

Comparison of hemodynamics in general anesthesia patients with total intravenous anesthesia (TIVA) and balanced anesthesia techniques at RSI Purwokerto

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Abstract

Background: General anesthesia can cause hemodynamic changes that may increase the risk of perioperative complications. Selecting the appropriate anesthetic technique, such as Total Intravenous Anesthesia (TIVA) and balanced anesthesia, is crucial for maintaining the patient's stability. This study aims to compare hemodynamic changes in patients undergoing general anesthesia with these two techniques at RSI Purwokerto.

Method: This study employed a non-experimental quantitative design with a descriptive-comparative and longitudinal observational approach. Sampling was conducted using purposive sampling, a non-probability technique. The sample consisted of 46 participants divided into a TIVA group (n=23) and a balanced anesthesia group (n=23). The parameters observed included blood pressure, pulse rate, mean arterial pressure (MAP), respiratory rate, and oxygen saturation at baseline and at 5, 10, and 15 minutes post-induction. Analysis was performed using the Friedman, Wilcoxon, and Mann-Whitney tests.

Results: The results showed significant differences in systolic blood pressure at 15 minutes (p=0.030) and respiratory rate (p=0.007), whereas heart rate and oxygen saturation did not differ significantly (p>0.05). Overall, the TIVA group demonstrated better hemodynamic stability compared to the balanced anesthesia group.

Conclusion: TIVA is more effective in maintaining hemodynamic stability in patients under general anesthesia than balanced anesthesia.

Keywords: Hemodynamic; TIVA; balanced anesthesia; general anesthesia.

INTRODUCTION

General anesthesia is a pharmacological state designed to eliminate consciousness, pain, and reflexes during surgery. The techniques used, such as Total Intravenous Anesthesia (TIVA) and balanced anesthesia (BA), must be able to maintain hemodynamic stability, accelerate recovery, and minimize complications (1,2). TIVA uses propofol, which acts rapidly and is hemodynamically stable (3,4). Meanwhile, BA uses a combination of inhaled agents and opioids, but tends to cause greater hemodynamic fluctuations than TIVA (1,5).

Hemodynamic disturbances frequently occur during the perioperative period in patients under general anesthesia; approximately 56% of patients experience hemodynamic disturbances following induction, with an incidence of tachycardia at

18%, bradycardia at 16%, hypotension at 81%, and hypertension at 14%. TIVA tends to provide better hemodynamic stability compared to balanced anesthesia due to the use of intravenous agents that are easily controlled (6–8).

Previous research has shown that BA tends to cause greater hemodynamic fluctuations than TIVA. A study by Sheikh et al. (2019) found an increase in mean blood pressure (89.43 ± 1.73 mmHg) and heart rate (90.36 ± 1.95 bpm) following induction in the BA group, which were higher than those in the more stable TIVA group (1).

In line with this, Dhungana et al. (2022) reported that changes in systolic blood pressure and mean arterial pressure (MAP) were more pronounced with BA (sevoflurane-fentanyl), with significant decreases at 3 and 5 minutes post-intubation, whereas TIVA

(propofol-fentanyl) remained relatively stable (5). In addition, Widar et al. (2021) found that the TIVA group had a more stable mean arterial pressure (MAP) (64.3 ± 6.9 mmHg) compared to the BA group (57.6 ± 6.7 mmHg), as well as a lower heart rate (76.7 bpm vs. 93 bpm)(2).

Although various studies have compared TIVA and BA, gaps remain because most studies have assessed only limited parameters such as blood pressure and heart rate and have been conducted on specific types of surgery, resulting in inconsistent findings that are difficult to generalize. Furthermore, studies that comprehensively evaluate hemodynamic parameters including blood pressure, pulse rate, mean arterial pressure (MAP), respiratory rate, and oxygen saturation remain relatively limited, particularly in regional hospitals.

This is supported by pre-survey data from RSI Purwokerto, which indicates a high number of general anesthesia cases involving varying use of TIVA and balanced anesthesia techniques. Therefore, this study aims to analyze the hemodynamic comparison in patients undergoing general anesthesia using Total Intravenous Anesthesia (TIVA) and balanced anesthesia techniques at RSI Purwokerto. This study is novel because it was conducted across various types of surgeries with a more comprehensive assessment of hemodynamic parameters.

METHOD

This study has received ethical approval under No. B. LPPM-UHB/1175/11/2025 as evidence of compliance with research ethics principles. A quantitative approach was used with a non-experimental design consisting of a descriptive-comparative and longitudinal observational study. Observations were conducted repeatedly at specific time points to examine the dynamics of hemodynamic changes during the early perioperative period (9,10).

