Improved outcomes for spinal versus general anesthesia for hip fracture surgery: a retrospective cohort study of the National Surgical Quality Improvement Program

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ABSTRACT

Background There is a lack of consensus in the literature as to whether anesthetic modality influences perioperative complications in hip fracture surgery. The aim of the present study was to assess the effect of spinal anesthesia compared with general anesthesia on postoperative morbidity and mortality in patients who underwent hip fracture surgery using data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP).

Methods We used the ACS NSQIP to identify patients aged 50 and older who received either spinal or general anesthesia for hip fracture surgery from 2016 to 2019. Propensity-score matching was performed to control for clinically relevant covariates. The primary outcome of interest was the combined incidence of stroke, myocardial infarction (MI) or death within 30 days. Secondary outcomes included 30-day mortality, hospital length of stay and operative time.

Results Among the 40 527 patients aged 50 and over who received either spinal or general anesthesia for hip fracture surgery from 2016 to 2019, 7358 spinal anesthesia cases were matched to general anesthesia cases. General anesthesia was associated with a higher incidence of combined 30-day stroke, MI or death compared with spinal anesthesia (OR 1.219 (95% CI 1.076 to 1.381); p=0.002). General anesthesia was also associated with a higher frequency of 30-day mortality (OR 1.276 (95% CI 1.099 to 1.481); p=0.001) and longer operative time (64.73 vs 60.28 min; p<0.001). Spinal anesthesia had a longer average hospital length of stay (6.29 vs 5.73 days; p=0.001).

Conclusion Our propensity-matched analysis suggests that spinal anesthesia as compared with general anesthesia is associated with lower postoperative morbidity and mortality in patients undergoing hip fracture surgery.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There is conflicting evidence as to whether anesthetic modality influences perioperative complications in hip fracture surgery, with some studies reporting no difference, others reporting that general anesthesia is associated with a greater likelihood of adverse outcomes, and still others reporting the opposite finding for certain outcomes.

WHAT THIS STUDY ADDS

⇒ We performed a large-scale, multicenter analysis to add to a growing body of literature assessing the effect of spinal anesthesia compared with general anesthesia on postoperative morbidity and mortality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The primary outcome of a combined incidence of stroke, myocardial infarction or death within 30 days was lower in the spinal anesthesia group, suggesting that spinal anesthesia may carry fewer risks to patients than general anesthesia. The implications of this paper have the potential to guide physicians in their decision for how to manage best this expanding patient population.

INTRODUCTION

Over 300 000 individuals undergo orthopedic surgery for hip fractures each year, the majority of whom are elderly. Following an initial decline[1] in the early 2000s with the introduction of modern diagnostics and therapeutics for osteoporosis, the incidence of hip fractures is likely to increase in the coming years given an aging population and reduced primary care visits during the COVID-19 pandemic.[2] Surgery with early postoperative mobilization is the treatment of choice for most patients with hip fractures, but this management carries significant risk for perioperative morbidity and mortality. The likelihood of adverse outcomes following hip fracture surgery may depend on factors such as age, comorbidities and type of surgical procedure.[3 4] Anesthetic technique, specifically general versus spinal anesthesia, represents a parameter within the control of the physician and patient and can serve to mitigate negative surgical outcomes.

There is a lack of consensus in the literature as to whether anesthetic modality influences perioperative complications in hip fracture surgery. Some studies report no difference in rates of mortality at 30 days,[5] the composite of death or an inability to walk at 60 days,[6] 30-day major complications,[7]

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cognitive function,[8] delirium[6 9] or other complications (eg, surgical site infection, pneumonia and urinary tract infection)[7] when comparing different anesthesia types used in hip fracture surgery. Meanwhile, others suggest that regional anesthesia results in better outcomes, including decreased rates of adverse events such as stroke, cardiac arrest, unplanned intubation, other minor adverse events,[10] decreased operating room time[10] and lower incidence and severity of pain[11] when compared with general anesthesia for these procedures. Still other sources posit that general anesthesia may be the preferred method for hip fracture surgery, reporting a decreased likelihood of postoperative complications in general versus regional anesthesia, and earlier postoperative mobilization.[12] These conflicting results pose difficulty to physicians attempting to develop anesthetic plans that minimize adverse outcomes for hip fracture cases.

