



Systematic Review

The Effect of General Versus Neuraxial Anaesthesia on Bleeding and Thrombotic Outcomes in Neck of Femur Fracture Surgery: A Meta-Analysis

Alexandra Lyons *, Nathan Yii , Leigh White , Matthew Bright and Gina Velli

The Department of Anaesthesia and Pain Medicine, Sunshine Coast University Hospital, 6 Doherty Street, Birtinya, QLD 4575, Australia

* Correspondence: alexandra.lyons2@health.qld.gov.au

Abstract

Background: Hip fracture surgery in elderly patients carries significant risks of both bleeding and thrombotic complications. Anaesthetists frequently face a dilemma between neuraxial anaesthesia, which may reduce thrombotic risk but is often limited by contraindications, and general anaesthesia, which is widely applicable but may exacerbate bleeding. Previous reviews have not specifically addressed bleeding and thrombotic outcomes, leaving a critical gap that this meta-analysis seeks to answer. **Study objective:** To evaluate the effect of neuraxial anaesthesia compared to general anaesthesia on the incidence of bleeding and thrombotic complications in acute neck of femur fracture surgery. **Methods:** Relevant studies comparing neuraxial and general anaesthetic for hip fracture surgery were searched for through Medline, Embase, Scopus, CINAHL and PubMed. Inclusion criteria were randomised control trials of hip fracture surgery patients aged >16 years with relevant outcome data. In total, 24 randomised control trials were included, with 5479 patients. A meta-analysis was performed using RevMan 5.4 software. The study was registered with PROSPERO ID: CRD42022348039. **Outcome measurement:** Primary outcomes were intra-operative blood loss, intra- or post-operative blood transfusion and post-operative deep vein thrombosis. Secondary outcomes were post-operative pulmonary embolism, post-operative myocardial infarction and post-operative stroke. **Results:** Neuraxial anaesthesia reduced deep vein thrombosis incidence by 45% and reduced blood loss by 58 mL, both of which reached statistical significance ($p < 0.05$). Albeit not reaching statistical significance, neuraxial anaesthesia also had a 35% relative risk reduction in myocardial infarction, and a 35% relative decrease in stroke in current studies published after 2010. Despite practise evolution over the decades, protective neuraxial trends have remained. **Conclusions:** Patients undergoing acute hip fracture surgery under general anaesthesia have higher volumes of blood loss, without requiring increased blood transfusion. General anaesthesia is also associated with higher thrombotic complications, with a 45% increased relative risk of deep vein thrombosis, compared to neuraxial anaesthesia. Multi-modal thromboprophylaxis is important, as up to a third of DVT cases occur in the non-operative leg. In frail patients with a low cardiopulmonary reserve for bleeding or in high-thrombotic-risk patients, extra consideration and optimisation for neuraxial technique is advised. Future studies on comorbidities and operation type may reveal a subgroup of patients which would benefit from a specific anaesthetic type.



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Keywords: deep vein thrombosis; general anaesthesia; neuraxial; spinal; neck of femur fracture; blood loss

1. Introduction

The average incidence of hip fractures exceeds 40 per day in Australia [1], 190 per day in the United Kingdom [2] and 700 per day in America [3]. Hip fractures are a significant cause for morbidity and mortality, particularly in the elderly, with 1 in 4 patients aged over 45 dying within one year of hip fracture [4]. Early operative repair restores mobility and provides analgesia, improving quality of life and survival when compared with non-operative conservative management [5]. Despite the prevalence, there remains no clear consensus on the optimal anaesthetic technique for hip fracture surgery, and practice varies widely between institutions and across countries [6].

For the anaesthetist, the decision between neuraxial (spinal/epidural) and general anaesthesia (GA) is not trivial. These patients are typically high-risk, with frailty and limited cardiopulmonary reserve [4]. Neuraxial anaesthesia offers potential advantages, including reduced sympathetic tone, attenuated stress response and lower thrombotic risk through improved lower limb blood flow [7]. Yet, it is often precluded by recent anticoagulant exposure, spinal pathology or the inability to position safely, according to analgesic requirements. While the induction of GA offers a speed advantage, it comes with greater haemodynamic instability [8], increasing the risk of myocardial stress, cerebral hypoperfusion and delirium [9].

The dilemma between anaesthetic approaches is confounded by the unique bleeding and thrombotic profile of hip fracture surgery [10]. The rich vascularity of the proximal femur and inability to apply a tourniquet predispose patients to substantial blood loss [11]. Blood transfusions in frail patients increase the risk of morbidity with delirium, fluid overload and prolonged length of stay [12]. At the same time, hip fracture surgery is an independent risk factor for venous thromboembolism (VTE) [10], in a population already vulnerable to adverse cardiac events and immobilisation-related thrombosis [13]. These competing risks of bleeding and thrombosis make the choice of anaesthetic technique clinically consequential.

Large randomised trials (REGAIN and RAGA) and meta-analyses have primarily evaluated mortality, delirium and functional recovery [14,15]. While these trials suggested no material difference between neuraxial and GA for global outcomes, bleeding and thrombotic events were secondary endpoints, often inconsistently defined and underpowered. The most cited synthesis, the 2016 Cochrane review, likewise did not meta-analyse intra-operative blood loss or transfusion, leaving this clinically important question unanswered [2].

Therefore, this meta-analysis specifically addresses the anaesthetist's clinical dilemma: when facing a frail patient with an acute hip fracture, does choosing neuraxial or general anaesthesia meaningfully alter bleeding and thrombotic outcomes? By targeting intra-operative blood loss, transfusion requirements and DVT as primary endpoints, and myocardial infarction, stroke and pulmonary embolism as secondary outcomes, this study provides further data to enable clinicians to make evidence-based decisions where uncertainty persists. The findings will help clinicians weigh the competing risks of bleeding and thrombosis, supporting safer, more individualised anaesthetic choices in a vulnerable population.

2. Method

2.1. Study Registration

The protocol for this systematic review was registered with PROSPERO (CRD42022348039).

2.2. Search Strategy

An electronic search of studies was performed on Medline, Embase, Scopus, CINAHL and PubMed, up to the date of 14 February 2023. Two independent reviewers (AL,

NY) screened the search results for the study inclusion criteria. Following the identification of eligible studies for inclusion, a manual screen of reference lists and citations was also performed.

2.3. Types of Studies

Only randomised control trials were eligible for inclusion. There were no limitations placed on the date of publication, language or geographical location. Cohort studies, case studies, case series and laboratory studies were excluded.

2.4. Types of Participants

Studies were considered if they included patients who had hip fracture surgery aged >16 years.

2.5. Types of Intervention

Studies were included if they directly compared neuraxial (spinal or epidural single-shot, continuous infusion or combined) and general anaesthetic. Neuraxial anaesthesia included single-dose or continuous neuraxial anaesthesia with or without sedation. General anaesthesia included inhalational or intravenous techniques with or without associated regional analgesia.

2.6. Type of Outcome Measures

Primary outcomes included intra-operative blood loss, intra- or post-operative blood transfusion and post-operative deep vein thrombosis. Secondary outcomes included post-operative pulmonary embolism, post-operative myocardial infarction and post-operative stroke.

2.7. Data Extraction

Three reviewers, AL, NY and MB, independently screened abstracts and titles. Disagreements were resolved by discussion between AL and NY. When a consensus was not reached, LW made the final determination. Duplicate publications and pilot trials were removed. Data analysis was performed in Review Manager (Cochrane) software. Reported variables (range, interquartile range and standard error of the mean) were converted to standard deviation via standardised formulae [16].

2.8. Data Analysis

The Cochrane Handbook of Systematic Reviews was used to assess bias. A study was deemed to be high quality if it was assessed as low risk across all domains.

