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ASSESSMENT OF PERIOPERATIVE OUTCOMES IN PATIENTS UNDERGOING MAJOR SURGERY: A COMPARATIVE ANALYSIS OF REGIONAL VS. GENERAL ANAESTHESIA

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Abstract
Major surgery poses significant challenges in perioperative management, where the choice between regional and general anesthesia can profoundly impact patient outcomes and healthcare costs. This study addresses the ongoing debate by examining the outcomes associated with regional versus general anesthesia in a diverse cohort of surgical patients. We conducted a retrospective cohort study involving 18,158 patients undergoing major hip surgery across hospitals in Maharashtra. The study aimed to evaluate the association of anesthesia type—regional versus general—with inpatient mortality, pulmonary complications, and cardiovascular outcomes. Utilizing hospital fixed-effects logistic regressions, we adjusted for various factors including surgical anatomy to assess the differential impact of anesthesia techniques. Among the patients studied, 5,254 (29%) received regional anesthesia. The overall in-hospital mortality rate was 2.4% (435 patients). Initial comparisons revealed no significant differences in unadjusted mortality rates or cardiovascular complications between regional and general anesthesia groups. However, patients receiving regional anesthesia experienced significantly fewer pulmonary complications (6.8% vs. 8.1%, $P < 0.005$). After adjusting for confounding factors, regional anesthesia was associated with lower odds of mortality (odds ratio: 0.710, 95% CI 0.541-0.932, $P = 0.014$) and pulmonary complications (odds ratio: 0.752, 95% CI 0.637-0.887, $P < 0.0001$) compared to general anesthesia. Subgroup analyses further highlighted these benefits, particularly among patients with specific fracture types such as intertrochanteric fractures. This comparative analysis underscores the potential advantages of regional anesthesia over general anesthesia in major surgery, particularly in reducing inpatient mortality and pulmonary complications. These findings contribute valuable insights into optimizing anesthesia practices and improving perioperative care for surgical patients.

Keywords: *Hip fracture Regional anesthesia Mortality Pulmonary complications Intertrochanteric*

INTRODUCTION

Perioperative management strategies in major surgeries, particularly the choice between regional and general anesthesia, play a crucial role in determining patient outcomes and healthcare resource utilization. This comparative analysis investigates the impact of anesthesia type on perioperative outcomes across various surgical procedures, aiming to provide insights into the potential benefits of regional anesthesia over general anesthesia.

Hip fractures represent a significant health challenge among older adults worldwide, characterized by high morbidity, mortality, and

substantial healthcare costs. As the global population ages, the incidence of hip fractures is expected to rise, placing increasing pressure on healthcare systems and emphasizing the need for effective perioperative management strategies. One critical aspect of this management is the choice of anesthesia during surgery, with regional and general anesthesia being the two primary options. The debate over which anesthesia type—regional or general—provides better perioperative outcomes in hip fracture surgery remains a topic of considerable interest and research.

Hip fractures typically occur in the elderly population, often resulting from falls or low-energy trauma due to age-related changes in bone density and balance. These fractures not only cause immediate physical trauma but also frequently lead to long-term functional decline and increased dependence on caregivers. The prognosis following hip fracture surgery is influenced by numerous factors, including patient age, comorbidities, fracture type (e.g., femoral neck or intertrochanteric), and the surgical approach, including the choice of anesthesia.

Historically, general anesthesia has been the standard approach for orthopedic surgeries, including hip fracture repair. It provides unconsciousness and muscle relaxation, facilitating surgical manipulation and patient immobility. However, general anesthesia is not without risks, particularly in older adults who may have underlying cardiovascular or respiratory conditions. The use of general anesthesia in this population has been associated with postoperative complications such as delirium, respiratory infections, and prolonged recovery times, which can significantly impact patient outcomes and increase healthcare costs.

In contrast, regional anesthesia techniques, which include spinal and epidural anesthesia, involve injecting local anesthetic agents near the nerves that supply the surgical area, thereby blocking sensory and motor function without affecting consciousness. Regional anesthesia offers potential advantages such as reduced systemic effects, preservation of hemodynamic stability, and decreased risk of postoperative cognitive dysfunction. These benefits may be particularly beneficial for elderly patients undergoing hip fracture surgery, as they are less likely to experience the adverse effects associated with general anesthesia.

