Anesthesia Type Is Not Associated With Postoperative Complications in the Care of Patients With Lower Extremity Traumatic Fractures

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BACKGROUND: Lower extremity fracture fixation is commonplace and represents the majority of orthopedic trauma surgical volume. Despite this, few studies have examined the use of regional anesthesia or neuraxial anesthesia (RA/NA) versus general anesthesia (GA) in this surgical population. We aimed to determine the overall rates of RA/NA use and whether RA/NA was associated with lower mortality and morbidity versus GA for patients with lower extremity orthopedic trauma.
METHODS: We conducted a propensity-matched, retrospective cohort study of hospitalized patients. We used the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) dataset to identify patients undergoing surgical correction of low velocity orthopedic lower extremity traumas between 2011 and 2016. Patients were separated into 2 groups based on anesthesia type (RA/NA versus GA). The primary outcome was 30-day mortality. Secondary outcomes included return to the operating room, failure to wean from the ventilator, intubation, pneumonia, acute kidney injury, myocardial infarction, transfusion, venous thromboembolism (VTE), urinary tract infection, sepsis, length of stay, days from operation to discharge, number of complications, and unplanned readmission.
RESULTS: We identified 18,467 patients undergoing surgical repair of lower extremity fractures. Approximately 9.58% had RA/NA and 89.9% had GA as their primary anesthetic. After 1:1 propensity matching, the final cohort had 3254 patients. Our analysis did not find a difference in 30-day mortality between the 2 groups. There were also no significant differences in secondary outcomes.
CONCLUSIONS: Despite the potential advantages of RA/NA, utilization for lower extremity trauma was low in our analysis; only 9.58% of patients were in the RA/NA group, with the majority receiving spinal anesthesia. This may be due to surgeon preference to allow for postoperative monitoring for neurologic injury and compartment syndrome or logistical factors given the urgent nature of these trauma cases. No significant differences in 30-day mortality and postoperative complications were found between RA/NA and GA for patients with lower extremity orthopedic fractures. The choice of anesthesia is multifactorial and may be driven by patient and provider preferences in these operations. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** What is the overall rate of regional anesthesia or neuraxial anesthesia (RA/NA) use in patients with lower extremity orthopedic trauma and is RA/NA associated with lower mortality and morbidity versus general anesthesia (GA)?
- **Findings:** Approximately 9.58% had RA/NA and 90.4% had GA for their anesthetic; there was no difference in 30-day mortality between the 2 groups or significant differences in secondary outcomes.
- **Meaning:** RA/NA techniques are utilized in only a small portion of the lower extremity orthopedic trauma population, and anesthesia choice may be driven by patient and provider preferences.

GLOSSARY

ACS-NSQIP = American College of Surgeons National Surgical Quality Improvement Project; **ADLs** = activities of daily living; **ASA** = American Society of Anesthesiologists; **BMI** = body mass index; **CAD** = coronary artery disease; **CHF** = congestive heart failure; **CI** = confidence interval; **CKD** = chronic kidney disease; **CNS** = central nervous system; **COPD** = chronic obstructive pulmonary disease; **CPT** = current procedure terminology; **GA** = general anesthesia; **HR** = hazard ratio; **IRB** = Institutional Review Board; **NA** = neuraxial anesthesia; **OR** = odds ratio; **PS** = physical status; **RA** = regional anesthesia; **RVU** = relative value unit; **SD** = standard deviation; **UTI** = urinary tract infection; **VTE** = venous thromboembolism

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Accepted for publication May 7, 2019.

DOI: 10.1213/ANE.0000000000004270

Funding: None.

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (www.anesthesia-analgesia.org).

Reprints will not be available from the authors.

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Extremity injuries make up a large percentage of all trauma cases presenting to hospitals, and the lower extremity is involved in 12.8% of all injuries, with many of these patients requiring surgical management.[1] For the anesthesia provider, the choice of general anesthesia (GA) or regional or neuraxial anesthesia (RA/NA) for these cases represents an important clinical decision for which adequate guiding data are unavailable.

The use of RA/NA has been increasing over the past several decades.[2] Benefits of RA/NA have been seen in several studies comparing outcomes between GA and RA/NA for elective orthopedic surgeries and hip fractures.[3–10] However, there is a paucity of studies of RA use in lower extremity trauma. Patients with low-energy fractures of the lower extremity are specifically a group of patients where RA/NA use would be suitable. These patients are likely to be hemodynamically stable, and there are several effective regional techniques available.[11] Because the economic burden of trauma is high with estimated cost of $671 billion annually and the prevalence of low-energy, lower extremity trauma is significant, the use patterns and potential benefits of RA/NA in this surgical population warrant further investigation.[12]

