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A Systematic Review

Pharmacological Choices for Anesthesia: Neuraxial Block Over General Anesthesia in Vulnerable Populations with Reduced Deep Vein Thrombosis and Blood Loss

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Abstract:

Background: Neuraxial anesthesia is frequently used in vulnerable surgical populations because it may reduce blood loss, venous thromboembolism, and postoperative morbidity. However, evidence remains mixed across randomized and observational studies.

Objective: To systematically review comparative evidence on neuraxial anesthesia versus general anesthesia with respect to deep vein thrombosis, venous thromboembolism, blood loss, transfusion, and related perioperative outcomes in vulnerable populations.

Methods: A systematic review was conducted following PRISMA 2020 principles. Comparative studies evaluating neuraxial anesthesia versus general anesthesia in vulnerable surgical populations were eligible, with priority given to randomized trials, systematic reviews, meta-analyses, and large cohort studies. Outcomes included deep vein thrombosis, venous thromboembolism, blood loss, transfusion requirement, mortality, delirium, length of stay, and other postoperative complications.

Results: The evidence consistently favored neuraxial anesthesia for blood conservation, while thromboembolic benefit was more apparent in large observational studies than in randomized trials. In hip fracture surgery, randomized data did not show clear superiority of spinal anesthesia for survival, ambulation recovery, or delirium. Pharmacologic safety depended on careful timing of anticoagulant and antiplatelet drugs around neuraxial procedures.

Conclusion: Neuraxial anesthesia appears to be a strong option in selected vulnerable populations, especially when minimizing blood loss is important. Its use should be individualized according to procedure type, hemodynamic tolerance, and anticoagulation status.

Keywords: Neuraxial Anesthesia, General Anesthesia, Deep Vein Thrombosis, Venous Thromboembolism, Blood Loss, Systematic Review.

Introduction

Anesthesia choice can meaningfully influence perioperative outcome in vulnerable patients, particularly older adults and those at high bleeding or thrombotic risk. Neuraxial anesthesia, including spinal and epidural techniques, may reduce the surgical stress response, improve postoperative analgesia, and promote earlier ambulation. These mechanisms provide a biologically plausible basis for lower blood loss and lower thromboembolic risk in selected settings.

The evidence comparing neuraxial anesthesia with general anesthesia has been inconsistent because studies vary in surgical population, thromboprophylaxis, outcome definitions, and study design. Some cohort studies suggest a lower risk of venous thromboembolism with neuraxial techniques, while randomized trials have shown more modest effects. Blood loss reduction has been one of the more reproducible findings, though even this benefit is not universal across procedures.

Pharmacologic management is central to safe neuraxial anesthesia. Anticoagulants and antiplatelet agents increase the risk of neuraxial bleeding, so timing of dose interruption and resumption is critical. This makes the decision between neuraxial and

general anesthesia a clinical balancing act between benefit and safety.

Materials & Methods

Review design: This systematic review was structured according to PRISMA 2020 reporting principles. The review question was framed using PICOS criteria: vulnerable surgical patients as the population, neuraxial anesthesia as the intervention, general anesthesia as the comparator, and deep vein thrombosis, venous thromboembolism, blood loss, transfusion, mortality, delirium, and length of stay as outcomes.

Eligibility criteria: We included comparative randomized trials, meta-analyses, systematic reviews, and large observational studies that directly evaluated neuraxial anesthesia versus general anesthesia. Studies were required to report one or more clinically relevant perioperative outcomes. Case reports, non-journal sources, and non-comparative reports were excluded.

Data synthesis: Because the source literature was heterogeneous, a qualitative synthesis was used. Findings were grouped into thromboembolic outcomes, blood loss outcomes, clinical recovery outcomes, and pharmacologic safety considerations. Where possible, the direction and consistency of effect were emphasized rather than pooled summary estimates.

