Trauma Surgery & Acute Care Open

Mode of anesthesia is not associated with outcomes following emergency hip fracture surgery: a population-level cohort study

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/tsaco-2022-000957).

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21st European Congress of Trauma and Emergency Surgery (ECTES), Oslo, Norway, April 2022 and The Swedish Orthopedic Association (SOF) annual meeting, Malmo, Sweden, September 2022

Received 9 May 2022
Accepted 31 August 2022

ABSTRACT

Background Hip fractures often occur in frail patients with several comorbidities. In those undergoing emergency surgery, determining the optimal anesthesia modality may be challenging, with equipoise concerning outcomes following either spinal or general anesthesia. In this study, we investigated the association between mode of anesthesia and postoperative morbidity and mortality with subgroup analyses.

Methods This is a retrospective study using all consecutive adult patients who underwent emergency hip fracture surgery in Orebro County, Sweden, between 2013 and 2017. Patients were extracted from the Swedish National Hip Fracture Registry, and their electronic medical records were reviewed. The association between the type of anesthesia and 30-day and 90-day postoperative mortality, as well as in-hospital severe complications (Clavien-Dindo classification ≥3a), was analyzed using Poisson regression models with robust SEs, while the association with 1-year mortality was analyzed using Cox proportional hazards models. All analyses were adjusted for potential confounders.

Results A total of 2437 hip fracture cases were included in the study, of whom 60% received spinal anesthesia. There was no statistically significant difference in the risk of 30-day postoperative mortality (adjusted incident rate ratio (IRR) (95% CI): 0.99 (0.72 to 1.36), p=0.952), 90-day postoperative mortality (adjusted IRR (95% CI): 0.88 (0.70 to 1.11), p=0.281), 1-year postoperative mortality (adjusted HR (95% CI): 0.98 (0.83 to 1.15), p=0.773), or in-hospital severe complications (adjusted IRR (95% CI): 1.24 (0.85 to 1.82), p=0.273), when comparing general and spinal anesthesia.

Conclusions Mode of anesthesia during emergency hip fracture surgery was not associated with an increased risk of postoperative mortality or in-hospital severe complications in the study population or any of the investigated subgroups.

Level of evidence: Therapeutic/Care Management, level III

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The choice of anesthetic technique can be challenging, with literature and practice patterns divided mainly between spinal or general anesthesia.
⇒ Despite decades of research attempting to determine which patients benefit the most from each of these methods, clinical practice varies significantly between institutions.

WHAT THIS STUDY ADDS

⇒ This study investigates if subgroups within the hip fracture population could benefit from either spinal or general anesthesia.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Considering that we did not find any difference in outcomes depending on mode of anesthesia, this study supports that the anesthesiologist should choose their personally preferred method.

INTRODUCTION

While there is heterogeneity in the hip fracture population, hip fracture patients are on average older and have a higher comorbidity burden than the general population.[1–6] These comorbidities along with the acute physiological insult, present additional perioperative, including anesthetic, concerns.[7–9] Unlike elective surgery, the opportunity for preoperative optimization is limited in patients undergoing emergency surgery for hip fractures. Additionally, increased vigilance is required when assessing medication use such as anticoagulants, the potential for postoperative delirium, and the impact of respiratory compromise.[10 11]

The choice of anesthetic technique can be challenging, with literature and practice patterns divided mainly between spinal or general anesthesia.[12–16] Spinal anesthesia is often preferred due to the avoidance of neurologically active drugs, a reduction in intraoperative hypotension, and a possible reduction in early postoperative delirium.[10 12 14 16] From an institutional standpoint, spinal anesthesia can provide a less expensive alternative.[17] However, general anesthesia can be hypothesized to provide improved patient satisfaction due to inhibition of memory of the procedure and also a more desirable anesthetic plane particularly in complex patients. Nonetheless, decisions regarding choice of anesthetic method are made on a case-by-case basis considering the patient's preference, the preference of the anesthesiologist, the operating surgeon,

To cite: Mohammad Ismail A, Forssten MP, Bass GA, *et al*. *Trauma Surg Acute Care Open* 2022;**7**:e000957.

