Hospital-, Anesthesiologist-, and Patient-level Variation in Primary Anesthesia Type for Hip Fracture Surgery

A Population-based Cross-sectional Analysis

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ABSTRACT

Background: Substantial variation in primary anesthesia type for hip fracture surgery exists. Previous work has demonstrated that patients cared for at hospitals using less than 20 to 25% neuraxial anesthesia have decreased survival. Therefore, the authors aimed to identify sources of variation in anesthesia type, considering patient-, anesthesiologist-, and hospital-level variables.

Methods: Following protocol registration (NCT02787031), the authors conducted a cross-sectional analysis of a population-based cohort using linked administrative data in Ontario, Canada. The authors identified all people greater than 65 yr of age who had emergency hip fracture surgery from April 2002 to March 2014. Generalized linear mixed models were used to account for hierarchal data and measure the adjusted association of hospital-, anesthesiologist-, and patient-level factors with neuraxial anesthesia use. The proportion of variation attributable to each level was estimated using variance partition coefficients and the median odds ratio for receipt of neuraxial anesthesia.

Results: Of 107,317 patients, 57,080 (53.2%) had a neuraxial anesthetic. The median odds ratio for receiving neuraxial anesthesia was 2.36 between randomly selected hospitals and 2.36 between randomly selected anesthesiologists. The majority (60.1%) of variation in neuraxial anesthesia use was explained by patient factors; 19.9% was attributable to the anesthesiologist providing care and 20.0% to the hospital where surgery occurred. The strongest patient-level predictors were absence of preoperative anticoagulant or antiplatelet agents, absence of obesity, and presence of pulmonary disease.

Conclusions: While patient factors explain most of the variation in neuraxial anesthesia use for hip fracture surgery, 40% of variation is attributable to anesthesiologist and hospital-level practice. Efforts to change practice patterns will need to consider hospital-level processes and anesthesiologists' intentions and behaviors. (Anesthesiology 2018; 129:1121-31)

VARIATIONS in clinical practice are well documented across different areas of medicine and jurisdictions.[1,2] Some variation in care delivery is warranted and expected. Differences in patient illness and preferences should drive individualization of care in pursuit of better outcomes. However, in some cases, medical practice variation unexplained by patient illness, risk factors, or preferences[2,3] is associated with adverse outcomes.[1,4,5] Identification of reasons for such variation could help inform development of strategies to minimize unexplained variation and improve patient outcomes.

More than 300,000 hip fracture surgeries are performed in the United States annually;[6] more than 20,000 are performed in Canada.[7] Hip fracture surgery is associated with relatively high morbidity and mortality rates (more than 20%[8] and 6%,[9]

Editor's Perspective

What We Already Know about This Topic

- Neuraxial anesthesia use for hip fracture surgery has wide variation in use across hospitals, and hospitals using it for less than 25% of patients may have increased 30-day mortality
- The proportion of the variation in use attributable to patient, provider, and hospital factors remains unknown

What This Manuscript Tells Us That Is New

- Canadian administrative data demonstrate that approximately 60% of the variation in neuraxial use is attributable to patient factors, 20% to provider factors, and 20% to hospital factors
- The specific anesthesiologist or hospital a patient receives care from affects the likelihood of neuraxial use more than most clinical factors

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respectively). Efforts are needed to improve the quality and outcomes of anesthesia care for these high-risk patients. Substantial variation in the use of general anesthesia *versus* neuraxial anesthesia has been documented in the United States,[10] United Kingdom,[11] and Canada.[12] While the current evidence does not convincingly support the role of neuraxial anesthesia in improving postoperative outcomes,[8,10,13–16] neuraxial anesthesia may decrease respiratory and hematologic adverse events,[13] and length of stay.[10] In addition, we have recently shown that patients who have hip fracture surgery in hospitals that use more than 20 to 25% neuraxial anesthesia for hip fracture surgery have significantly higher risk-adjusted survival.[12]

A key step to guiding efforts to decrease unexplained practice variation and improve outcomes is understanding how much variation in anesthesia type is explained by patient-level factors *versus* other factors, such as clinician or hospital practice patterns.[17] We, therefore, conducted a cross-sectional analysis of a population-based cohort to measure the extent of practice variation in choice of anesthesia type attributable to hospital-, anesthesiologist-, and patient-level factors, as well as to identify specific characteristics at each of these levels that significantly influence a patient's likelihood of receiving a neuraxial anesthesia.