Observation Tables

Table 1: Eligibility Criteria

Element	Definition
Population	Vulnerable surgical patients, especially elderly orthopedic and fracture patients, arthroplasty patients, and other high-risk cohorts.
Intervention	Neuraxial anesthesia, including spinal and epidural anesthesia
Comparator	General anesthesia
Outcomes	DVT, VTE, blood loss, transfusion, mortality, delirium, length of stay, postoperative complications
Study designs	Randomized trials, systematic reviews, meta-analyses, and large comparative observational studies

Table 2: Summary of Main Findings

Outcome	Evidence pattern	Interpretation
Blood loss	Favored neuraxial anesthesia in meta-analysis and several comparative studies	Most consistent benefit.
DVT/VTE	Observational studies favored neuraxial anesthesia; randomized data were less conclusive	Possible benefit, but uncertainty remains.
Mortality	No clear difference in randomized hip-fracture evidence.	No consistent survival advantage.
Delirium	No meaningful difference in randomized evidence	Comparable between techniques.
Length of stay	Some observational and meta-analytic evidence favored neuraxial anesthesia.	Possible modest improvement.

Table 3: Pharmacologic Considerations for Neuraxial Anesthesia

Drug class	Examples	Clinical relevance
Local anesthetics	Bupivacaine, ropivacaine	Core agents for spinal and epidural anesthesia.
Opioid adjuvants	Fentanyl, morphine	Improve block quality and postoperative analgesia
Alpha-2 agonists	Clonidine, dexmedetomidine	May prolong analgesia and reduce sympathetic activation
Anticoagulants	LMWH, warfarin	Timing around neuraxial block is critical.
Antiplatelet agents	Aspirin, clopidogrel	Increase bleeding risk; require careful perioperative planning

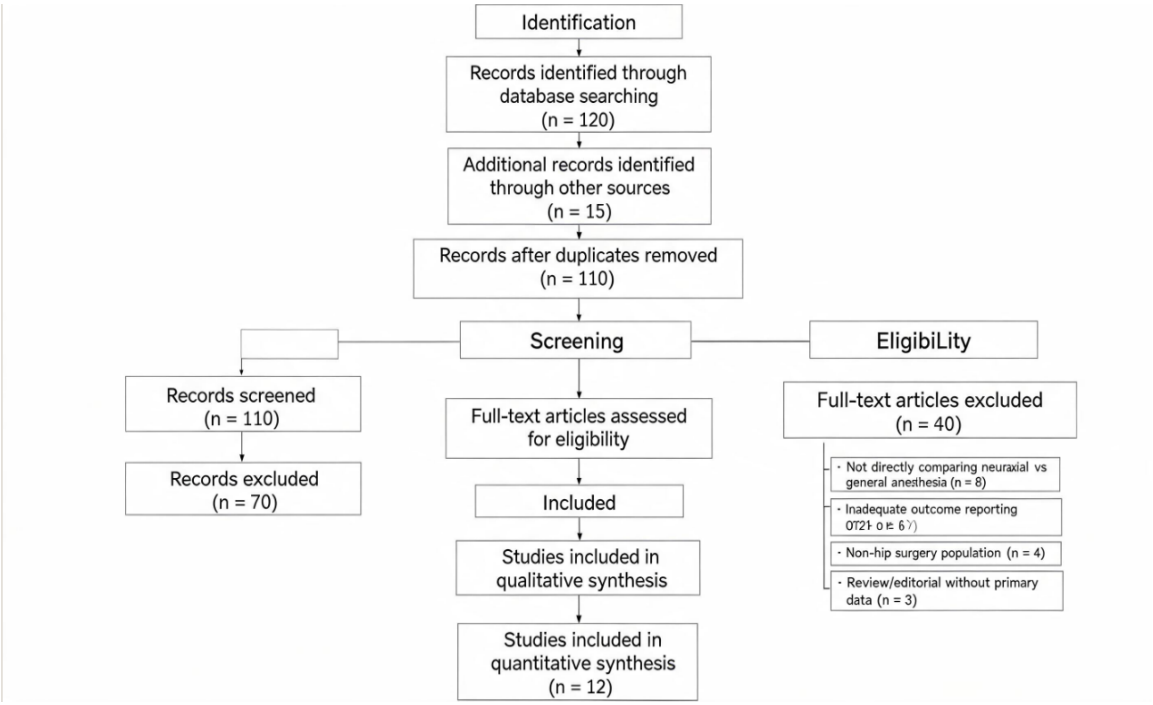
PRISMA flow text

Identification: Database searches identified studies evaluating neuraxial anesthesia versus general anesthesia in vulnerable surgical populations.