The effect of anesthetic technique on postsurgical outcomes has been an area of interest over the past several decades. Early trials and meta-analyses found significant benefits to RA/NA over GA including decreased rates of all-cause mortality, pulmonary complications, cardiac dysthymias, blood transfusions, venous thromboembolism (VTE), and surgical site infection in vascular, general, and orthopedic surgeries.[13–17] However, a recent study of patients undergoing total hip and knee arthroplasties found no significant differences in outcomes.[9] This could be due to improved safety of both RA/NA and GA, which had led to decreased complications, potentially making recent studies underpowered to detect small outcomes differences between anesthetic techniques.[2]

Despite the potential benefits, RA/NA also has inherent risks such as infection, nerve injury, and intravascular injection. Perhaps most importantly for lower extremity fracture surgery, there is concern about masking compartment syndrome.[11] Therefore, further investigation into the use of RA/NA in lower extremity orthopedic fractures is necessary to determine whether RA/NA is a safe and effective alternative to GA in this type of surgery. Utilizing the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP), we hypothesized that RA/NA for lower extremity orthopedic fractures would be associated with a decreased incidence of postoperative adverse outcomes when compared to operations performed under GA.

METHODS

Data Source

The NSQIP participant user file from years 2011 to 2016 was compiled into a single data file containing 4,273,816 records from over 600 participating hospitals. NSQIP data gathering procedures have been described previously.[18–20] This study was approved by the Partners Healthcare Institutional Review Board (IRB), and the requirement for written informed consent was waived by the IRB given the retrospective nature of the study and due to all data being deidentified. We retrospectively examined patients who underwent surgical repair of lower extremity fractures from January 1, 2011 through December 31, 2016.

Patient Selection

The compiled data file was queried for cases of surgical repair of lower extremity fractures using current procedure terminology (CPT) codes. Table 1 describes the CPT codes used to define the procedures (27766, 27792, 27814, 27822, 27823, and 27829). Specifically, we included lower extremity fractures encompassing malleolar fractures, distal fibular fracture, and distal tibiofibular joint. Exclusion criteria, due to exclusion from the NSQIP dataset, included patients under the age of 18 years, major trauma cases, transplant surgeries, cases failing to report the variable "anesthesia type," and all cases where the patient was listed as an American Society of Anesthesiologists (ASA) physical status (PS) class VI, representing a brain-dead organ donor. Major trauma is defined by NSQIP as patients requiring surgery for trauma. Excluded from the definition are subsequent operations performed during separate hospital admissions.[21] Patients undergoing concurrent operations at the time of fracture repair were also excluded from the analysis. Anesthesia type in the NSQIP database is coded hierarchically, with GA being given preference. Type of regional anesthetic was differentiated into spinal, epidural, or a nerve block and grouped together as RA/NA for the purpose of this analysis. The specific type of nerve block cannot be elucidated from the data. Cases listed as being performed under NA (spinal or epidural) or nerve block were performed using these anesthetics as the primary surgical anesthetic.

Demographic and Baseline Variables

Baseline demographic variables included age, sex, ethnicity, ASA PS classification, and body mass index (BMI). Functional status was assessed by 2 independent categorical values. First, by the presence of dyspnea at rest or with exertion, and second, by the ability to perform activities of daily living (ADLs). Comorbid conditions included in the analysis were diabetes, smoking history with number of pack-years,

Table 1. Description of CPT Codes

CPT Code	Code Description
27766	Open treatment of medial malleolus fracture includes internal fixation, when performed
27792	Open treatment of distal fibular fracture (eg, lateral malleolus) includes internal fixation, when performed
27814	Open treatment of bimalleolar ankle fracture (eg, lateral and medial malleoli, or lateral and posterior malleoli, or medial and posterior malleoli) includes internal fixation, when performed
27822	Open treatment of trimalleolar ankle fracture includes internal fixation, when performed, medial and/or lateral malleolus, without fixation of posterior lip
27823	Open treatment of trimalleolar ankle fracture includes internal fixation, when performed, medial and/or lateral malleolus, with fixation of posterior lip
27829	Open treatment of distal tibiofibular joint (syndesmosis) disruption includes internal fixation, when performed

Abbreviation: CPT, current procedural terminology.

chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), coronary artery disease (CAD), chronic kidney disease (CKD), steroid dependence, presence of wound infection, bleeding disorders, sepsis, and/or weight loss. Baseline laboratory data included hematocrit and platelet count. Surgical urgency was assessed if either the surgeon or anesthesiologist reported the case as emergent. Patients were grouped by anesthetic technique.

Statistical Analysis

A propensity score–matched analysis was performed. To identify whether preoperative or operative characteristics were independent risk factors associated with anesthetic type, univariable logistic regression analyses were fitted for all variables. Risk factors were defined as statistically significant when the odds ratios (OR) did not include 1.00 in their 95% confidence interval (CI), representing an α of <.05.

