

Comparison of Total Intravenous Anesthesia (TIVA) Versus Spinal Anesthesia in Total Knee Arthroplasty (TKA)

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ABSTRACT

Objective: To assess outcomes of two anesthesia techniques utilized in total knee arthroplasty (TKA): total intravenous anesthesia (TIVA) and spinal anesthesia.

Study Design: Prospective Comparative Study.

Place and Duration of Study: Orthopedics Department, Combined Military Hospital, Rawalpindi, Pakistan, from May to Nov 22.

Methodology: A total of 78 patients, aged <75 years and with end-stage osteoarthritis, underwent TKA by either TIVA or spinal anesthesia. Individuals with medical comorbidities were excluded. Spinal anesthesia was provided by means of 0.5% bupivacaine, whereas TIVA was administered by using Propofol plus Remifentanyl. A visual analogue scale (VAS) was applied to assess postoperative pain. Postoperative complications, e.g., nausea, vomiting, dizziness, postural drop, and deep venous thrombosis (DVT) were monitored for both groups. SPSS-23.0 was used to conduct statistical analysis, while a p -value<0.05 was considered significant.

Results: Thirty-eight patients (48.7%) underwent TIVA, while the remaining 40 cases (51.3%) were treated with spinal anesthesia. The mean age of the former group was 67.4±4.3 years and 66.5±4.7 years for spinal anesthesia. TIVA was capable of significantly lowering the incidence of postoperative pain ($p=0.023$). The median VAS was 5.0 (IQR: 2.0) for the TIVA and 6.0 (IQR: 2.0) for the spinal anesthesia group. A higher incidence of postoperative dizziness was reported during recovery from spinal anesthesia ($n=22$; 52%) as compared to TIVA ($n=13$; 34.2%). No significant difference was observed in terms of nausea/vomiting, postural drop, or DVT during patient recovery. Additionally, hospital stay also remained uniform in both groups.

Conclusion: TIVA is a potentially suitable candidate for the administration of general anesthesia in TKA.

Keywords: Postoperative pain; Propofol ; Spinal anesthesia; Total knee arthroplasty.

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INTRODUCTION

A substantial body of evidence supports the correlation between the type of anesthesia and postoperative outcomes among patients undergoing orthopedic procedures. A plethora of clinical studies have weighed the efficacy of different anesthesia techniques and evaluated their potential impact on patient-related outcomes.¹ The overall efficacy of general anesthesia has often been debated, while locoregional and neuraxial types of anesthesia have been found to be associated with a comparatively reduced incidence of perioperative mortality along with a lower risk of cardiopulmonary morbidities, blood transfusions, urinary retention, ileus, and wound infections.²

Total knee arthroplasty (TKA) is an orthopaedic

procedure commonly undertaken in the management of advanced osteoarthritis.³ Taking patient-related parameters into account, the anesthesia team plays a critical role in the selection of the most suitable technique for perioperative analgesia.⁴ Over the past few decades, a multitude of anesthesia modalities have been implemented in TKA, including general analgesia with or without spinal anesthesia, regional nerve block, and local anesthesia, which can be directly infiltrated into joint cavity intraoperatively. Total intravenous analgesia (TIVA) is a subtype of general anesthesia that induces analgesia by combining a short-acting opioid medication with Propofol.⁵ TIVA has been generally considered safe and cost-effective in TKA since it seldom requires an input of volatile anesthetic agents. TIVA has been utilized separately as well as in combination with spinal anesthesia to facilitate TKA. Using intravenous Propofol or dexmedetomidine in addition to spinal or epidural routes of analgesia is significantly capable of

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providing a satisfactory level of anesthesia along with hemodynamic stability.⁶ Moreover, this can also lessen the overall duration of hospital stay.⁷ A relatively lower risk of deep venous thrombosis (DVT) has also been determined in relation to TIVA.⁸

Most of the TKA procedures are preferably conducted under general anesthesia. Spinal or neuraxial block is the next most commonly used anesthesia modality and has been considered a safe and effective method of spinal anesthesia.⁹ During analysis of a large cohort of patients from the American College of Surgeons (ACS) database, the overall risk of minor complications as well as the incidence of postoperative blood transfusions was found to be significantly associated with general anesthesia as compared to spinal analgesia.¹⁰

This study has been designed to compare the overall outcomes of TIVA versus spinal anesthesia during the procedure of total knee replacement. The study aims to determine which anaesthetic approach offers better pain control and fewer postoperative adverse effects in total knee arthroplasty.