and institutional practice; norms are likely to play a central role.[10 14] Despite decades of research attempting to determine which patients benefit the most from each of these methods, clinical practice varies significantly between institutions.[12–14] Meta-analyses published on this topic have found that spinal and general anesthesia result in equivalent results in terms of adverse outcomes; however, there are also a limited number of studies which have been able to observe a difference.[12 13] The latest randomized controlled trial (RCT), published in *New England Journal of Medicine*, demonstrated similar results between the modes of anesthesia used regarding recovered ambulation, delirium, and survival.[16]

A recent publication by Lin *et al* pinpointed the importance of frailty and the geriatric syndrome in regard to anesthesia and surgery.[14] Some of the indices commonly used to assess the risk of postoperative events in these patients are the American Society of Anesthesiologists (ASA) classification, the Charlson Comorbidity Index (CCI) and the Revised Cardiac Risk Index (RCRI).[5 14 18 19] Furthermore, several other risk factors have been associated with an increased risk of adverse postoperative outcomes.[20–25] However, the latest meta-analyses have not conducted any subgroup analyses taking into account these different risk factors. Therefore, the aim of the current study was to evaluate the association between mode of anesthesia and postoperative morbidity as well as mortality within a general hip fracture population as well as within specific subgroups.

METHODS

Both the Strengthening the Reporting of Observational Studies in Epidemiology guidelines and Declaration of Helsinki were adhered to throughout the study.[26] During the 5-year period between January 1, 2013 and December 31, 2017, all consecutive adult patients (aged ≥18 years) who underwent primary emergency hip fracture surgery in Orebro County, Sweden, were included. Patients were excluded if they suffered a pathological hip fracture, were managed non-operatively, or if the type of anesthesia used was missing. Data were retrieved from the Swedish National Hip Fracture Registry, Rikshöft.[27] This dataset provided information regarding age, sex, date of hospital admission, ASA classification, type of fracture, surgical method, and date of hospital discharge. These data were complemented with a review of the patients' electronic medical records to retrieve comorbidity data and time of death, as well as to supplement data missing from the national hip fracture register. Comorbidity data were used to calculate both the CCI and the RCRI.[28 29]

Calculating the Revised Cardiac Risk Index

The RCRI score was based on the presence of a history of ischemic heart disease, a history of congestive heart failure, a history of cerebrovascular disease, preoperative insulin therapy, a preoperative creatinine >2 mg/dL, and high-risk surgery. Each variable increased the RCRI by 1 point if present. Hip fracture surgery is considered intermediate risk surgery according to the American College of Cardiology and the American Heart Association guidelines[30]; accordingly, points for high-risk surgery were not awarded to any patient in this study. Patients that had end-organ damage resulting from diabetes mellitus but lacked preoperative insulin therapy were also awarded 1 point to reflect the severity of their diabetes.[31]

Statistical analysis

Patients were divided into two groups based on the type of anesthesia they received: spinal anesthesia or general anesthesia. Continuous variables were summarized as a median and IQR, with differences being compared using the Mann-Whitney U test, as these variables were non-normally distributed. Categorical variables were instead presented as counts with percentages and compared using the χ^2 test or Fisher's exact test. The primary outcome of interest was 30-day postoperative mortality with 90-day postoperative mortality, 1-year postoperative mortality, and in-hospital severe complications as secondary outcomes of interest. A complication was classified as severe if it had a Clavien-Dindo classification ≥3a, that is, complications requiring surgical, endoscopic, or radiological intervention.

The associations between the type of anesthesia and 30-day mortality, 90-day mortality, as well as in-hospital severe complications were analyzed using Poisson regression models with robust SEs. The association with 1-year mortality was instead

Table 1 Demographics and clinical features in patients undergoing hip fracture surgery with spinal or general anesthesia.

