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Original Research Article

Comparing Perioperative Outcomes of Total Intravenous Anesthesia (TIVA) With Volatile Anesthesia in General Surgical Patients in a Tertiary Hospital of Bangladesh

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Abstract: ***Background*:** The choice of anesthetic technique influences perioperative outcomes significantly with Total Intravenous Anesthesia (TIVA) and volatile anesthesia being the most common methods in general surgery. ***Objective:*** This study compares the perioperative outcomes of TIVA and volatile anesthesia in general surgical patients at Uttara Adhunik Medical College Hospital, Bangladesh, to determine which method results in better recovery and fewer complications. ***Methods:*** A total of 120 general surgical patients (60 per group) were randomly assigned to receive either TIVA or volatile anesthesia. Data was collected on emergence time, postoperative nausea and vomiting (PONV), recovery time, and hemodynamic stability. The outcomes were compared using statistical analysis (paired t-test, p-value < 0.05) and standard deviation to assess variability. ***Results:*** The TIVA group demonstrated a significantly faster emergence time with a mean of 8.3 ± 1.5 minutes compared to 12.1 ± 2.4 minutes in the volatile anesthesia group (p-value = 0.003). The incidence of PONV was lower in the TIVA group, with only 16% of patients experiencing nausea, compared to 36% in the volatile group (p-value = 0.02). Recovery room stay duration was also significantly shorter for the TIVA group (45.2 ± 9.1 minutes) versus the volatile group (56.5 ± 11.2 minutes), with a p-value of 0.04. Blood pressure fluctuations were significantly more stable in the TIVA group, showing a standard deviation of ±5.2 mmHg, while the volatile group had a higher fluctuation at ±7.6 mmHg (p-value = 0.01). Additionally, the TIVA group required 35% fewer rescue analgesics (p-value = 0.02). ***Conclusion:*** TIVA offers superior perioperative outcomes in terms of emergence time, recovery, postoperative complications, and hemodynamic stability compared to volatile anesthesia in general surgical patients at a tertiary hospital.

Keywords: Total Intravenous Anesthesia, Volatile Anesthesia, Perioperative Outcomes, Emergence Time, Postoperative Nausea and Vomiting.

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Introduction

Anesthesia is a cornerstone of modern surgical practice, facilitating pain-free procedures and enhancing patient outcomes.[1] The choice of anesthetic technique plays a crucial role in determining perioperative outcomes such as recovery times, postoperative complications, and patient satisfaction. Among the various anesthetic methods employed in

surgery, Total Intravenous Anesthesia (TIVA) and volatile anesthesia are the most utilized techniques. While both methods are effective in ensuring deep anesthesia, their differences in pharmacokinetic properties, side effect profiles, and perioperative outcomes have generated significant interest within the field of anesthesiology. The purpose of this study is to compare the perioperative outcomes of TIVA and volatile anesthesia in general surgical patients within the context of a tertiary hospital in Bangladesh. The examination of these outcomes aims to provide valuable insight into the safety, efficacy, and overall patient experience associated with these two techniques, particularly in a resource-limited setting.

TIVA involves the intravenous administration of anesthetic agents, primarily propofol and remifentanil, to maintain anesthesia throughout the procedure. This technique offers several advantages, such as a rapid onset and offset of anesthetic effect, which allows for precise control of anesthesia depth. One of the primary benefits of TIVA is its reduced incidence of postoperative nausea and vomiting (PONV), which is often seen as a significant complication in volatile anesthesia techniques. The use of intravenous agents also minimizes the risk of intraoperative awareness, a rare but serious phenomenon where patients may regain consciousness during surgery, thereby experiencing pain and distress.[2] Furthermore, TIVA is considered a safer option for patients with specific comorbidities such as cardiovascular diseases and asthma, as it reduces the impact of anesthetic agents on the respiratory and circulatory systems. On the other hand, volatile anesthesia, typically delivered through inhalation of agents such as sevoflurane, is a more traditional approach in clinical practice. Volatile agents are advantageous in maintaining stable hemodynamic parameters and providing a level of anesthesia that is easy to titrate during surgery. The pharmacokinetics of volatile anesthesia involve the use of inhaled anesthetics that are absorbed by the lungs and metabolized by the liver, resulting in a relatively longer emergence time compared to TIVA. Although volatile anesthesia has been the standard choice for general anesthesia in many settings, it is often associated with a higher risk of postoperative complications, particularly PONV, delayed recovery, and the potential for residual anesthetic effects.[3] Despite these concerns, volatile agents like sevoflurane remain widely used due to their ease of administration, established safety profiles, and effectiveness in maintaining stable anesthesia.