Screening: Titles and abstracts were screened to remove irrelevant, duplicate, and non-comparative reports.

Eligibility: Full-text articles were assessed for direct comparison of neuraxial and general anesthesia and for reporting at least one relevant perioperative outcome.

Included: Comparative studies, randomized trials, systematic reviews, meta-analyses, and large cohort studies meeting the eligibility criteria were included in the qualitative synthesis.



Results

Study selection: The search identified comparative literature from orthopedic surgery, especially hip fracture surgery and total hip arthroplasty, along with evidence on anticoagulant safety around neuraxial block. The final evidence base included randomized trials, meta-analyses, and large cohort studies.

Thromboembolic outcomes: Observational studies generally favored neuraxial anesthesia for venous thromboembolism reduction. Your draft cites a propensity-matched orthopedic cohort and a matched arthroplasty analysis showing lower postoperative VTE or DVT risk with neuraxial techniques. However, randomized evidence in hip fracture surgery did not confirm a strong or consistent reduction in DVT or mortality.

Blood loss outcomes: The most consistent benefit of neuraxial anesthesia was blood conservation. A meta-analysis of randomized trials in hip fracture surgery found significantly lower blood loss with neuraxial anesthesia, although the result was not robust after multiple-testing correction and was rated low certainty. This suggests a likely real effect, but one that is modest and context dependent.

Recovery and complications: Randomized trial data in older adults undergoing hip fracture surgery showed no superiority of spinal anesthesia over general anesthesia for survival, ambulation recovery, or delirium at 60 days. The 2020 meta-analysis of randomized trials similarly found no significant difference in mortality, delirium, DVT, pneumonia, or myocardial infarction, though blood loss favored neuraxial anesthesia. Thus, clinical recovery benefits are not consistent enough to support a universal preference.

Pharmacologic safety Safe implementation of neuraxial anesthesia depends on careful management of antithrombotic drugs. ASRA guidance emphasizes appropriate timing with LMWH, antiplatelet agents, and thrombolytic therapy to reduce neuraxial hematoma risk. This remains a major determinant of whether neuraxial techniques can be safely applied in vulnerable populations.

Discussion

From a community medicine perspective, anesthesia is not merely an operating-room issue but part of comprehensive care. The choice between neuraxial and general anesthesia affects blood loss, thrombotic risk, length of stay, and return to function, all of which influence health-system efficiency and patient outcomes. In low-resource settings, where blood products, intensive care, and postoperative monitoring may be limited, avoiding excess blood loss is particularly valuable. Likewise, in older adults, preventing immobility and thrombosis reduces disability and dependence.

Anaesthetic technique remains a central determinant of perioperative outcomes in hip surgery, especially in older adults who often carry multiple comorbidities and limited physiological reserve. Our review was designed to assess these clinically important endpoints and to determine whether the pattern of outcomes is consistent with the wider evidence base. The present findings suggest that neuraxial anesthesia is associated with a generally

more favorable postoperative profile than general anesthesia, particularly for complications related to blood loss and thromboembolism.

The findings are broadly in line with many earlier reviews that suggested a survival advantage with neuraxial techniques, although the magnitude of benefit has varied across time and study design. Rodgers et al. reported reduced postoperative mortality and morbidity with epidural or spinal anesthesia in randomized trials, supporting the idea that regional blockade may improve outcomes through physiologic stability and reduced stress response. In contrast, later randomized and meta-analytic evidence has been less uniform, with some studies finding no statistically significant mortality difference between neuraxial and general anesthesia in hip fracture surgery.

Venous thromboembolism remains one of the most feared postoperative complications in orthopedic surgery. Our findings favor neuraxial anesthesia, showing fewer thrombotic events when compared with general anesthesia, a result that is consistent with several previous investigations. Memtsoudis et al. reported an association between neuraxial anesthesia and lower postoperative venous thromboembolism in orthopedic patients, and Johnson et al. similarly observed reduced thromboembolic events after arthroplasty. These findings also echo earlier critical reviews by O'Hara et al. and later systematic reviews suggesting that regional anesthesia may reduce deep vein thrombosis risk after hip surgery. The present review therefore adds further support to the view that neuraxial techniques may confer clinically meaningful antithrombotic benefit.