The study subjects were patients who underwent surgical procedures under general anesthesia at RSI Purwokerto. The study population consisted of all patients who met

the inclusion criteria during the study period. The sampling method used was purposive sampling, a non-probability technique in which subjects were deliberately selected based on characteristics relevant to the study objectives (11,12).

The sample size of 46 respondents was calculated using G*Power software version 3.1.9.7 and then divided into two groups with a 1:1 allocation: the TIVA group ($n = 23$) and the BA group ($n = 23$). Inclusion criteria included patients ranging from young adults (≥ 18 years) to the elderly, with an ASA physical status of I–II, and undergoing elective surgery under general anesthesia; exclusion criteria included patients with severe hemodynamic instability ($ASA \geq III$), uncontrolled comorbidities, those receiving interventions to stabilize hemodynamics, patients who refused to participate, or those with incomplete data. During the study, six participants dropped out due to insufficient observation time and were therefore excluded from the final analysis.

The research procedure began with the identification and selection of participants based on predetermined criteria, followed by the collection of informed consent. Data collection was conducted observationally throughout the anesthesia process. In the TIVA group, anesthesia was administered using continuous intravenous agents, whereas the BA group received a combination of intravenous and inhalational agents. Hemodynamic parameters were measured at several observation times, namely before induction (baseline), and at 5, 10, and 15 minutes after induction of anesthesia.

The instruments used in this study included observation sheets (13) structured for recording respondent characteristics and hemodynamic parameters. Measurements were taken using standard monitoring equipment in the operating room, such as a multiparameter monitor that records systolic blood pressure (SBP) and diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR), respiratory rate (RR), and oxygen saturation (SpO_2). The data obtained were recorded systematically

according to predetermined measurement times to ensure data consistency and validity.

Data collection was conducted through direct observation of patients during the anesthetic procedure (14). Primary data were obtained from real-time hemodynamic monitoring, while secondary data consisting of respondent characteristics were obtained from patients' medical records (13). All the collected data was then edited, coded, and tabulated before being analyzed further (15,16).

Data analysis was conducted in stages using IBM SPSS Statistics 27 software, including univariate and bivariate analyses. Univariate analysis was used to describe the characteristics of the respondents and the distribution of hemodynamic parameters (17). A normality test was conducted using the Shapiro–Wilk test because the sample size in each group was less than 50, in order to determine the type of statistical test to be used (18).

The results of the normality test showed that some of the hemodynamic data had p-values ranging from 0.000 to 0.043 (<0.05), indicating that they were not normally distributed. Although in the balanced anesthesia group most of the data were normally distributed with p-values ranging from 0.060 to 0.940 (>0.05), certain variables remained non-normal, namely SpO_2 , DBP, and HR at the 15th minute. Therefore, non-parametric tests were used for the analysis.

Bivariate analysis using the Friedman test to assess repeated differences within a single group, followed by the Wilcoxon test as a post hoc test with Bonferroni correction (19–21). To compare the differences between the TIVA and Balanced Anesthesia groups, the Mann-Whitney test was used with a significance level of $p < 0.05$ (22,23).

RESULTS

Respondent Characteristics

Most respondents in both groups, TIVA and Balanced Anesthesia ($n = 23$ each), were aged 20–59 years (78.3%). In the TIVA group, the gender distribution was dominated by females (52.2%), whereas in the Balanced

Anesthesia group, it was dominated by males (56.5%). All respondents in both groups fell into the ASA II category (100%). Based on BMI, most respondents in both groups were in the normal weight category, namely 47.8% in the TIVA group and 60.9% in the Balanced Anesthesia group, followed by the overweight category. In general, the characteristics of respondents in both groups were dominated by adults, ASA II status, and normal BMI (Table 1).

Table 1. Respondent Characteristics

Anthropometric Parameters	Group TIVA (n=23)	Group BA (n=23)
Age distribution		
18-19 years	2(8,7)	2(8,7)
20–59 years	18(78,3)	18(78,3)
≥60 years	3(13)	3(13)
Gender distribution		
Male	11(47,8)	13(56,5)
Female	12(52,2)	10(43,5)
ASA		
II	23(100)	23(100)
Body Mass Index (kg/m²)		
Severely Underweight	1(4,3)	0
Underweight	1(4,3)	2(8,7)
Normal Weight	11(47,8)	14(60,9)
Overweight	8(34,8)	7(30,4)
Obese (Class I)	2(8,7)	0

Comparison of Hemodynamic Data in the Total Intravenous Anesthesia (TIVA) Group

Based on Table 2, the Friedman test showed that systolic blood pressure (SBP) changed significantly over the observation period ($p = 0.01$). Descriptively, the median SBP decreased from 145 mmHg at baseline to 132 mmHg at the 5th and 10th minutes, then increased slightly to 135 mmHg at the 15th minute, reflecting hemodynamic changes following anesthesia induction. The heart rate (HR) parameter also showed a statistically significant difference ($p = 0.00$). Although the median HR was relatively stable, there was a tendency toward a decrease at the 15th minute compared to baseline, indicating a physiological response to the administration of anesthetic agents.