The matched cohort was developed using a propensity scoring method. All statistically significant variables (defined as $P < .05$) from the unmatched analysis were incorporated into a propensity score model. The following variables were included in the propensity score model: age, sex, race, BMI, ASA PS classification, presence of dyspnea, functional status, smoking history, hypertension, diabetes mellitus, COPD, CHF, recent steroid use, emergency surgery status, elective surgery status, CPT code, and procedure relative value units. A 1:1 greedy, nearest neighbor matching strategy was used utilizing the MatchIt library (Match-IT Limited, West Cross, Swansea, UK) with a caliper of 0.1, successfully matching 1627 cases performed under RA/NA to 1627 cases under GA. Success of the matching process was evaluated using univariable logistic regression and calculation of the absolute standardized differences between variables and revealed adequate matching on all variables except for the presence of a bleeding disorder preoperatively.[22] The presence of this unmatched variable was accounted for in the analysis of outcomes. Absolute standardized differences for the included covariables in the propensity score model are reported in Supplemental Digital Content, Appendix 1, http://links.lww.com/AA/C849. Analysis of the primary and secondary end points between anesthesia types for the matched cohort was done using multivariable logistic regression for all outcomes. Length of stay was analyzed using a Cox proportional hazard model, right censoring for death as a competing event. In addition, the number of complications experienced on an individual patient level was calculated as the sum of the total number of postoperative complications for each patient. This variable was analyzed using Poisson regression due to the nonnormal distribution of the data. For the logistic regression, ORs were reported with associated 95% CIs. Sample size was defined by the availability of cases using the inclusion criteria as outlined above. Power calculations were performed on our data using G*Power, version 3.1 (Dusseldorf, Germany) assuming a linear multiple regression model with a single regression coefficient and a fixed model with a total sample size of 3254, α error of .003, and 2 total predictors.[23] Using the assumptions above and setting a desired power of 0.8 and a 2-tailed model, the analysis had sufficient power to detect an effect size of 0.004 corresponding to a mortality difference of 0.4%. To account for the multiple comparisons, a Bonferroni correction was applied in assessing postoperative outcomes. Outcomes with a P value <.003 were considered significant for the purpose of this analysis. All analyses were conducted using R Studio version 1.1.463 (Boston, MA) and R Project for Statistical Computing, version 3.2.3 (Vienna, Austria).[24,25]

RESULTS

Inclusion and exclusion criteria and the study flow diagram are shown in Figure 1.

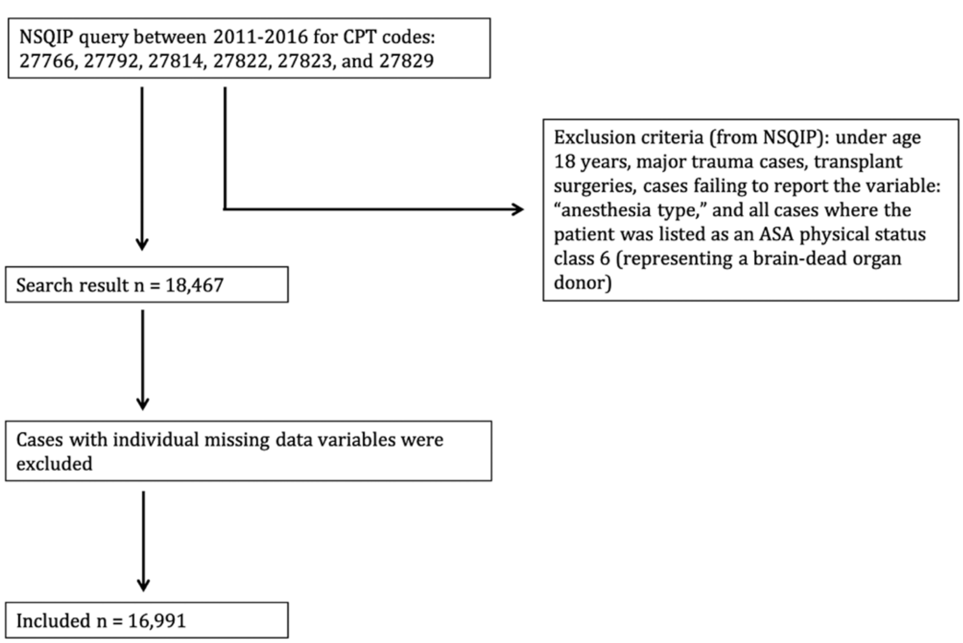

Figure 1. Flow diagram of data selection. ASA indicates American Society of Anesthesiologists; CPT, current procedure terminology; NSQIP, National Surgical Quality Improvement.

Between the years 2011 and 2016, a total of 18,467 patients who underwent surgery for lower extremity trauma below the level of the femoral neck were identified.