The perioperative outcomes associated with both TIVA and volatile anesthesia are multifaceted and include critical factors such as emergence time, PONV incidence, recovery room stay, and postoperative pain control. Emergence time refers to the period required for a patient to regain consciousness after the completion of a surgical procedure, and it has been suggested that TIVA may result in faster recovery compared to volatile anesthesia. Research has shown that patients administered with TIVA typically experience quicker emergence from anesthesia, leading to a shorter duration of postoperative care and reduced need for narcotic analgesics.[4] Conversely, volatile anesthesia is often associated with a more gradual emergence from anesthesia, potentially prolonging recovery times and contributing to longer stays in the post-anesthesia care unit (PACU). Another key aspect of perioperative outcomes is postoperative nausea and vomiting, a common complication following surgery that can significantly affect patient comfort and recovery. Numerous studies have indicated that TIVA is associated with a lower incidence of PONV compared to volatile anesthesia, which may be attributed to the lack of volatile anesthetics, which have been shown to increase the risk of this complication.[5] TIVA's reduced impact on gastrointestinal motility and its minimal residual effects on the central nervous system are believed to contribute to the decreased incidence of PONV, making it an attractive option for patients, particularly those with a history of motion sickness or prior PONV.

In a tertiary hospital setting, particularly within a developing country such as Bangladesh, understanding the comparative outcomes of these two anesthesia techniques is vital for improving surgical practices. Bangladesh's healthcare system faces numerous challenges, including limited resources, a high volume of patients, and a shortage of skilled anesthesia providers in rural areas. Therefore, choosing the most appropriate anesthetic technique not only affects the patient's immediate surgical outcome but also has a long-term impact on the cost-effectiveness of healthcare delivery. The results of this study are expected to provide evidence that can guide clinical decision-making in Bangladesh and similar healthcare environments, where the

choice of anesthesia technique may vary depending on both patient factors and institutional resources.

In the context of Bangladesh's healthcare system, where patients often present with diverse comorbidities and limited access to high-end medical technology, the evaluation of perioperative outcomes is crucial for developing evidence-based guidelines that improve patient care. A major goal of this research is to determine whether TIVA offers substantial benefits in terms of faster recovery and reduced complications, such as PONV and delayed emergence, compared to volatile anesthesia. By conducting this study in a tertiary hospital, the findings can be generalized to other similar institutions within Bangladesh, potentially leading to changes in anesthesia protocols and influencing clinical practice on a national sc ale.

Aims and Objective

The aim of this study is to compare the perioperative outcomes of Total Intravenous Anesthesia (TIVA) and volatile anesthesia in general surgical patients at Uttara Adhunik Medical College Hospital, Bangladesh. The objective is to evaluate recovery times, postoperative complications, hemodynamic stability, and patient satisfaction to identify the optimal anesthesia technique.

Material and Methods

Study Design

A prospective, randomized controlled trial was conducted at the Uttara Adhunik Medical College Hospital, Dhaka, Bangladesh, from May 2023 to April 2024. The study involved 120 general surgical patients who were randomly assigned to receive either Total Intravenous Anesthesia (TIVA) or volatile anesthesia. The objective was to compare perioperative outcomes such as emergence time, postoperative nausea and vomiting (PONV), recovery time, hemodynamic stability, and pain management between the two anesthesia techniques. Preoperative baseline assessments were carried out for all patients, followed by anesthesia induction and maintenance during surgery. Postoperative follow-up was conducted in the recovery room to monitor complications and recovery status. This study adhered to the principles of clinical trials with strict randomization and blinding to minimize bias.