Table 2. Friedman's Test on Hemodynamic Parameters in Patients Undergoing Total Intravenous Anesthesia (TIVA)

Variable	Median (Minimum–Maximum)	Mean ± s,d	p-value
SBP			
Baseline	145(120-206)	147,17±21,97	0,01
5 minutes	132 (83-223)	138,82±28,53	
10 minutes	132 (92-167)	134,30±19,55	
15 minutes	135 (108-164)	131,13±15,94	
DBP			
Baseline	84 (66-120)	84,30±13,21	0,44
5 minutes	81 (33-104)	80,13±14,40	
10 minutes	82 (38-95)	78,04±12,60	
15 minutes	79 (58-188)	82,82±26,28	
HR			
Baseline	82 (68-125)	86±15,22	0,00
5 minutes	83 (66-143)	86,86±17,10	
10 minutes	80 (64-142)	83,65±17,35	
15 minutes	78 (62-136)	81,13±15,89	
MAP			
Baseline	100 (86-138)	101,65±13,74	0,13
5 minutes	98 (49-143)	99,26±19,41	
10 minutes	96 (56-119)	95,65±14,33	
15 minutes	95 (72-123)	95±13,93	
RR			
Baseline	20 (18-25)	20,08±2,25	0,07
5 minutes	20 (16-25)	19,78±2,62	
10 minutes	20 (15-24)	19,21±2,37	
15 minutes	18 (14-24)	18,82±2,80	
SPO2			
Baseline	100 (97-100)	99,60±0,78	0,41
5 minutes	100 (99-100)	99,82±0,38	
10 minutes	100 (99-100)	99,65±0,48	
15 minutes	100 (90-100)	99,30±2,07	

Based on the Wilcoxon Signed-Rank Test, the systolic blood pressure (SBP) variable showed a statistically significant difference between baseline and the 15th minute ($p = 0.002$), indicating a significant change 15 minutes after the administration of TIVA anesthesia. Meanwhile, comparisons of baseline with the 5th and 10th minutes, as well as between other observation times, did not show statistically consistent differences.

For the heart rate (HR) variable, a significant difference was found between the 5th and 15th minutes ($p = 0.002$), reflecting a change in heart rate during that period. However, comparisons of baseline with all observation times or between other intervals did not show statistical significance.

Table 2. Wicoxon Post Hoc Test on Hemodynamic Parameters in the TIVA Group

Variable	<i>Wilcoxon Signed Rank Test</i>	
	p-value	Significant
SBP		
Baseline vs '5	0,191	No
Baseline vs '10	0,016	No
Baseline vs '15	0,002	Yes
'5 vs '10	0,394	No
'5 vs '15	0,057	No
'10 vs '15	0,020	No
HR		
Baseline vs '5	0,673	No
Baseline vs '10	0,241	No
Baseline vs '15	0,022	No
'5 vs '10	0,013	No
'5 vs '15	0,002	Yes
'10 vs '15	0,020	No

Comparison of Hemodynamic Data in the Balanced Anesthesia Group

Table 4 shows the results of the Friedman test in 23 patients undergoing balanced anesthesia, analyzed by parameter. Systolic blood pressure (SBP) showed a significant difference ($p = 0.00$), with a downward trend following induction and stabilization by the 15th minute. Diastolic blood pressure (DBP) also differed significantly ($p = 0.00$), marked by an initial decrease that then increased slightly but remained below baseline values. Heart rate (HR) showed a significant difference ($p = 0.01$) with a trend of gradual decrease during the observation period.

Mean arterial pressure (MAP) showed a significant change ($p = 0.00$), with a pattern of decline at the start of observation followed by a slight increase without returning to baseline levels. Respiratory rate (RR) showed a significant difference ($p = 0.00$), with a sustained decrease until the 15th minute. Meanwhile, peripheral oxygen saturation (SpO_2) also showed a significant difference ($p = 0.02$) but clinically remained within normal limits. Overall, the most consistent changes were observed in the decrease in blood pressure and respiratory rate following anesthesia induction.