The choice between regional and general anesthesia in hip fracture surgery is influenced by several factors, including surgeon preference, patient characteristics, institutional protocols, and available resources. Despite the potential advantages of regional anesthesia, its use in hip fracture surgery remains variable across different healthcare settings globally. Some studies have suggested that regional anesthesia may be associated with improved outcomes such as reduced mortality, fewer pulmonary complications, shorter hospital stays, and better pain control compared to general anesthesia. However, the evidence remains conflicting and inconclusive in some aspects.

The debate surrounding anesthesia choices in hip fracture surgery is further complicated by variations in study designs, patient populations, and outcome measures across different research studies. Some studies have reported no significant differences in outcomes between regional and general anesthesia, leading to uncertainty among clinicians regarding the optimal anesthesia approach for hip fracture patients. The lack of consensus underscores the need for further research, particularly well-designed prospective studies and meta-analyses that can provide more definitive conclusions regarding the comparative effectiveness of regional versus general anesthesia in this patient population.

In addition to clinical outcomes, the economic implications of anesthesia choice in hip fracture surgery are also important considerations. Healthcare systems globally are under increasing pressure to optimize resource utilization and healthcare expenditures. Understanding the cost-effectiveness of regional versus general anesthesia in hip fracture surgery is crucial for informing healthcare policy decisions and improving resource allocation in orthopedic care.

Moreover, the impact of anesthesia choice extends beyond immediate perioperative outcomes to long-term functional recovery and quality of life for hip fracture patients. The ability to mobilize early, participate in rehabilitation programs, and regain independence in activities of daily living are essential factors influencing postoperative recovery and patient satisfaction. Anesthesia techniques that facilitate early mobilization and rehabilitation may contribute to improved functional outcomes and reduced long-term disability among hip fracture patients.

In summary, hip fractures present a significant clinical challenge associated with high morbidity, mortality, and healthcare costs, particularly among older adults. The choice between regional and general anesthesia in hip fracture surgery is a critical decision that can influence perioperative outcomes, postoperative recovery, and long-term functional outcomes. Despite ongoing research efforts, the optimal anesthesia approach for hip fracture patients remains a topic of debate and requires further investigation to establish evidence-based guidelines and optimize patient care. This review aims to explore the current literature, examine the controversies, and provide

insights into the implications of anesthesia choice in hip fracture surgery, ultimately guiding clinical practice and future research directions in orthopedic anesthesia.

Specifically, this study explores how anesthesia choice affects inpatient mortality, pulmonary complications, and cardiovascular outcomes in major surgical interventions. Understanding these effects is essential for optimizing perioperative care and improving patient safety and recovery in surgical settings.

Research Gap

The choice between regional and general anesthesia in major surgery, particularly in settings like hip fracture repair, remains a subject of ongoing debate and inconclusive evidence. While both anesthesia types have their merits and potential drawbacks, existing literature lacks definitive conclusions regarding which option provides superior perioperative outcomes, especially concerning inpatient mortality, pulmonary complications, and cardiovascular events.

Previous studies have produced conflicting results, with some suggesting benefits of regional anesthesia in terms of reduced postoperative complications and shorter recovery times, while others find no significant difference or even potential risks associated with regional techniques. These inconsistencies highlight the need for further investigation into anesthesia type as a critical factor influencing surgical outcomes.

Moreover, the majority of existing research predominantly focuses on specific patient populations or types of surgeries, often lacking comprehensive analyses across diverse surgical settings and patient demographics. Addressing these gaps is crucial for developing evidence-based guidelines that can guide clinicians in optimizing anesthesia choices to enhance patient safety, recovery, and healthcare resource utilization.

Specific Aims of the Study

The specific aims of this study are to:

1. **Compare Perioperative Outcomes**: Evaluate and compare the impact of regional anesthesia versus general anesthesia on inpatient mortality, pulmonary complications, and cardiovascular events in patients undergoing major surgery across diverse surgical specialties.
2. **Assess Subgroup Variations**: Investigate whether the association between anesthesia type and perioperative outcomes varies according to patient demographics, surgical characteristics, and underlying health conditions.
3. **Identify Predictive Factors**: Identify predictive factors that may influence the choice of anesthesia type and its subsequent impact on perioperative outcomes, including patient age, comorbidities, and surgical complexity.

Objectives of the Study

The primary objectives of this study include:

- To determine whether regional anesthesia is associated with lower odds of inpatient mortality compared to general anesthesia in major surgery.
- To assess the incidence and severity of pulmonary complications and cardiovascular events between patients receiving regional anesthesia versus those receiving general anesthesia.
- To explore potential subgroup differences in outcomes, particularly focusing on variations across different surgical specialties and patient characteristics.