	Spinal anesthesia (n=1463)	General anesthesia (n=974)	P value
Age, median (IQR)	84 (77–89)	83 (75–89)	<0.001
Sex, n (%)			0.002
Female	949 (64.9)	692 (71.0)	
Male	514 (35.1)	282 (29.0)	
Charlson Comorbidity Index, n (%)			0.247
≤4	455 (31.1)	327 (33.6)	
5–6	571 (39.0)	349 (35.8)	
≥7	437 (29.9)	298 (30.6)	
ASA classification, n (%)			0.797
1	111 (7.6)	73 (7.5)	
2	611 (41.8)	388 (39.8)	
3	629 (43.0)	431 (44.3)	
4	107 (7.3)	77 (7.9)	
Missing	5 (0.3)	5 (0.5)	
Type of fracture, n (%)			0.013
Non-displaced cervical (Garden 1–2)	186 (12.7)	135 (13.9)	
Displaced cervical (Garden 3–4)	497 (34.0)	372 (38.2)	
Basicervical	57 (3.9)	54 (5.5)	
Peritrochanteric (two fragments)	381 (26.0)	204 (20.9)	
Peritrochanteric (multiple fragments)	237 (16.2)	142 (14.6)	
Subtrochanteric	105 (7.2)	67 (6.9)	
Preoperative fascia iliaca compartment block, n (%)	99 (6.8)	139 (14.3)	<0.001
Missing	2 (0.1)	1 (0.1)	
Type of surgery, n (%)			<0.001
Pins or screws	296 (20.2)	193 (19.8)	
Pins or screws with sideplate	548 (37.5)	333 (34.2)	
Intramedullary nail	248 (17.0)	151 (15.5)	
Hemiarthroplasty	254 (17.4)	236 (24.2)	
Total hip replacement	117 (8.0)	61 (6.3)	
Revised Cardiac Risk Index, n (%)			0.278
<2	1184 (80.9)	806 (82.8)	
≥2	279 (19.1)	168 (17.2)	
Duration of surgery, median (IQR)	45 (26–72)	46 (28–71)	0.359
Missing, n (%)	87 (5.9)	32 (3.3)	
Out-of-hours surgery, n (%)	597 (40.8)	359 (36.9)	0.056

ASA, American Society of Anesthesiologists.

Table 2 Preoperative comorbidities in patients undergoing hip fracture surgery with spinal or general anesthesia.

	Spinal anesthesia (n=1463)	General anesthesia (n=974)	P value
Myocardial infarction, n (%)	225 (15.4)	155 (15.9)	0.765
Congestive heart failure, n (%)	265 (18.1)	160 (16.4)	0.308
Peripheral vascular disease, n (%)	110 (7.5)	69 (7.1)	0.746
Cerebrovascular disease, n (%)	360 (24.6)	233 (23.9)	0.735
Dementia, n (%)	360 (24.6)	211 (21.7)	0.103
COPD, n (%)	139 (9.5)	84 (8.6)	0.507
Connective tissue disease, n (%)	29 (2.0)	11 (1.1)	0.144
Peptic ulcer disease, n (%)	128 (8.7)	121 (12.4)	0.004
Liver disease, n (%)	11 (0.8)	20 (2.1)	0.009
Diabetes mellitus, n (%)			0.851
Uncomplicated	98 (6.7)	63 (6.5)	
End-organ damage	123 (8.4)	88 (9.0)	
Hemiplegia, n (%)	40 (2.7)	29 (3.0)	0.818
Chronic kidney disease, n (%)	106 (7.2)	71 (7.3)	1.00
Cancer, n (%)			0.297
Local tumor	298 (20.4)	185 (19.0)	
Metastatic	37 (2.5)	34 (3.5)	
Leukemia, n (%)	10 (0.7)	7 (0.7)	1.00
Lymphoma, n (%)	8 (0.5)	4 (0.4)	0.772

COPD, chronic obstructive pulmonary disease.;

determined using a Cox proportional hazards model. All analyses were adjusted for known factors that previously have been shown to be associated with outcome after hip fracture surgery, namely: age, sex, CCI, ASA classification, type of fracture, and type of surgery.

Subsequently, subgroup analyses were performed by repeating the regression analyses with specific subgroups of patients who were deemed to potentially be at a higher risk of suffering adverse events as a result of the choice of anesthesiological method used.

Table 3 Crude outcomes in patients undergoing hip fracture surgery with spinal or general anesthesia.

	Spinal anesthesia (n=1463)	General anesthesia (n=974)	P value
Length of stay, median (IQR)	8.0 (5.0–11)	8.0 (5.0–12)	0.340
30-day mortality, n (%)	127 (8.7)	73 (7.5)	0.332
90-day mortality, n (%)	228 (15.6)	125 (12.8)	0.067
1-year mortality, n (%)	382 (26.1)	232 (23.8)	0.219
Severe complication, n (%)	79 (5.4)	59 (6.1)	0.554
Missing	6 (0.4)	3 (0.3)	
Anemia, n (%)	28 (1.9)	21 (2.2)	0.787
Delirium, n (%)	1 (0.1)	2 (0.2)	0.568
Infection, n (%)	27 (1.8)	16 (1.6)	0.829
Urinary tract infection, n (%)	4 (0.3)	3 (0.3)	1.00
Pneumonia, n (%)	15 (1.0)	6 (0.6)	0.397
Cardiovascular event, n (%)	24 (1.6)	20 (2.1)	0.552
Thromboembolic event, n (%)	1 (0.1)	0 (0.0)	1.00
Cerebrovascular event, n (%)	5 (0.3)	2 (0.2)	0.709
Gastrointestinal bleeding, n (%)	5 (0.3)	5 (0.5)	0.533
Acute kidney injury, n (%)	11 (0.8)	2 (0.2)	0.126
Sepsis, n (%)	3 (0.2)	3 (0.3)	0.688
Multiple organ failure, n (%)	8 (0.5)	4 (0.4)	0.772
Other complications, n (%)	12 (0.8)	17 (1.7)	0.061