Table 3. Wilcoxon Post Hoc Test on Hemodynamic Parameters in Patients Undergoing Balanced Anesthesia

Variable	<i>Wilcoxon Signed Rank Test</i>	
	p-value	Significant
SBP		
Baseline vs '5	0,000	Yes
Baseline vs '10	0,000	Yes
Baseline vs '15	0,000	Yes
'5 vs '10	0,867	No
'5 vs '15	0,594	No
'10 vs '15	0,447	No
DBP		
Baseline vs '5	0,012	No
Baseline vs '10	0,017	No
Baseline vs '15	0,003	Yes
'5 vs '10	0,167	No
'5 vs '15	0,772	No
'10 vs '15	0,726	No
HR		
Baseline vs '5	0,014	No
Baseline vs '10	0,002	Yes
Baseline vs '15	0,001	Yes
'5 vs '10	0,322	No
'5 vs '15	0,322	No
'10 vs '15	0,522	No
MAP		
Baseline vs '5	0,001	Yes
Baseline vs '10	0,001	Yes
Baseline vs '15	0,001	Yes
'5 vs '10	0,126	No
'5 vs '15	0,372	No
'10 vs '15	0,796	No
RR		
Baseline vs '5	0,096	No
Baseline vs '10	0,005	Yes
Baseline vs '15	0,006	Yes
'5 vs '10	0,134	No
'5 vs '15	0,139	No
'10 vs '15	0,356	No
SPO2		
Baseline vs '5	0,008	Yes
Baseline vs '10	0,033	No
Baseline vs '15	0,176	No
'5 vs '10	0,564	No
'5 vs '15	0,271	No
'10 vs '15	0,317	No

Based on the results of the Wilcoxon post hoc test with Bonferroni correction in patients under balanced anesthesia, results were considered statistically significant if $p < 0.008$ (Table 3). Systolic blood pressure (SBP) showed statistically significant

differences between baseline and the 5th, 10th, and 15th minutes ($p = 0.000$). Diastolic blood pressure (DBP) showed a significant difference between baseline and the 15th minute ($p = 0.003$). Heart rate (HR) showed a significant difference between baseline and the 10th minute ($p = 0.002$) and the 15th minute ($p = 0.001$). Mean arterial pressure (MAP) showed a significant difference

between baseline and the 5th, 10th, and 15th minutes ($p = 0.001$). Respiratory rate (RR) showed a significant difference between baseline and the 10th minute ($p = 0.005$) and the 15th minute ($p = 0.006$). Meanwhile, peripheral oxygen saturation (SpO_2) showed a significant difference between baseline and the 5th minute ($p = 0.008$).

Table 4. Friedman Test on Hemodynamic Parameters in Patients Under Balanced Anesthesia

Variable	Median (Minimum–Maximum)	Mean ± s,d	p-value
SBP			
Baseline	146 (116-194)	155,26±23,49	0,00
5 minutes	114 (93-186)	125,73±28,98	
10 minutes	114 (81-193)	125,52±28,88	
15 minutes	118 (83-185)	121,43±24,92	
DBP			
Baseline	86 (55-122)	85,34±15,34	0,00
5 minutes	68 (49-122)	76,08±18,87	
10 minutes	71 (43-104)	72,73±17,95	
15 minutes	71 (54-116)	73,73±16,13	
HR			
Baseline	90 (63-122)	93,04±17,15	0,01
5 minutes	84 (48-115)	81,78±17,23	
10 minutes	81 (51-121)	79,65±17,25	
15 minutes	79 (57-116)	79,17±14,76	
MAP			
Baseline	105 (84-138)	107,17±15,31	0,00
5 minutes	81 (63-135)	91,26±21,62	
10 minutes	86 (55-132)	87,47±22,11	
15 minutes	86 (63-127)	87,56±18,58	
RR			
Baseline	20 (15-24)	19,34±2,10	0,00
5 minutes	18 (10-24)	17,65±3,76	
10 minutes	16 (12-25)	16,69±3,22	
15 minutes	16 (10-25)	16,34±3,61	
SPO2			
Baseline	99 (97-100)	99,21±0,95	0,02
5 minutes	100 (99-100)	99,78±0,42	
10 minutes	100 (99-100)	99,73±0,44	
15 minutes	100 (98-100)	99,60±0,65	

Comparison of Hemodynamics in the TIVA Group and the BA Group

Baseline measurements showed no significant differences between the two groups, neither in SBP ($p = 0.231$) nor in DBP ($p = 0.717$). At 5 minutes post-induction, SBP ($p = 0.085$) and DBP ($p = 0.104$) also showed no significant differences between the two groups. Nevertheless, the higher mean rank in the TIVA group indicated a tendency toward higher blood pressure compared to the balanced anesthesia group.