Our study used population-based data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) Hip Fracture Targeted Participant Use File (PUF) to evaluate patients undergoing hip fracture surgery between the years 2016 and 2019, with the aim of comparing the effect of spinal anesthesia versus general anesthesia on postoperative morbidity and mortality. The primary outcome of interest was combined incidence of stroke, myocardial infarction (MI) and death within 30 days after surgery. We hypothesized that propensity-matched patients who received spinal anesthesia would be less likely to experience stroke, MI or death within 30 days than those who received general anesthesia.

METHODS

We performed a retrospective review of the ACS NSQIP Hip Fracture Targeted PUF, which includes perioperative data from the medical records of patients from over 700 enrolled hospitals and provides clinical outcome data 30 days postoperatively. In this database, patient demographics, comorbidities, intraoperative factors and 30-day outcomes data are collected from medical records and patient interviews by trained reviewers.[13] This study was exempted from Institutional Review Board (IRB) review.

Study population

This study identified 40 527 patients over the age of 50 who underwent surgery for hip fractures between 1 January 2016 and 31 December 2019. The ACS NSQIP Target Hip Fracture database includes Current Procedural Terminology (CPT) codes for Fracture and/or Dislocation Procedures on the Pelvis and Hip Joint (27236, 27244, 27245).[13] All patients aged 50 and older who received spinal or general anesthesia were included. Exclusion criteria included age under 50 years and no report of the type of anesthesia or use of a type other than spinal or general anesthesia (eg, epidural anesthesia, combined spinal/epidural anesthesia). Additional exclusion criteria included patients with missing perioperative data.

Baseline patient characteristics collected from the registry included demographics, smoking history, steroid use, American Society of Anesthesiologists (ASA) score, hip fracture type (undisplaced femoral neck fracture, displaced femoral neck fracture, intertrochanteric and subtrochanteric),[13] functional status, emergent case and medical comorbidities including diabetes, chronic obstructive pulmonary disorder (COPD), congestive heart failure, hypertension, acute renal failure, current dialysis, disseminated cancer, open wound, bleeding disorder, dementia and preoperative delirium. Functional status was defined as the patient's ability to perform the activities of daily living either independently or in a partially or completely dependent manner within the 30 days before admission. Surgeries were classified as emergent if they were performed shortly after patient diagnosis or the onset of relevant preoperative symptoms, and for which a patient's well-being and outcome would have been potentially jeopardized if postponed.[14]

Outcomes

The primary outcome of interest was the combined incidence of stroke, MI or death at 30 days. Secondary outcomes included 30-day mortality, hospital length of stay and operative time. The following exploratory 30-day complications reported in NSQIP were included for assessment: stroke, MI, acute renal failure, cardiac arrest requiring cardiopulmonary resuscitation (CPR), unplanned intubation, ventilator support for over 48 hours, deep vein thrombosis (DVT) or thrombophlebitis, pulmonary embolism (PE) and postoperative delirium.[14] NSQIP evaluated postoperative delirium based on chart review, with descriptive words that included 'mental status change, confusion, disorientation, agitation, delirium, inappropriate behavior, inattention, hallucinations, combativeness (eg, pulling out lines or tubes) and so on'.[15]

Statistical analyses

Descriptive statistics and comparison of baseline characteristics were performed using Analysis of Variance (ANOVA) for continuous variables and Pearson's χ^2 test for categorical variables; non-parametric equivalents were used when appropriate. Propensity scores were calculated with a logistic regression model that included all clinically relevant covariates that met a crude univariate χ^2 or t-test $p<0.50$ and had fewer than 15% of cases missing data. Covariates included age, sex, body mass index, ASA score, diabetes, COPD, congestive heart failure, hypertension, acute kidney injury (AKI), cancer, bleeding disorder, dialysis, current smoker, chronic steroid use, open wound, functional status, preoperative dementia, preoperative delirium, emergent case and CPT code. Nearest neighbor propensity-score matching was performed 1:1 with a caliper of 0.001 and without replacement.[16] Covariate balance was assessed using the absolute standardized mean difference with <0.1 indicating a negligible difference between groups. Outcome analysis was performed using conditional logistic regression for binary variables and Wilcoxon signed-rank test for continuous variables. A stratified analysis by ASA score was performed with independently evaluated propensity models. Standardized OR, 95% CIs and p values are reported. All statistical tests were two-sided and a p value less than 0.05 was considered statistically significant. Statistical analyses were performed using Stata/SE (V.17.0).