Materials and Methods

Setting and Data

Following ethical approval from the Sunnybrook Health Sciences Research Board (Toronto, Canada), we conducted a population-based cross-sectional analysis in Ontario, Canada, where hospital and physician services are provided to all residents through a publicly funded healthcare system and recorded in health administrative datasets that are collected using standardized methods.[18,19] All data were linked deterministically using anonymized, encrypted, patient-specific identifiers at the Institute for Clinical Evaluative Sciences, an independent research institute that houses the health administrative data for the province of Ontario. Datasets used for the study included the Discharge Abstract Database, which captures all hospitalizations; the Ontario Health Insurance Plan database, which captures physician service claims; the National Ambulatory Care Reporting System, which captures details of all emergency and outpatient care; the Continuing Care Reporting System, which records details of long-term and respite care; the Ontario Drug Benefits Database, which captures prescription drug claims for residents 65 yr and older; the Institute for Clinical Evaluative Sciences Physician Database, which houses information on physician specialty, demographics, training, and workload; and the Registered Persons Database, which captures all death dates for residents of Ontario. The analytic dataset was assembled by a trained data analyst independent of the study team. Analysis was performed by the lead author (D.I.M.) and overseen by the senior author (C.v.W). The study protocol was registered at clinicaltrials.gov (NCT02787031, which included two objectives: the outcome study previously reported[12] and the current variation analysis). The manuscript is reported according to guidelines.[20,21]

Cohort

We identified all Ontario residents who were 66 yr or older on the day of their emergency hip fracture surgery, an age cutoff that allowed us to identify prescription medications in the year before surgery (universal drug coverage is available starting at age 65 yr). These patients were identified using Canadian Classification of Interventions codes to identify hip fracture surgery (diagnostic code S72 for hip fracture; then procedural codes 1VA53, 1VA74, 1VC74, or 1SQ53).[22] Reabstraction studies demonstrate that these codes are accurate and reliable (κ 0.95; positive predictive value, 0.95).[23] We limited our sample to individuals who were admitted to hospital on a nonelective basis to exclude elective hip operations. Participants were identified from April 2002, the date of introduction of the *International Classification of Diseases, Tenth Edition (ICD-10)* to identify diagnoses, and the Canadian Classification of Interventions to identify procedures, to March 2014, the latest time at which all datasets were complete. Patients were excluded if they were treated in a hospital that did fewer than 10 hip fracture surgeries per year or if the anesthesia type was missing from their administrative records.

Exposure

Anesthesia type was captured from the Discharge Abstract Database, where anesthesia type is coded for every operative procedure; reabstraction demonstrates 94% agreement for this field.[24] Anesthesia type was coded in the Discharge Abstract Database as general, spinal, epidural, or combined general and neuraxial. Patients who received an epidural or spinal anesthetic without concurrent general anesthesia were categorized as having received neuraxial anesthesia, while any patient who received general anesthesia (including those who had a combined general anesthesia and neuraxial anesthesia) were categorized as not having received neuraxial anesthesia.

Outcomes

Although adjusted outcome rates have been previously reported,[12] we collected 30-day all-cause mortality (from the Registered Persons Database) and postoperative length of stay (from the Discharge Abstract Database).

Covariates

For each patient, we identified variables available in our data sources that we postulated could influence the receipt of a neuraxial anesthetic. Because our purpose was to explore all possible contributing factors that we could measure, as opposed to creating a parsimonious prediction model, we included factors that could be related, such as diagnosis of pulmonary disease, as well as treatments for pulmonary disease. Demographics were identified from the Registered Persons Database and from the Canadian Census. Standard methods were used to identify all Elixhauser comorbidities based on International

