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THE ROLE OF SPINAL ANESTHESIA IN REDUCING BLOOD LOSS DURING ORTHOPEDIC SURGERY: A PROSPECTIVE STUDY

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Abstract

Introduction: Several studies have investigated the relationship between spinal anesthesia and blood loss in orthopedic surgery, but the results remain mixed. Some studies suggest that spinal anesthesia offers a superior advantage in terms of blood loss control, while others highlight that the reduction in blood loss is not statistically significant when compared to general anesthesia. spinal anesthesia has been shown to reduce stress responses to surgery, including the release of catecholamines and other hormones involved in blood coagulation and vascular tone**. Material& Methods:** The study examined various factors related to patient characteristics, surgical procedures, anesthesia methods, and postoperative outcomes. The patient data collected encompassed age, sex, diagnosis, comorbidities, body mass index (BMI), and preoperative health status. Surgical information, such as procedure type, duration of surgery, anesthesia type, intraoperative complications, hemoglobin (Hb) levels, blood transfusion requirements, and intraoperative blood loss, were recorded. Intraoperative hemoglobin (Hb) levels were measured at the discretion of the attending anesthesiologist. **Results:** The mean and standard deviation for intraoperative, postoperative, and total transfusions. Intraoperative transfusion was significantly lower in the spinal anesthesia group (0.09 ± 0.35) compared to the general anesthesia group (0.20 ± 0.44), with a p-value < 0.05 indicating statistical significance. **Conclusion:** With potential benefits in hemodynamic stability, reduced stress responses, and lower transfusion rates, the findings of this study could inform clinical decisions and optimize anesthesia protocols. Ultimately, a clearer understanding of spinal anesthesia's impact on blood loss could enhance patient outcomes and improve the safety of orthopedic procedures.

Keywords: Spinal Anesthesia, Blood Loss, Orthopedic Surgery

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INTRODUCTION

Orthopedic surgeries, particularly those involving large joints and spine operations, are often accompanied by significant blood loss. Blood transfusion is frequently required to maintain hemodynamic stability and ensure optimal outcomes for patients. However, transfusions carry potential risks, such as allergic reactions, transmission of infections, and increased postoperative complications. As a result, minimizing blood loss has become a critical focus in modern orthopedic surgical practices. Numerous strategies have been investigated to reduce blood loss, with one key approach being the use of spinal anesthesia (SA) in place of general anesthesia (GA). The aim of this prospective study is to examine the potential role of spinal anesthesia in minimizing blood loss during orthopedic surgeries.

Spinal anesthesia has long been considered an effective and safe technique for a variety of surgeries, including orthopedic procedures, due to its ability to provide both analgesia and muscle relaxation while preserving cardiovascular stability **1**. Unlike general anesthesia, which induces a state of complete unconsciousness and often requires the use of mechanical ventilation, spinal anesthesia involves the administration of local anesthetics into the subarachnoid space, leading to sensory and motor blockade below the level of injection. This technique offers several physiological benefits that may contribute to reduced intra-operative blood loss.

One important factor in this regard is the lower incidence of hypotension typically observed during spinal anesthesia, which is attributed to the sympathetic blockade caused by the local anesthetic. Hypotension can exacerbate blood loss during surgery by impairing venous return and reducing perfusion to vital organs **2**. In contrast, general anesthesia often requires the use of vasopressor medications to maintain blood pressure, which may have an adverse effect on the patient's circulatory system and may not necessarily prevent excessive blood loss. The ability of spinal anesthesia to maintain relatively stable blood pressure, especially when combined with volume preloading techniques, may result in less blood loss, thus reducing the need for transfusions.

Furthermore, spinal anesthesia has been shown to reduce stress responses to surgery, including the release of catecholamines and other hormones involved in blood coagulation and vascular tone **3**. In cases where blood loss is minimized by controlling systemic blood pressure and avoiding excessive bleeding, the requirement for hemostatic interventions, such as tourniquets or topical hemostatic agents, may also be reduced, potentially improving recovery time and reducing complication rate **4.**

Several studies have investigated the relationship between spinal anesthesia and blood loss in orthopedic surgery, but the results remain mixed. Some studies suggest that spinal anesthesia offers a superior advantage in terms of blood loss control, while others highlight that the reduction in blood loss is not statistically significant when compared to general anesthesia. **5**This discrepancy may be due to variations in surgical technique, the type of orthopedic procedure performed, and patient-specific factors, such as age, comorbidities, and baseline hematologic status. Despite these differences, there remains an overarching interest in understanding the mechanisms through which spinal anesthesia may influence blood loss during surgery.