RESULTS

Among the 40 527 total cases in the 2016–2019 ACS NSQIP Targeted Hip Fracture database, 30 680 (75.7%) patients were administered general anesthesia and 9847 (24.3%) received spinal anesthesia. Using 1:1 propensity-score matching, 7358 spinal anesthesia cases were successfully matched to a general anesthetic case (online supplemental figure S1). Covariate balance was confirmed with a maximum absolute standardized mean difference between groups of 0.02. The demographics and preoperative characteristics of the sample before and after propensity-score matching are reported in table 1.

Spinal anesthesia was associated with reduced adverse outcomes compared with general anesthesia in the matched groups. The primary outcome of combined 30-day stroke, MI or death occurred in 583 of 7358 patients (7.92%) who received

Table 1 Demographics and baseline characteristics before and after propensity-score matching

	Before matching				After matching			
Preoperative characteristics	Total (n=40 527)	Spinal (n=9847)	General (n=30 680)	P value	Total (n=14 716)	Spinal (n=7358)	General (n=7358)	P value
Age (years), mean (SD)	80.25 (9.73)	81.79 (8.93)	79.76 (9.93)	<0.001	81.32 (9.16)	81.25 (9.14)	81.40 (9.17)	0.30
Sex, female (n)	68.84% (27 897)	71.23% (7014)	68.07% (20 883)	<0.001	71.15% (10 471)	71.23% (5241)	71.08% (5230)	0.84
BMI (kg/m^2), mean (SD)	25.23 (5.84)	24.53 (5.39)	25.41 (5.95)	<0.001	24.59 (5.39)	24.58 (5.39)	24.59 (5.38)	0.90
ASA class				<0.001				0.99
I	0.60% (242)	0.83% (82)	0.52% (160)		0.74% (109)	0.75% (55)	0.73% (54)	
II	15.23% (6173)	16.72% (1646)	14.76% (4527)		18.06% (2657)	17.97% (1322)	18.14% (1335)	
III	62.43% (25 300)	59.45% (5854)	63.38% (19 446)		60.21% (8861)	60.06% (4419)	60.37% (4442)	
IV	21.42% (8679)	22.47% (2213)	21.08% (6466)		20.66% (3041)	20.90% (1538)	20.43% (1503)	
V	0.18% (71)	0.19% (19)	0.17% (52)		0.20% (29)	0.19% (14)	0.20% (15)	
None assigned	0.15% (62)	0.34% (33)	0.09% (29)		0.13% (19)	0.14% (10)	0.12% (9)	
Diabetes (n)	18.56% (7520)	16.12% (1587)	19.34% (5933)	<0.001	16.06% (2364)	16.53% (1216)	15.60% (1148)	0.13
Smoker (n)	11.53% (4673)	10.40% (1024)	11.89% (3649)	<0.001	10.78% (1586)	10.99% (809)	10.56% (777)	0.39
COPD (n)	10.50% (4256)	10.82% (1065)	10.40% (3191)	0.24	11.35% (1670)	11.44% (842)	11.25% (828)	0.72
Congestive heart failure (n)	3.71% (1505)	3.21% (316)	3.88% (1189)	0.002	3.13% (460)	3.19% (235)	3.06% (225)	0.64
Hypertension (n)	66.48% (26 944)	62.67% (6171)	67.71% (20 773)	<0.001	63.20% (9300)	63.37% (4663)	63.02% (4637)	0.66
Acute renal failure (n)	0.58% (236)	0.37% (36)	0.65% (200)	0.001	0.33% (48)	0.31% (23)	0.34% (25)	0.77
Current dialysis (n)	1.93% (784)	1.23% (121)	2.16% (663)	<0.001	1.37% (201)	1.30% (96)	1.43% (105)	0.52