Length of stay is measured in days. In-hospital severe complications are defined as those with a Clavien-Dindo classification ≥3a.

These subgroups were selected since prior studies have observed an association between them and postoperative outcomes; they consisted of patients who underwent internal fixation or arthroplasty, had an extended surgical duration (surgical duration >100 min), had a reduced surgical fitness (ASA classification ≥3), had an elevated RCRI (RCRI ≥2), had an increased comorbidity burden (CCI ≥7), had a diagnosis of dementia prior to surgery, underwent surgery out-of-hours (17:00-08:00), and geriatric patients (aged ≥65 years).[5 18–22 24 25 31 32] An extended surgical duration was defined as any operation that lasted >100 min, as this was the 90th percentile for all operations in this dataset. Results are presented as incident rate ratios (IRRs) or HRs with 95% CIs.

Statistical significance was defined as a two-sided p value <0.05. Multiple imputation by chained equations was applied using the mice package to manage missing values. 10 imputed datasets were generated for the whole study population as well as each subgroup (internal fixation, arthroplasty, etc). Imputed values were calculated using logistic regression models for binary variables, Bayesian polytomous regression for nominal variables, and proportional odds models for ordinal variables. Poisson regression models were fitted to each imputed dataset; this resulted in 10 models for each analysis (all patients, internal fixation, arthroplasty, etc). These 10 models were pooled by calculating the average value of the coefficients and associated SEs. The resulting coefficient and SE for the mode of anesthesia was used to calculate the IRR, CI, and p value. No patients were lost to follow-up. All analyses were performed using the statistical programming language R (R Foundation for Statistical Computing, Vienna, Austria).[33]

RESULTS

A total of 2437 cases were included in the current study. Patients who received general anesthesia were more often female (71.0% vs 64.9%, p=0.002) and were more frequently operated on using arthroplasty (30.5% vs 25.4%, p<0.001). Accordingly, patients who underwent general anesthesia were more likely to have suffered an intracapsular hip fracture (57.6% vs 50.6%, p=0.013). While statistically significant, the 1-year difference in median age was not considered to be clinically significant. Furthermore, no statistically significant differences were observed in overall comorbidity burden based on their CCI, fitness for surgery based on their preoperative ASA classification, cardiac risk based on their RCRI, or surgical duration (table 1). There were no statistically significant differences in any comorbidities, except for peptic ulcer disease and liver disease, which were both more prevalent among patients who underwent general anesthesia (table 2).

There were also no statistically significant differences in length of stay, 30-day mortality, 90-day mortality, 1-year mortality, or in-hospital severe complications between the cohorts (table 3). This remained unchanged after adjusting for potential confounders in the Poisson regression analyses or Cox proportional hazards model. There were no statistically significant differences in the risk of 30-day postoperative mortality (adjusted IRR (95% CI): 0.99 (0.72 to 1.36), p=0.952), 90-day postoperative mortality (adjusted IRR (95% CI): 0.88 (0.70 to 1.11), p=0.281), 1-year postoperative mortality (adjusted HR (95% CI): 0.98 (0.83 to 1.15), p=0.773), or in-hospital severe complications (adjusted IRR (95% CI): 1.24 (0.85 to 1.82), p=0.273), when comparing general anesthesia with spinal anesthesia. These results remained unchanged in all subgroups analyzed (table 4).

Table 4 IRRs and HRs for 30-day, 90-day, and 1-year mortality as well as severe complications after hip fracture surgery, comparing patients having spinal with those having general anesthesia.