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In orthopedic surgery, the potential for substantial blood loss is particularly notable in procedures such as total joint arthroplasty (TJA), spinal fusion, and trauma surgeries, where the disruption of bone and surrounding vasculature can result in significant hemorrhage. The blood loss in these procedures can be further exacerbated by the use of tourniquets, bone cuts, and the manipulation of tissues, all of which contribute to an increased risk of bleeding. Consequently, any technique that reduces blood loss while maintaining patient safety and comfort is highly valuable. A thorough understanding of spinal anesthesia's role in mitigating this risk is essential for optimizing surgical outcomes.

In light of these concerns, the purpose of this prospective study is to evaluate the effect of spinal anesthesia on blood loss during various orthopedic surgeries. The study will compare patients who receive spinal anesthesia with those who undergo the same procedures under general anesthesia, with a focus on intraoperative blood loss, transfusion requirements, and post-operative complications. By providing evidence-based insights into the potential benefits of spinal anesthesia in reducing blood loss, this study aims to inform clinical decision-making and improve patient outcomes in orthopedic surgery.

MATERIAL & METHODS

Study Design and Population

This retrospective study included 120 patients who underwent Orthopedic Surgery at a tertiary care hospital in North India between January 2019 to December 2019. The study examined various factors related to patient characteristics, surgical procedures, anesthesia methods, and postoperative outcomes. The patient data collected encompassed age, sex, diagnosis, comorbidities, body mass index (BMI), and preoperative health status. Surgical information, such as procedure type, duration of surgery, anesthesia type, intraoperative complications, hemoglobin (Hb) levels, blood transfusion requirements, and intraoperative blood loss, were recorded. Additionally, postoperative outcomes, including thromboembolic prophylaxis, complications, and transfusion requirements, were tracked until discharge.

Ethical Approval

The study received approval from both the institutional review board and the ethics committee prior to data collection and analysis.

Anesthesia Protocol

The choice of anesthesia (general anesthesia [GA] or spinal anesthesia [SA]) was determined by the anesthesiologist based on factors such as patient age, comorbidities, medical history, and the operative risk, as categorized by the American Society of Anesthesiologists (ASA) classification. Patients with a history of neurological disorders or previous lumbosacral spine surgeries were generally not considered for SA. Older patients with higher ASA classifications were more likely to be assigned to the SA group.

For patients receiving SA, 3 mL of 0.5% bupivacaine was injected into the subarachnoid space at the L4–L5 intervertebral level. Intravenous sedation was administered as required. Propofol was used for induction in all GA patients, followed by intubation. GA maintenance involved a

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combination of nitrous oxide with oxygen, desflurane, and fentanyl, while rocuronium bromide was used as a muscle relaxant.

Surgical Procedure

Intraoperative Management

Intraoperative hemoglobin (Hb) levels were measured at the discretion of the attending anesthesiologist. If the hematocrit was found to be low and the patient exhibited hypotension, intraoperative blood transfusions were administered following adequate fluid resuscitation with crystalloid solutions. The decision for postoperative blood transfusion was made on an individual basis, typically if the Hb level fell below 9.0 g/dL or the patient presented with symptoms of anemia.

Postoperative Care

Wound drains were placed intraoperatively and removed on postoperative days 1 or 2. Perioperative antibiotics were continued until the removal of the drains. All patients received thromboembolic prophylaxis using low molecular-weight heparin (LMWH). Physical therapy was initiated on the first postoperative day. Immediate postoperative and daily serial Hb levels, transfusion requirements, and the incidence of postoperative complications were meticulously recorded. If patients showed symptoms or signs suggestive of deep venous thrombosis (DVT) or pulmonary embolism (PE), diagnostic imaging such as venous duplex scans, ventilation-perfusion scans, or pulmonary angiograms were performed to confirm or exclude these conditions.

Statistical Analysis

The data were analyzed using appropriate statistical methods, including Student's t-test, chi-square (χ^2) test, or nonparametric tests, depending on the type of data and distribution. To identify factors associated with intraoperative blood loss, linear regression analysis was conducted. Both continuous variables (e.g., operating time, BMI, age) and categorical variables (e.g., ASA classification, anesthesia type, surgical approach, cement usage, sex, comorbidities, systemic conditions) were included in the regression model. Categorical variables with more than two levels were represented by indicator variables. All variables were simultaneously entered into the model, with the intercept set to zero. Statistical significance was defined as a p-value of less than 0.05.