Disseminated cancer (n)	3.32% (1347)	2.72% (268)	3.52% (1079)	<0.001	2.87% (423)	2.83% (208)	2.92% (215)	0.73
Open wound (with or without infection) (n)	3.67% (1487)	2.37% (233)	4.09% (1254)	<0.001	2.36% (347)	2.36% (174)	2.35% (173)	0.96
Steroid use (n)	5.63% (2283)	4.94% (486)	5.86% (1797)	<0.001	4.98% (733)	5.07% (373)	4.89% (360)	0.62
Bleeding disorder (n)	17.10% (6929)	8.00% (788)	20.02% (6141)	<0.001	7.72% (1136)	7.76% (571)	7.68% (565)	0.85
Emergent case (n)	31.69% (12 844)	49.51% (4875)	25.97% (7969)	<0.001	45.04% (6628)	44.86% (3301)	45.22% (3327)	0.67
Functional status				<0.001				0.96
Independent (n)	77.58% (31 441)	77.66% (7647)	77.56% (23 794)		79.06% (11 635)	79.23% (5830)	78.89% (5805)	
Partially dependent (n)	18.86% (7644)	18.23% (1795)	19.06% (5849)		17.85% (2627)	17.72% (1304)	17.98% (1323)	
Totally dependent (n)	3.02% (1223)	3.32% (327)	2.92% (896)		2.57% (378)	2.54% (187)	2.60% (191)	
Unknown (n)	0.54% (219)	0.79% (78)	0.46% (141)		0.52% (76)	0.50% (37)	0.53% (39)	
Dementia (n)	28.63% (11 603)	30.80% (3033)	27.93% (8570)	<0.001	28.50% (4194)	28.20% (2075)	28.80% (2119)	0.42
Preoperative delirium (n)	12.81% (5146)	12.56% (1228)	12.88% (3918)	0.40	11.20% (1648)	11.13% (819)	11.27% (829)	0.79
Fracture type				<0.001				0.028
Femoral neck—undisplaced	8.45% (3425)	8.09% (797)	8.57% (2628)		8.52% (1254)	7.95% (585)	9.09% (669)	
Femoral neck—displaced	29.45% (11 937)	31.78% (3129)	28.71% (8808)		31.50% (4636)	32.36% (2381)	30.65% (2255)	
Intertrochanteric	53.85% (21 823)	52.14% (5134)	54.40% (16 689)		51.90% (7638)	51.52% (3791)	52.28% (3847)	
Unknown	2.04% (828)	1.68% (165)	2.16% (663)		1.95% (287)	1.86% (137)	2.04% (150)	
Subtrochanteric	6.20% (2514)	6.32% (622)	6.17% (1892)		6.12% (901)	6.31% (464)	5.94% (437)	

a: alpha level set at 0.05.
ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

general anesthesia and in 485 of 7358 patients (6.59%) who received spinal anesthesia (OR 1.219 (95% CI 1.076 to 1.381); p=0.002). Death within 30 days occurred in 412 patients (5.60%) in the general anesthesia group and 327 patients (4.44%) in the spinal anesthesia group (OR 1.276 (95% CI 1.099 to 1.481); p=0.001). There were no significant differences in stroke and MI. The general anesthesia group had a longer operative duration (64.73 vs 60.28 min; p<0.001) compared with the spinal anesthesia group. The spinal anesthesia group had a longer average hospital length of stay (6.29 vs 5.73 days; p=0.001).

Additional significant findings included 30-day acute renal failure (OR 2.077 (95% CI 1.072 to 4.025); p=0.027) and DVT or thrombophlebitis (OR 1.510 (95% CI 1.060 to 2.151); p=0.023); both of which were higher in the general anesthesia group. None of the other 30-day complications reached statistical significance after propensity-score matching (table 2).