Figure 2 demonstrates RA/NA use over the years included, 2011–2016. The utilization of RA decreased with each year, with the majority of regional anesthetics performed being spinal anesthesia, followed by nerve blocks and epidural techniques. Specifically, as shown in Table 2, in the RA/NA group, 1421 patients received spinal anesthesia (87.3%), 192 received a nerve block (11.8%), and 14 received epidural anesthesia (0.9%).

Table 2 provides patient demographic information after exclusion of missing data.

In terms of demographics for the unmatched groups, the RA/NA group was significantly older (57.9 vs 48.6, $P < .001$), were female (63.6% vs 57.3%, $P < .001$), and were non-Caucasian (44.7% vs 32.5%, $P < .001$). Functionally, the RA/NA group had fewer patients with no dyspnea (93.6% vs 97.5%, $P < .001$) and fewer ASA class I patients (14.3% vs 21.4%, $P < .001$). In terms of comorbidities, the RA/NA group had a higher incidence of systemic hypertension (42.1% vs 31.4%, $P < .001$), diabetes mellitus (15.9% vs 11.4%, $P < .001$), COPD (7.2% vs 2.8%, $P < .001$), and CHF (1.3% vs 0.5%, $P < .001$) than the GA group. The RA/NA group had a lower rate of patients who were smokers (19.2% vs 25.9%, $P < .001$). Patients in the RA/NA group had higher preoperative platelet counts (157 vs 124, $P < .001$). Significantly more cases listed as emergent received RA/NA versus GA (29.0% vs 14.9%, $P < .001$).

Results after propensity score matching are shown in Table 3. There were significantly fewer patients with bleeding disorders in the RA/NA group (3.1% vs 6.0%, $P < .001$). This difference was accounted for when assessing postoperative outcomes. There were no other statistically significant differences between the 2 groups in terms of demographic characteristics, comorbidities, functional status, or type of surgical complexity.

Thirty-day postoperative outcomes are reported in Table 4. There was no significant difference in 30-day mortality between the RA/NA and GA cohorts. There were no significant differences in secondary outcomes including return to the operating room, failure to wean from the ventilator, reintubation, surgical site infection, pneumonia, acute kidney injury, acute myocardial infarction, transfusion, VTE, sepsis, and number of complications.

DISCUSSION

In this retrospective propensity score–matched cohort study, we identified 18,467 patients in the NSQIP database with complete data who had surgical correction of low-energy, lower extremity fractures between 2011 and 2016. The utilization of RA/NA was relatively low, observed in only 9.58% of cases. There was no difference in 30-day mortality between the 2 groups. Secondary outcomes, including surgical site infections, pulmonary complications, VTE, number of transfusions, cardiac complications, and length of hospital stay were also not significantly different.

It is unclear whether the theoretical advantages of RA/NA are actually seen in contemporary surgical populations, and few studies have analyzed traumatic surgical cases. Decreased morbidity and mortality has been seen in several studies looking at heterogeneous surgical populations as well as elective orthopedic surgeries and hip fracture surgeries.[3–10,13–17] However, other studies have found no differences between RA/NA and GA.[2,26–28] The benefits previously observed from RA/NA included decreased rates of pneumonia, VTEs, and blood transfusions.[4–6,9,10,13–15] Some of these benefits were thought to stem from the effects of sympathetic blockage causing peripheral vasodilation and VTEs, as well as lower blood pressures near the surgical site, thereby decreasing blood loss.[5,6,9,10] In the studies that found no differences between RA/NA and GA, the potential advantages of RA/NA were thought to have