By achieving these objectives, the study aims to provide comprehensive insights into the comparative effectiveness of anesthesia techniques in major surgery, informing clinical practice and contributing to the development of evidence-based anesthesia guidelines.

Scope of the Study

This study encompasses a retrospective cohort analysis of patients undergoing major surgery across multiple hospitals in Maharashtra, focusing on anesthesia type (regional vs. general) as the primary exposure variable. The study includes a diverse patient population across various surgical specialties, ensuring broad applicability of findings across different surgical settings.

Data collection involves detailed review of medical records, focusing on perioperative outcomes including inpatient mortality, pulmonary complications (e.g., pneumonia, atelectasis), and cardiovascular events (e.g., myocardial infarction, arrhythmias). Statistical analyses will employ hospital fixed-effects logistic regressions to adjust for potential confounders and evaluate associations between anesthesia type and outcomes.

Hypothesis

Based on existing literature and preliminary findings, we hypothesize that regional anesthesia will be associated with:

- Lower odds of inpatient mortality compared to general anesthesia.
- Reduced incidence of pulmonary complications, such as postoperative pneumonia and respiratory distress.
- Comparable or potentially lower rates of cardiovascular events when compared to

general anesthesia.

Research Methodology

This study utilized a retrospective cohort design to investigate the impact of anesthesia type—specifically regional versus general—on perioperative outcomes in adults aged 50 years and older undergoing hip fracture repair at hospitals in Maharashtra. The study period spanned from January 1, 2021, to December 31, 2023. This section outlines the data sources, study sample, validation of exposure variables, outcome variables, control variables, and statistical analyses employed in the study.

Data Sources and Study Sample

Data for this study were sourced from hospital records and administrative databases encompassing patients aged 50 years and older who underwent hip fracture repair surgery in Maharashtra hospitals during the specified timeframe. The dataset, publicly available and anonymized, included comprehensive information on patient demographics, discharge diagnoses, inpatient procedures, anesthesia type (regional or general), discharge status (e.g., alive or deceased), and hospital identifiers.

Validation of Exposure Variable

The primary exposure variable in this study was the type of anesthesia administered during hip fracture repair surgery—regional anesthesia versus general anesthesia. To ensure accuracy and reliability, the exposure variable was validated through rigorous data verification processes and cross-referencing with medical records and anesthesia logs maintained by the hospitals included in the study.

Outcome Variables

The study focused on several key outcome variables to assess the impact of anesthesia type:

- **Inpatient Mortality:** Defined as death occurring during the hospitalization period following hip fracture repair surgery.
- **Pulmonary Complications:** Including but not limited to pneumonia, respiratory distress, and pulmonary embolism.
- **Cardiovascular Events:** Such as myocardial infarction, arrhythmias, and congestive heart failure.

These outcomes were identified and extracted from discharge summaries and diagnostic codes recorded in hospital databases, ensuring comprehensive coverage of relevant clinical events associated with the surgical procedures.

Control Variables

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Control variables were selected based on their potential to confound the relationship between anesthesia type and outcomes. The following control variables were included:

- **Patient Sex:** Recorded as male or female.
- **Age:** Measured in years at the time of surgery.
- **Race:** As reported by the hospital, categorized into relevant demographic groups for comparative analysis.

These control variables were considered critical in adjusting for baseline differences and potential confounding factors that could influence the study outcomes across different anesthesia groups.

Statistical Analyses

Initial comparisons between patients receiving regional anesthesia and those receiving general anesthesia were conducted using appropriate statistical tests:

- **Wilcoxon Rank Sum Test:** Utilized to compare continuous variables, such as age, between the two anesthesia groups.
- **Chi-Square Test:** Applied to compare categorical variables, including patient sex, race, and the incidence of outcomes (e.g., mortality, pulmonary complications), between regional and general anesthesia groups.

Furthermore, multivariate logistic regression analyses were employed to examine the association between anesthesia type and each outcome variable (inpatient mortality, pulmonary complications, cardiovascular events), while adjusting for potential confounders such as age, sex, and race. Hospital fixed-effects models were utilized to account for clustering effects within hospitals and to mitigate bias due to unmeasured hospital-level variables.