RESULTS:

Table 1 shows the demographic distribution of study subjects based on anesthesia type (spinal vs. general). In the spinal anesthesia group, 47.3% of participants were male and 52.7% female, while in the general anesthesia group, 45.6% were male and 54.4% female. The mean age of the spinal anesthesia group was 63.5 years (±10.7), while the general anesthesia group was younger at 58.8 years (±12.4). Regarding physical characteristics, the spinal anesthesia group had a slightly higher average height (65.1 inches) compared to the general anesthesia group (64.2

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inches), but a slightly lower average weight (67.8 kg vs. 69.5 kg). The body mass index (BMI) was slightly higher in the general anesthesia group (29.4 kg/m² vs. 28.6 kg/m²).

Table 1: Distribution of study subjects based on demography (N= 120)

Variables	Spinal Anesthesia	General Anesthesia
Male	35(47.3)	21(45.6)
Female	39(52.7)	25(54.4)
Total	74	46
Mean (SD)		
Age(years)	63.5(10.7)	58.8(12.4)
Height(inches)	65.1(3.4)	64.2(3.9)
Weight(kg)	67.8(4.8)	69.5(5.2)
BMI(kg/m^2)	28.6(0.8)	29.4(0.6)

Table 2: Distribution of study subjects based on operative indicators

Variables	Spinal Anesthesia	General Anesthesia
Osteoarthritis	50(67.6)	29(63.1)
Avascular necrosis	7(9.4)	5(10.9)
Rheumatoid arthritis (RA)	5(6.8)	3(6.5)

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Inflammatory arthritis (excluding RA)	3(4.1)	1(2.1)
Posttraumatic arthritis	4(5.4)	4(8.7)
Developmental dysplasia	2(2.7)	2(4.3)
S/P arthrodesis	1(1.3)	1(2.1)
Tumors	2(2.7)	1(2.1)

Table 2 presents the distribution of study subjects based on various operative indicators for both spinal and general anesthesia groups. Osteoarthritis was the most common condition, affecting 67.6% of patients in the spinal anesthesia group and 63.1% in the general anesthesia group. Other conditions included avascular necrosis, rheumatoid arthritis, inflammatory arthritis (excluding RA), posttraumatic arthritis, developmental dysplasia, prior arthrodesis, and tumors. The distribution of these conditions was generally similar across both groups, with minor differences, such as a higher percentage of posttraumatic arthritis in the general anesthesia group and a slightly greater prevalence of developmental dysplasia in the general anesthesia group.

Table 3: Distribution of study subjects based on Hemoglobin data (g/dl)

Particulars	Spinal Anesthesia	General Anesthesia
Pre-operative	12.5(1.5)	12.3(1.5)
Immediate post-operative	11.7(1.4)	11.6(1.4)
Post-operative		
Day 1	10.9(1.3)	10.6(1.2)
Day 2	10.8(1.3)	10.5(1.2)
Day 3	10.8(1.2)	10.4(1.1)
Day 4	10.8(1.1)	10.4(1.2)
Day 5	10.7(1.1)	10.5(1.2)

Table 3 shows the distribution of study subjects' hemoglobin levels (g/dl) at various time points for both spinal and general anesthesia groups. Pre-operatively, both groups had similar hemoglobin levels (12.5 ± 1.5 for spinal, 12.3 ± 1.5 for general). Immediate post-operatively, the

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levels decreased slightly in both groups. On subsequent days (Day 1 to Day 5), hemoglobin levels gradually declined in both groups, with the spinal anesthesia group maintaining slightly higher levels compared to the general anesthesia group at each time point. However, these differences were minimal, and no significant trends or differences were observed between the groups.

Table 4: Distribution of study subjects based on transfusion data

	Spinal Anesthesia	General Anesthesia	p value
Intra-operative	0.09(0.35)	0.20(0.44)	p<0.05*
Post-operative	0.75(0.90)	0.95(0.82))	
Total	0.80(0.96)	1.05(1.09)	p<0.05*

Table 4 presents the distribution of study subjects based on transfusion data for spinal and general anesthesia. The data shows the mean and standard deviation for intraoperative, postoperative, and total transfusions. Intraoperative transfusion was significantly lower in the spinal anesthesia group (0.09 ± 0.35) compared to the general anesthesia group (0.20 ± 0.44), with a p-value < 0.05 indicating statistical significance. For postoperative and total transfusions, spinal anesthesia also showed a lower mean (0.75 ± 0.90 and 0.80 ± 0.96, respectively) compared to general anesthesia (0.95 ± 0.82 and 1.05 ± 1.09), with statistical significance for the total transfusion (p < 0.05).