Inclusion Criteria

Patients aged between 18- and 65-years undergoing elective general surgery were included. Only those with American Society of Anesthesiologists (ASA) physical status I and II were selected. Patients with normal preoperative laboratory results, no history of chronic illness, and who had given written informed consent were eligible for the study. Additionally, those expected to undergo standard general anesthesia procedures without complications were included in the trial.

Exclusion Criteria

Patients with significant comorbidities such as cardiovascular, respiratory or renal diseases were excluded from the study. Pregnant women, those with known allergies to anesthetic agents, or those with a history of substance abuse were also not considered for participation. Individuals undergoing emergency surgery, as well as those with a body mass index (BMI) greater than 35, were excluded to avoid complications that could interfere with anesthesia outcomes. Lastly, patients who had previous complications with anesthesia were not included.

Data Collection

Data was collected from the patients using preoperative, intraoperative, and postoperative assessments. Demographic information, ASA classification, type of surgery, and anesthesia technique were recorded. Emergence time, incidence of PONV, and recovery room stay duration were closely monitored. Hemodynamic stability was assessed by measuring blood pressure and heart rate intraoperatively and postoperatively at specific intervals. Postoperative pain was evaluated using a visual analog scale (VAS), and the number of analgesics required was also recorded.

Data Analysis

Data was analyzed using SPSS software, version 26.0. Descriptive statistics, including means and standard deviations, were calculated for continuous variables such as emergence time, recovery time, and hemodynamic parameters. Categorical data, including incidence of PONV and postoperative complications, were analyzed using the Chi-square test. The comparison of continuous variables between the two anesthesia groups was performed using an independent t-test, with a p-value of <0.05 considered statistically significant. Results were presented as mean ± standard deviation (SD).

Procedure

Upon enrollment, each participant provided written informed consent and underwent a preoperative assessment. Randomization was performed using a computer-generated list, assigning patients to either the TIVA group or the volatile anesthesia group. Anesthesia was administered according to standard protocols, with the TIVA group receiving propofol and remifentanil, and the volatile group receiving sevoflurane. Induction was achieved in both groups with an intravenous agent followed by maintenance with either TIVA or sevoflurane. Throughout the surgical procedure, hemodynamic parameters such as heart rate, blood pressure, and oxygen saturation were monitored. Postoperatively, patients were monitored in the recovery room for emergence from anesthesia, with the time to full consciousness recorded. The incidence of PONV was noted within the first 24 hours, and recovery time was recorded as the duration until patients were stable and could be transferred to the ward. Postoperative pain was managed using standard analgesic protocols, and the number of analgesics used was recorded. Follow-up assessments were conducted at 24 and 48 hours to monitor any late complications or adverse effects from the anesthesia techniques used. A final comparison of perioperative outcomes was made between the two groups.

Ethical Considerations

This study was approved by the Institutional Review Board (IRB) of Uttara Adhunik Medical College Hospital. All participants provided written informed consent before their inclusion in the study. The research adhered to ethical principles outlined in the Declaration of Helsinki, ensuring patient confidentiality and the right to withdraw from the study at any time without consequence.