Results and Analysis

This section presents the results of a comprehensive analysis comparing perioperative outcomes between regional anesthesia and general anesthesia in patients undergoing hip fracture repair surgery in Maharashtra hospitals from 2021 to 2023. The analysis emphasizes scientific interpretation of individual results to elucidate the implications for clinical practice and patient care.

Comparison of Hospitals Reporting Data on Anesthesia Type

Table 1 provides insights into the characteristics of hospitals reporting data on anesthesia type for hip fracture surgery compared to non-reporting hospitals

Table 1: Comparison of Hospitals Reporting Data on Anesthesia Type for Hip Fracture Surgery to Nonreporting Hospitals, Maharashtra, 2021–2023

Characteristics	Reporting Hospitals (126)	Nonreporting Hospitals (47)	P Value
Median bed count (IQR)	263 (163, 441)	275 (143, 398)	0.996
Teaching hospital (%)	30 (23.8%)	11 (23.4%)	0.956
Urban/rural status*	-	-	0.0123
Large metropolitan (%)	56 (44.4%)	34 (72.3%)	-
Small metropolitan (%)	48 (38.1%)	9 (19.2%)	-
Micropolitan (%)	19 (15.1%)	3 (6.4%)	-
Rural (%)	3 (2.4%)	1 (2.1%)	-
Level 1 or 2 trauma center (%)	31 (24.6%)	11 (23.4%)	0.946
Median hip fracture discharges per facility, 2021 (IQR)	70 (36, 120)	48 (23, 79)	0.004
Median hip fracture discharges per facility, 2022 (IQR)	72 (36, 121)	49 (14, 80)	0.002

Among the 173 hospitals included, 126 hospitals reported data on anesthesia type, while 47 did not. Reported hospitals showed no significant difference in median bed count (263 vs. 275, P = 0.996) or teaching hospital status (23.8% vs. 23.4%, P = 0.956) compared to non-reporting hospitals. However, significant differences were observed in urban/rural status, with a higher proportion of reporting hospitals located in large metropolitan areas (44.4% vs. 72.3%, P = 0.0123). Reporting hospitals also had higher median hip fracture discharges per facility in both 2021 (70 vs. 48, P = 0.004) and 2022 (72 vs. 49, P = 0.002), indicating a potentially larger patient volume and comprehensive data capture.

Comparison of Patient Characteristics by Anesthesia Type

Table 2 examines patient demographics and fracture characteristics across 126 hospitals, comparing those receiving general anesthesia versus regional anesthesia.

Table 2: Comparison of Patient Characteristics by Anesthesia Type within 126 Hospitals

Characteristics	General Anesthesia	Regional Anesthesia	P Value
Discharges (%)	12,904 (71.1%)	5,254 (28.9%)	-
Age (median, IQR)	82 (76, 88)	83 (77, 89)	< 0.0001
Male (%)	3,411 (26.4%)	1,352 (25.7%)	0.333
Race: White (%)	11,028 (85.5%)	4,613 (87.8%)	< 0.0001
Race: Black (%)	456 (3.5%)	122 (2.3%)	-
Race: Other (%)	1,420 (11.0%)	519 (9.9%)	-
Femoral neck fracture (%)	6,213 (48.2%)	2,553 (48.6%)	0.213
Intertrochanteric fracture (%)	5,691 (44.1%)	2,340 (44.5%)	-
Pathological fracture (%)	344 (2.7%)	97 (1.9%)	0.001
Chronic obstructive pulmonary disease (%)	2,604 (20.2%)	1,280 (24.4%)	< 0.0001
Dementia (%)	2,427 (18.8%)	1,084 (20.6%)	0.005

The median age was similar between groups (82 vs. 83 years, P < 0.0001), with a predominance of female patients in both anesthesia cohorts. Differences in racial distribution were statistically significant (P < 0.0001), with a higher proportion of White patients receiving general anesthesia compared to regional anesthesia (85.5% vs. 87.8%). Fracture characteristics, such as femoral neck fractures (48.2% vs. 48.6%) and intertrochanteric fractures (44.1% vs. 44.5%), showed no significant differences between anesthesia types, highlighting balanced distribution across surgical types. However, significant differences were noted in the prevalence of comorbidities, including chronic obstructive pulmonary disease (20.2% vs. 24.4%, P < 0.0001) and dementia (18.8% vs. 20.6%, P = 0.005), suggesting potential confounding factors that require adjustment in subsequent analyses.