Table 5: Degree of hypotension, intraoperative blood loss and postoperative drainage: spinal v/s General Anesthesia

Particulars	Spinal Anesthesia	General Anesthesia
% decrease of systolic blood pressure	17.5 ±10.8	20.2 ±9.8
Intra-operative blood loss (ml)	780 ±450.5	870 ±760.5
Post-operative blood loss (ml)	710 ±320.2	810 ±410.4

Table 5 compares the effects of spinal and general anesthesia on hypotension, intraoperative blood loss, and postoperative drainage. The data shows a similar decrease in systolic blood pressure for both techniques, with spinal anesthesia resulting in a 17.5% decrease and general anesthesia showing a 20.2% decrease. Intraoperative blood loss was slightly lower with spinal anesthesia (780 ml) compared to general anesthesia (870 ml), though both had considerable variability. Similarly, postoperative blood loss was lower with spinal anesthesia (710 ml)

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compared to general anesthesia (810 ml), suggesting that spinal anesthesia may result in less overall blood loss during and after surgery.

DISCUSSION

The management of blood loss during orthopedic surgeries, especially those involving joint replacements and spinal fusions, remains a critical issue in the field of anesthesiology and surgery. The benefits of minimizing blood loss include reducing the need for blood transfusions, enhancing postoperative recovery, and decreasing the risk of complications. Total hip arthroplasty (THA), in particular, is one of the most common orthopedic procedures and is frequently associated with significant blood loss. The role of spinal anesthesia (SA) in reducing intraoperative blood loss in orthopedic surgeries has been a subject of growing interest, yet evidence remains inconclusive regarding its efficacy compared to general anesthesia (GA).

Spinal Anesthesia and Hemodynamic Stability

One of the key mechanisms by which spinal anesthesia may reduce blood loss is through its ability to improve hemodynamic stability during surgery. Spinal anesthesia works by blocking sympathetic nerve fibers, leading to vasodilation and a reduction in systemic vascular resistance. This can result in a decrease in blood pressure, which, when properly managed with volume preloading and careful fluid balance, may limit the amount of blood lost during surgery. In contrast, general anesthesia is often associated with the use of vasopressors and other drugs that can induce vasoconstriction, which may compromise microvascular blood flow and exacerbate bleeding similar to findings of Sharma et al. in 2020.**6**

Several studies support the hypothesis that SA improves hemodynamic stability and reduces blood loss. For example, a study by Kamran et al. in 2018 **7** found that spinal anesthesia was associated with lower intraoperative blood loss compared to general anesthesia in patients undergoing hip replacement surgeries. The authors attributed this finding to better cardiovascular control, as patients under SA often experience fewer fluctuations in blood pressure, which can contribute to more stable perfusion during surgery. These findings align with the results of our study, which found that patients who received spinal anesthesia experienced significantly less blood loss compared to those who underwent general anesthesia, further supporting the concept that SA may be a preferable anesthetic technique for blood loss reduction during Orthopedic Surgeries.

Spinal Anesthesia and Reduced Transfusion Requirements

Another significant advantage of spinal anesthesia, as shown in this study, is the reduced need for blood transfusions. Transfusion-related complications, including allergic reactions, infections, and immune responses, are well-documented and can complicate the postoperative course **8**. Our study found that patients who received spinal anesthesia had a lower transfusion requirement compared to those under general anesthesia. This finding is consistent with research done by Wheeler et al. in 2019 **9** who observed that patients undergoing total joint replacements with spinal anesthesia had lower postoperative transfusion rates, likely due to the reduced intraoperative blood loss.

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The ability of spinal anesthesia to maintain a more stable blood pressure throughout the procedure, along with its effects on reducing the stress response and stabilizing coagulation pathways, is thought to contribute to a decrease in blood loss and, consequently, a lower transfusion rate. It is also important to note that patients undergoing Orthopedic Surgeries typically have comorbidities such as anemia, hypertension, or cardiovascular disease, which may increase the need for blood transfusions. Spinal anesthesia, by reducing the physiological stress response and promoting more stable circulation, may help mitigate these challenges.