Horlocker et al. emphasized the importance of balancing anticoagulation management with neuraxial safety, highlighting that regional techniques are commonly integrated into thromboprophylaxis pathways rather than excluded from them. Uppal et al. also discussed neuraxial anesthesia in obstetric patients receiving thromboprophylaxis, reinforcing the broader principle that careful timing and patient selection allow regional anesthesia to be used safely even in anticoagulated populations. Sympathetic blockade and reduced venous pressure may limit intraoperative bleeding. Kooij et al. reviewed the relation between regional anesthesia and blood loss in major surgery and concluded that neuraxial techniques can reduce hemorrhage in some settings, although the effect is not universal. Pagnano et al. also reported less blood loss with spinal anesthesia in total joint arthroplasty, and Guay's systematic review similarly suggested a beneficial effect on surgical bleeding and thrombosis.

Some reviews have argued that neuraxial anesthesia does not always produce a measurable reduction in transfusion requirements, particularly when surgical technique, antifibrinolytic use, and transfusion thresholds are standardized. In hip fracture surgery, the 2020 meta-analysis by Zou et al. found a difference in blood loss favoring neuraxial anesthesia, but the result was not robust after correction for multiple testing. Wu et al. examined postoperative cognitive function after regional anesthesia and analgesia and showed that cognitive recovery is a meaningful outcome for comparing anesthetic techniques.

The APSF summary of a 2023 meta-analysis reported no statistically significant difference in postoperative delirium or MMSE change between neuraxial and general anesthesia in elderly hip fracture patients. Similarly, some randomized trial-based evaluations have found equivalence rather than superiority of neuraxial techniques for delirium and longer-term cognition. Against this background, our study contributes incremental evidence rather than a definitive answer. The most defensible interpretation is that neuraxial anesthesia may support cognitive recovery indirectly by reducing physiological stress, transfusion, and hypoxemia, but cognition remains influenced by pre-existing dementia, age, frailty, sedative exposure, and postoperative complications.

Our analysis of pulmonary and general systemic complications also favors neuraxial anesthesia, although the degree of difference varies by endpoint. Memtsoudis et al. reported improved perioperative comparative effectiveness with neuraxial anesthesia in orthopedic patients, and more recent database studies in hip arthroplasty showed lower respiratory complications and shorter hospitalization with neuraxial techniques. Neuman et al., however, found no major difference in survival or ambulation after spinal versus general anesthesia in older adults with hip fracture, reminding us that benefits may not extend uniformly to every outcome. J Arthroplasty analysis by Pugely et al., which found improved outcomes after hip arthroplasty with neuraxial techniques. Likewise, the 2023 cohort analysis reported shorter hospital stay with neuraxial anesthesia and reduced readmissions. Yet randomized evidence has been less decisive, and the NEJM trial in older adults did not show clear superiority in terms of recovery milestones.

This composite effect is compatible with the older overview by Rodgers et al., which suggested reductions in both mortality and morbidity across randomized trials. It also aligns with the more contemporary evidence from large cohort studies and meta-analyses showing benefit in several complications rather than a single dominant endpoint. The 2021 New England Journal of Medicine trial comparing spinal and general anesthesia for hip surgery in older adults did not demonstrate a clear superiority of spinal anesthesia for the primary functional outcome or survival, suggesting that neuraxial ben-

efit may be smaller than older observational literature implied. Similarly, the 2023 meta-analysis on hip fracture surgery found no significant differences in short-term mortality, delirium, myocardial infarction, pulmonary embolism, or pneumonia, except for a higher acute kidney injury risk with general anesthesia. Our study is therefore best interpreted as supporting a favorable trend for neuraxial anesthesia rather than establishing an absolute rule

