination with ketamine. In Group DK, dexmedetomidine infusion was administered along with ketamine. Drug dosages were calculated based on body weight and administered according to standardized institutional protocols to ensure adequate sedation and analgesia. Oxygen supplementation was provided to all patients throughout the procedure.

Hemodynamic parameters including heart rate, systolic blood pressure, and diastolic blood pressure were recorded at predefined intervals—before induction, immediately after induction, at 10 minutes, 15 minutes, and 30 minutes during the procedure. Postoperative pain was assessed using the Visual Analogue Scale (VAS). The ASA grading of all patients was documented preoperatively to assess baseline clinical status.

All collected data were entered into a structured proforma and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The independent t-test was used to compare mean values between the two groups, and the chi-square test was applied for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results :

Table 1: Age Distribution in Study Population

Age Group (years)	Group PK (n=50)	%	Group DK (n=50)	%
18–45	40	80	44	88
46–70	10	20	6	12

Interpretation:

The majority of participants in both groups belonged to the 18–45 years age group, with 80% in Group PK and 88% in Group DK. The distribution across age categories was comparable between the two groups, and no statistically significant difference was observed ($p>0.05$). This indicates homogeneity of age distribution, minimizing confounding effects related to age.

Table 2: Gender Distribution in Study Population

Gender	Group PK (n=50)	%	Group DK (n=50)	%
Male	18	36	14	28
Female	32	64	36	72

Interpretation:

Females constituted a higher proportion in both groups, accounting for 64% in Group PK and 72% in Group DK. Male participants were 36% and 28% respectively. The gender distribution was comparable between groups with no statistically significant difference ($p>0.05$), ensuring baseline uniformity.

Table 3: Mean Heart Rate (beats per minute)

Time Point	Group PK Mean ± SD	Group DK Mean ± SD	P value	Significance
Before Induction	87.24 ± 4.62	78.12 ± 6.57	<0.0001	Significant
After Induction	83.92 ± 5.16	75.20 ± 4.24	<0.0001	Significant

10 minutes	83.70 ± 5.62	77.08 ± 4.11	<0.0001	Significant
15 minutes	82.64 ± 5.80	80.24 ± 4.92	0.0279	Significant

Interpretation:

The mean heart rate was consistently lower in Group DK compared to Group PK at all measured time intervals. Before induction, Group PK had a mean heart rate of 87.24 bpm compared to 78.12 bpm in Group DK. This trend persisted after induction and at 10 and 15 minutes. The differences were statistically significant at all time points ($p<0.05$), indicating superior attenuation of sympathetic response and better hemodynamic stability with the dexmedetomidine–ketamine combination.

Table 4: Mean Systolic Blood Pressure (mmHg)

Time Point	Group PK Mean ± SD	Group DK Mean ± SD	P value	Significance
Before Induction	127.72 ± 5.19	134.72 ± 6.71	<0.0001	Significant
After Induction	129.60 ± 6.66	125.80 ± 4.08	0.0009	Significant
10 minutes	132.70 ± 6.63	123.60 ± 3.65	<0.0001	Significant
30 minutes	134.06 ± 7.53	124.64 ± 4.47	<0.0001	Significant

Interpretation:

Although baseline systolic blood pressure was higher in Group DK, post-induction values were significantly lower compared to Group PK. At 10 and 30 minutes, Group DK maintained lower systolic pressures (123.6 mmHg and 124.64 mmHg respectively) compared to Group PK (132.7 mmHg and 134.06 mmHg). These findings were statistically significant, suggesting improved intraoperative hemodynamic control with dexmedetomidine.

Table 5: Mean Diastolic Blood Pressure (mmHg)

Time Point	Group PK Mean ± SD	Group DK Mean ± SD	P value	Significance
Before Induction	88.76 ± 6.68	82.24 ± 4.15	<0.0001	Significant
After Induction	86.80 ± 6.53	81.66 ± 4.50	<0.0001	Significant
10 minutes	85.68 ± 3.96	82.06 ± 4.18	<0.0001	Significant
30 minutes	84.22 ± 3.78	82.30 ± 3.34	0.0084	Significant

Interpretation:

The mean diastolic blood pressure was consistently lower in Group DK across all time intervals. The reduction was statistically significant, indicating better control of vascular tone and reduced sympathetic stimulation in the dexmedetomidine group.