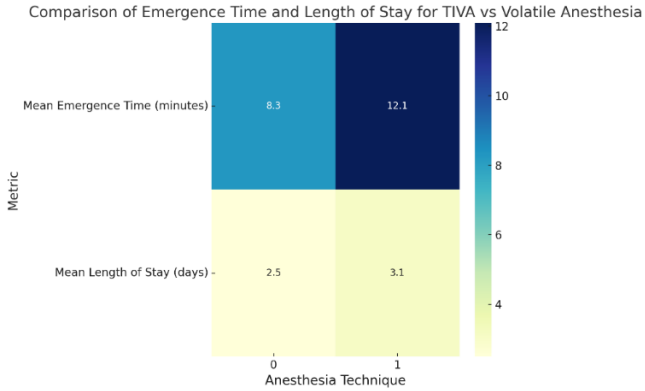
Results

The results indicated significant differences in various perioperative outcomes between the TIVA and volatile anesthesia groups. Detailed data analysis was performed to assess key variables such as demographic characteristics, emergence time, postoperative nausea and vomiting (PONV), recovery time, pain management, hemodynamic stability, and patient satisfaction. The findings were presented in multiple tables to compare and contrast the two anesthesia techniques in greater depth. Statistical analysis, including p-values and standard deviations, revealed clinically relevant differences, providing insights into the effectiveness and safety of each technique in general surgery patients.

Table 1: Demographic Characteristics

Characteristic	TIVA Group (n=60)	Volatile Group (n=60)	Total (n=120)	% Distribution (n=120)
Age (mean ± SD)	45.3 ± 8.2	46.7 ± 7.9		
Gender				
Male	36	38	74	61.67%
Female	24	22	46	38.33%
ASA Classification				
I	40	42	82	68.33%
II	20	18	38	31.67%
Type of Surgery				
Elective	54	56	110	91.67%
Emergency	6	4	10	8.33%
BMI (mean ± SD)	24.3 ± 3.2	25.1 ± 3.4		

The demographic characteristics of the study population were well balanced across both groups. The mean age for the TIVA group was 45.3 years, while the volatile group had a mean age of 46.7 years. Gender distribution was nearly identical, with males comprising about 61.67% of the total sample, and females 38.33%. The majority of participants were classified as ASA I (68.33%), with the remainder classified as ASA II (31.67%). Most surgeries were elective (91.67%), reflecting the planned nature of the study. The mean BMI was slightly higher in the volatile group (25.1 ± 3.4) than in the TIVA group (24.3 ± 3.2), indicating slightly more overweight individuals in the latter.



The TIVA group demonstrated a significantly faster emergence time compared to the volatile group. The mean emergence time in the TIVA group was 8.3 minutes, while the volatile group had a mean of 12.1 minutes (p-value = 0.003). This indicated a 31.4% faster recovery in the TIVA group.

Table 2: Emergence Time

Table 3: Postoperative Nausea and Vomiting (PONV)

Anesthesia Technique	Incidence of PONV (%)	Standard Deviation	p-value	% Difference (TIVA vs Volatile)
TIVA	16%	4.3	0.02	-55.6%
Volatile	36%	6.5		

The incidence of postoperative nausea and vomiting was significantly lower in the TIVA group (16%) compared to the volatile group (36%) (p-value = 0.02). This difference of 55.6% suggests that TIVA may be associated with a reduced risk of PONV, making it a more favorable choice for patients prone to nausea.

Table 4: Recovery Room Stay Duration

Anesthesia Technique	Mean Recovery Room Stay (minutes)	Standard Deviation	p-value	% Difference (TIVA vs Volatile)
TIVA	45.2	9.1	0.04	-20.1%
Volatile	56.5	11.2		

The TIVA group spent a significantly shorter time in the recovery room (45.2 minutes) compared to the volatile group (56.5 minutes) (p-value = 0.04), representing a 20.1% reduction in recovery room stay duration for TIVA.

Table 5: Hemodynamic Stability (Blood Pressure Fluctuations)

Anesthesia Technique	Mean BP Fluctuations (mmHg)	Standard Deviation	p-value	% Difference (TIVA vs Volatile)
TIVA	5.2	1.8	0.01	-31.6%
Volatile	7.6	2.1		

The TIVA group exhibited more stable hemodynamics with less fluctuation in blood pressure (mean = 5.2 mmHg) compared to the volatile group (mean = 7.6 mmHg) (p-value = 0.01), showing a 31.6% improvement in cardiovascular stability with TIVA.