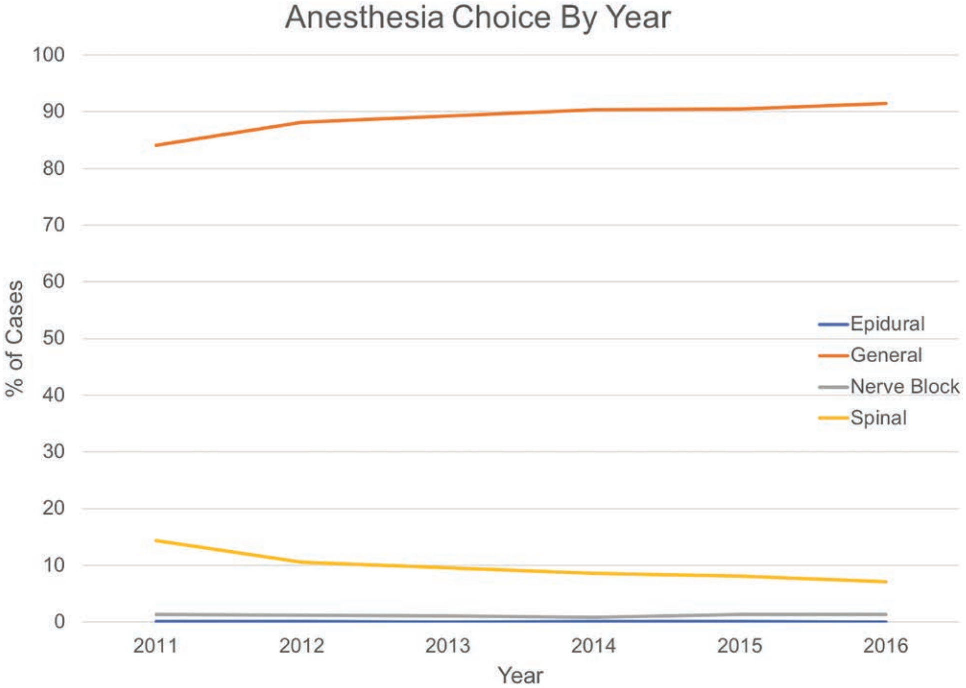

Figure 2. Anesthesia choice by year.

Table 2. Baseline Demographics in the RA/NA and GA Cohorts

	RA/NA	GA	OR (95% CI)	*P* Value
	n (%)	n (%)		
Cases	1627 (9.58)	15,364 (90.42)		
	Mean (SD)	Mean (SD)		
Age	57.86 (17.54)	48.64 (17.85)	1.02 (1.01–1.03)	<.001
Age groups	n (%)	n (%)	OR (95% CI)	
<50	480 (29.5)	7767 (50.55)	Reference	<.001
50–65	521 (32.02)	4411 (28.71)	1.63 (1.41–1.87)	
65–80	450 (27.66)	2506 (16.31)	2.13 (1.81–2.51)	
>80	176 (10.82)	680 (4.43)	2.71 (2.16–3.4)	
Sex				
Male	592 (36.39)	6566 (42.74)	Reference	<.001
Female	1035 (63.61)	8798 (57.26)	1.03 (0.92–1.15)	
Demographics				
Caucasian	899 (55.26)	10,371 (67.5)	Reference	<.001
African American	80 (4.92)	1683 (10.95)	0.71 (0.56–0.91)	
Asian	42 (2.58)	284 (1.85)	2.09 (1.48–2.94)	
Other	23 (1.41)	211 (1.37)	1.85 (1.18–2.89)	
Not reported	583 (35.83)	2815 (18.32)	2.48 (2.18–2.81)	
	Mean (SD)	Mean (SD)	OR (95% CI)	
BMI	30.63 (7.16)	30.84 (7.18)	1 (0.99–1.01)	.25
BMI groups	n (%)	n (%)	OR (95% CI)	
<18.5	12 (0.74)	83 (0.54)	1.09 (0.57–2.08)	.29
18.5–25	305 (18.75)	2836 (18.46)	Reference	
25–30	574 (35.28)	5162 (33.6)	1.02 (0.88–1.19)	
>30	736 (45.24)	7283 (47.4)	0.88 (0.76–1.03)	
Functional status				
No dyspnea	1523 (93.61)	14,974 (97.46)	Reference	<.001
Dyspnea with moderate exertion	92 (5.65)	363 (2.36)	1.63 (1.26–2.11)	
Dyspnea at rest	12 (0.74)	27 (0.18)	2.83 (1.37–5.86)	
Independent	1563 (96.07)	14,912 (97.06)	Reference	.02
Partially dependent	62 (3.81)	414 (2.69)	0.87 (0.65–1.16)	
Totally dependent	2 (0.12)	38 (0.25)	0.3 (0.07–1.28)	
ASA PS class				
I	233 (14.32)	3283 (21.37)	Reference	<.001
II	754 (46.34)	7965 (51.84)	1.35 (1.14–1.6)	
III	557 (34.23)	3773 (24.56)	1.6 (1.31–1.96)	
IV/V	83 (5.1)	343 (2.23)	1.99 (1.44–2.74)	
Comorbidities				
Smoking	312 (19.18)	3973 (25.86)	0.8 (0.7–0.92)	<.001
Hypertension	685 (42.1)	4821 (31.38)	0.93 (0.82–1.07)	<.001
Diabetes	258 (15.86)	1745 (11.36)	0.96 (0.82–1.13)	<.001
COPD	117 (7.19)	430 (2.8)	1.63 (1.28–2.07)	<.001
CHF	21 (1.29)	82 (0.53)	0.94 (0.56–1.59)	<.001
CKD	20 (1.23)	128 (0.83)	0.8 (0.48–1.35)	.10
Steroid use	35 (2.15)	238 (1.55)	0.83 (0.57–1.21)	.07
Wound infection	58 (3.56)	421 (2.74)	0.86 (0.64–1.15)	.06
Bleeding disorder	51 (3.13)	519 (3.38)	0.51 (0.37–0.69)	.60
Sepsis	46 (2.83)	385 (2.51)	0.83 (0.6–1.15)	.43
Laboratories	Mean (SD)	Mean (SD)	OR (95% CI)	
Platelets	157 (159)	124 (179)	1.01 (0.95–1.09)	<.001
Surgical urgency	n (%)	n (%)	OR (95% CI)	
Elective	634 (38.97)	9173 (59.7)	0.75 (0.66–0.85)	<.001
Emergent	472 (29.01)	2282 (14.85)	1.41 (1.23–1.61)	<.001
Surgical procedure (CPT code)				
27766	80 (4.92)	863 (5.62)	Reference	<.001
27792	436 (26.8)	4623 (30.09)	0.64 (0.41–1.01)	
27814	643 (39.52)	5169 (33.64)	0.29 (0.09–0.87)	
27822	314 (19.3)	2861 (18.62)	0.21 (0.05–0.79)	
27823	94 (5.78)	833 (5.42)	0.08 (0.01–0.66)	
27829	60 (3.69)	1015 (6.61)	0.46 (0.28–0.77)	
Surgical complexity	Mean (SD)	Mean (SD)	OR (95% CI)	
RVU	10.2 (1.28)	10.05 (1.32)	1.59 (1.07–2.36)	<.001
Anesthesia				
Spinal	1421 (87.3%)			
Nerve block	192 (11.8%)			
Epidural	14 (0.9%)			