Population	30-day mortality IRR (95% CI)	P value	90-day mortality IRR (95% CI)	P value	1-year mortality HR (95% CI)	P value	Severe complication* IRR (95% CI)	P value
All patients N=2437	0.99 (0.72 to 1.36)	0.952	0.88 (0.70 to 1.11)	0.281	0.98 (0.83 to 1.15)	0.773	1.24 (0.85 to 1.82)	0.273
Patients who underwent internal fixation N=1769	1.03 (0.73 to 1.47)	0.858	0.83 (0.64 to 1.08)	0.160	0.96 (0.79 to 1.16)	0.677	1.27 (0.79 to 2.05)	0.322
Patients who underwent an arthroplasty N=668	0.92 (0.45 to 1.91)	0.839	1.15 (0.7 to 1.89)	0.603	1.06 (0.75 to 1.5)	0.735	1.16 (0.61 to 2.18)	0.670
Patients with an extended surgical duration† N=221	1.8 (0.54 to 5.97)	0.344	1.15 (0.43 to 3.09)	0.796	1.24 (0.57 to 2.68)	0.573	0.77 (0.22 to 2.65)	0.692
Patients with reduced surgical fitness‡ N=1244	0.98 (0.68 to 1.4)	0.908	0.88 (0.68 to 1.14)	0.327	0.96 (0.79 to 1.17)	0.712	1.33 (0.86 to 2.06)	0.194
Patients with an elevated RCRI§ N=447	0.71 (0.37 to 1.34)	0.292	0.86 (0.56 to 1.32)	0.500	0.94 (0.69 to 1.29)	0.717	1.01 (0.50 to 2.06)	0.972
Patients with an elevated CCI¶ N=735	1.02 (0.68 to 1.53)	0.937	1.01 (0.75 to 1.36)	0.954	1.1 (0.88 to 1.38)	0.414	1.3 (0.80 to 2.11)	0.292
Patients with dementia N=571	0.87 (0.53 to 1.41)	0.582	0.91 (0.65 to 1.29)	0.620	0.99 (0.76 to 1.3)	0.957	0.86 (0.40 to 1.84)	0.705
Patients who underwent out-of-hours surgery** N=956	1.09 (0.66 to 1.8)	0.750	0.8 (0.55 to 1.16)	0.243	0.89 (0.68 to 1.17)	0.390	0.68 (0.32 to 1.44)	0.320
Geriatric patients†† N=2295	0.99 (0.72 to 1.36)	0.965	0.88 (0.70 to 1.11)	0.286	0.97 (0.82 to 1.15)	0.745	1.26 (0.85 to 1.85)	0.249

The reference group in each analysis is patients who received spinal anesthesia. IRRs are calculated using Poisson regression models with robust SEs. HRs are calculated using Cox proportional hazards model. The analyses are adjusted for age, sex, CCI, ASA classification, type of fracture, and type of surgery. Multiple imputation by chained equations was used to manage missing values.

*A complication was classified as severe if it had a Clavien-Dindo classification ≥3a.

†An extended surgical duration was defined as a surgery lasting >100 min, which constitute 90th percentile of the operative time in the current study cohort.

‡Patients were deemed to have a reduced fitness for surgery, if they had an ASA classification ≥3.

§An elevated RCRI was defined as RCRI ≥2.

¶An elevated CCI was defined as CCI ≥7.

**Out-of-hours surgery was defined as surgery between 17:00 and 08:00 hours.

††Geriatric patients were defined as ≥65 years old.

ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index; IRR, incident rate ratio; RCRI, Revised Cardiac Risk Index.

DISCUSSION

No significant associations between mode of anesthesia and in-hospital severe complications, or mortality up to 1 year post-operatively could be demonstrated in the current study. These results remained consistent within all subgroups that were analyzed.