2.9. Strategy for Data Synthesis

The meta-analysis was performed using Review Manager 5.4 (Cochrane). For dichotomous variables, the Mantel–Haenszel test was used with random effects modelling. For the continuous variable (blood loss), the mean difference was calculated via inverse variance modelling. In the event of a study having zero events for both treatment arms, a continuity correction of 0.5 was applied using SPSS version 29 (IBM Statistics) to detect any changes to the initial risk ratio calculated in Review Manager 5.4. The I² squared statistic was used to quantify heterogeneity, with values categorised as low (<25%), moderate (25–75%) and high (>75%) heterogeneity.

2.10. Analysis of Subgroups or Subsets

We reported the pooled effect size as risk ratio estimates for all the studies, as a measure of association between the anaesthetic type and adverse event. A subgroup analysis of

studies with conventional methods was performed, excluding drugs and techniques no longer used (e.g., halothane).

2.11. Assessment of the Certainty of Evidence

The certainty of evidence was manually performed in accordance with the Cochrane Handbook of Systematic Reviews of Interventions [17].

3. Results

3.1. Search Results

A total of 24 studies were included in the final quantitative analysis (Figure 1). The initial search yielded 367 studies for review. Following title screening, 51 full texts were assessed for study inclusion. In total, 24 studies were included and contained a total of 5479 patients. Patient and study characteristics are outlined in Figure 2. Detailed study characteristics are included in Supplementary Figure S3. If patients had different methods for general anaesthesia, their results were pooled. A risk bias assessment for all included outcomes was performed (Supplementary Figures S1, S4 and S5).

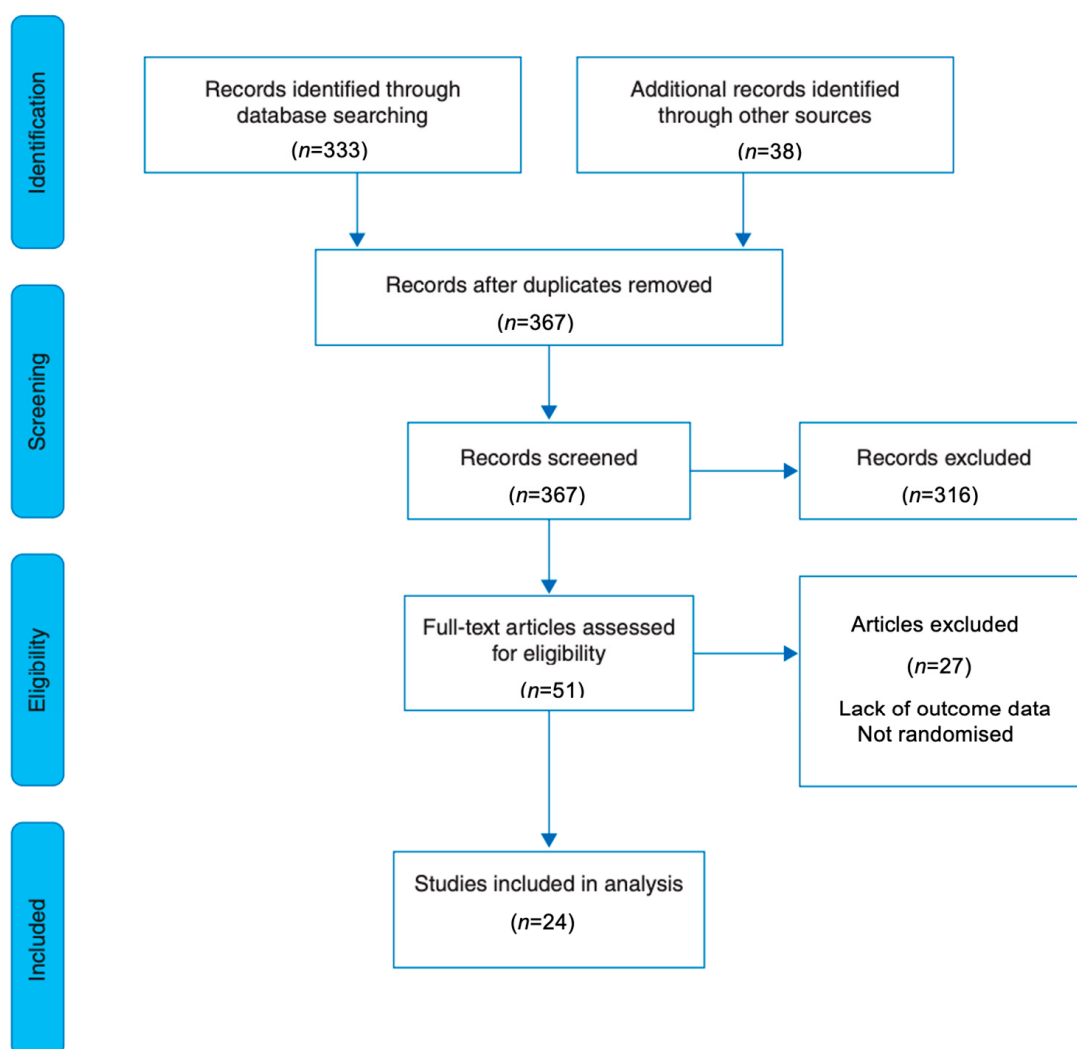


Figure 1. PRISMA flow diagram of article selection.

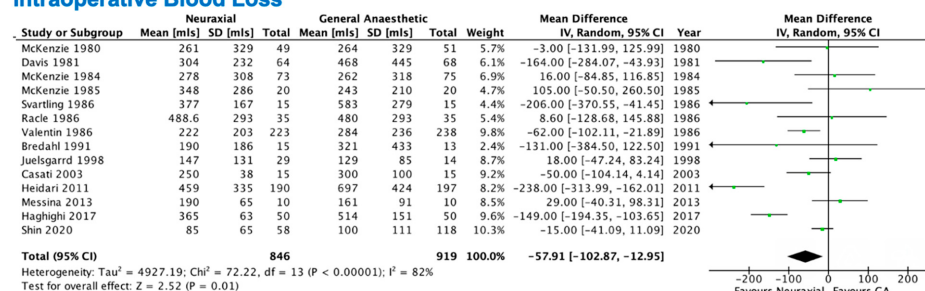
Name	Year	Country	Patients	Female %	ASA classification(n)	Anaesthetic technique	Outcome measured
Davis	1980	New Zealand	74	86	-	Spinal v GA	DVT, PE
McKenzie	1980	Scotland	100	-	-	Spinal v GA	Blood loss
White	1980	South Africa	56	86	1 (4), 2 (22), 3 (26), 4 (4)	Spinal v GA	DVT
Davis	1981	New Zealand	132	85	3-4	Spinal v GA	Blood loss, transfusion, DVT, PE, AMI, stroke
McKenzie	1984	Scotland	148	-	-	Spinal v GA	Blood loss, AMI
Bigler	1985	Denmark	40	83	1(4), 2(29), 3(7)	Spinal v GA	PE, stroke
McKenzie	1985	Scotland	40	75	-	Spinal v GA	Blood loss, DVT, AMI
Racle	1986	France	70	100	-	Spinal v GA	Blood loss, DVT, PE, stroke, AMI
Svartling	1986	Finland	30	87	2 (13), 3(17)	Spinal v GA	Blood loss
Valentin	1986	Denmark	578	80	1 (140), 2 (234), 3(105), 4 (29)	Spinal v GA	Blood loss
Davis	1987	New Zealand	538	-	1 or 2(31), 3(258), 4(48)	Spinal v GA	PE, AMI, stroke
Berggren	1987	Sweden	57	81	-	Epidural v GA	Stroke
Bredahl	1991	Denmark	28	-	1-2	Spinal v GA	Blood loss
Juulsgaard	1998	Denmark	43	81	2 (24), 3(18), 4 (1)	Spinal / spinal catheter v GA	AMI
Casati	2003	Italy	30	93	2(13), 3(17)	Spinal v GA	Blood loss
Heidari	2011	Iran	387	26	1-3	Spinal v GA	Blood loss, PE, AMI
Biboulet	2012	France	45	69	3 (28), 4 (16)	Spinal catheter v GA	Blood loss, AMI, stroke
Messina	2013	Italy	20	65	3	Spinal v GA	Blood loss
Parker	2015	UK	322	73	1-2	Spinal v GA	Transfusion, DVT, PE, AMI, stroke
Haghighi	2017	Iran	100	20	1 (14), 2 (64), 3 (22)	Spinal v GA	Blood loss
Meuret	2018	France	40	80	1-3	Spinal v GA	Transfusion, DVT, PE, AMI, stroke
Shin	2020	Korea	176	74	-	Spinal v GA	Blood loss, transfusion, PE, stroke
Neuman	2021	America	1600	67	1 (40), 2 (499), 3 (949), 4 (87)	Spinal v GA	Transfusion, PE, AMI, stroke
Li	2021	China	942	74	1 (39), 2(713), 3 (188), 4 (2)	Spinal / epidural / CSE v GA	Transfusion, AMI, stroke