Classification of Diseases, 9th Edition and International Classification of Diseases, 10th Edition, codes from the Discharge Abstract Database in the 3 yr preceding surgery.[25] We also measured the preoperative length of stay. We identified receipt of the following prescription medications in the year before surgery: angiotensin converting enzyme inhibitors or angiotensin receptor blockers, antiarrhythmics, anticoagulants, anticonvulsants, antidepressants, antipsychotics, insulin, oral antihyperglycemics, antiplatelet agents, benzodiazepines, beta blockers, oral corticosteroids, inhaled corticosteroids, inhaled bronchodilators, or dementia drugs (donepezil, rivastigmine, memantine, or galantamine). The Hospital-patient One-year Mortality Risk score was also calculated to measure death risk based on present on admission variables. This score is an externally validated risk adjustment instrument with excellent discrimination (c-statistic, 0.89 to 0.92) and calibration for predicting 1-yr mortality risk in hospitalized patients.[26]

We also identified information about individual anesthesiologists and individual hospitals from which patients received their care. For each physician, we captured their age, sex, years of experience (calculated as year of surgery – [year of graduation + 5 yr for residency training]), and their overall case volume (both hip fractures and non–hip fracture surgery), which reflects each physicians' annual billings compared with that year's average from all physicians in the specialty. We characterized each hospital based on its teaching hospital status (*i.e.*, whether it had a residency training programs in anesthesiology), and volume of hip fracture surgeries performed in the year before the index surgery.

Analysis

SAS (SAS Institute, USA) version 9.4 was used for all analyses. We used standardized differences to compare characteristics between patients who did and did not receive a neuraxial anesthesia for their surgery. Although no universal threshold has been established, differences of 10% or less are considered to indicate balance.[27] All multilevel models were specified and analyzed using PROC GLIMMIX, a part of the SAS software.

Sources of Variation and Predictors of Neuraxial Anesthesia Use

To determine the relative contribution of hospital-, anesthesiologist-, and patient-level factors to variation in neuraxial use, we developed a generalized linear mixed model with a logit link and binary response distribution (*i.e.*, multilevel logistic regression). The multilevel model included two random intercept terms: one for a hospital identifier and one for an anesthesiologist identifier (nested within hospitals). These random intercepts were used to calculate the variance partition coefficient (also known as intraclass correlation coefficient in linear models) and the median odds ratio for receipt of a neuraxial anesthetic.[28] The variance partition coefficient characterizes the proportion of variation attributable to the cluster levels (*i.e.*, hospital and anesthesiologist level). In multilevel logistic models, variance between clusters is measured on the logistic scale, while individual level variance is on the probability scale. To account for this, we calculated the variance partition coefficient using the linear threshold model method, which normalizes variance measurements to the logistic scale using the formula: variance partition coefficient = variance / (variance + $[\pi^2/3]$).[28] Modified Wald *P* values were used to test if the variance was significantly different from zero.[29] We performed covariance tests to estimate whether model fit was improved with addition of these random intercepts compared to the model with only fixed effects. The median odds ratio is the median value obtained from comparing the adjusted odds of having a neuraxial anesthesia if the same individual underwent surgery at two different randomly selected hospitals, or under the care of two randomly selected anesthesiologists.[28] The median odds ratio always takes a value greater than 1; therefore, a median odds ratio of 1.5 suggests that the median odds of receiving neuraxial anesthesia is 50% higher if the same patient had surgery at one randomly selected hospital *versus* another randomly selected hospital, or under the care of one randomly selected anesthesiologist *versus* another randomly selected anesthesiologist. The median odds ratio was calculated using the formula: median odds ratio = $e^{0.95\sqrt{\text{variance}}}$.[28]

The model also included fixed patient-level effects. Patient-level covariates were chosen based on their postulated role in influencing the choice of anesthesia type: age (classified as 66 to 74 yr, or 75 yr and older as recommended by the National Surgical Quality Improvement Program universal risk calculator[30]); sex (male or female); Hospital-patient One-year Mortality Risk score (as a continuous linear variable, where higher score means higher risk of death); rural residence (binary); neighborhood income quintile (five-level categorical variable); all Elixhauser comorbidities (as binary variables); preoperative length of stay (categorical: 0 to 1 days, 2 days, greater than 2 days); whether surgery was performed on a weekend (binary); acute care hospitalization in the year before admission (binary); emergency department visit in the year before surgery (binary); and each prescription medication described in the Covariates section (as binary variables). We had initially included use of an intraoperative arterial line in our model, but after discussions in the peer-review process, it was agreed that an arterial line may have preceded choice of anesthesia type in some patients (and therefore fit appropriately on the causal pathway), whereas in other cases it may have been placed after (or even due to) effects of the primary anesthesia type (in which case it would be inappropriate to include as a predictor). Therefore, our final analyses did not include an arterial line variable.