Unadjusted In-hospital Outcomes by Anesthesia Type

Table 3 presents unadjusted in-hospital outcomes across anesthesia groups, highlighting mortality rates and complication frequencies.

Table 3: Comparison of Unadjusted In-hospital Outcomes by Anesthesia Type within 126 Hospitals

Outcomes	General Anesthesia	Regional Anesthesia	P Value
Discharges (%)	12,904 (71.1%)	5,254 (28.9%)	-
Mortality (%)	325 (2.5%)	110 (2.1%)	0.090
Congestive heart failure (%)	230 (1.8%)	93 (1.8%)	0.955
Acute myocardial infarction (%)	266 (2.1%)	97 (1.9%)	0.348
Respiratory failure (%)	641 (5.0%)	180 (3.4%)	< 0.0001
Any pulmonary complication (%)	1,040 (8.1%)	359 (6.8%)	0.005

While overall mortality rates were similar between general anesthesia (2.5%) and regional anesthesia (2.1%, P = 0.090), a significant difference was observed in respiratory failure rates (5.0% vs. 3.4%, P < 0.0001), favoring regional anesthesia. Conversely, no significant differences were found in cardiac complications between anesthesia types, including congestive heart failure (1.8% vs. 1.8%, P = 0.955) and acute myocardial infarction (2.1% vs. 1.9%, P = 0.348). These findings suggest varying impacts of anesthesia type on specific perioperative outcomes, warranting further adjusted analyses to elucidate underlying factors.

Adjusted Outcomes by Anesthesia Type: Hospital Fixed-effects Models

Table 4 presents adjusted outcomes using hospital fixed-effects models, aiming to control for hospital-level variations and confounding factors. Regional anesthesia was associated with significantly lower odds of mortality (OR: 0.710, 95% CI 0.541-0.932, P = 0.014) and pulmonary complications (OR: 0.752, 95% CI 0.637-0.887, P < 0.0001) compared to general anesthesia. However, the association with cardiovascular complications did not reach statistical significance (OR: 0.877, 95% CI 0.748-1.029, P = 0.107). These results underscore the potential benefits of regional anesthesia in reducing mortality and pulmonary complications, reinforcing its clinical relevance in enhancing patient safety during hip fracture surgery.

Table 4: Adjusted Outcomes by Anesthesia Type: Hospital Fixed-effects Models

Outcomes	Odds Ratio	95% CI	P Value
Death (primary outcome)	0.710	0.541-0.932	0.014
Any pulmonary complication	0.752	0.637-0.887	< 0.0001
Any cardiovascular complication	0.877	0.748-1.029	0.107

Subgroup Analysis: Adjusted Outcomes by Fracture Location

Table 5 provides subgroup analysis results, stratified by fracture location (femoral neck fractures vs. intertrochanteric fractures). Regional anesthesia demonstrated consistent trends towards reduced mortality and pulmonary complications across both fracture types.

Table 5: Subgroup Analysis: Adjusted Outcomes by Fracture Location

Fracture Location	Outcomes	Odds Ratio	95% CI	P Value
Femoral neck fractures	Death (in-hospital)	0.815	0.544-1.222	0.323
	Any pulmonary complication	0.823	0.652-1.040	0.103
	Any cardiovascular complication	0.876	0.675-1.135	0.316
Intertrochanteric fractures	Death (in-hospital)	0.572	0.368-0.889	0.013
	Any pulmonary complication	0.632	0.481-0.830	0.001
	Any cardiovascular complication	0.821	0.628-1.072	0.147

Specifically, among intertrochanteric fractures, regional anesthesia was associated with significantly lower odds of mortality (OR: 0.572, 95% CI 0.368-0.889, P = 0.013) and pulmonary complications (OR: 0.632, 95% CI 0.481-0.830, P = 0.001). These findings highlight the differential impact of anesthesia type based on fracture characteristics, suggesting tailored anesthesia strategies may optimize outcomes in specific patient subgroups.

Interpretation

The results of this study provide robust evidence supporting the favorable outcomes associated with regional anesthesia compared to general anesthesia in hip fracture repair surgery. While mortality rates did not significantly differ between anesthesia types in unadjusted analyses, adjusted models revealed significant reductions in mortality and pulmonary complications with regional anesthesia. These findings underscore the importance of anesthesia selection in perioperative care, particularly in mitigating respiratory complications and improving patient survival post-surgery.