Figure 2. Study characteristics [14,15,18–39]. DVT (deep vein thrombosis), PE (pulmonary embolism), AMI (acute myocardial infarction) and CSE (combined spinal epidural).

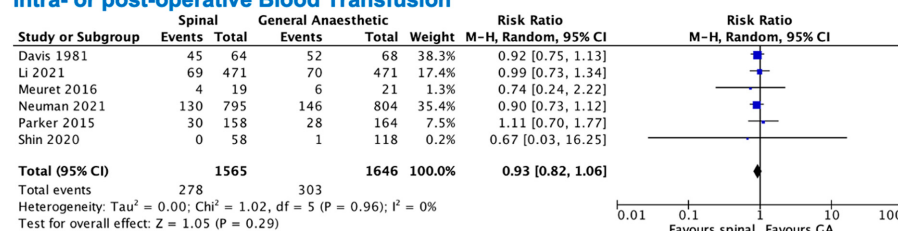
3.2. Primary Outcomes

Intra-operative blood loss was evaluated in 14 studies ($n = 1765$). The pooled results indicate a reduction in blood loss of 57.91 mL ($p = 0.01$, 95%CI = -102.87 to -12.95 mL) with neuraxial anaesthesia (Figure 3).

Intraoperative Blood Loss



Intra- or post-operative Blood Transfusion



Postoperative Deep Vein Thrombosis

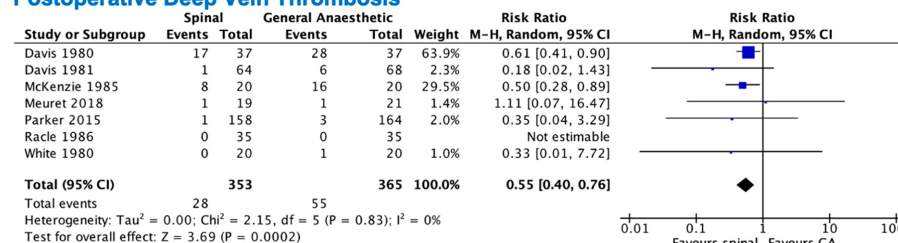


Figure 3. Forest plot for intra-operative blood loss, blood transfusion and post-operative deep vein thrombosis [14,15,18–39].

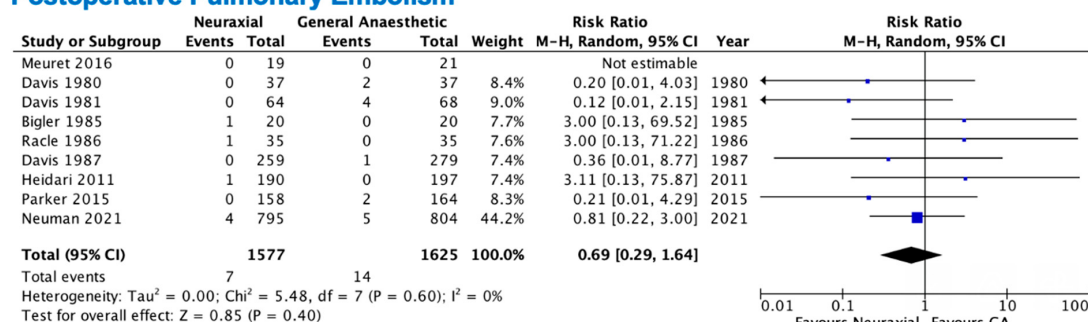
The requirement for intra- or post-operative blood transfusion was assessed by six studies ($n = 3211$). The pooled risk ratio of 0.93 ($p = 0.29$, 95%CI = 0.82 to 1.06) was not statistically significant (Figure 3).

Post-operative deep vein thrombosis (DVT) was assessed by seven studies ($n = 718$). The pooled risk ratio of 0.55 indicates a statistically significant reduction in DVT by 45% ($p = 0.0002$, 95%CI = 0.40 to 0.76) with neuraxial anaesthesia (Figure 3).

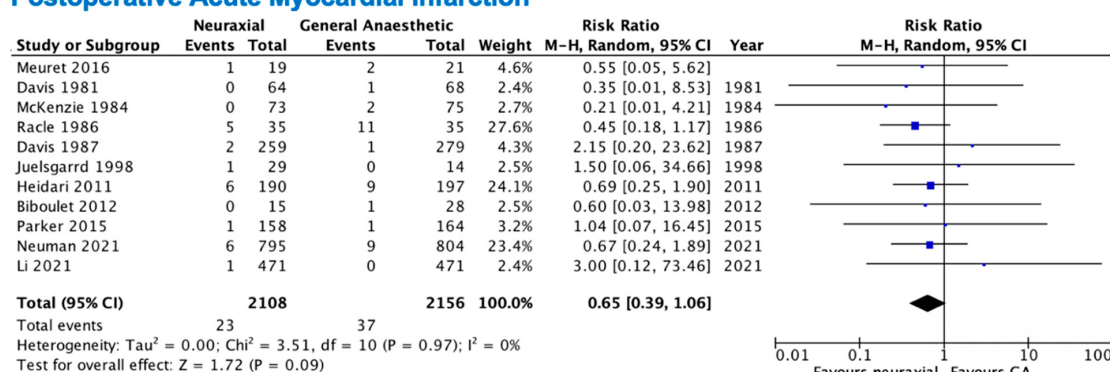
3.3. Secondary Outcomes

There were no statistically significant differences in the risks of post-operative pulmonary embolism (PE), acute myocardial infarction (AMI) and post-operative stroke. Post-operative PE was assessed by nine studies ($n = 3202$). The pooled risk ratio was 0.69 ($p = 0.40$, 95%CI = 0.39 to 1.06) with neuraxial anaesthesia (Figure 4).