We performed a prespecified sensitivity analysis where we excluded patients who had an epidural and patients who had neuraxial anesthesia with concurrent general anesthesia. We also performed a *post hoc* sensitivity analysis where physicians were not assumed to be nested in hospitals, but were specified as a second random intercept at the same level of the data hierarchy as hospitals.

Finally, we created a model that, in addition to the random intercepts and patient-level fixed effects described in our primary model, also included anesthesiologist-level variables (sex [binary], age quintile, experience quintile, overall case volume quintile), and hospital characteristics (teaching status [binary], annual volume quintile, quintile of average operative time [added after peer-review]). This model was used to determine the adjusted association of patient-, anesthesiologist-, and hospital-level variables with receipt of neuraxial anesthesia. Variables with 95% CIs that did not include 1 (the null value) were considered to be independently associated with the receipt of neuraxial anesthesia.

Missing Data

Outcome data was complete for all participants. Anesthesia type was missing for 96 people (0.08%); these cases were excluded from all analyses. Rural residency status was missing for 0.09% and was imputed with the most common value (not rural). Income quintile was missing and imputed with the group median (3) for 0.5%.

Results

We identified 107,317 hip fracture surgery patients, from 80 different hospitals, greater than 65 yr who had a valid anesthesia type entered in their Discharge Abstract Database record. Neuraxial anesthesia without concurrent general anesthesia was used in 57,080 (53.2%) patients (fig. 1). Hospital-specific rates of neuraxial anesthesia use varied from 0 to 100%. Of the patients receiving general anesthesia, 3.1% had a concurrent neuraxial anesthesia. A spinal anesthetic was placed in 98.9% of patients having a neuraxial anesthesia without general anesthesia. Characteristics of patients by anesthesia type are provided in table 1. Death within 30 days of surgery occurred in 9,122 (8.5%) individuals. Median postoperative hospital length of stay was 9 days (interquartile range 6 to 18).

From the null model (model 1), which contained only a random intercept term for hospital, but no anesthesiologist clusters or patient-level fixed effects, the hospital-level variance was 1.117 ($P < 0.001$), and the variance partition coefficient was 25.3%. When anesthesiologists were nested within each hospital (model 2), the variance at the hospital level decreased to 0.779 (variance partition coefficient = 19.1%, $P < 0.001$), and the anesthesiologist-level variance was 0.776 (variance partition coefficient = 19.1%, $P < 0.001$). Following addition of patient-level fixed effects (model 3), the variance at the hospital level was 0.821 ($P < 0.001$), and the variance at the anesthesiologist level was 0.816 ($P < 0.001$). Based on these measures of between-cluster variance, 20.0% of variation in neuraxial anesthesia use was attributable to the hospital level, 19.9% to the anesthesiologist, and 60.1% to patient factors. Covariance tests supported improved model fit with addition of hospital-level ($P < 0.001$) and anesthesiologist-level ($P < 0.001$) random intercepts.