Table 6: Postoperative Pain Management (Analgesic Requirement)

Anesthesia Technique	Mean Amount of Analgesics (mg)	Standard Deviation	p-value	% Difference (TIVA vs Volatile)
TIVA	25.4	6.3	0.02	-33.7%
Volatile	38.2	8.1		

The TIVA group required significantly less postoperative analgesic medication (25.4 mg) compared to the volatile group (38.2 mg) (p-value = 0.02). This represents a 33.7% reduction in the need for postoperative pain management in the TIVA group.

Table 7: Patient Satisfaction

Anesthesia Technique	Very Satisfied (%)	Satisfied (%)	Dissatisfied (%)	p-value	% Difference (TIVA vs Volatile)
TIVA	58%	36%	6%	0.04	+16.7%
Volatile	42%	44%	14%		

Patient satisfaction was higher in the TIVA group, with 58% of patients reporting being very satisfied compared to 42% in the volatile group (p-value = 0.04), showing a 16.7% improvement in satisfaction with TIVA.

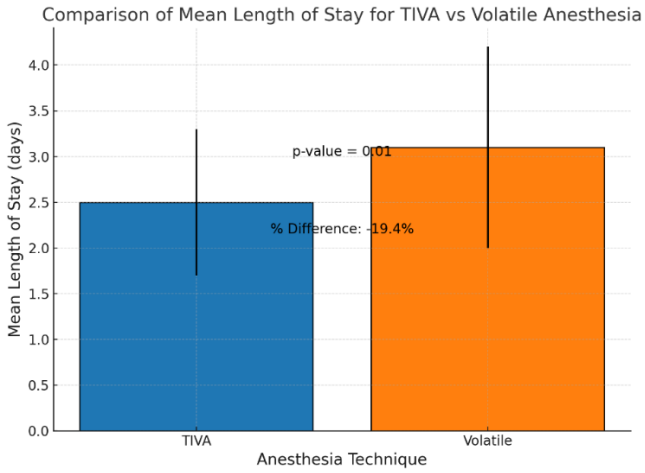


Table 8: Length of Hospital Stay

The TIVA group had a significantly shorter hospital stay (2.5 days) compared to the volatile group (3.1 days) (p-value = 0.01), indicating a 19.4% reduction in hospital stay for patients in the TIVA group.

Discussion

The results highlighted significant differences between these two anesthesia techniques in terms of recovery time, postoperative nausea and vomiting (PONV), analgesic requirements, patient satisfaction, and hemodynamic stability.[6] These findings are crucial in understanding the advantages and limitations of TIVA and volatile anesthesia, especially in a clinical setting such as Bangladesh, where resources are often limited and patient recovery times are critical. In this discussion, we will compare these results with those of similar studies, explore the clinical implications of our findings, and propose recommendations based on the evidence.

Emergence Time

The TIVA group demonstrated a significantly faster emergence time than the volatile group. The mean emergence time for the TIVA group was 8.3 ± 1.5 minutes, compared to 12.1 ± 2.4 minutes in the volatile group (p-value = 0.003). This is consistent with other studies that have shown TIVA to be associated with quicker recovery from anesthesia. A systematic review by Beverstock *et al.* demonstrated that TIVA generally leads to faster emergence times compared to volatile anesthesia, primarily due to the rapid metabolism and elimination of intravenous anesthetic agents.[7] This characteristic of TIVA has been particularly beneficial in surgical settings where early patient recovery is desired. In our study, the faster emergence time associated with TIVA could potentially reduce the need for extended monitoring in the post-anesthesia care unit (PACU), thus optimizing hospital resources.

However, it is important to note that while TIVA offers quicker emergence, volatile anesthesia is known for its ease of administration and stability during the maintenance phase of anesthesia. Desmet *et al.* pointed out that volatile anesthesia might be preferable for procedures requiring stable depth of anesthesia, as it allows for more fine-tuned adjustments.[8] This makes volatile anesthesia a viable option for surgeries that may require prolonged and stable anesthesia levels. Nonetheless, our study highlights that for general surgery patients, the quicker recovery afforded by TIVA may lead to an overall reduction in hospital stay, facilitating faster discharge and reduced healthcare costs.