Postoperative Pulmonary Embolism



Postoperative Acute Myocardial Infarction



Postoperative stroke

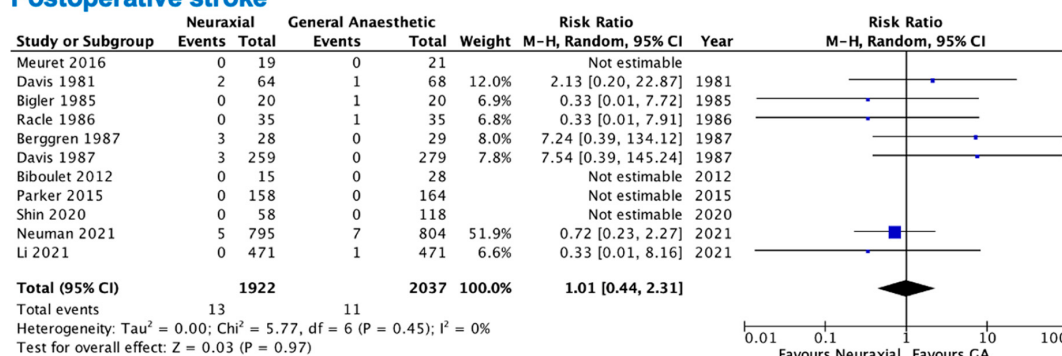


Figure 4. Forest plot for post-operative PE, AMI and stroke [14,15,18–39].

Post-operative AMI was assessed by eleven studies ($n = 4174$). The pooled risk ratio was 0.65 ($p = 0.09$, 95%CI = 0.39 to 1.06) with neuraxial anaesthesia (Figure 4). A post-operative AMI event was included in the analysis if it was documented in the morbidity or mortality reporting within 28 post-operative days (Supplementary Figure S2).

Post-operative stroke was assessed by eleven studies ($n = 3959$). The pooled risk ratio of 1.01 ($p = 0.97$, 95%CI = 0.44 to 2.31) indicated no difference between neuraxial and general

anaesthesia (Figure 4). A post-operative stroke event was included if it was documented to occur within 28 post-operative days (Supplementary Figure S2).

3.4. Overall

Figure 5 summarises the findings of primary and secondary dichotomous outcomes. The statistically significant results (p value < 0.05) were a 57.9 mL reduction in blood loss with neuraxial anaesthesia (see Figure 3) and a 45% risk reduction in DVT with neuraxial anaesthesia.

Patient or population: Patients with hip fracture repair								
Settings: Surgery								
Intervention: Neuraxial block								
Comparison: General anaesthesia								
Outcome	Number of studies	Design	Number of patients		Relative effect (95% CI)	Quality of evidence (GRADE)	Anticipated absolute effects	
			Neuraxial	GA			GA assumed risk*	Neuraxial (95% CI)
Blood loss	14	RCT	846	919	MD -57.91ml (-102.9,-12.9)	⊕⊕⊕⊕ Low 1,2,3,4,5,8		57.91ml less blood loss (13 to 103ml)
Blood transfusion	6	RCT	1565	1646	RR 0.93 (0.82,1.06)	⊕⊕⊕⊕ Very low 1,3,4,5,8,9	184 per 1000	171 per 1000 (151 to 195)
DVT	7	RCT	353	365	RR 0.55 (0.40, 0.76)	⊕⊕⊕⊕ Very low 1,4,5,6,7,8	151 per 1000	83 per 1000 (60 to 115)
PE	9	RCT	1577	1625	RR 0.69 (0.39,1.06)	⊕⊕⊕⊕ Very low 1,3,5,7,8,9	9 per 1000	6 per 1000 (3 to 9)
AMI	11	RCT	2018	2156	RR 0.65 (0.39,1.06)	⊕⊕⊕⊕ Very low 1,3,4,5,7,8,9	17 per 1000	11 per 1000 (7 to 18)
Stroke	11	RCT	1922	2037	RR 1.01 (0.44,2.31)	⊕⊕⊕⊕ Very low 1,3,4,5,8,9	5 per 1000	5 per 1000 (2 to 12)

MD: mean difference. RR: risk ratio. CI: confidence interval. RCT: randomised control trial. DVT: deep vein thrombosis, PE: pulmonary embolism, AMI: acute myocardial ischaemia.

*Assumed risk for GA (baseline) is based on pooled event frequency of the outcome from included studies, per 1000 patients

Corresponding risk is the estimated risk of the intervention group (neuraxial) calculated by multiplying the pooled relative risk to the assumed risk

GRADE working group grades of evidence

High: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low: We are very uncertain about the estimate.

¹ Allocation concealment and/or blinding of outcome assessors was unclear/ inadequate in 75% studies

² I² larger than 25%

³ Outcomes were secondary outcomes in the population of interest

⁴ Correcting for the possibility of publication bias could change the conclusion

⁵ Confounding factors were identified that could change the effect

⁶ Optimal patient size was not achieved

⁷ Surrogate marker for clinical outcome used (eg fibrinogen uptake and venography) instead of clinically relevant event

⁸ Due to other identified risk of bias

⁹ CI includes effects suggesting benefit as well as no benefit

Figure 5. Meta-analysis summary of findings using Cochrane GRADE approach [40].

3.5. Year Dependant Confounders

Thirteen studies in the ‘pre-1990’ and eight studies in the ‘2010+’ were assessed in a subgroup analysis of thrombotic complications (Figure 6). These date ranges were chosen due to the clustering of studies in these two time periods (Figure 2). Four studies were published between 1990 and 2010; however, three lacked outcomes on thrombotic complications and the only excluded study in this analysis had a low sample size of 43 patients [19].

Pre 1990		DVT	PE	AMI	Stroke
Total events	spinal	26 (14.8%)	2 (0.5%)	7 (1.6%)	8 (1.9%)
	GA	51 (28.3%)	5 (1.2%)	15 (3.3%)	3 (0.7%)
Risk Ratio		0.52	0.73	0.51	1.85

2010+		DVT	PE	AMI	Stroke
Total events	spinal	2 (1.1%)	5 (0.4%)	17 (1.0%)	5 (0.3%)
	GA	4 (2.2%)	7 (0.5%)	27 (1.5%)	8 (0.5%)
Risk Ratio		0.53	0.79	0.74	0.66

Figure 6. Comparison of studies pre-1990 vs. post-2010 in regard to outcome. Results represented by number (%).

There were no statistically significant differences in the year-dependent subgroup analysis. Diagnosis of DVT had a reduction from 28% to 2% in the general anaesthesia group from pre-1990 to post-2010; however, the risk ratio of 0.53 ($p = 0.51$, 95%CI = 0.10 to 3.14) remained constant post-2010. The incidence of PE in the spinal group remained the same, whereas PE in general anaesthesia patients reduced from 1.2% to 0.5% post-2010. The PE risk ratio of 0.79 ($p = 0.69$, 95%CI = 0.26 to 2.44) did not change significantly post-2010. Myocardial infarction rates decreased by 38% and 55%, respectively, in the spinal and general anaesthesia subgroups post-2010. The AMI spinal post-2010 risk ratio was 0.74 ($p = 0.32$, 95%CI = 0.41 to 1.34). The pooled risk ratio for stroke of 1.85 ($p = 0.35$, 95%CI = 0.51 to 6.68) indicates an 85% increased risk of stroke with spinal anaesthesia pre-1990. Post-2010, the risk ratio reduced to 0.66 ($p = 0.45$, 95%CI = 0.23 to 1.94) indicating that spinal anaesthesia now has a 34% risk reduction in stroke incidence, albeit this is not statistically significant.

4. Discussion

The results of this systematic review and meta-analysis show that patients who receive general anaesthesia for an acute hip fracture have a statistically significant increased risk of deep vein thrombosis and a clinically insignificant increased risk of bleeding. Despite this, general anaesthesia has been shown to result in a shorter-duration hospital stay, due to neuraxial anaesthesia having a higher rate of UTIs in patients, likely due to the increased duration of bladder catheterisation [41].