METHODOLOGY

This study was conducted at the Department of Orthopedics, Combined Military Hospital (CMH), Rawalpindi, Pakistan, from May to Nov 22. After ethical approval was obtained from the hospital's institutional review board (296), the authors committed to the standardized guidelines of the Helsinki Protocol. All the patients voluntarily consented to their participation in the study. Participant selection was based on a convenience non-probability sampling technique. Keeping in view the population size estimated in a randomized controlled trial by Harsten *et al.*, (n=60) for both the TIVA and spinal anesthesia groups, an equal proportion of patients was considered for both groups in this study.¹¹ Hence, an approximated sample size of 98 participants was calculated by using the Cochran formula: $Z = \text{Confidence interval at 95\%} = 1.96$, $p_1 = \text{Percentage of patients undergoing total intravenous general anesthesia for TKA} = 50\%$, $p_2 = \text{Percentage of patients undergoing spinal anesthesia for TKA} = 50\%$, $d = \text{Absolute precision} = 10\%$.

Inclusion Criteria: Patients of either gender with age <75 years, body mass index (BMI) < 30 kg/m², and a normal clotting profile were included in the study.

Exclusion Criteria: Patients of either gender, age > 75 years, body mass index (BMI) > 30 kg/m², and with

past medical history of cardiovascular, neurological, or endocrine abnormalities were excluded from the study.

The sample population comprised 98 patients initially, all of whom were selected for TKA under TIVA or spinal anesthesia and had been diagnosed with end-stage osteoarthritis. After exclusion, a total of 78 patients were included within the final study population. All the 78 participants were evaluated for their surgical fitness through a series of investigations, i.e., Electrocardiogram (ECG) or echocardiography, chest X-ray, and baseline blood investigations. Up to 38 patients were incorporated into the TIVA group, and the remaining 40 individuals were planned to undergo spinal anesthesia. The study primarily targeted the assessment of postoperative outcomes of two different anesthesia techniques utilized in total knee arthroplasty, i.e., total intravenous anesthesia (TIVA) and spinal anesthesia. Postoperative outcomes mainly focused on the assessment of pain intensity and detection of adverse symptoms, including post-anesthesia nausea and/or vomiting, postural drop, and dizziness. In addition, the overall duration of stay at the hospital was also treated as a major post-intervention outcome.

Before TKA was commenced, spinal anesthesia was provided preoperatively by using 10 mg (~2 ml) of 0.5% Bupivacaine injection (5 mg/ml) through a 25-G lumbar puncture needle. Before administration, the patient was advised to secure a sitting posture on the operating table. The patient's neck and both hip and knee joints were flexed, while a local anesthetic was administered into the 3/L4 subarachnoid space. The efficacy of spinal anesthesia was then confirmed by conducting a distal sensorineural examination. Furthermore, all the participants were asked to keep a supine head posture during the postoperative recovery period. Contrariwise, TIVA was provided by using a controlled combination infusion of Propofol and a strong parenteral opioid i.e., Remifentanyl.

For all the patients undergoing TKA, the duration of hospital admission was determined from the point of patients' recovery from anesthesia until the time when they eventually satisfied the department's protocol for hospital discharge. The discharge protocol consisted of the following parameters: (1) Free mobilization; (2) Ability to walk up to 10 meters with or without a physical aid; (3) Ability to flex the knee joint; (4) Satisfactory pain control, and (5) Absence of adverse cardiovascular complications.