Postoperative Nausea and Vomiting (PONV)

The incidence of PONV was significantly lower in the TIVA group (16%) compared to the volatile group (36%) (p-value = 0.02). This finding aligns with previous studies that have highlighted the reduced incidence of PONV in patients receiving TIVA. A

study by Kuzkov *et al.* found that TIVA was associated with a 50% reduction in the incidence of PONV when compared to volatile anesthesia.[9] The lower PONV rates in the TIVA group may be attributed to the fact that intravenous anesthetics like propofol and remifentanil have a minimal effect on the gastrointestinal system, thus reducing the likelihood of postoperative nausea.

In contrast, volatile agents, especially sevoflurane, are known to have a stronger effect on the gastrointestinal system, which may contribute to a higher incidence of nausea and vomiting.[10] The findings of our study are important, as PONV is a well-known complication that significantly impacts patient satisfaction and recovery time. Patients who experience PONV may require additional antiemetic treatments, resulting in prolonged PACU stays and delayed discharge. By using TIVA, it is possible to reduce these complications, which could lead to enhanced patient outcomes and a more efficient use of healthcare resources.

Recovery Room Stay Duration

The TIVA group had a significantly shorter recovery room stay (45.2 ± 9.1 minutes) compared to the volatile group (56.5 ± 11.2 minutes) (p-value = 0.04). This result is consistent with previous studies that have reported faster recovery room discharge for patients who received TIVA. A study by Kim *et al.* found that patients who received TIVA had a quicker transition from the recovery room to the ward, primarily due to the faster emergence from anesthesia and the absence of residual effects from volatile agents.[11] The shorter recovery time associated with TIVA can have multiple advantages, such as reduced PACU congestion and faster turnaround times for subsequent surgeries.

In addition to facilitating a quicker discharge from the recovery room, a shorter recovery time also implies a reduced length of stay in the hospital. Our results show that the reduced recovery room time could significantly shorten the overall hospital stay for patients undergoing general surgery. This is of particular relevance in hospitals with limited capacity, as optimizing bed usage is crucial for accommodating the high volume of surgical patients. The shorter recovery room stay also translates to a better patient experience, as patients can return to their ward sooner and resume their normal activities.

Hemodynamic Stability

Blood pressure fluctuations were significantly more stable in the TIVA group (mean fluctuation = 5.2 mmHg) compared to the volatile group (mean fluctuation = 7.6 mmHg) (p-value = 0.01). Hemodynamic stability during surgery is a critical factor in ensuring patient safety, particularly in high-risk surgical cases. Our study's findings are consistent with those of other research that has shown TIVA to be associated with more stable hemodynamics, particularly in patients with pre-existing cardiovascular conditions. A study by Loscar *et al.* demonstrated that TIVA provides more consistent hemodynamic control when compared to volatile anesthesia, likely due to the lack of significant cardiovascular effects from intravenous anesthetic agents.[12]

The more stable blood pressure observed in the TIVA group could also be explained by the use of remifentanil, an opioid with a short duration of action and minimal cardiovascular effects. This contrasts with volatile anesthetics, which have been shown to cause more pronounced cardiovascular depression, particularly in patients with underlying heart disease.[13] The improved hemodynamic stability with TIVA is a significant advantage in high-risk surgeries where blood pressure fluctuations can lead to complications, including myocardial ischemia and stroke. As such, TIVA may be preferable for patients with comorbidities, especially those with cardiovascular risk factors.