5. Primary Outcomes

Intra-operative blood loss was higher in the patients receiving general anaesthesia by an average of 58-millilitres, which is not clinically significant, despite being statistically significant ($p = 0.01$). There is no absolute consensus on what constitutes clinically significant blood loss in frail patients undergoing surgery for neck of femur fracture, and debate persists regarding the optimal haemoglobin transfusion trigger in this cohort [42,43]. NICE guidelines define a blood loss of 500 mL as “moderate,” warranting heightened vigilance and the consideration of blood-conservation measures [44]. Similarly, the Association of Anaesthetists recommend a pre-operative haemoglobin threshold > 90 g/L, reflecting the recognition of the high risk of bleeding-related morbidity in the frail population [45,46]. However, in elderly patients with limited cardiorespiratory reserve, even

volumes lower than the NICE “moderate” cut-off may precipitate decompensation [47]. A more individualised approach is provided by the following maximum allowable blood loss (MABL) formula: $MABL = \text{estimated blood volume} \times (\text{actual haematocrit} - \text{acceptable haematocrit}) / \text{actual haematocrit}$, which incorporates both physiology and reserve, based on the clinician’s determination of the acceptable haematocrit [48]. For this study, a clinically significant blood loss was defined as 800 mL, based on a 60 kg elderly female with an initial haematocrit of 35% and a lowest acceptable haematocrit of 27%. This approach is an ongoing example of the complexity faced by anaesthetists managing these fragile patients having major orthopaedic surgery where even “moderate” blood loss can have disproportionate consequences.

Benson et al. (2000) found a major contributing factor for increased blood loss under general anaesthesia to be an increased duration of surgery [49]. Additionally, core body temperature drops lower when using general anaesthesia, as the ability to self-thermoregulate is lost, compared to neuraxial anaesthesia, where non-affected dermatomes, myotomes and the hypothalamus can adjust [49]. When core temperature drops below 35-degrees, platelet function and fibrinogen synthesis can be impaired, hence causing a temperature-dependent coagulopathy [50].

Of the medications used in the studies, halothane and single high-dose droperidol have been shown to inhibit platelet aggregation and hence potentially increase the bleeding outcomes in the general anaesthetic group of these studies. The studies using halothane and induction-dose droperidol were removed in a subgroup analysis of blood loss, which resulted in the greater blood loss of 80.7 mls ($p = 0.007$; 95%CI = -139.8 to -21.58 mls; $I^2 = 86\%$) in the general anaesthetic group, compared to 57.5 mls when these medications were included. Therefore, these medications were not a confounding factor in the overall pooled analysis.

Intra- or post-operative blood transfusion rate was similar between groups. Given that the risk ratio of 0.93 is approaching 1, this indicates there is no statistical difference between neuraxial and general anaesthesia.

Post-operative deep vein thrombosis risk is classically described by Virchow’s triad of inflammation, venous stasis and hypercoagulability. In our analysis, rates of thrombotic complications declined substantially in studies published after 2010. This trend likely reflects broader advances in peri-operative care, including the routine use of tranexamic acid, anti-embolism stockings, chemical thromboprophylaxis, cemented arthroplasty techniques and fast-track surgical pathways [13,51,52]. The pooled subgroup analysis demonstrated a 15-fold reduction in DVT incidence over time across both the neuraxial and general anaesthesia groups, underscoring the importance of temporal confounders that have dramatically reduced the absolute risk of DVT. While the core principles of orthopaedic post-operative management have remained consistent over time, the increasing implementation of enhanced recovery after surgery (ERAS) protocols, with multi-modal analgesia for early mobilisation, may reduce the relative importance of anaesthetic technique on DVT incidence in the future.

However, few trials quantified time to ambulation, limiting our ability to directly compare mobilisation as a confounder of thrombotic risk. Neuman et al. (2021) provided the most contemporary evidence, finding no difference in DVT incidence between anaesthetic techniques in 1600 patients, with both groups mobilised by post-operative day one [14]. This is consistent with neuraxial anaesthesia, which consistently shows a 50% lower DVT rate compared with general anaesthesia across the eras. Despite neuraxial anaesthesia causing paralysis of the skeletal muscle pump, sympatholysis results in vasodilation and increased blood flow to the lower limbs, which offsets venous stasis and may explain the reduced rate of DVT in both legs [18,21]. Additional evidence found neuraxial anaesthesia was associated

with reduced post-operative C-reactive protein levels in knee arthroplasty patients, possibly due to the inhibition of nociceptive afferent pathway activation subsequently reducing antidromic neurogenic inflammation and systemic stress responses [53].

The persistent trend toward lower DVT incidence when using neuraxial anaesthesia raises an important clinical consideration for anaesthetists managing elderly patients. While modern prophylaxis and surgical techniques reduce baseline risk, anaesthetic choice remains one of the few modifiable intra-operative factors influencing venous thromboembolism and must be weighed against patient comorbidities and contraindications to neuraxial techniques.

Secondary Outcomes

Post-operative pulmonary embolism rates have remained relatively consistent across anaesthetic techniques from pre-1990 to post-2010. Apparent similarities in earlier decades are likely influenced by under-detection bias since computed tomography pulmonary angiography (CTPA), the current diagnostic gold standard, only became widely available in the mid-to-late 1980s. Consequently, most trials conducted before this period relied on clinical suspicion or post-mortem findings to establish a diagnosis of PE [54,55].

In current practice, persistently low rates of PE may reflect the marked reduction in deep vein thrombosis (DVT) incidence with improved thromboprophylaxis strategies [56,57]. However, given that DVT is the primary precursor to PE, the inability to fully account for the numerous confounding factors influencing DVT risk reduces confidence in attributing changes in PE incidence directly to anaesthetic technique.

Post-operative myocardial infarction has a 35% relative risk reduction when using neuraxial anaesthesia compared to general anaesthesia. Overall, the incidence of AMI has declined substantially, halving from pre-1990 levels to the rates observed in the post-2010 period. Interestingly, earlier studies demonstrated larger relative risk reductions with neuraxial techniques. This discrepancy may reflect advances in peri-operative care and the improvement of cardiac-stable general anaesthesia delivery [58].

Post-operative stroke events were included if they occurred within 28 post-operative days. This is in keeping with the SNACC consensus definition of peri-operative stroke as occurring within 30 days of surgery [59].

Stroke was twice as likely to occur in the neuraxial group in studies conducted prior to 1990. McKenzie et al. [19] observed that neuraxial anaesthesia was associated with a 20 mmHg greater drop in systolic blood pressure. Two neuraxial patients who developed stroke experienced sustained hypotension exceeding 30% of baseline values, suggesting intra-operative hypotension as a causal factor [19].

In contrast, data from post-2010 studies suggest that the association between neuraxial anaesthesia and stroke has reversed, with a trend toward risk reduction. This shift likely reflects improvements in haemodynamic monitoring and neuraxial agent and dosing, in addition to advances in imaging for accurate diagnosis. Neuraxial anaesthesia is now considered more hemodynamically stable than GA [35,60,61]. This contextualises how historical trial results for stroke complications are no longer applicable to modern clinical practice. Therefore, the post 2010 data showing spinal anaesthesia is protective (rather than having no difference) against stroke, with a 34% relative risk reduction, although not statistically significant, is likely more reflective of current practice, and would require further investigation. Nevertheless, the findings reinforce the limited cerebral autoregulatory reserve of elderly patients and the importance of blood pressure management, regardless of anaesthetic type.