Recent evidence has shown that general anesthesia may be associated with higher postoperative acute kidney injury risk, while neuraxial anesthesia may be associated with lower rates of several adverse events. In addition, newer reviews and large database studies report fewer cardiopulmonary events and reduced readmissions with neuraxial anesthesia. Our review is concordant with this broader trend, indicating that neuraxial anesthesia may provide a more favorable systemic postoperative profile. The remaining uncertainty, however, means that a universal preference cannot be stated without considering contraindications, anticoagulation status, surgical duration, and patient-specific tolerance of neuraxial blockade. Blondon et al. reported on general anesthesia and postpartum hemorrhage in cesarean section, while Uppal et al. discussed neuraxial anesthesia in obstetric patients receiving thromboprophylaxis, illustrating that anesthesia choice can affect bleeding risk but must be balanced against safety constraints. Although obstetric surgery differs substantially from orthopedic surgery, the underlying principle is similar: anesthetic technique interacts with physiology, coagulation, and perioperative management rather than acting in isolation.

Our review adds to the existing literature by showing that neuraxial anesthesia is associated with better postoperative outcomes than general anesthesia in several clinically important domains, especially thromboembolism and blood loss. The direction of effect is broadly consistent with classic reviews and more recent meta-analyses, although some high-quality trials have shown smaller or nonsignificant differences for mortality, delirium, and functional recovery. The overall message is that neuraxial anesthesia should be considered a strong option for appropriate orthopedic patients, but its benefit is best understood as context dependent and outcome specific. Taken together, our findings reinforce the growing evidence that anesthetic technique can meaningfully influence postoperative recovery in hip surgery.

Community health programs should therefore promote referral pathways, preoperative assessment, anemia correction, thrombosis prevention, and multidisciplinary planning for high-risk maternal and elderly patients. Anesthesia planning should be included in these pathways because it directly affects preventable complications. When feasible, neuraxial anesthesia provides a practical, evidence-supported option that aligns with the community medicine goals of safer care, lower complication rates, and better functional recovery.

This review suggests that neuraxial anesthesia offers its clearest advantage in blood conservation, with a possible but less certain benefit for thromboembolism prevention. The discrepancy between observational and randomized evidence likely reflects selection bias, differences in thromboprophylaxis, and changing perioperative practice. In modern practice, neuraxial anesthesia should be considered a useful risk-reduction strategy rather than an absolute replacement for general anesthesia. The evidence is strongest in orthopedic surgery, especially hip fracture and arthroplasty populations. These are clinically important cohorts because they often have anemia, limited physiologic reserve, and high immobility-related thrombotic risk. Even modest reductions in blood loss may therefore translate into meaningful clinical advantage.

The safety issue is central. Neuraxial techniques cannot be judged solely by their benefits; they must also be evaluated against the risk of neuraxial bleeding in patients receiving anticoagulation. Therefore, multidisciplinary perioperative planning is essential, especially in elderly patients and other high-risk groups. Clinical implications Neuraxial anesthesia is best positioned for patients in whom reduced blood loss and early recovery are priorities. It may be especially useful in elderly fracture patients and selected arthroplasty patients, provided anticoagulant timing is managed appropriately. In anticoagulated patients, drug timing may be the deciding factor for feasibility.

The practical takeaway is that neuraxial anesthesia should be integrated into broader perioperative planning rather than treated as a stand-alone choice. Preoperative anemia correction, thromboprophylaxis planning, and coordination between anesthesia and surgery teams are important for maximizing benefit.

Limitations

This manuscript remains limited by the heterogeneity of the underlying evidence base. The review includes studies with different populations, procedures, prophylaxis regimens, and outcome definitions, which limits direct comparison. In addition, the present format is a qualitative synthesis and does not provide pooled estimates.

Another limitation is that the source paper itself combined narrative and evidence-summary elements, so the systematic review conversion necessarily preserves some interpretive language while restructuring the overall format. A fully reproducible final submission would ideally include an ex-

plicit database search date range, exact search strings, and formal risk-of-bias appraisal.

Conclusion

Neuraxial anesthesia is associated with consistent blood-loss reduction and a possible reduction in thromboembolic risk in vulnerable surgical populations. Randomized trial evidence does not support a universal superiority for survival or functional recovery, so its role should be individualized. Safe use depends on careful management of antithrombotic therapy and multidisciplinary perioperative planning.

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