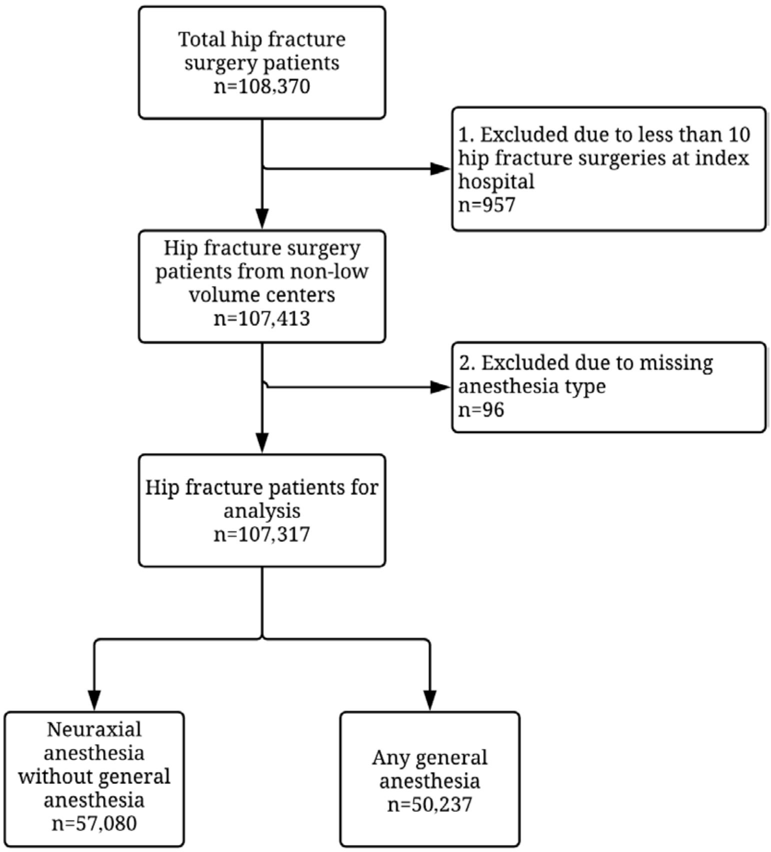

Fig. 1. Study flow diagram.

Table 1. Characteristics of Study Population, by Anesthesia Type

	General Anesthesia (n = 50,237)	Neuraxial Anesthesia (n = 57,080)	Standardized Difference
Demographics			
Age (mean, ±SD)	82 (8)	83 (7)	13.3
Female (%)	73.4	73.5	0.2
Rural (%)	12.2	13.8	4.8
Neighborhood income quintile (median, IQR)	3 (2,4)	3 (2,4)	0
Comorbidities			
Alcohol abuse (%)	2.1	2.1	0.0
ASA Score ≤ 2	16.1	12.8	9.4
ASA Score 3	48	48.2	0.4
ASA Score 4	35	38.4	7.1
ASA Score 5	0.7	0.6	1.2
Atrial arrhythmia (%)	9.4	9.1	1.0
Blood loss anemia (%)	17.1	17.1	0.0
Cardiac valvular disease (%)	4.1	3.1	5.4
Cerebrovascular disease (%)	6.7	6	2.9
Chronic obstructive pulmonary disease (%)	10.9	14.1	9.7
Coagulopathy (%)	3.8	2.7	6.2
Deficiency anemia	—	—	—
Dementia (%)	9.3	10.1	2.7
Depression (%)	4.8	4.6	0.9
Diabetes mellitus without complications (%)	12.8	12	2.4
Diabetes mellitus with complications (%)	9.8	9.9	0.3
Dialysis (%)	1.4	1.2	1.8
Disease of pulmonary circulation (%)	2.3	2.2	0.7
Drug abuse (%)	0.4	0.4	0.0
Heart failure (%)	13.4	13.9	1.5
Hemiplegia (%)	1.2	1.0	1.9
Hypertension without complications (%)	46.3	36.4	20.2
Hypertension with complications (%)	2.6	2.7	0.6
Liver disease (%)	0.8	0.7	1.2
Malignancy (%)	5.8	5.1	3.1
Metastases (%)	1.8	1.4	3.2
Obesity (%)	1.1	0.8	3.1
Peptic ulcer disease (%)	1.4	1.2	1.8
Peripheral vascular disease (%)	2.4	2.5	0.6
Psychoses (%)	1.6	1.3	2.5
Renal disease (%)	4.3	4.4	0.5
Rheumatic disease (%)	1.4	1.2	1.8
Venous thromboembolism (%)	1.1	0.8	3.1
Weight loss (%)	2.5	2.8	1.9
1-yr risk of death	38 (5)	39 (5)	10.4
Healthcare resource use			
Hospitalization in last year	27.5	25.9	3.6
Emergency department visit in last year (%)	60.8	60.8	0.0
Anesthesia care			
Preoperative LOS ≤1 day	79.9	82.9	7.7
2 days	11.4	10.2	3.9
≥3 days	8.7	6.9	6.7
Prescription drugs			
ACE-I/ARB (%)	42.4	42.3	0.2
Antiarrhythmic (%)	3.4	3.0	2.3
Antiplatelet agent (%)	9.9	4.8	19.6
Antipsychotic (%)	13.7	14.2	1.4
Insulin (%)	4.6	4.3	1.5
Anticoagulant (%)	14.1	12.5	4.7