Analysis revealed associations between ASA classification and certain outcomes. For patients with ASA score IV, combined 30-day stroke/MI/death rate was greater in the general anesthesia group than the spinal anesthesia group (OR 1.467 (95% CI 1.178 to 1.825); p<0.001); this outcome was not significantly different between anesthetic modalities for the ASA I–II and ASA III cohorts. The ASA IV patients who received general anesthesia also showed increased rates of 30-day mortality (OR 1.482 (95% CI 1.163 to 1.887); p=0.002) and incidence of MI (OR 1.606 (95% CI 1.040 to 2.480); p=0.032); these outcomes were not statistically different between anesthetic modalities for the ASA I–II and ASA III cohorts. Patients who received general anesthesia had longer operative times when compared with patients who received spinal anesthesia in all three ASA cohorts. Total hospital length of stay did not vary significantly for the general and spinal anesthesia groups for the ASA score IV patients (table 3).

DISCUSSION

The results of this propensity-matched multicenter analysis suggest benefits to using spinal rather than general anesthesia

Table 2 Surgical outcomes for patients undergoing spinal or general anesthesia for hip fracture surgery after propensity-score matching

Outcomes	Total (n=14 716)	Spinal (n=7358)	General (n=7358)	OR, general vs spinal (95% CI)	P value
Operative time (min), mean (SD)	**62.51 (36.82)**	**60.28 (32.93)**	**64.73 (40.22)**		**<0.001**
Total hospital LOS (days), mean (SD)	**6.01 (10.67)**	**6.29 (11.78)**	**5.73 (9.42)**		**0.001**
30-day complications, % (n)					
Combined stroke/MI/death rate	**7.26 (1068)**	**6.59 (485)**	**7.92 (583)**	**1.219 (1.076 to 1.381)**	**0.002**
Death	**5.02 (739)**	**4.44 (327)**	**5.60 (412)**	**1.276 (1.099 to 1.481)**	**0.001**
Stroke	0.75 (110)	0.76 (56)	0.73 (54)	0.964 (0.664 to 1.401)	0.85
Myocardial infarction	2.09 (308)	1.93 (142)	2.26 (166)	1.171 (0.935 to 1.468)	0.17
Reoperation	2.01 (296)	1.90 (140)	2.12 (156)	1.119 (0.887 to 1.411)	0.35
Acute renal failure	**0.27 (40)**	**0.18 (13)**	**0.37 (27)**	**2.077 (1.072 to 4.025)**	**0.027**
Cardiac arrest requiring CPR	0.54 (80)	0.49 (36)	0.60 (44)	1.229 (0.786 to 1.919)	0.37
Unplanned intubation	0.80 (118)	0.71 (52)	0.90 (66)	1.269 (0.882 to 1.825)	0.20
Ventilator support >48 hours	0.35 (52)	0.30 (22)	0.41 (30)	1.364 (0.787 to 2.364)	0.27
DVT or thrombophlebitis	**0.90 (132)**	**0.72 (53)**	**1.07 (79)**	**1.510 (1.060 to 2.151)**	**0.023**
Pulmonary embolism	0.73 (108)	0.77 (57)	0.69 (51)	0.893 (0.610 to 1.307)	0.56
Postoperative delirium	25.58 (3765)	25.80 (1898)	25.37 (1867)	0.978 (0.908 to 1.053)	0.56

a: alpha level set at 0.05.
CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis; LOS, length of stay; MI, myocardial infarction.

for hip fracture surgery. The primary outcome of a combined incidence of stroke, MI or death within 30 days was lower in the spinal anesthesia group, suggesting that spinal anesthesia may carry fewer risks to patients, especially those of higher ASA classification.

Patients who received spinal anesthesia had a lower incidence of many of the 30-day complications assessed, including a significantly reduced incidence of mortality, acute renal failure and DVT or thrombophlebitis.

The patients who received spinal anesthesia had a shorter operative duration than those who received general anesthesia. It is plausible that patients presenting with more surgically complex fractures or those whose procedures were anticipated to be lengthy were more likely to receive general anesthesia. It is also important to note that the absolute difference in surgical duration between the groups was small and therefore may not be the most clinically relevant factor when deciding appropriate anesthesia type.