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Postoperative incidence of pain was analysed by the utilization of the visual analogue scale (VAS), where pain intensity was graded as a single numeral out of 10. Pain assessment was carried out only once, i.e., at approximately 6 hours in the post-operative period. Mean arterial blood pressure (MAP) was also determined following the completion of operation. Furthermore, both reclining and standing blood pressures were estimated to rule out the incidence of postural hypotension. A drop of 20 mmHg in systolic or 10 mmHg in diastolic pressure was considered significant. In addition, postoperative occurrence of dizziness was also evaluated. Moreover, frequency of postoperative nausea and vomiting was also recorded accordingly. Incidence of DVT or other thromboembolic complications was also assessed and compared between the two study groups.

A standardized data collection tool was implemented to record perioperative vital signs of the patients. Data were analyzed by using the version 23.0 of IBM Statistical Package for Social Sciences (SPSS). Mean±SD were evaluated for variables including patient age and systolic blood pressure values. Median (IQR) was used for pain intensity scores. Independent t-test (age, SBP) and Pearson's chi-square (χ^2) test were applied. Moreover, the Mann-Whitney U test was applied to compare the VAS scores between the two anesthesia groups. A p -value <0.05 was considered significant by the authors.

RESULTS

Out of a total of 78 participants with advanced osteoarthritis, thirty-eight cases (48.7%) underwent TIVA-assisted TKA, and 40 patients (51.3%) were administered spinal anesthesia. Mean age was 67.4±4.3 years for the TIVA group and 66.5±4.7 years for the spinal anesthesia group. Up to 20 (TIVA = 52.6% and spinal anesthesia = 50%) individuals in each group were males. The average duration of surgery was estimated to be 51.4±8.2 minutes for TIVA and 52.0±8.2 minutes for TKA with spinal anesthesia (Table-I).

Table-I: Patient Biodata and Duration of Types of Anesthesia in Total Knee Arthroplasty Surgery (n=78)

Parameters	Type of Anesthesia (n=78)		p-value
	TIVA (n=38)	Spinal (n=40)	
Mean Age in Years(±SD)	67.4±4.3	66.5±4.7	0.357
Gender	Male (%)	20(52.6%)	20(50.0%)
	Female (%)	18(47.4%)	20(50.0%)
Duration of Surgery±SD (in minutes)	51.4±8.2	52.0 ± 8.2	0.736

TIVA was found to significantly lower the incidence of postoperative pain ($p=0.023$). Moreover, the median and interquartile range (IQR) values were calculated for VAS scores: TIVA = 5.0 (2.0) and Spinal = 6.0 (2.0). Mean arterial blood pressure was slightly lower in the TIVA group (105.9±14.7 mmHg) compared with the control group (111.6±14.8 mmHg). Moreover, a relatively higher incidence of postoperative dizziness was reported by patients undergoing spinal anesthesia (n=22; 52%) as compared to TIVA (n=13; 34.2%). However, no significant variation was seen in the occurrence of nausea/vomiting, postural drop, or DVT in the postoperative state. Furthermore, the duration of hospitalization remained consistent in both anesthesia groups (Table-II).

Table-II: Comparison of Operative Parameters among Patients Undergoing Total Knee Arthroplasty under Total Intravenous Anesthesia and Spinal Anesthesia (n=78)

Operative Parameters	Type of Anesthesia (n=78)		p-value
	TIVA (n=38)	Spinal (n=40)	
Mean Arterial Pressure (MAP) in mmHg (±SD)	105.9±14.7	111.6±14.8	0.091
Median VAS (IQR)	5.0 (2.0)	6.0 (2.0)	>0.05
Postural Drop (%)	11 (28.9%)	12 (30.0%)	0.919
Nausea/Vomiting (%)	21 (55.3%)	25 (62.5%)	0.516
Dizziness (%)	13 (34.2%)	22 (52.0%)	0.065
Deep Venous Thrombosis (DVT) (%)	3 (7.9%)	6 (15.0%)	0.326
Duration of Hospital Stay in days (± SD)	4.6±1.1	4.7±1.1	0.634

DISCUSSION

Out of all the parameters assessed in the perioperative state, only the incidence of postoperative pain determined at 6 hours after the completion of surgery showed a significant variation between individuals undergoing spinal and total intravenous general anesthesia. While the individuals undergoing TIVA had a relatively lower Mean Arterial Pressure, TKA under spinal anesthesia led to a potentially higher incidence of postoperative dizziness. The latter two results, however, were not found to be statistically significant. The results, therefore, hint at a better efficacy and tolerance of TIVA among the osteoarthritis patients undergoing orthopedic intervention.