(*Continued*)

Table 1. (Continued)

	General Anesthesia (n = 50,237)	Neuraxial Anesthesia (n = 57,080)	Standardized Difference
Oral diabetes agent (%)	12.5	12.1	1.2
Beta-blocker (%)	28.2	27.1	2.5
Inhaled bronchodilator (%)	12.6	15.8	9.2
Inhaled corticosteroid (%)	10.3	13	8.4
Oral corticosteroid (%)	6.7	7.1	1.6
Physician characteristics			
Full-time equivalency (mean, ±SD)	1.1 (0.2)	1.1 (0.3)	4.1
Age (mean, ±SD)	48 (10)	47 (9)	15.9
Years in practice (mean, ±SD)	17 (10)	16 (10)	14.1
Female anesthesiologist (%)	23.2	22.5	1.7
Hospital characteristics			
Yearly no. of hip fracture surgeries (mean, ±SD)	228 (130)	212 (94)	14.1
Teaching hospital	35.5	25.2	22.5

— indicates cell sizes less than 6 cannot be reported.

ACE-I/ARB, Angiotensin converting enzyme inhibitor/angiotensin receptor blocker; ASA Score, American Society of Anesthesiologists physical status classification; IQR, interquartile range; LOS, length of stay.

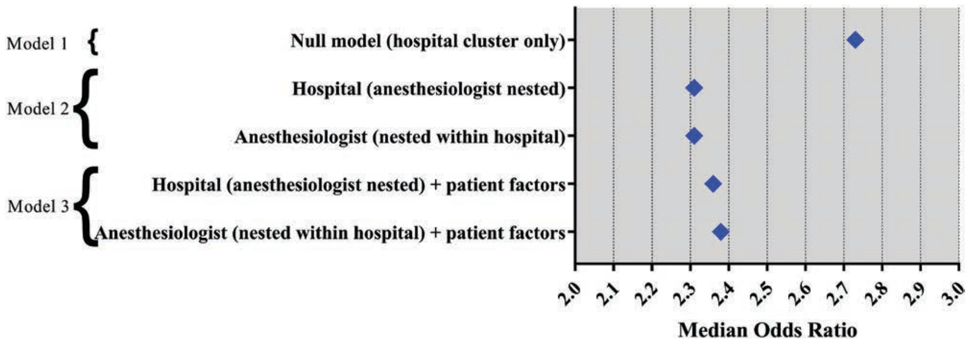

Fig. 2. Median odds ratio for hospital- and anesthesiologist-level clustering in each of the three multilevel models created.

Median odds ratios for model 1 to 3 are compared in figure 2. The model 3 (adjusted) median odds ratio for neuraxial anesthesia use was 2.36 at the physician- and 2.36 at the hospital-level. This means that for a given patient, their median odds of receiving neuraxial anesthesia would differ by more than 2.3-fold, depending on the anesthesiologist or hospital that they received care from. In our sensitivity analysis, in which patients who had an epidural and patients who had neuraxial anesthesia with concurrent general anesthesia were excluded, there was almost no change in the proportion of variation attributable to hospital (20.1%), anesthesiologist (19.9%), or patient (60.0%); the median odds ratio for neuraxial anesthesia use was 2.36 for the hospital and 2.36 for the anesthesiologist. When physicians were not assumed to be nested in hospitals, there was almost no change in the proportion of variation attributable to hospital (19.2%), anesthesiologist (19.4%), or patient (60.4%); the median odds ratio for neuraxial anesthesia use was 2.32 for the hospital and 2.33 for the anesthesiologist.

The adjusted associations of patient, hospital, and physician characteristics with neuraxial anesthesia use are presented as odds ratios in table 2. The c-statistic for this model was 0.83, and a calibration plot suggested that the model was well calibrated (see Supplemental Digital Content, http://links.lww.com/ALN/B789). The strongest patient-level predictors (greater than or equal to 20% change in relative effect size) of neuraxial anesthesia receipt were coagulopathy, dialysis, metastases, obesity, American Society of Anesthesiologists physical status III or IV (*vs.* V), antiplatelet or anticoagulant prescriptions, and having a hemiarthroplasty for surgical fixation. At the hospital level, having surgery at a non–teaching center significantly increased the odds that a patient received an neuraxial anesthesia, while surgical volume was significantly associated with neuraxial anesthesia receipt, but without a clear dose–response relationship. Shorter average case duration was associated with lower odds of neuraxial anesthesia receipt. Anesthesiologists in the highest quintile of overall case volume were the most likely to provide neuraxial anesthesia, however, other measurable anesthesiologist-level variables were not consistently associated with neuraxial anesthesia use.