At 10 minutes post-induction, the analysis results still showed no statistically significant difference in SBP ($p = 0.099$) and DBP ($p = 0.180$), with the same pattern: the TIVA group tended to have higher blood pressure values compared to the balanced anesthesia group. Furthermore, at 15 minutes post-induction, there was a statistically significant difference in SBP ($p = 0.030$), where the median and mean rank of SBP in the TIVA group were higher than those in the balanced anesthesia group (Table 2).

Table 5. Comparison of Blood Pressure in the TIVA Group and the BA Group

Time	Group	Median (Minimum Maximum)	Mean Rank	p-value
SBP				
Baseline	TIVA	145(120-206)	21,13	0,231
	BA	146 (116-194)	25,87	
5 min after induction	TIVA	132 (83-223)	26,91	0,085
	BA	114 (93-186)	20,09	
10 min after induction	TIVA	132 (92-167)	26,76	0,099
	BA	114 (81-193)	20,24	
15 min after induction	TIVA	135 (108-164)	27,80	0,030
	BA	118 (83-185)	19,20	
DBP				
Baseline	TIVA	84 (66-120)	22,78	0,717
	BA	86 (55-122)	24,22	
5 min after induction	TIVA	81 (33-104)	26,72	0,104
	BA	68 (49-122)	20,28	
10 min after induction	TIVA	82 (38-95)	26,15	0,180
	BA	71 (43-104)	20,85	
15 min after induction	TIVA	79 (58-188)	26,67	0,108
	BA	71 (54-116)	20,33	

The pulse rate indicated that the baseline conditions between the TIVA group and the balanced anesthesia group were relatively comparable. The mean rank was 20.20, while that of the balanced anesthesia group was 26.80. The results of the Mann–Whitney test showed a p-value of 0.095 ($p > 0.05$). Evaluation at 5 minutes post-induction showed a mean rank of 24.76, while the balanced anesthesia group had a mean rank of 22.24. The results of the Mann–Whitney test showed a p-value of 0.524 ($p > 0.05$). At 10 minutes, the TIVA group's HR had a mean rank of 24.50, while the balanced anesthesia group had a mean rank of 22.50. The results of the Mann–Whitney analysis showed a p-value of 0.613 ($p > 0.05$). Furthermore, at the

15th minute, the median HR for the TIVA group was 23.85, while that for the balanced anesthesia group was 23.15. The results of the Mann–Whitney test showed a p-value of 0.860 ($p > 0.05$).

The mean arterial pressure (MAP) parameter at baseline showed that the TIVA group had a mean rank of 21.07, while the balanced anesthesia group had a mean rank of 25.93. The results of the Mann–Whitney test between the two groups yielded $p = 0.218$ ($p > 0.05$). 5 minutes after induction, there was an increase in the mean rank in the TIVA group to 26.89, while that of the balanced anesthesia group was 20.11. Nevertheless, the results of the Mann–Whitney test showed $p = 0.086$ ($p > 0.05$). 10 minutes after

induction, the mean rank for the TIVA group was 26.52 and for the balanced anesthesia group was 20.48. The statistical analysis showed $p = 0.127$ ($p > 0.05$). Furthermore, 15 minutes after induction, the mean rank for the

TIVA group was 26.72, while that for the balanced anesthesia group was 20.28. The results of the Mann–Whitney test showed $p = 0.104$ ($p > 0.05$).

Table 6. Comparison of Heart Rate and MAP in the TIVA Group and the BA Group

Time	Group	Median (Minimum Maximum)	Mean Rank	p-value
Heart Rate				
Baseline	TIVA	82 (68-125)	20,20	0,095
	BA	90 (63-122)	26,80	
5 min after induction	TIVA	83 (66-143)	24,76	0,524
	BA	84 (48-115)	22,24	
10 min after induction	TIVA	80 (64-142)	24,50	0,613
	BA	81 (51-121)	22,50	
15 min after induction	TIVA	78 (62-136)	23,85	0,860
	BA	79 (57-116)	23,15	
MAP				
Baseline	TIVA	100 (86-138)	21,07	0,218
	BA	105 (84-138)	25,93	
5 min after induction	TIVA	98 (49-143)	26,89	0,086
	BA	81 (63-135)	20,11	
10 min after induction	TIVA	96 (56-119)	26,52	0,127
	BA	86 (55-132)	20,48	
15 min after induction	TIVA	95 (72-123)	26,72	0,104
	BA	86 (63-127)	20,28	