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CPT, current procedure terminology; GA, general anesthesia; NA, neuraxial anesthesia; OR, odds ratio; PS, physical status; RA, regional anesthesia; RVU, relative value unit; SD, standard deviation.

Table 3. Baseline Demographics and Comorbidities After Propensity Score Matching for RA/NA Versus GA

	RA/NA	GA		
	Mean (SD)	Mean (SD)	OR (95% CI)	*P* Value
Age	57.86 (17.54)	56.87 (17.93)	1 (1–1.01)	.11
Age groups	n (%)	n (%)	OR (95% CI)	
<50	480 (29.5)	478 (29.38)	Reference	.36
50–65	521 (32.02)	511 (31.41)	1.02 (0.85–1.21)	
65–80	450 (27.66)	486 (29.87)	0.92 (0.77–1.1)	
>80	176 (10.82)	152 (9.34)	1.15 (0.9–1.48)	
Sex				
Male	592 (36.39)	611 (37.55)	Reference	.49
Female	1035 (63.61)	1016 (62.45)	1.05 (0.91–1.21)	
Demographics				
Caucasian	899 (55.26)	916 (56.3)	Reference	.63
African American	80 (4.92)	78 (4.79)	1.05 (0.75–1.45)	
Asian	42 (2.58)	53 (3.26)	0.81 (0.53–1.22)	
Other	23 (1.41)	27 (1.66)	0.87 (0.49–1.53)	
Not reported	583 (35.83)	553 (33.99)	1.07 (0.93–1.25)	
	Mean (SD)	Mean (SD)	OR (95% CI)	
BMI	30.63 (7.16)	30.75 (7.14)	1 (0.99–1.01)	.63
BMI groups	n (%)	n (%)	OR (95% CI)	
<18.5	12 (0.74)	12 (0.74)	0.99 (0.44–2.23)	
18.5–25	305 (18.75)	301 (18.5)	Reference	.99
25–30	574 (35.28)	575 (35.34)	0.99 (0.81–1.2)	
>30	736 (45.24)	739 (45.42)	0.98 (0.81–1.19)	
Functional status				
No dyspnea	1523 (93.61)	1525 (93.73)	Reference	.79
Dyspnea with moderate exertion	92 (5.65)	87 (5.35)	1.06 (0.78–1.43)	
Dyspnea at rest	12 (0.74)	15 (0.92)	0.8 (0.37–1.72)	
Independent	1563 (96.07)	1567 (96.31)	Reference	.93
Partially dependent	62 (3.81)	58 (3.56)	1.07 (0.74–1.54)	
Totally dependent	2 (0.12)	2 (0.12)	1 (0.14–7.13)	
ASA PS class				
I	233 (14.32)	216 (13.28)	Reference	.13
II	754 (46.34)	804 (49.42)	0.87 (0.7–1.07)	
III	557 (34.23)	509 (31.28)	1.01 (0.81–1.27)	
IV/V	83 (5.1)	98 (6.02)	0.79 (0.56–1.11)	
Comorbidities				
Smoking	312 (19.18)	292 (17.95)	1.08 (0.91–1.29)	.37
Hypertension	685 (42.1)	695 (42.72)	0.98 (0.85–1.12)	.72
Diabetes mellitus	258 (15.86)	263 (16.16)	0.98 (0.81–1.18)	.81
COPD	117 (7.19)	127 (7.81)	0.92 (0.7–1.19)	.51
CHF	21 (1.29)	23 (1.41)	0.91 (0.5–1.65)	.76
CKD	20 (1.23)	28 (1.72)	0.71 (0.4–1.27)	.25
Steroid use	35 (2.15)	37 (2.27)	0.94 (0.59–1.51)	.81
Wound infection	58 (3.56)	72 (4.43)	0.8 (0.56–1.14)	.21
Bleeding disorder	51 (3.13)	98 (6.02)	0.5 (0.36–0.71)	<.001
Sepsis	46 (2.83)	63 (3.87)	0.72 (0.49–1.06)	.10
	Mean (SD)	Mean (SD)	OR (95% CI)	
Platelets	157 (159)	146 (166)	1.04 (1–1.09)	.05
Surgical urgency	Mean (SD)	Mean (SD)	OR (95% CI)	
Elective	634 (38.97)	644 (39.58)	0.97 (0.85–1.12)	.72
Emergent	472 (29.01)	496 (30.49)	0.93 (0.8–1.08)	.36
Surgical procedure (CPT code)				
27766	80 (4.92)	75 (4.61)	Reference	.68
27792	436 (26.8)	432 (26.55)	0.95 (0.67–1.33)	
27814	643 (39.52)	622 (38.23)	0.97 (0.69–1.35)	
27822	314 (19.3)	317 (19.48)	0.93 (0.65–1.32)	
27823	94 (5.78)	104 (6.39)	0.85 (0.56–1.29)	
27829	60 (3.69)	77 (4.73)	0.73 (0.46–1.16)	
Surgical complexity	Mean (SD)	Mean (SD)	OR (95% CI)	
RVU	10.2 (1.28)	10.21 (1.29)	0.99 (0.94–1.05)	.74