6. Overall

The number of patients included in the analysis is too small to make definitive conclusions; however, the data in analysis supports a trend toward neuraxial anaesthesia being protective for both bleeding and thrombotic complications. The finding that neuraxial anaesthesia reduces bleeding and thrombotic complications means more diligence should be used with general anaesthesia in regard to VTE prevention. High-thrombotic-risk patients should be considered for neuraxial anaesthesia but these patients are often on pre-operative anticoagulation, which may preclude neuraxial procedures. This patient population may result in an anti-thrombotic bias in the general anaesthesia group; however, this was not reflected in our subgroup analysis in regard to deep vein thrombosis, stroke or myocardial infarction. Ensuring TEDs and SCUD application to the non-operative lower leg would decrease DVT risk, as up to a third of DVT cases occur in the non-operative leg [18].

Strengths and Limitations

This meta-analysis is the first to specifically evaluate bleeding and thrombotic complications in patients undergoing hip fracture surgery. A major strength of our study is the inclusion of a large pooled sample size from randomised control trials, including two recent high-quality RCTs (RAGA and REGAIN) [14,15]. Furthermore, our findings are consistent with evidence from trials comparing spinal versus general anaesthesia in total hip arthroplasty patients [62], which supports the external validity of our results.

Several limitations should be acknowledged. Firstly, the included trials varied considerably in sample size, methodological quality and era of conduct. Many older studies utilised anaesthetic techniques and pharmacological agents that are no longer considered standard practice, and advances in peri-operative diagnostics and management, particularly the routine adoption of mechanical and chemical thromboprophylaxis, limit comparability across decades. Smaller studies may also have introduced greater confounding effects, thereby contributing to heterogeneity. However, sensitivity analyses restricted to higher-quality trials did not demonstrate statistically significant differences, which strengthens confidence in the robustness of the findings.

Secondly, the overall low incidence of certain outcomes, coupled with selective outcome reporting in several trials, likely reduced the statistical power of this meta-analysis and contributed to non-significant results. Thirdly, the studies included a large range of patient comorbidities and different fracture and operation types. It is possible that a subgroup of these comorbidities or surgical types may be best managed by a specific anaesthetic type. Unfortunately, the inconsistent reporting of patient-level and procedure-level data across trials prevented subgroup analyses exploring these potential confounders.

7. Conclusions

Patients undergoing acute hip fracture surgery under general anaesthesia have higher volumes of blood loss, without requiring increased blood transfusion. General anaesthesia is also associated with higher thrombotic complications, with a 45% increased relative risk of deep vein thrombosis, compared to neuraxial anaesthesia. Multi-modal thromboprophylaxis is important, as up to a third of DVT cases occur in the non-operative leg. In frail patients with low cardiopulmonary reserve for bleeding or high-thrombotic-risk patients, extra consideration and optimisation for neuraxial technique is advised. Future studies would benefit from investigating whether comorbidities and operation type has an influence on bleeding and thrombotic complications that might be best managed by a specific anaesthetic type.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/anesthres2040025/s1>, Figure S1: Risk of bias assessment; Figure S2: Secondary outcome diagnostic inclusion—support for judgement; Figure S3: Study characteristics; Figure S4: Justification for risk of bias assessment; Figure S5: Funnel plot representation of publication bias.

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References

1. Australian Institute of Health and Welfare (AIHW). *The Problem of Osteoporotic Hip Fracture in Australia*; Bulletin 76; Australian Government: Canberra, Australia, 2010. Available online: <https://www.aihw.gov.au/getmedia/ea96bc4d-0b97-4c5a-b792-08b343752adc/10695.pdf.aspx?inline=true> (accessed on 23 May 2023).
2. Royal College of Physicians. *National Hip Fracture Database*; FFFAP: London, UK, 2024. Available online: <https://www.nhfd.co.uk/2024report> (accessed on 4 July 2024).
3. Swenning, T.; Liegton, J.; Nentwig, M.; Dart, B. Hip fracture care and national systems: The United States and Canada. *OTA Int.* **2020**, *3*, e000073. [CrossRef] [PubMed]
4. Australian Institute of Health and Welfare (AIHW). *Hip Fracture Care Pathways in Australia*; PHE 336; Australian Government: Canberra, Australia, 2023. Available online: <https://www.aihw.gov.au/getmedia/dc202a83-d8b2-4477-9bbc-6890ed2e226c/aihw-phe-336.pdf?v=20240618123107&inline=true> (accessed on 10 September 2025).
5. American Academy of Orthopaedic Surgeons. *Management of Hip Fractures in Older Adults: Evidence-Based Clinical Practice Guideline*; AAOS: Rosemont, IL, USA, 2021. Available online: <https://www.aaos.org/hipfxcp> (accessed on 1 April 2023).
6. Guay, J.; Parker, M.; Gajendragadkar, P.; Kopp, S. Anaesthesia for hip fracture surgery in adults. *Cochrane Database Syst. Rev.* **2016**, *2*, CD000521. [CrossRef] [PubMed]
7. National Health and Medical Research Council (NHMRC). *Clinical Practice Guideline for the Prevention of Venous Thromboembolism in Patients Admitted to Australian Hospitals*; Australian Government: Canberra, Australia, 2009. Available online: <https://ranzocg.edu.au/wp-content/uploads/NHMRC-Prevention-Venous-Thromboembolism-Australia.pdf> (accessed on 23 May 2023).
8. Finsterwald, M.; Muster, M.; Farshad, M.; Saporito, A.; Brada, M.; Aguirre, J.A. Spinal versus general anesthesia for lumbar spine surgery in high risk patients: Perioperative hemodynamic stability, complications and costs. *J. Clin. Anesth.* **2018**, *46*, 3–7. [CrossRef] [PubMed]
9. Ehsani, R.; Motlagh, S.; Zaman, B.; Sehat Kashani, S.; Ghodrati, M.R. Effect of general versus spinal anesthetic on postoperative delirium and early cognitive dysfunction in elderly patients. *Anesthesiol. Pain Med.* **2020**, *10*, e101815. [CrossRef]
10. Fleisher, L.A.; Beckman, J.A.; Brown, K.A.; Calkins, H.; Chaikof, E.; Fleischmann, K.E.; Freeman, W.K.; Froehlich, J.B.; Kasper, E.K.; Kersten, J.R.; et al. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery. *Circulation* **2007**, *116*, e418–e500. [CrossRef]
11. Quintero, J.; Cardenas, L.; Navas, M.; Bautista, M.P.; Bonilla, G.A.; Llinás, A.M.; Clinical Care Program in Joint Replacement Surgery. Primary joint arthroplasty surgery: Is the risk of major bleeding higher in elderly patients? A retrospective cohort study. *J. Arthroplast.* **2016**, *31*, 2264–2268. [CrossRef]
12. Gu, A.; Maybee, C.; Wei, C.; Probasco, W.V.; Ast, M.P.; Sculco, P.K. Preoperative blood transfusion associated with increased length of stay and postoperative complications after revision total knee arthroplasty. *J. Orthop.* **2019**, *16*, 265–268. [CrossRef]
13. Peng, S.; Haijing, M.; Jin, J.; MacCormick, A. The effectiveness of venous thromboembolism prophylaxis interventions in trauma patients: A systematic review and network meta-analysis. *Injury* **2023**, *54*, 111078. [CrossRef]
14. Neuman, M.; Feng, R.; Carson, J.; Gaskins, L.J.; Dillane, D.; Sessler, D.I.; Sieber, F.; Magaziner, J.; Marcantonio, E.R.; Mehta, S.; et al. Spinal anesthesia or general anesthesia for hip surgery in older adults. *N. Engl. J. Med.* **2021**, *385*, 2025–2035. [CrossRef]