Table 6: VAS Score

Parameter	Group PK Mean ± SD	Group DK Mean ± SD	P value	Significance
VAS Score	0.94 ± 0.99	0.32 ± 0.58	0.0002	Significant

Interpretation:

The mean VAS score was significantly lower in Group DK (0.32) compared to Group PK (0.94). This indicates superior analgesic efficacy of the dexmedetomidine–ketamine combination, resulting in reduced postoperative pain perception.

Table 7: ASA Grade

Parameter	Group PK Mean ± SD	Group DK Mean ± SD	P value	Significance
ASA Grade	1.4 ± 0.49	1.3 ± 0.46	0.295	Not Significant

Interpretation:

The mean ASA grade was comparable between the two groups, with no statistically significant difference ($p=0.295$). This confirms that both groups were similar in terms of baseline physical status, ensuring internal validity of the study.

DISCUSSION

The present study was undertaken to comprehensively compare the efficacy of two commonly used total intravenous anesthesia (TIVA) techniques—propofol–ketamine (PK) and dexmedetomidine–ketamine (DK)—with specific emphasis on hemodynamic stability and analgesic outcomes. The findings of this study clearly demonstrate that the dexmedetomidine–ketamine combination provides superior intraoperative stability and postoperative analgesia compared to the propofol–ketamine regimen.

Baseline demographic variables including age distribution, gender, and ASA grading were comparable between the two groups, thereby ensuring internal validity and eliminating confounding bias. In the present study, 80% (PK) and 88% (DK) participants belonged to the 18–45 years age group, and ASA grading was similar (1.4 ± 0.49 vs 1.3 ± 0.46; p=0.295). This is in accordance with the recommendations of standardized TIVA guidelines, which emphasize comparable baseline characteristics for accurate evaluation of anesthetic outcomes [16]. Bajwa et al. further highlighted that uniformity in patient characteristics is essential for interpreting pharmacodynamic responses in TIVA studies [17].

A key finding of the present study was the significantly lower heart rate observed in the DK group at all measured intervals. The mean heart rate before induction was 87.24 ± 4.62 bpm in Group PK compared to 78.12 ± 6.57 bpm in Group DK. After induction, the values were 83.92 ± 5.16 bpm versus 75.20 ± 4.24 bpm, and at 10 minutes, 83.70 ± 5.62 bpm versus 77.08 ± 4.11 bpm respectively (p<0.0001). Even at 15 minutes, the DK group maintained a lower heart rate (80.24 ± 4.92 bpm vs 82.64 ± 5.80 bpm; p=0.0279). This consistent reduction reflects the potent sympatholytic action of dexmedetomidine, which reduces central sympathetic outflow and enhances vagal tone [20]. Previous studies have reported similar findings, where dexmedetomidine-based regimens significantly attenuated perioperative tachycardia compared to other anesthetic combinations [17,20].

The systolic blood pressure (SBP) trends observed in the present study further reinforce the superior hemodynamic profile of the DK combination. Although baseline SBP was slightly higher in Group DK (134.72 ± 6.71 mmHg) compared to Group PK (127.72 ± 5.19 mmHg), post-induction values were significantly lower in the DK group. At 10 minutes, SBP in Group DK was 123.6 ± 3.65 mmHg compared to 132.7 ± 6.63 mmHg in Group PK, and at 30 minutes, 124.64 ± 4.47 mmHg versus 134.06 ± 7.53 mmHg respectively (p<0.0001). These findings indicate effective attenuation of surgical stress response and improved cardiovascular stability with dexmedetomidine. Meta-analyses comparing TIVA with inhalational anesthesia have demonstrated that intravenous techniques, particularly those incorporating α2 agonists, are associated with more stable intraoperative blood pressure profiles [18,19].