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CPT, current procedure terminology; GA, general anesthesia; NA, neuraxial anesthesia; OR, odds ratio; PS, physical status; RA, regional anesthesia; RVU, revenue value unit; SD, standard deviation.

Table 4. Thirty-Day Outcomes for RA/NA Versus GA

Category	RA/NA	GA	Propensity Matching	*P* Values
	n (%)	n (%)	OR (95% CI)	
Outcomes				
Death	5 (0.31)	6 (0.37)	0.91 (0.27–3.02)	.88
Return operating room	27 (1.66)	30 (1.84)	0.92 (0.55–1.56)	.77
Failure to wean	3 (0.18)	5 (0.31)	0.68 (0.16–2.89)	.60
Reintubation	4 (0.25)	5 (0.31)	1.13 (0.29–4.35)	.86
Surgical site infection	29 (1.78)	20 (1.23)	1.46 (0.82–2.59)	.20
Dehiscence	8 (0.49)	5 (0.31)	1.64 (0.53–5.06)	.39
Pneumonia	12 (0.74)	16 (0.98)	0.9 (0.42–1.93)	.78
Renal insufficiency	2 (0.12)	2 (0.12)	1.15 (0.16–8.35)	.89
Acute MI	3 (0.18)	5 (0.31)	0.63 (0.15–2.65)	.53
Transfusion	15 (0.92)	23 (1.41)	0.76 (0.39–1.47)	.41
VTE	7 (0.43)	18 (1.11)	0.38 (0.16–0.92)	.03
UTI	21 (1.29)	29 (1.78)	0.77 (0.44–1.37)	.38
Sepsis	5 (0.31)	8 (0.49)	0.74 (0.24–2.29)	.60
	Mean (SD)	Mean (SD)	HR (95% CI)	
Length of stay	2.9 (4.69)	2.71 (4.86)	0.57 (0.19–1.74)	.32
No. of complications	0.07 (0.25)	0.08 (0.28)	0.87 (0.67–1.12)	.29

Abbreviations: CI, confidence interval; GA, general anesthesia; HR, hazard ratio; MI, myocardial infarction; NA, neuraxial anesthesia; OR, odds ratio; RA, regional anesthesia; SD, standard deviation; UTI, urinary tract infection; VTE, venous thromboembolism.

eroded with improved safety of both GA and RA/NA.[2] For instance, improved VTE prophylaxis has decreased rates of VTE in both populations.[2]