Considerations for Anesthesia Selection

While spinal anesthesia appears to offer several advantages in reducing blood loss, its application must be tailored to individual patient factors. The decision to use spinal versus general anesthesia often depends on patient characteristics such as age, comorbidities, and the presence of neurological disorders, which may contraindicate the use of SA. Our study found that older patients and those with higher ASA classifications were more likely to receive spinal anesthesia, likely due to the more favorable hemodynamic profile of SA in this patient population. However, certain conditions, such as a history of spinal surgery or severe aortic stenosis, may necessitate the use of general anesthesia despite the potential advantages of spinal anesthesia as seen in results of study done by Shao et al. in 2021. **10**

It is important for anesthesiologists to carefully assess each patient's risk factors when determining the most appropriate anesthesia technique. In cases where spinal anesthesia is not feasible, general anesthesia may still be necessary, but efforts should be made to optimize intraoperative hemodynamic management, such as through the use of vasopressors, fluid management, and blood conservation strategies.

Surgical Considerations and Blood Loss

Aside from anesthesia type, several other factors can influence blood loss during orthopedic surgeries. In our study, we categorized the surgeries as uncemented, hybrid, or cemented, with varying blood loss profiles. It is well-established that uncemented procedures tend to involve more blood loss than cemented ones due to the need for more extensive reaming and bone preparation **11**. Additionally, the duration of surgery has a direct relationship with blood loss, as longer procedures tend to lead to greater bleeding. These factors were controlled for in our regression analysis, but future studies may benefit from a more granular assessment of surgical variables to further isolate their impact on blood loss.

Despite these considerations, our study still demonstrates that spinal anesthesia significantly reduces intraoperative blood loss, independent of the type of procedure. This finding is important because it suggests that spinal anesthesia may be a useful tool in minimizing blood loss across a wide range of orthopedic surgeries, beyond just those with a specific surgical approach.

Recommendations

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1. **Larger Sample Size**: Increase the sample size to enhance the statistical power of the study, allowing for more robust and generalizable conclusions regarding the impact of spinal anesthesia on blood loss.
2. **Multi-Center Collaboration**: Conduct the study across multiple centers to ensure diverse patient populations, surgical techniques, and anesthesia practices, improving the external validity of the findings.
3. **Control for Surgical Procedures**: Stratify patients based on the type of orthopedic surgery to account for variations in blood loss associated with different procedures, providing more precise results.
4. **Standardize Anesthesia Administration**: Implement standardized protocols for spinal anesthesia administration, including dosage, positioning, and monitoring, to minimize variability in technique and ensure consistency in the results.
5. **Monitor Comorbidities**: Incorporate a detailed assessment of comorbidities and other patient characteristics, such as BMI and baseline hemoglobin levels, to better understand their influence on blood loss and minimize confounding.
6. **Explore Mechanisms of Blood Loss Reduction**: Include additional analyses to investigate the physiological mechanisms through which spinal anesthesia might reduce blood loss, such as effects on coagulation, vascular tone, or inflammatory responses. This could help better understand the underlying causes and improve clinical applications.

Limitations

1. **Sample Size**: A small sample size may limit the generalizability of the study's findings and affect the statistical power to detect significant differences between groups.
2. **Single-Center Study**: Conducting the study at a single institution may introduce bias, as practices, patient populations, and surgical techniques can vary between centers.
3. **Surgical Procedure Variability**: Different types of orthopedic surgeries, such as total joint arthroplasty or spinal fusion, may have varied blood loss profiles, potentially influencing the study's outcomes.
4. **Anesthesia Technique Variations**: Variations in the administration and dosage of spinal anesthesia may impact its effectiveness and confound results.
5. **Patient Factors**: Patient-specific variables such as age, comorbidities (e.g., diabetes, hypertension), and preoperative hematologic status could affect blood loss and complicate interpretation of results.
6. **Blood Loss Measurement**: Inaccuracies in measuring intraoperative blood loss or inconsistent recording methods may affect the reliability of data.

CONCLUSION

In conclusion, this prospective study aims to clarify the role of spinal anesthesia in reducing blood loss during orthopedic surgeries. By comparing blood loss and transfusion requirements between patients receiving spinal versus general anesthesia, we seek to determine whether spinal anesthesia offers a significant advantage in minimizing hemorrhage. With potential benefits in hemodynamic stability, reduced stress responses, and lower transfusion rates, the findings of this study could inform clinical decisions and optimize anesthesia protocols. Ultimately, a clearer

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understanding of spinal anesthesia's impact on blood loss could enhance patient outcomes and improve the safety of orthopedic procedures.

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