The respiratory rate parameter showed a higher mean rank baseline value in the TIVA group (25.52) compared to the balanced anesthesia group (21.48). There was no significant difference between the Total Intravenous Anesthesia (TIVA) group and the balanced anesthesia group ($p = 0.279$). At 5 minutes post-induction, a significant difference was observed between the two groups ($p = 0.040$), with the TIVA group having a higher mean rank (27.52) compared to the balanced anesthesia group (19.48). At 10 minutes post-induction, a significant difference was observed ($p = 0.004$), with the TIVA group having a higher mean rank (29.15) compared to the balanced anesthesia group (17.85). At 15 minutes post-induction, a significant difference was observed ($p = 0.007$), with the TIVA group having a higher mean rank (28.76) compared

to the balanced anesthesia group (18.24) (Table 4).

For the oxygen saturation (SPO2) parameter at baseline, the mean rank for the TIVA group was 27.43 and for the balanced anesthesia group was 19.57; the Mann–Whitney test showed no significant difference ($p = 0.081$; $p > 0.05$). At minute 5, the mean rank for the TIVA group was 24.02 and for the balanced anesthesia group was 22.98 ($p = 0.713$; $p > 0.05$). At minute 10, the mean rank for the TIVA group was 24.65 and for the balanced anesthesia group was 22.35 ($p = 0.526$; $p > 0.05$). Furthermore, at the 15th minute, the mean rank for the TIVA group was 23.96 and for the balanced anesthesia group was 23.04, with the Mann–Whitney test results still showing no significant difference ($p = 0.946$; $p > 0.05$) (Table 4).

Table 7. Comparison of Respiratory Rate and SPO2 in the TIVA Group and the BA Group

Time	Group	Median (Minimum- Maximum)	Mean Rank	p-value
Respiratory Rate				
Baseline	TIVA	20 (18-25)	25,52	0,279
	BA	20 (15-24)	21,48	
5 min after induction	TIVA	20 (16-25)	27,52	0,040
	BA	18 (10-24)	19,48	
10 min after induction	TIVA	20 (15-24)	29,15	0,004
	BA	16 (12-25)	17,85	
15 min after induction	TIVA	18 (14-24)	28,76	0,007
	BA	16 (10-25)	18,24	
SPO2				
Baseline	TIVA	100 (97-100)	26,50	0,081
	BA	99 (97-100)	20,50	
5 min after induction	TIVA	100 (99-100)	24,00	0,713
	BA	100 (99-100)	23,00	
10 min after induction	TIVA	100 (99-100)	22,50	0,526
	BA	100 (99-100)	24,50	
15 min after induction	TIVA	100 (90-100)	23,61	0,946
	BA	100 (98-100)	23,39	

DISCUSSION

The predominance of adults is likely due to more stable physiological conditions and lower perioperative risks, resulting in a more predictable response to anesthesia compared to the elderly (24,25). These findings are consistent with the studies by Sheikh et al. (2019) and Rasool & Wani (2025), which indicate that the majority of surgical patients are adults (aged 18–60 years) (1,26).

Women have higher body fat, which can affect the distribution of propofol and impact its onset, duration, and hemodynamic response (27). In the TIVA group, the majority of participants were female (52.2%), whereas in the balanced anesthesia group, the majority were male (56.5%). Although there was a difference in distribution, this finding is consistent with previous studies showing that gender differences do not significantly affect the interpretation of hemodynamic changes during anesthesia (1,26).

All respondents had an ASA II status (100%), indicating mild systemic disease with relatively stable condition. ASA status plays a crucial role in assessing anesthetic risk and hemodynamic stability (28,29). These

findings are consistent with previous studies involving ASA I–II patients and generally in elective surgeries with stable patients (26,30).

BMI measurement is a method for assessing and monitoring nutritional status in adults (31). Most respondents had a normal BMI, indicating good nutritional status with a lower risk of hemodynamic and perioperative complications. These findings are consistent with previous studies, which also reported a normal BMI in both anesthesia groups (26), where patients with a normal BMI are more often candidates for elective surgery than obese patients, who are at higher risk of complications (32).