Discussion

In this population-based cross-sectional study of hip fracture surgery patients, 40% of variation in use of neuraxial anesthesia

Table 2. Predictors of Neuraxial Anesthesia Use

Predictors	Odds Ratio	95% CI
Demographic characteristics		
Age 75 years or older	1.36	1.30–1.42*
Female (*vs.* male)	0.94	0.91–0.97*
Rural (*vs.* not rural)	1.00	0.95–1.05
Neighborhood income quintile (*vs.* highest quintile)		
1 (lowest)	1.03	0.99–1.08
2	1.04	0.99–1.09
3	1.05	0.99–1.10
4	0.99	0.95–1.04
Comorbidities		
Alcohol abuse	1.00	0.90–1.11
Atrial arrhythmia	1.07	1.01–1.13*
Blood loss anemia	1.05	1.01–1.10*
Cardiac valvular disease	0.70	0.65–0.76*
Cerebrovascular disease	1.07	1.01–1.15*
Chronic obstructive pulmonary disease	1.28	1.22–1.35*
Coagulopathy	0.79	0.72–0.85*
Deficiency anemia	1.00	0.87–1.17
Dementia	0.99	0.94–1.05
Depression	0.96	0.89–1.03
Diabetes mellitus without complications	0.99	0.95–1.05
Diabetes mellitus with complications	0.99	0.93–1.05
Dialysis	0.81	0.70–0.93*
Disease of pulmonary circulation	1.00	0.91–1.10
Drug abuse	0.98	0.78–1.24
Heart failure	1.08	1.03–1.13*
Hemiplegia	0.90	0.77–1.04
Hypertension without complications	1.01	0.98–1.05
Hypertension with complications	1.19	1.07–1.31*
Liver disease	0.84	0.71–0.99*
Malignancy	0.93	0.87–1.01
Metastases	0.76	0.67–0.87*
Obesity	0.71	0.62–0.83*
Peptic ulcer disease	0.89	0.78–1.01
Peripheral vascular disease	1.14	1.04–1.25*
Psychoses	0.89	0.79–1.01
Renal disease	1.11	1.02–1.21*
Rheumatic disease	0.87	0.76–0.99*
Venous thromboembolism	0.92	0.79–1.07
Weight loss	1.17	1.07–1.28*
1-yr risk of death (1-point increase in Hospital One-year Mortality Risk score)	1.01	1.01–1.02*
Healthcare resource use		
Hospitalization in last year	0.92	0.89–0.96*
Emergency department visit in last year	1.01	0.98–1.05
ASA Physical Status (*vs.* V)		
II	1.16	0.96–1.49
III	1.42	1.18–1.71*
IV	1.49	1.24–1.79*

(*Continued*)

Table 2. (Continued)