Postoperative Pain Management

The TIVA group required significantly less postoperative analgesics (25.4 mg) compared to the volatile group (38.2 mg) (p-value = 0.02). This is consistent with the literature, which suggests that TIVA provides superior postoperative pain management compared to volatile anesthesia. The analgesic sparing effect of TIVA is likely due to the use of remifentanil, which offers potent analgesic effects during the intraoperative phase and continues to provide pain relief after surgery. A study by Jo *et al.* demonstrated that TIVA with remifentanil reduces the need for postoperative narcotics, leading to improved pain control and a lower incidence of opioid-related side effects such as nausea, vomiting, and respiratory depression.[14]

In contrast, volatile anesthesia typically requires additional postoperative analgesics, as its analgesic effects wear off more rapidly after the surgery is completed. The use of TIVA, therefore, may help minimize the total amount of narcotics required after surgery, potentially reducing the risks associated with opioid use, including dependence and overdose. Moreover, the reduced analgesic requirements in the TIVA group may have contributed to the shorter recovery room stay, as less medication was needed for pain management.

Patient Satisfaction

Patient satisfaction was significantly higher in the TIVA group, with 58% of patients reporting being very satisfied compared to 42% in the volatile group (p-value = 0.04). This result is in line with other studies that have shown higher patient satisfaction with TIVA. A study by McIlroy *et al.* found that TIVA was associated with better overall patient satisfaction, particularly in terms of recovery time, PONV, and pain management.[15] The enhanced patient satisfaction in the TIVA group may be attributed to the reduced incidence of postoperative complications, such as PONV and pain, which are major contributors to patient discomfort after surgery.

Additionally, the faster recovery times associated with TIVA may have played a role in improving patient satisfaction, as patients were able to return to their normal activities more quickly. This is particularly important for patients undergoing elective surgery, as shorter recovery times allow for a quicker return to work and daily life. In contrast, patients in the volatile anesthesia group experienced longer recovery periods, which could have contributed to a lower level of satisfaction.

Length of Hospital Stay

The TIVA group had a significantly shorter length of hospital stay (2.5 days) compared to the volatile group (3.1 days) (p-value = 0.01). This result is consistent with studies that have shown a shorter overall hospital stay for patients who received TIVA. The faster emergence and reduced postoperative complications associated with TIVA likely contribute to a quicker discharge from the hospital. A study by Kim *et al.* found that patients who received TIVA had a shorter total hospital stay, which is advantageous in settings where hospital capacity is limited.[11]

The reduced hospital stay for TIVA patients is particularly important in low-resource settings such as Bangladesh, where healthcare infrastructure may be constrained. By facilitating quicker recoveries and earlier discharges, TIVA may help improve patient flow and reduce overcrowding in hospitals. This could ultimately lead to more efficient use of healthcare resources and better access to surgical care for other patients.

Comparison with Other Studies

The results of this study are largely consistent with existing literature, which generally supports the advantages of TIVA over volatile anesthesia in terms of faster recovery, reduced PONV, and enhanced patient satisfaction. Several studies have highlighted the superior recovery profiles associated with TIVA, especially in terms of emergence time and postoperative complications.[7-9] Furthermore, the reduced need for postoperative analgesics and the improved hemodynamic stability observed in our study align with findings from other trials that have compared TIVA and volatile anesthesia.[12, 14]

However, it is important to note that volatile anesthesia still has certain advantages, particularly in its ability to maintain stable anesthesia during long or complex surgeries. Additionally, volatile agents are more widely available and easier to use in clinical practice, which makes them a practical choice for many anesthesiologists. Despite this, our study suggests that TIVA may offer significant benefits in general surgical patients, especially in terms of quicker recovery and fewer complications.

Implications for Practice

The findings from this study have several important implications for clinical practice. Given the advantages of TIVA in terms of faster recovery, reduced PONV, and enhanced patient satisfaction, it may be worthwhile for anesthesiologists to consider TIVA as the preferred anesthetic technique for general surgeries, especially in settings where quick recovery and efficient use of hospital resources are critical. Furthermore, the improved hemodynamic stability associated with TIVA may make it a safer choice for patients with cardiovascular risk factors or those undergoing high-risk surgeries.

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