15. Li, T.; Li, J.; Yuan, L.; Wu, J.; Jiang, C.; Daniels, J.; Mehta, R.L.; Wang, M.; Yeung, J.; Jackson, T.; et al. Effect of regional vs general anesthesia on incidence of postoperative delirium in older patient undergoing hip fracture surgery: The RAGA randomized trial. *JAMA* **2022**, *327*, 50–58. [CrossRef]
16. Higgins, J.P.T.; Li, T.; Deeks, J.J. Chapter 6: Choosing effect measures and computing estimates of effect. In *Cochrane Handbook for Systematic Reviews of Interventions*; Version 6.3; Higgins, J.P.T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M.J., Welch, V.A., Eds.; Cochrane: London, UK, 2022. Available online: <https://training.cochrane.org/handbook/current/chapter-06> (accessed on 1 April 2023).
17. Schünemann, H.; Higgins, J.; Vist, G.; Glasziou, P.; Akl, E.; Skoetz, N.; Guyatt, G.; on behalf of the Cochrane GRADEing Methods Group (formerly Applicability and Recommendations Methods Group) and the Cochrane Statistical Methods Group. Chapter 14: Completing “Summary of findings” tables and grading the certainty of the evidence. In *Cochrane Handbook for Systematic Reviews of Interventions*; Version 6.3; Cochrane: London, UK, 2022. Available online: <https://training.cochrane.org/handbook/current/chapter-14> (accessed on 1 April 2023).
18. Davis, F.M.; Quince, M.; Laurenson, V.G. Deep vein thrombosis and anaesthetic technique in emergency hip surgery. *Br. Med. J.* **1980**, *281*, 1528–1529. [CrossRef] [PubMed]
19. McKenzie, P.J.; Wishart, H.Y.; Smith, G. Long-term outcome after repair of fractured neck of femur: Comparison of subarachnoid and general anaesthesia. *Br. J. Anaesth.* **1980**, *56*, 581–584. [CrossRef] [PubMed]
20. White, I.; Chappell, W. Anaesthesia for surgical correction of fractured femoral neck: A comparison of three techniques. *Anaesthesia* **1980**, *35*, 1107–1110. [CrossRef] [PubMed]
21. Davis, F.M.; Laurenson, V.G. Spinal anaesthesia or general anaesthesia for emergency hip surgery in elderly patients. *Anaesth. Intensive Care* **1981**, *9*, 352–358. [CrossRef]
22. McKenzie, P.; Wishart, H.; Dewar, K.; Gray, I.; Smith, G. Comparison of the effects of spinal anaesthesia and general anaesthesia on postoperative oxygenation and perioperative mortality. *Br. J. Anaesth.* **1984**, *52*, 49–54. [CrossRef]
23. Bigler, D.; Adelhof, B.; Petting, O.; Pederson, N.; Busch, P.; Kahlke, P. Mental function and morbidity after acute hip surgery during spinal and general anaesthesia. *Anaesthesia* **1985**, *40*, 672–676. [CrossRef]
24. Racle, J.; Benkhadra, A.; Poy, J.; Gleizal, B.; Gaudray, A. Comparative study of general and spinal anaesthesia in the elderly female patient undergoing hip surgery. *Ann. Fr. Anesth. Reanim.* **1986**, *5*, 24–30. [CrossRef]
25. McKenzie, P.; Wishart, H.; Gray, I.; Smith, G. Effects of anaesthetic technique on deep vein thrombosis: A comparison of subarachnoid and general anaesthesia. *Br. J. Anaesth.* **1985**, *57*, 853–857. [CrossRef]
26. Svartling, N.; Lehtinen, A.; Tarkkanen, L. The effect of anaesthesia on changes in blood pressure and plasma cortisol levels induced by cementation with methylmethacrylate. *Acta Anaesthesiol. Scand.* **1986**, *30*, 247–252. [CrossRef]
27. Valentin, N.; Lomholt, B.; Jensen, S.; Hejgaard, N.; Kreiner, S. Spinal or General Anaesthesia for Surgery of the Fractured Hip? *Br. J. Anaesth.* **1986**, *58*, 284–291. [CrossRef]
28. Davis, F.; Woolner, D.; Frampton, C.; Wilkinson, A.; Grant, A.; Harrison, R.; Roberts, M.; Thadaka, R. Prospective, multi-centre trial of mortality following general or spinal anaesthesia for hip fracture surgery in the elderly. *Br. J. Anaesth.* **1987**, *59*, 1080–1088. [CrossRef] [PubMed]
29. Berggren, D.; Gustafson, Y.; Eriksson, B.; Bucht, G.; Hansson, L.I.; Reiz, S.; Winblad, B. Postoperative confusion after anesthesia in elderly patients with femoral neck fractures. *Anesth. Analg.* **1987**, *66*, 497–504. [CrossRef] [PubMed]
30. Bredahl, C.; Hindsholm, K.; Frandsen, P. Changes in body heat during hip fracture surgery: A comparison of spinal analgesia and general anaesthesia. *Acta Anaesthesiol. Scand.* **1991**, *35*, 548–552. [CrossRef] [PubMed]
31. Juelsgaard, P.; Sand, N.; Felsby, S.; Dalsgaard, J.; Jakobsen, K.B.; Brink, O.; Carlsson, P.S.; Thygesen, K. Perioperative myocardial ischaemia in patients undergoing surgery for fractured hip randomized to incremental spinal, single-dose spinal or general anaesthesia. *Eur. J. Anaesthesiol.* **1998**, *15*, 656–663. [CrossRef]
32. Casati, A.; Aldegheri, G.; Vinciguerra, F.; Marsan, A.; Fraschini, G.; Torri, G. Randomised comparison between sevoflurane anaesthesia and unilateral spinal anaesthesia in elderly patients undergoing orthopaedic surgery. *Eur. J. Anaesthesiol.* **2003**, *20*, 640–646. [CrossRef]
33. Heidari, S.; Soltani, H.; Hashemi, S.; Talakoub, R.; Soleimani, B. Comparative study of two anesthesia methods according to postoperative complications and one month mortality rate in the candidates of hip surgery. *J. Res. Med. Sci.* **2011**, *16*, 323–330.
34. Biboulet, P.; Jourdan, A.; Van Haevre, V.; Morau, D.; Bernard, N.; Bringuier, S.; Capdevila, X. Hemodynamic profile of target-controlled spinal anesthesia compared with 2 target-controlled general anesthesia techniques in elderly patients with cardiac comorbidities. *Reg. Anesth. Pain Med.* **2012**, *37*, 433–440. [CrossRef]
35. Messina, A.; Frassanito, L.; Colombo, D.; Vergari, A.; Draisci, G.; Della Corte, F.; Antonelli, M. Hemodynamic changes associated with spinal and general anesthesia for hip fracture surgery in severe ASA III elderly population: A pilot trial. *Minerva Anesthesiol.* **2013**, *79*, 1021–1029.
36. Parker, M.; Griffiths, R. General versus regional anaesthesia for hip fractures. A pilot randomised controlled trial of 322 patients. *Injury* **2015**, *46*, 1562–1566. [CrossRef]