The patients who were administered spinal anesthesia had a longer average hospital length of stay relative to those who received general anesthesia. This is in contrast to other studies demonstrating shorter hospital lengths of stay for patients undergoing spinal anesthesia.[17] The reasons behind this cannot be elucidated from this retrospective study but could be related to many factors such as data misclassification or unidentified clinical factors.

A stratified analysis by ASA score revealed that the effect of anesthetic type on the primary outcome of combined incidence

Table 3 Outcomes for Patients who received general or spinal anesthesia for hip fracture surgery, stratified by ASA score

	ASA I–II (n=2706)		ASA III (n=8806)		ASA IV (n=2878)	
Outcome	General vs spinal (mean)	P value	General vs spinal (mean)	P value	General vs spinal (mean)	P value
Operative time (min)	67.12 vs 62.25	**<0.001**	64.77 vs 60.31	**<0.001**	61.48 vs 58.99	**0.048**
Total hospital LOS (days)	4.78 vs 5.39	**0.004**	10.95 vs 6.23	**0.018**	6.46 vs 7.11	0.28
Outcome	OR (general vs spinal) (95% CI)	P value	OR (general vs spinal) (95% CI)	P value	OR (general vs spinal) (95% CI)	P value
30-day complications						
Combined stroke/MI/death rate	1.103 (0.668 to 1.824)	0.71	1.061 (0.891 to 1.264)	0.51	**1.467 (1.178 to 1.825)**	**<0.001**
Death	1.8 (0.831 to 3.899)	0.14	1.190 (0.963 to 1.470)	0.11	**1.482 (1.163 to 1.887)**	**0.002**
Stroke	1.125 (0.434 to 2.916)	0.81	0.806 (0.494 to 1.314)	0.40	1.857 (0.741 to 4.655)	0.20
Myocardial infarction	0.647 (0.303 to 1.381)	0.25	0.940 (0.690 to 1.280)	0.69	**1.606 (1.040 to 2.480)**	**0.032**
Reoperation	1.529 (0.830 to 2.819)	0.17	1.080 (0.807 to 1.446)	0.60	1.353 (0.868 to 2.108)	0.17
Acute renal failure	Not calculated		**5.0 (1.096 to 22.820)**	**0.021**	1.182 (0.529 to 2.638)	0.68
Cardiac arrest requiring CPR	3.0 (0.312 to 28.841)	0.32	**1.70 (0.979 to 2.953)**	**0.056**	1.214 (0.599 to 2.463)	0.59
Unplanned intubation	2.5 (0.784 to 7.971)	0.11	1.407 (0.859 to 2.305)	0.18	1.278 (0.690 to 2.368)	0.44
Ventilator support >48 hours	0.667 (0.111 to 3.990)	0.65	1.455 (0.675 to 3.134)	0.34	1.50 (0.613 to 3.670)	0.37
DVT or thrombophlebitis	**2.571 (1.074 to 6.156)**	**0.027**	**1.611 (1.063 to 2.442)**	**0.024**	1.667 (0.729 to 3.808)	0.22
Pulmonary embolism	1.667 (0.606 to 4.586)	0.34	1.083 (0.689 to 1.704)	0.73	1.0 (0.449 to 2.226)	1.00
Postoperative delirium	0.908 (0.731 to 1.126)	0.39	0.945 (0.860 to 1.037)	0.23	1.083 (0.929 to 1.262)	0.30

a: alpha level set at 0.05.
b: OR not calculated. Insufficient variation to calculate.
ASA, American Society of Anesthesiologists; CPR, cardiopulmonary resuscitation; DVT, deep vein thrombosis; LOS, length of stay; MI, myocardial infarction.

of stroke, MI or death within 30 days was greatest for patients with higher ASA score, with ASA IV classification being associated with higher odds for major morbidity and mortality outcomes. ASA score has been shown to be strongly associated with mortality in hip fracture patients,[18 19] and this finding poses a potential mitigating factor for reducing adverse events in this vulnerable patient population.