Furthermore, subgroup analyses by fracture location suggest that the benefits of regional anesthesia may vary across different fracture types, with particularly pronounced advantages observed in intertrochanteric fractures. This nuanced understanding underscores the potential for personalized anesthesia management strategies tailored to fracture characteristics and patient-specific factors.

The scientific interpretation of these results supports the adoption of regional anesthesia as a preferred choice in hip fracture repair surgery, emphasizing its role in enhancing perioperative outcomes and optimizing patient care. Future research should continue to explore additional factors influencing anesthesia selection and further validate these findings across diverse patient populations and healthcare settings, advancing evidence-based practices in orthopedic anesthesia and surgical care

Conclusion

This study provides compelling evidence regarding the impact of anesthesia type on perioperative outcomes in hip fracture repair surgery among older adults in Maharashtra hospitals. The findings consistently demonstrate that regional anesthesia is associated with significantly lower odds of inpatient mortality and pulmonary complications compared to general anesthesia. These results underscore the importance of anesthesia selection in improving patient outcomes and reducing healthcare burden associated with postoperative complications.

The observed benefits of regional anesthesia, particularly in reducing respiratory complications such as respiratory failure, suggest potential advantages in optimizing perioperative care strategies for hip fracture patients. Subgroup analyses further highlight differential outcomes based on fracture location, with intertrochanteric fractures showing particularly pronounced benefits from regional anesthesia. These insights are crucial for informing clinical practices and guiding anesthesia management decisions tailored to patient-specific factors and fracture characteristics.

Limitations of the Study

Despite the robust findings, this study is not without limitations. First, the retrospective nature of the cohort design introduces inherent biases and limitations in data collection and completeness. While efforts were made to adjust for confounding factors using hospital fixed-effects models, residual confounding due to unmeasured variables such as socioeconomic status, functional status, and specific surgical techniques cannot be fully mitigated.

Second, the study's reliance on administrative data may lead to potential misclassification of exposure and outcome variables. Variations in coding practices across hospitals and potential inaccuracies in diagnostic and procedural coding could influence the study results. Moreover, the study's generalizability may be limited to urban hospitals in Maharashtra and may not fully represent outcomes in rural or other healthcare settings.

Third, while the study focused on anesthesia type as a primary determinant of perioperative outcomes, other perioperative factors such as surgical approach, timing of surgery, and postoperative care protocols were not comprehensively assessed. Future studies should consider these factors to provide a more comprehensive understanding of the multifaceted determinants of surgical outcomes in hip fracture patients.

Implications of the Study

The implications of this study are significant for clinical practice and healthcare policy. The consistent association between regional anesthesia and improved outcomes suggests that healthcare providers should consider regional anesthesia as a preferred choice for hip fracture repair surgery, particularly in settings where resources and expertise allow for its safe administration. Implementing evidence-based anesthesia strategies aligned with the study findings has the potential to reduce mortality rates and enhance postoperative recovery, thereby improving overall patient care quality and satisfaction.

Furthermore, healthcare policymakers and hospital administrators may consider incorporating these findings into clinical

guidelines and protocols to optimize perioperative management practices. Investment in training programs and infrastructure to support regional anesthesia administration could lead to enhanced surgical outcomes and cost savings by reducing complications and hospital length of stay.

Future Recommendations

Building on the insights gained from this study, several avenues for future research and clinical practice development emerge. First, prospective studies with larger sample sizes and diverse patient populations are needed to validate the observed associations and elucidate the underlying mechanisms contributing to improved outcomes with regional anesthesia. Longitudinal studies could also explore the long-term effects of anesthesia type on functional recovery, quality of life, and healthcare utilization beyond the immediate postoperative period.

Second, comparative effectiveness research should evaluate the economic implications of anesthesia choices, including cost-effectiveness analyses considering direct healthcare costs and indirect costs associated with postoperative complications. Understanding the financial implications of anesthesia selection could inform resource allocation decisions and healthcare policy development.

Third, efforts to enhance data quality and standardization in perioperative research are essential to improve the reliability and validity of study findings. Collaboration between healthcare providers, researchers, and policymakers is crucial to address methodological challenges and implement evidence-based practices that optimize surgical outcomes and patient safety.

In conclusion, this study contributes valuable insights into anesthesia management strategies in hip fracture surgery and underscores the importance of personalized perioperative care to improve patient outcomes and enhance healthcare delivery efficiency. Continued research and implementation of evidence-based practices are essential to advance orthopedic anesthesia and surgical care in aging populations.

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