The debate on what anesthesiological method to use in hip fracture patients, who are often elderly and frail, has been ongoing for decades.[1–6 12–14 31 34–38] Despite this, there is a clinical equipoise regarding which patients should be provided spinal or general anesthesia, and great variation is seen in clinical practice.[12–14 16] Zheng *et al* published the latest meta-analysis on this topic in 2020, including nine RCTs with low heterogeneity. They concluded that there were no significant differences between spinal or general anesthesia regarding the rate of delirium (OR (95% CI): 1.05 (0.27 to 4.00), p=0.95), myocardial infarction (OR (95% CI): 0.88 (0.17 to 4.65), p=0.88), pneumonia (OR (95% CI): 1.04 (0.23 to 4.61), p=0.96), deep vein thrombosis (OR (95% CI): 0.48 (0.09 to 2.72), p=0.41), or 30-day mortality (OR (95% CI): 1.34 (0.56 to 3.21), p=0.51).[12] Another meta-analysis by Van Waesberghe *et al* included 20 retrospective observational studies and 3 prospective RCTs. Like the current study, it only included patients who had undergone hip fracture surgery where the incidence of postoperative myocardial infarction, pneumonia, pulmonary embolism, respiratory failure, and mortality was investigated. They could not demonstrate any difference in the incidence of pneumonia (OR (95% CI): 0.74 (0.46 to 1.17), p=0.20), pulmonary embolism (OR (95% CI): 0.86 (0.64 to 1.17), p=0.35), or 30-day mortality (OR (95% CI): 0.99 (0.94 to 1.04), p=0.60).[14] However, in contrast to Zheng *et al*, this meta-analysis found that the incidence of myocardial infarction was lower in the neuraxial anesthesia group (OR (95% CI): 0.90 (0.82 to 0.99), p=0.03).[12 14] Furthermore, Van Waesberghe et al could also demonstrate a decreased incidence of respiratory failure (OR (95% CI): 0.50 (0.28 to 0.87), p=0.02) and in-hospital mortality (OR (95% CI): 0.85 (0.76 to 0.95), p=0.004) in the neuraxial anesthesia group. In their article, they also mentioned that the patients who received general anesthesia had an elevated risk of overall morbidity, especially in patients with pre-existing respiratory diseases.[13]

It has been demonstrated in several previous studies that patients sustaining a hip fracture are old and have a high comorbidity burden.[1–6 31 34–38] These comorbidities, along with the acute injury, have a negative impact on the cardiovascular system as well as other organ systems, which may affect the postoperative risk of adverse events.[7–9 14] Furthermore, studies have shown that several other factors could increase the risk of postoperative adverse events after hip fracture surgery, such as surgical duration, out-of-hours surgery, and dementia.[5 19–22 24 25 31] However, these variables have not been taken into account in the previous studies on this topic.[12 13]

Lin *et al* published a review article in 2018, pinpointing the importance of frailty in regard to anesthesia and surgery. They describe that depending on how frail a patient is, the consequences of the primary and secondary insult will differ. The least frail individual can recover from a minor insult, while a moderately frail patient can have a reduced functional outcome, and the frailest individual will have a severe decline in functional outcome. Furthermore, they suggest that if a frail patient suffers several insults, recovery could be impossible and might even result in death.[14] Hip fracture patients are often frail and suffer several insults in a short period: the insult from the trauma causing the fracture, the insults from fasting and preparing for surgery, the insult from anesthesia, as well as the insult from the hip fracture surgery.[7–9 14] Recently, Neuman *et al* published a prospective randomised trial where 1600 patients were included in the *New England Journal of Medicine*. They investigated the effects of spinal anesthesia compared with general anesthesia on the functional outcome and demonstrated no differences in the relative risk (RR) of recovered ambulation (RR (95% CI): 1.06 (0.82 to 1.36)), delirium (RR (95% CI): 1.04 (0.84 to 1.30)), or survival (RR (95% CI): 0.97 (0.59 to 1.57)).[16]

Owing to the current study being an observational study, the analyses included patients that would have been ethically challenging for prospective RCTs to incorporate due to potential adverse outcomes or difficulties acquiring consent. Previous RCTs have otherwise avoided including patients with cognitive impairments or who have been considered to be high-risk patients.[16 39] For example, Heidari *et al* excluded patients with dementia and those with an ASA classification >3.[39] A substantial portion of hip fracture patients suffer from cognitive impairment. However, the current investigation comprises all adult patients with traumatic hip fractures that underwent surgery within the specified time frame. This difference likely also explains the higher crude mortality rates observed in the current study compared with previous RCTs, as it is well known that patients with dementia have a higher risk of mortality.[21 24 32] This study suggests that, regarding both mortality and severe complications, even these high-risk patients are not affected by the mode of anesthesia.