Despite the potential advantages of RA/NA, utilization for lower extremity trauma was low in our analysis. Only 9.58% of patients received RA or NA, with 87.3% of the RA/NA group receiving spinal anesthesia, 11.8% receiving a nerve block, and 0.9% receiving epidural anesthesia. While NA is used more frequently than nerve blocks, both NA and RA were used in only a minority of cases in the timeframe studied. Despite the development of several effective peripheral nerve block techniques suitable for lower extremity trauma (femoral, sciatic, posterior tibial, or popliteal nerve blocks) and standard neuraxial techniques (spinal and epidural), there are likely additional factors and barriers to more widespread use of RA/NA in lower extremity trauma. These may include surgeon, patient, and anesthesia provider preference, concern for neurologic injury, and masking signs of compartment syndrome.[11] RA/NA is sometimes avoided to allow for postoperative monitoring for neurologic injury and development of compartment syndrome. Also, many of these surgeries are done on an urgent basis during evening and weekend hours, which may limit the number of anesthesiologists who are available and experienced to perform nerve blocks. The choice of primary anesthetic may also be guided by the projected length of the case. We are unable to further assess the impact of these factors on anesthetic choice due to the absence of these variables in the dataset.

Our results show no difference in rates of infection or need for blood transfusions with RA/NA. Although the "masking" of compartment syndrome with RA/NA has been reported in case studies, the actual incidence of this complication remains unknown.[29–32] NSQIP does not specifically include compartment syndrome as a variable so we were unable to determine if this occurred in any patients included in our study, although there was no difference in the rates of reoperation or total number of complications between the 2 groups.

Before matching, there were significant differences in demographic characteristics and functional status between the RA/NA and GA patients. The RA/NA patients had significantly higher rates of comorbidities and worse overall functional status. These patterns suggest that patients with poorer functional status are more likely to receive RA/NA for their anesthetic for lower extremity trauma correction. While we are unable to elucidate the precise reasons for these differences, we hypothesize that in higher-risk patients, RA may be preferred to decrease the total anesthetic requirement for the operation and reduce the perceived anesthetic risk to the patient. These differences were eliminated by the propensity matching methodology.

In addition, much of the economic burden of trauma stems from lengthy recovery times preventing the patient from returning to work. The NSQIP database does not include any measures of postoperative pain and/or functional assessment. One analysis of RA/NA versus GA for distal radial fractures showed that there were decreased pain scores and increased functional status postoperatively with RA/NA.[33] This effect had several proposed explanations including fewer pain impulses reaching the central nervous system (CNS), decreased neurogenic inflammation, and decreased need for extensive dissections of fracture fragments due to complete paralysis of the forearm muscles.[33] If this effect were also seen in lower extremity trauma, then there is the potential for improved patient satisfaction and decreased economic burden with RA/NA. The length of stay was similar for the 2 groups, which might indicate that there was not enough difference in acute postoperative pain to cause delay of discharge in the GA group. Our analysis is, however, unable to assess the incidence of chronic postsurgical pain.

There are several limitations to our study. Limitations in the data collection process have been described previously.[18] The analysis was limited by the set of variables that NSQIP collects. While NSQIP excludes cases of major trauma, we are unable to determine whether a patient presented with a single lower extremity injury or had multiple fractures. Although we excluded cases with concurrent operations, this does not preclude instances of nonoperative management of other injuries or planned delayed operative intervention on other fractures. Patients with multiple fractures would be at higher risk for postoperative complications, and GA might be preferentially used, especially if RA or NA would not be feasible based on the trauma locations. However, the absence of significant differences in length of hospital stay or mortality makes significant confounding by this phenomenon less likely. Furthermore, we were unable to discern combined RA/GA cases in the database; if there was a significant number of these cases, this could decrease the ability to detect a difference between RA and GA by conferring some of the benefits of RA to the GA group. Our analysis also lacked information on the agents and dosages used for both types of anesthesia, as well as catheter versus single-shot nerve block utilization. Despite these limitations, our analysis was still able to capture many significant 30-day postoperative outcomes.

Our analysis found no significant differences between RA/NA and GA for lower extremity fracture patients. There may yet be benefits to RA/NA that we were unable to capture as discussed above, such as pain control or patient satisfaction. Further studies are needed to assess the impact of RA on acute and chronic postoperative pain, as well as other functional outcomes. However, this study suggests that anesthetic choice can be reasonably driven by patient and provider preferences, without adversely impacting 30-day outcomes.

In conclusion, no significant differences in 30-day mortality and postoperative complications were found between RA/NA and GA for patients with lower extremity trauma. The utilization of RA/NA in the anesthetic management of lower extremity fracture cases remains low, occurring in only 9.58% of cases.

DISCLOSURES

Name: Ethan Y. Brovman, MD.
Contribution: This author helped write the manuscript, collect the data, analyze presentation, and edit and approve the final version of the manuscript.
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Contribution: This author helped collect the data, analyze the presentation, and edit and approve the final version of the manuscript.
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Name: Sasha S. Beutler, MD, PhD.
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Name: Richard D. Urman, MD, MBA.
Contribution: This author helped collect the data, analyze the presentation, and edit and approve the final version of the manuscript.
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