37. Haghighi, M.; Sedighinejad, A.; Nabi, B.; Mardani-Kivi, M.; Tehran, S.G.; Mirfazli, S.A.; Mirbolook, A.; Saheli, N.A. Is spinal anesthesia with low dose lidocaine better than sevoflurane anesthesia in patients undergoing hip fracture surgery. *Arch. Bone Jt. Surg.* **2017**, *5*, 226–230.
38. Meuret, P.; Bouvet, L.; Villet, B.; Hafez, M.; Allaouchiche, B.; Boselli, E. Hypobaric unilateral spinal anaesthesia versus general anaesthesia in elderly patients undergoing hip fracture surgical repair: A prospective randomised open trial. *Turk. J. Anaesthesiol. Reanim.* **2018**, *46*, 121–130. [\[CrossRef\]](#)
39. Shin, S.; Kim, S.; Park, K.; Kim, S.J.; Bae, J.C.; Choi, Y.S. Effects of anesthesia techniques on outcomes after hip fracture surgery in elderly patients: A prospective, randomized, controlled trial. *J. Clin. Med.* **2020**, *9*, 1605. [\[CrossRef\]](#)
40. Schünemann, H.; Brożek, J.; Guyatt, G.; Oxman, A. GRADE Handbook. 2013. Available online: <https://gdt.gradepro.org/app/handbook/handbook.html> (accessed on 23 May 2023).
41. Basques, B.; Bohl, D.; Golinvaux, N.; Samuel, A.M.; Grauer, J.G. General versus spinal anaesthesia for patients aged 70 years and older with a fracture of the hip. *Bone Joint J.* **2015**, *97-B*, 689–695. [\[CrossRef\]](#)
42. Bouarfa, L.; Passini, E.; Sucher, J.F.; Blake, N.; Balcome, C.D.; Prokusi, L.; Dzandu, J.; Barletta, J.F.; Shirah, G.R. Consequences of anemia in geriatric hip fractures: How low is too low? *Trauma Surg. Acute Care Open* **2024**, *9*, e001175. [\[CrossRef\]](#) [\[PubMed\]](#)
43. Brunskill, S.; Millette, S.; Shokoohi, A.; Pulford, E.C.; Doree, C.; Murphy, M.; Stanworth, S. Red blood cell transfusion for people undergoing hip fracture surgery. *Cochrane Database Syst. Rev.* **2015**, CD009699. [\[CrossRef\]](#) [\[PubMed\]](#)
44. National Institute for Health and Care Excellence (NICE). *Quality Statement 2: Tranexamic Acid for Adults—Moderate Blood Loss (>500 mL)*; NICE Quality Standard QS138; NICE: London, UK, 2015. Available online: <https://www.nice.org.uk/guidance/qs138/chapter/quality-statement-2-tranexamic-acid-for-adults> (accessed on 23 May 2023).
45. Association of Anaesthetists. *Joint Guideline on the Management of Hip Fractures in Adults: Anaesthetic Management*; Association of Anaesthetists: London, UK, 2020. Available online: <https://anaesthetists.org/Home/Resources-publications/Guidelines> (accessed on 23 May 2023).
46. Carson, J.; Guyatt, G.; Heddle, N.; Grossman, B.J.; Cohn, C.S.; Fung, M.K.; Gernsheimer, T.; Holcomb, J.B.; Kaplan, L.J.; Katz, L.M.; et al. Clinical practice guidelines from the AABB: Red blood cell transfusion thresholds and storage. *JAMA* **2016**, *316*, 2025–2035. [\[CrossRef\]](#) [\[PubMed\]](#)
47. Murphy, M.; Estcourt, L.; Goodnough, L. Blood transfusion strategies in elderly patients. *Lancet Haematol.* **2017**, *4*, e453–e454. [\[CrossRef\]](#)
48. Lin, Y.; Yu, C.; Xian, G. Calculation methods for intraoperative blood loss: A literature review. *BMC Surg.* **2024**, *24*, 394. [\[CrossRef\]](#)
49. Benson, M.; Hartmann, B.; Junger, A.; Dietrich, G.; Böttger, S.; Hempelmann, G. Causes of higher blood loss during general anaesthesia compared to spinal anesthesia in total hip replacement—A retrospective analysis of data collected online. *Transfus. Med. Hemother.* **2000**, *27*, 311–316. [\[CrossRef\]](#)
50. Polderman, K. Hypothermia and coagulation. *Crit. Care* **2012**, *16*, 20. [\[CrossRef\]](#)
51. Qi, Y.; Wang, H.; Li, Y.; Ma, B.B.; Xie, T.; Wang, C.; Chen, H.; Rui, Y.F. The efficacy and safety of intravenous tranexamic acid in hip fracture surgery: A systematic review and meta-analysis. *J. Orthop. Transl.* **2019**, *19*, 1–11. [\[CrossRef\]](#) [\[PubMed\]](#)
52. Meibner, N.; Halder, A.; Schrednitzki, D. Cemented and hybrid total hip arthroplasty lead to lower blood loss in primary total hip arthroplasty: A retrospective study. *Arch. Orthop. Trauma Surg.* **2023**, *143*, 6447–6451. [\[CrossRef\]](#) [\[PubMed\]](#)
53. Kim, H.; Roychoudhury, P.; Lohia, S.; Kim, J.S.; Kim, H.T.; Ro, Y.J.; Koh, W.U. Comparison of general and spinal anaesthesia on systemic inflammatory response in patients undergoing total knee arthroplasty: A propensity score matching analysis. *Medicina* **2021**, *57*, 1250. [\[CrossRef\]](#) [\[PubMed\]](#)
54. White, R.H. The epidemiology of venous thromboembolism. *Circulation* **2003**, *107* (Suppl. S1), I4–I8. [\[CrossRef\]](#)
55. Stein, P.D.; Henry, J.W.; Relyea, B. Untreated patients with pulmonary embolism: Outcome, clinical, and laboratory assessment. *Chest* **1991**, *100*, 780–782.
56. Falck-Ytter, Y.; Francis, C.W.; Johanson, N.A.; Curley, C.; Dahl, O.E.; Schulman, S.; Ortel, T.L.; Pauker, S.G.; Colwell, C.W., Jr. Prevention of VTE in orthopedic surgery patients: Antithrombotic therapy and prevention of thrombosis, 9th ed: ACCP guidelines. *Chest* **2012**, *141* (Suppl. S2), e278S–e325S. [\[CrossRef\]](#)
57. Kakkos, S.K.; Gohel, M.; Baekgaard, N.; Bauersachs, R.; Bellmunt-Montoya, S.; Black, S.A.; Cate-Hoek, A.J.T.; Elalamy, I.; Enzmann, F.K.; Geroulakos, G.; et al. Editor's Choice-European Society for Vascular Surgery (ESVS) 2021 Clinical Practice Guidelines on the Management of Venous Thrombosis. *Eur. J. Vasc. Endovasc. Surg.* **2021**, *61*, 9–82.
58. Wijeyesundera, D.N.; Beattie, W.S.; Austin, P.C.; Hux, J.E.; Laupacis, A. Epidural anaesthesia and survival after intermediate-to-high risk non-cardiac surgery: A population-based cohort study. *Lancet* **2008**, *372*, 562–569. [\[CrossRef\]](#)
59. Mashour, G.; Moore, L.; Lele, A.; Robicsek, S.A.; Gelb, A.W. Perioperative care of patients at high risk for stroke during or after non-cardiac, non-neurologic surgery: Consensus statement from the society for neuroscience in anesthesiology and critical care. *J. Neurosurg. Anesthesiol.* **2014**, *26*, 273–285. [\[CrossRef\]](#)
60. Jeandin, T.; Albrecht, E.; Wegrzyn, J.; Cachemaille, M. Hemodynamic stability between spinal and general anaesthesia in patients undergoing primary total knee arthroplasty: A retrospective study. *Reg. Anesth. Pain Med.* **2021**, *70*, A30.

61. Kadkim, A.; Al-Khikani, H.; Hamza, Q.; Habib, Y.K.; Hussein, M.M.; Muhammad, H.T. Comparison between general and spinal anesthesia in the effect on hemodynamic stability in patients undergoing hernia repair. *Matthews J. Anesth.* **2022**, *5*, 10015. [[CrossRef](#)]
62. Basques, B.; Toy, J.; Bohl, D.; Golinvaux, N.S.; Grauer, J.N. General compared with spinal anesthesia for total hip arthroplasty. *J. Bone Jt. Surg. Am.* **2015**, *97*, 455–461. [[CrossRef](#)]

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