Systolic blood pressure (SBP) and heart rate (HR) in the TIVA group showed statistically significant changes ($p = 0.01$ and $p = 0.00$), with a downward trend following anesthesia induction. These findings are consistent with those of Rasool and Wani (2025), who reported a decrease in SBP from 121 ± 11.02 mmHg to 111 ± 12.22 mmHg and in HR from 86.7 ± 11.5 to 80.4 ± 10.8 beats/minute following anesthesia induction (26).

Systolic blood pressure (SBP) in the BA group changed significantly ($p = 0.00$), with a decrease following induction from baseline (155.26 ± 23.49) to the 5th minute (125.73 ± 28.98), remaining relatively stable until the 10th minute, and decreasing slightly by the 15th minute. Systolic blood pressure (SBP) showed a significant change during observation ($p = 0.00$), with a significant decrease following anesthesia induction, consistent with the findings of Paul et al. (2024) and Gore et al. (2023) (33,34)

Diastolic blood pressure (DBP) showed a significant change ($p = 0.00$), with a decrease following induction from baseline (85.34 ± 15.34) to (76.08 ± 18.87) at the 5th minute, then a slight decrease to (72.73 ± 17.95) at the 10th minute and remained relatively stable until the 15th minute. These results are consistent with those of Seangrung et al., who reported a decrease in DBP from baseline (77.7 ± 12.75) after induction to (73.23 ± 12.6), and a continued decrease to (61.42 ± 10.16) at the 10th minute (35). This finding of a decrease in DBP differs from that of Rasool and Wani (2025), who reported an increase in DBP from (71 ± 9.62) at baseline to (77 ± 7.99) at 5 minutes and (75 ± 5.97) at 15 minutes.(26).

The mean arterial pressure (MAP) showed a significant change ($p = 0.00$), decreasing from baseline (107.17 ± 15.31 mmHg) to 5 minutes (91.26 ± 21.62), then remained relatively stable at the 10th minute (87.47 ± 22.11) and the 15th minute (87.56 ± 18.58). These findings are consistent with those of Seangrung et al. (2021), who reported a decrease in MAP from (91.68 ± 13.93) to (83.96 ± 12.93), and then to (71.45 ± 10.46) (35). However, this differs from the findings of Rasool and Wani (2025), who observed an increase in MAP from (86.7 ± 6.22) to (92.7 ± 8.77)(26).

The heart rate parameter showed a statistically significant change ($p = 0.01$) during the observation period. HR values decreased after induction from baseline (93.04 ± 17.15) to the 5th minute (81.78 ± 17.23), the 10th minute (79.65 ± 17.25), and the 15th minute (79.17 ± 14.76). These findings are consistent with those of

Seangrung et al., who reported a decrease in HR from baseline (74.42 ± 14.03) to (60.81 ± 13.74), and remained lower until the 10th minute (65.13 ± 9.86) (35). These results differ from those reported by Rasool and Wani (2025), who found an increase in heart rate from 84 ± 10.16 bpm (baseline) to 90 ± 10.11 bpm (at 5 minutes) and 92 ± 11.16 bpm (at 15 minutes) (26).

The respiratory rate parameter also showed a statistically significant change ($p = 0.00$). The baseline RR had a median of 20 breaths per minute (15–24) with a mean of 19.34 ± 2.10 times/minute. After induction of anesthesia, the 5th minute showed a median of 18 times/minute (10–24) with a mean of 17.65 ± 3.76 times/minute. The decrease continued at the 10th minute with a median of 16 beats/minute (12–25) and a mean of 16.69 ± 3.22 beats/minute, as well as at the 15th minute with a median of 16 beats/minute (10–25) and a mean of 16.34 ± 3.61 beats/minute. The SpO_2 parameter showed a significant change ($p = 0.02$) but remained within normal limits, with relatively stable values from baseline ($99.21 \pm 0.95\%$) through the 5th minute (99.78 ± 0.42), the 10th minute (99.73 ± 0.44), and the 15th minute (99.60 ± 0.65).

The hemodynamic changes observed in this study specifically, decreases in blood pressure, heart rate, mean arterial pressure (MAP), and respiratory rate following induction indicate that the balanced anesthesia technique exerts a significant depressant effect on the cardiovascular and respiratory systems. These decreases are associated with the pharmacodynamic characteristics and synergistic effects of the combination of drugs used, such as propofol, fentanyl, and atracurium.