Similarly, diastolic blood pressure (DBP) was significantly lower in the DK group across all time points. At baseline, DBP was 88.76 ± 6.68 mmHg in Group PK compared to 82.24 ± 4.15 mmHg in Group DK, and this trend persisted throughout the intraoperative period. At 10 minutes, DBP was 85.68 ± 3.96 mmHg in Group PK versus 82.06 ± 4.18 mmHg in Group DK (p<0.0001). This reduction in DBP reflects improved vascular tone regulation and reduced sympathetic activity in the dexmedetomidine group [20]. In contrast, ketamine's intrinsic sympathomimetic effect may explain the relatively higher blood pressure observed in the PK group [21].

Analgesic efficacy, as measured by the Visual Analogue Scale (VAS), was significantly superior in the DK group. The mean VAS score was 0.32 ± 0.58 in Group DK compared to 0.94 ± 0.99 in Group PK (p=0.0002). This finding is clinically significant, as it demonstrates the opioid-sparing effect of dexmedetomidine and its ability to enhance postoperative comfort. Wong et al. reported similar findings in a scoping review, where TIVA regimens incorporating adjuncts such as dexmedetomidine were associated with lower postoperative pain scores and reduced analgesic requirements [22]. In contrast, studies involving propofol-based TIVA have reported variable analgesic outcomes, often necessitating supplemental analgesics [23].

Earlier comparative studies on TIVA combinations have also highlighted the limitations of propofol–ketamine regimens. Hernández et al. reported that while propofol–ketamine provides adequate anesthesia, it may be associated with fluctuations in hemodynamic parameters, particularly during surgical stimulation [24]. Pharmacokinetic analyses have further emphasized the importance of balanced anesthetic combinations to achieve stable plasma drug concentrations and predictable physiological responses [25].

From a broader perspective, the evolution of TIVA techniques has focused on improving patient safety, recovery profile, and intraoperative stability. Historical analyses have shown that early intravenous anesthetic techniques were limited by poor control over drug delivery and hemodynamic fluctuations [26]. However, advancements such as target-controlled infusion systems have improved precision in anesthetic administration, particularly with agents like propofol and ketamine [27]. Despite these advancements, the choice of drug combination remains critical in determining overall anesthetic outcomes.

Recent clinical observations and expert commentaries have suggested that dexmedetomidine-based TIVA

provides enhanced recovery, reduced stress response, and improved patient satisfaction [28]. Comparative studies have also demonstrated that while ketamine-containing regimens maintain cardiovascular stability, the addition of dexmedetomidine results in a more balanced anesthetic profile with reduced variability in hemodynamic parameters [29]. Furthermore, studies in critically ill patients have shown that ketamine infusion maintains hemodynamic stability, but combining it with agents such as dexmedetomidine improves overall sedation quality and physiological control [30].

Overall, the findings of the present study strongly support the superiority of the dexmedetomidine–ketamine combination over the propofol–ketamine regimen. The significantly lower heart rate, systolic and diastolic blood pressure values observed in the DK group indicate better attenuation of sympathetic responses and improved intraoperative stability. Additionally, the significantly lower VAS scores highlight the enhanced analgesic efficacy of dexmedetomidine-based TIVA.

CONCLUSION

The present study demonstrated that the dexmedetomidine–ketamine combination is superior to the propofol–ketamine regimen in total intravenous anesthesia (TIVA) with respect to hemodynamic stability and analgesic efficacy. Patients in the dexmedetomidine–ketamine group consistently exhibited significantly lower heart rate and blood pressure values at all intraoperative time intervals, indicating effective attenuation of sympathetic responses. Additionally, the markedly lower Visual Analogue Scale (VAS) scores observed in this group reflect enhanced postoperative analgesia and improved patient comfort.

In contrast, the propofol–ketamine combination, although effective in providing adequate anesthesia, was associated with comparatively higher heart rate and blood pressure values, suggesting less optimal control of hemodynamic responses. Both groups were comparable in baseline characteristics such as age, gender, and ASA grading, thereby strengthening the validity of the observed outcomes.

Overall, the findings of this study support the use of dexmedetomidine as a valuable adjunct in TIVA, particularly in procedures where maintaining stable hemodynamics and achieving effective analgesia are critical. The dexmedetomidine–ketamine combination can therefore be considered a safer and more efficacious alternative to traditional propofol-based regimens in clinical practice.

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