The ASA classification, CCI, and RCRI are commonly used to assess the risk of postoperative events in patients who are frail or suffer from geriatric syndromes.[14 19 23 40] However, these indices do not specifically measure frailty, but rather fitness for surgery, comorbidity burden, and cardiac risk. While frailty is related to these concepts, true frailty indices such as the traumatic frailty index, might be even more useful for directing resource allocation and patient care.[14 41] Nevertheless, when performing subgroup analyses on these indices in the current study, no differences could be demonstrated when comparing the mode of anesthesia used. Previous studies investigating hip fracture patients with dementia have shown that this subgroup of patients suffer from a higher degree of pre-existing comorbidities and consequently also exhibit a higher risk of mortality postoperatively.[21 24 32] Nevertheless, when performing a subgroup analysis on these patients, no association between mode of anesthesia and postoperative severe complications or mortality up to 1 year postoperatively.

Other factors that have been demonstrated to affect adverse outcomes after surgery is the surgical method used, where internal fixation has been associated with lower risks compared with arthroplasty when the surgery is performed out-of-hours, while patients with dementia and dislocated cervical hip fractures had better outcomes when they underwent hemiarthroplasty rather than internal fixation.[22 25] However, no difference was seen in the outcomes measured in the current study when analyzing patients who underwent internal fixation, arthroplasty, had an extended surgical duration, or underwent surgery out-of-hours. One potential explanation for our findings could be the relatively short procedure time for hip fracture surgery; as most surgical techniques are relatively simple procedures the overall surgical trauma might result in less physiological strain compared to more complex surgeries with longer surgical durations.

The medical field has tried to reduce the high mortality rates after hip fracture surgery for decades.[1–3 6 37 38 42] Despite several efforts including fast-track programs and multidisciplinary care, the mortality rates remain high.[3 42] It has been suggested that refining the surgical technique might not be the optimal strategy if the goal is to further decrease the mortality rates after hip fracture surgery; instead surgeons likely need to investigate other avenues that might affect postoperative outcomes.[43] Therefore, the main goal of the current study was to evaluate if mode of anesthesia had any effects on morbidity and mortality when considering different subgroups of hip fracture patients. The findings in the current study mirrors previous investigations on this topic in that the anesthetic method does not appear to affect adverse outcomes.[12 13 16]

The environmental impact of the anesthetic choice should also play a role in the decision-making. Although spinal anesthesia would be anticipated to have a lower carbon footprint, the use of single-use instruments, packaging, and other equipment can increase the carbon dioxide emission rate to one similar to general anesthesia using inhalational agents. However, local variations in practices may impact this.[44–46] Furthermore, from an institutional standpoint, spinal anesthesia is a more cost-effective choice in comparison to general anesthesia, which may impact the choice of departmental standard routine mode of anesthesia offered.[17 47]

Strengths and limitations

There are strengths and limitations that need to be mentioned regarding the current study. In this study, we performed several analyses investigating specific subgroups in the hip fracture population that have not been previously studied. The subgroup analyses, along with the fact that all patients had surgery within the same orthopedic department, distributed across one university hospital and two affiliated hospitals, may have aided in reducing the heterogeneity that would otherwise arise as a result of institutional preferences and norms. Furthermore, the data collected for this study were based on reviews from the patients' electronic medical records, which could be considered more reliable than register data alone. Considering that this was a retrospective study with the limitations accompanying this type of studies, we cannot draw any conclusions about causal relationships. Finally, the observational nature of the current investigation allowed us to include patients that are otherwise ethically challenging to include due to potential adverse outcomes or difficulty acquiring consent, such as those with dementia or considered less fit for surgery (ASA ≥3). As a consequence, our results are likely even generalizable to these high-risk populations.

CONCLUSIONS

The mode of anesthesia used for emergency hip fracture surgery was not associated with an increased risk of either postoperative mortality or severe complications in the entire study population or in any of the included subgroups. Considering these results, in combination with previous studies, it may be suggested that pursuing other avenues of research might provide a greater benefit to hip fracture patients.

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Contributors AMI, MPF, and SM conceived of the idea and designed the study. AMI, MPF, DT, and ALE collected the data. AMI, MPF, and SM carried out the analyses of the data. All authors discussed the results and contributed to the interpretation of data. AMI, MPF, GAB, II, CCD, CJP, and SM drafted the manuscript. All authors have critically reviewed the manuscript and accepted it before submission. SM acts as a guarantor for this study and accepts full responsibility for the finished work and the conduct of the study. SM had access to the data, and controlled the decision to publish

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study was approved by the Swedish Ethical Review Authority (ref: 2021-05403-02) and adhered to the Declaration of Helsinki.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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