The scarcity of literature has compared the practical effectiveness of spinal and intravenous anesthesia in total knee replacement. Randomized trial by Harsten *et al.*, included up to 120 patients, of whom

60 subjects received either form of anesthesia before TKA. Spinal anesthesia was provided via an intrathecal injection of bupivacaine, and TIVA was administered by using a cocktail of Propofol and Remifentanyl. Statistically significant differences were noted in favor of TIVA, where the total length of hospitalization and postoperative incidence of adverse events, e.g., gastrointestinal disturbance and dizziness, were curtailed. In line with the current findings, pain scores at 6 hours after surgery showed a higher severity of pain within the spinal anesthesia group.¹¹ Data regarding the relative efficacy of the above two anesthesia modalities has also been gathered in relation to total hip arthroplasty, according to the guidelines reported by Shrestha *et al.*,¹² Besides a shorter postoperative stay at the hospital, the TIVA group also reported a significantly lower risk of nausea and dizziness following hip replacement. In addition, pain intensity reported at 6 hours was comparatively lower in TIVA as compared to spinal anesthesia patients. It is also noteworthy that patients undergoing spinal anesthesia were more likely to request a change of anesthesia to TIVA, as concluded by Fu *et al.*¹³

Apart from orthopaedic procedures, Teulieres *et al.*, reported that the practical applicability of TIVA utilizing Propofol has also been assessed in thyroid surgery, where a combination of Propofol and Remifentanyl showed a substantially improved recovery rate as compared to inhalational anesthesia.¹⁴ Besides Propofol, intravenous anesthesia using Ketamine has also been widely implemented in TKA surgery. In a meta-analysis of 6 randomized controlled trials conducted by Li *et al.*, this analgesic agent was capable of significantly lowering the overall dependence on opioid medication while also limiting the incidence of postoperative nausea or vomiting.¹⁵ Moreover, Chandrashekar *et al.*, study randomized data have also supported the beneficial impact of total intravenous anesthetic agents, e.g., Ketamine, in long-term rehabilitation following TKA procedure. This emphasizes the importance of success in the initial attempt at SA for optimizing outcomes following TJA.¹⁶

Heterogeneous evidence exists regarding the superior efficacy of spinal anesthesia as compared to general anesthesia. Quality of recovery from spinal anesthesia did not vary substantially in contrast to general anesthesia in a trial involving up to 1,600 patients undergoing hip surgery. Moreover,

postoperative incidence of altered sensorium and mortality remained consistent regardless of the type of anesthesia used by Neuman *et al.*¹⁷ In contrast, Warren *et al.*, proved in a broad analysis consisting of 80,077 patients undergoing spinal anesthesia and 103,003 subjects undergoing general anesthesia for TKA that a significantly lower complication rate was encountered for the former cohort. Furthermore, no significant variation was seen in terms of postoperative mortality.¹⁸

Hence, the study advocated strongly for TIVA as a better version of an anesthetic technique, especially in total knee arthroplasty patients. It has confirmed manageable post-treatment outcomes and better patient safety aspects.

LIMITATIONS OF STUDY

Some potential chronic complications associated with spinal anesthesia might include spinal abscess, spinal haematoma, nerve root injury, or meningoencephalitis, etc. In addition, pain assessment was carried out at a single time interval only, rather than utilizing a course of serial evaluation. This could have potentially created a bias in favor of total intravenous anesthesia.

CONCLUSION

In comparison to spinal anesthesia, total intravenous analgesia with Propofol and opioids is considerably more effective as an anesthesia modality for patients undergoing total knee arthroplasty due to faster, more stable recovery profiles, reduced immediate postoperative complications, and improved mobilization capabilities. While spinal anesthesia is a widely accepted standard, TIVA addresses specific limitations associated with neuraxial blockade.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MHB & KB: Data acquisition, data analysis, critical review, approval of the final version to be published.

MHS & SI: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

TAK & OAM: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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