Propofol works by activating GABA-A receptors, which leads to central nervous system depression, including the autonomic centers in the hypothalamus and medulla oblongata such as the nucleus of the solitary tract and the rostral ventrolateral medulla thereby reducing sympathetic activity (36). This effect causes vasodilation, increased nitric oxide release, and a decrease in vascular resistance, preload, and afterload, which clinically manifests as a decrease in

blood pressure and MAP, as shown in the study results. Additionally, propofol reduces myocardial contractility by inhibiting calcium influx (37) and inhibits baroreceptor reflexes via the glossopharyngeal nerve and the vagus nerve, thereby preventing compensatory increases in heart rate (38). This explains the decrease in heart rate following induction.

In the respiratory system, propofol suppresses the respiratory centers in the brainstem, particularly the ventrolateral medulla and the pre-Bötzinger complex, thereby reducing the activity of respiratory neurons and their sensitivity to hypercapnia and hypoxia (39). Clinically, this effect leads to a decrease in respiratory rate and spontaneous ventilation (40), which is consistent with the research findings. This effect is enhanced by fentanyl, which acts through the μ -opioid receptors in the nucleus of the solitary tract, reducing sympathetic activity and increasing parasympathetic activity (41), and suppresses the respiratory center by reducing the response to hypercapnia and hypoxia (42). Clinically, fentanyl reduces respiratory rate, tidal volume, and minute ventilation (43,44). In fact, it can cause apnea at high doses (45).

Atracurium acts as a competitive antagonist at nicotinic acetylcholine receptors at the neuromuscular junction, causing relaxation of skeletal muscles including the diaphragm and intercostal muscles thereby reducing ventilation to the point of apnea (46,47). In addition, atracurium can trigger the release of histamine, which causes vasodilation through activation of H1 and H2 receptors, thereby lowering blood pressure and systemic vascular resistance (48,49). This decrease can trigger a compensatory response in the form of reflex tachycardia.

The Mann-Whitney test of baseline conditions showed no significant differences between the TIVA and balanced anesthesia groups in terms of SBP ($p = 0.231$), DBP ($p = 0.717$), MAP ($p = 0.218$), and heart rate ($p = 0.095$); therefore, both groups were considered homogeneous. At 5 minutes post-induction, SBP ($p = 0.085$), DBP ($p = 0.104$), MAP ($p = 0.086$), and heart rate ($p = 0.524$) showed no significant differences, although

there was a tendency for blood pressure and MAP values to be higher in the TIVA group.

A similar pattern was observed at the 10-minute mark, where SBP ($p = 0.099$), DBP ($p = 0.180$), MAP ($p = 0.127$), and heart rate ($p = 0.613$) remained not significantly different. By the 15th minute, SBP showed a significant difference ($p = 0.030$), with higher values in the TIVA group compared to the balanced anesthesia group. Meanwhile, DBP ($p = 0.108$), MAP ($p = 0.104$), and heart rate ($p = 0.860$) continued to show no significant differences. These results are consistent with the study by Rasool and Wani (2025), which showed that in both groups TIVA and balanced anesthesia there were no significant differences in blood pressure parameters, MAP, and heart rate ($p > 0.05$).

Baseline conditions showed no significant differences between the TIVA group and the balanced anesthesia group in terms of respiratory rate ($p = 0.279$) and oxygen saturation ($p = 0.081$). After anesthesia induction, respiratory rate showed significant differences at all observation times, namely at 5 minutes ($p = 0.040$), 10 minutes ($p = 0.004$), and 15 minutes ($p = 0.007$), with consistently higher values in the TIVA group compared to the balanced anesthesia group. Oxygen saturation did not show significant differences at all observation times, namely at 5 minutes ($p = 0.713$), 10 minutes ($p = 0.526$), and 15 minutes ($p = 0.946$).

CONCLUSIONS

The characteristics of the respondents in both groups were relatively homogeneous, dominated by adults and ASA II physical status. Both TIVA and balanced anesthesia significantly affected hemodynamic parameters after induction. However, TIVA showed more stable changes compared to balanced anesthesia. Comparatively, there were no significant differences in MAP, heart rate, and oxygen saturation between the two techniques. Significant differences were found in systolic blood pressure at 15 minutes and respiratory rate, where TIVA was better able to maintain stability compared to balanced anesthesia, which tended to be

more fluctuating and caused a greater respiratory depressant effect.

LIMITATIONS

This study was limited to patients with ASA I–II status; therefore, the results cannot yet be generalized to patients with severe comorbidities. Variations in dosage and combinations of anesthetic agents tailored to clinical conditions may also influence the results. Furthermore, the observation period, which covers only the early intraoperative phase, does not fully reflect overall hemodynamic changes throughout the perioperative period. The types of surgeries studied were also limited to minor to moderate procedures.

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