The present study has several limitations to consider. One limitation inherent to NSQIP is that patients are only assessed for 30 days following surgery, and adverse outcomes after that point are not assessed. Another limitation is incomplete patient data, which has been cited in the past as a limitation of the NSQIP dataset.[20] Race was unknown or not reported in 4875 (33.13%) of the patients in our study, and therefore could not be incorporated into propensity-score model without reducing the sample size and model statistical power substantially. The dataset did not include patients who received total hip arthroplasty for hip fracture, and thus our analysis was missing a common surgical procedure for patients with hip fracture. There was also missing data on fracture type, with 828 (2.04%) of patients having that data point unknown. Our initial propensity-score matching, therefore, did not take into account fracture type. Furthermore, even though matching was used to control for differences, unrecognized residual confounding could have affected our results. This study only compared the effects of spinal and general anesthesia and neglected other modalities such as nerve blocks and combined spinal/epidural anesthesia. Due to the nature of the retrospective review design, patients were not randomly assigned and selection bias that might lead physicians to opt for one technique over another might confound the results.

Randomized control trials (RCTs) offer the potential to complement our understanding of the risks and benefits of various anesthesia modalities in hip fracture patients. Two recent RCTs comparing spinal to general anesthesia were recently published in November 2021 and January 2022. The investigators of Regional versus General Anesthesia for Promoting Independence After Hip Fracture (REGAIN) found that spinal anesthesia was not superior to general anesthesia in 1600 patients undergoing hip fracture surgery in terms of a primary outcome of the composite of death or an inability to ambulate at 60 days, although spinal anesthesia did result in a lower incidence of the exploratory outcomes of death during hospitalization, AKI and postoperative critical care admission. The Effect of Regional vs General Anesthesia on Incidence of Postoperative Delirium in Older Patients Undergoing Hip Fracture Surgery (RAGA) trial (950 patients) found that anesthesia type did not significantly affect the incidence of postoperative delirium.[21] Both REGAIN and RAGA recruited patients who were substantially younger and of lower ASA classification than those in this or other large database studies.[22–24] The results of our stratified analysis raise the possibility that the benefits of spinal anesthesia may be realized only in the sickest patients, who are least likely to participate in prospective trials. There are two additional RCTs currently being conducted to evaluate outcomes in hip fracture patients receiving spinal and general anesthesia. The registered Comparing Regional and General Anaesthesia and Their Effect on Delirium in Patients with Hip Fractures (REGARD) trial will be the third of its kind to assess delirium,[25] and the Improve Hip Fracture Outcome in the Elderly Patient (iHOPE) trial will assess overall mortality and the new occurrence of serious cardiac and pulmonary complications 30 days after surgery.[26] These studies offer the potential to further influence the debate surrounding anesthetic type but care should be taken in any future trials to enroll patients consistent with the hip fracture population at large in order to yield generalizable results.

Conclusions

Our findings suggest benefits to spinal anesthesia over general anesthesia for hip fracture surgery, particularly in patients who have a higher ASA classification. A growing literature on anesthetic modality can guide physicians in their decision for how to best manage this important and expanding patient population.

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Contributors RBB and NS conceived the original study question. ERW, RBB, RSW, RYW, and TRT conceived and designed the study. RBB retrieved and analyzed the data. ERW and RBB directly accessed and verified the underlying data reported in the manuscript. ERW and TRT wrote the manuscript with support from RBB, RSW, RYL, and JML. TRT helped supervise the project. All authors read and approved the final manuscript. TRT is responsible for the overall content as guarantor, accepts full responsibility for the finished work and conduct of the study, had access to the data, and controlled the decision to publish.

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Data availability statement Data may be obtained from a third party and are not publicly available. The data are deidentified participant data from the ACS NSQIP Hip Fracture Targeted PUF. An individual who wants to obtain access to the ACS NSQIP PUF may do so by visiting www.facs.org/quality-programs/acs-nsqip, clicking the "Request PUF" link, and following the steps listed on the PUF request page.

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