Predictors	Odds Ratio	95% CI
Preoperative length of stay (*vs.* ≥3 days)		
≤1 day	1.14	1.08–1.21*
2 days	1.06	0.99–1.14
Type of hip fixation (*vs.* fixation of femoral shaft)		
Total hip arthroplasty	0.93	0.77–1.13
Hemiarthroplasty	1.27	1.23–1.31*
Fixation of femoral neck	1.17	1.13–1.22*
Weekend surgery (*vs.* weekday)	1.07	1.03–1.10*
Prescription drugs		
Angiotensin-converting enzyme inhibitor/angiotensin receptor blocker	1.04	1.01–1.07*
Antiarrhythmic	1.00	0.91–1.09
Anticoagulant	0.69	0.66–0.73*
Antidepressant	0.98	0.94–1.01
Antiplatelet agent	0.28	0.27–0.30*
Benzodiazepine	0.98	0.95–1.01
Dementia medication	1.01	0.97–1.06
Digoxin	1.13	1.06–1.21*
Insulin	0.93	0.86–1.00
Oral diabetes agent	0.97	0.91–1.03
Beta blocker	1.00	0.97–1.04
Inhaled bronchodilator	1.13	1.06–1.20*
Inhaled corticosteroid	1.08	1.01–1.16*
Oral corticosteroid	1.03	0.97–1.09
Antipsychotic	0.93	0.88–0.97*
Hospital characteristics		
Average operating room time quintile (*vs.* highest)		
1 (lowest)	0.76	0.69–0.84*
2	0.84	0.78–0.91*
3	0.94	0.87–1.00
4	1.15	1.06–1.24*
Hospital volume quintile (*vs.* highest)		
1 (lowest)	0.84	0.76–0.92*
2	1.02	0.93–1.12
3	1.25	1.15–1.35*
4	1.16	1.08–1.24*
Teaching hospital (*vs.* nonteaching)	0.80	0.68–0.96*
Physician characteristics		
Full-time equivalency quintile (*vs.* highest)		
1 (lowest)	0.90	0.82–0.97*
2	0.88	0.82–0.95*
3	0.82	0.79–0.85*
4	0.91	0.85–0.97*
Years in practice quintile (*vs.* highest)		
1 (lowest)	0.98	0.82–1.14
2	1.03	0.89–1.19
3	0.98	0.87–1.11
4	0.98	0.87–1.10
Age quintile (*vs.* oldest)		
1 (lowest)	1.08	0.92–1.28
2	1.00	0.87–1.15
3	1.00	0.89–1.13
4	1.00	0.92–1.09
Female anesthesiologist (*vs.* male)	0.98	0.88–1.09

*Significant at the alpha=0.05 level.
ASA, American Society of Anesthesiologists.

was not attributable to patient-level factors. In fact, the median odds of a given patient receiving neuraxial anesthesia varied by more than 2.3-fold between any two randomly selected hospitals or anesthesiologists, independent of baseline patient illness, sociodemographic characteristics, or other factors, such as antiplatelet, anticoagulant, or other medication use that we postulated may influence a patient's probability of receiving neuraxial anesthesia. These findings suggest that interventions targeted at changing anesthesia practice for hip fracture surgery should consider not only patients' risk factors but also hospital-level processes, as well as anesthesiologists' intentions and behaviors.

While practice variation exists across regions, hospitals, and physician practices for many medical conditions,[1] few studies have linked variation to outcomes, and only 10% of studies in a recent systematic review explored causes of variation.[1] While practice variation in anesthesia and perioperative medicine has not been extensively studied, when identified, variation is associated with decreased rates of risk-adjusted survival.[5,12] Therefore, understanding sources of variation is a necessary step toward decreasing unintended variation, and the possibility of associated adverse outcomes. Existing frameworks suggest that variation must be studied in the setting of adequate risk adjustment and should consider geographical and environmental factors (in the case of anesthesiology practice, hospital-level factors), as well as provider-level factors.[2] Our analysis incorporates these recommended best practices, in a cohort of patients where low hospital-level neuraxial anesthesia use is associated with decreased risk-adjusted survival.[12] Through multilevel modeling, we were able to assess hospital- and physician-level contributions to variation, while adjusting for an extensive set of patient-level factors that we postulated would influence choice of anesthesia type, and which did so with good discrimination.

The most important finding to emerge from this analysis is that a substantial proportion of the variation in anesthesia type is not attributable to patient-level characteristics. While neuraxial anesthesia is not consistently associated with decreased mortality,[13] other outcomes such as length of stay may be improved.[10] Combined with the association of decreased survival after surgery in low neuraxial anesthesia–use hospitals, and anticipated results from large patient-centered trials,[31] it is important to recognize that this variation may be unwarranted. That a given patient would be faced with a greater than 2.3-fold difference in their likelihood to receive one anesthesia type *versus* another, simply based on the hospital that he or she presented to, or the anesthesiologists assigned to his or her list, requires attention, especially in jurisdictions that already use low proportions of neuraxial anesthesia for hip fracture surgeries. In fact, this 2.3- to 2.4-fold difference in the probability of receiving a neuraxial anesthetic—attributable to hospitals or anesthesiologists—was more strongly tied to neuraxial anesthesia use than any single patient-level predictor other than receipt of an antiplatelet drug, which guidelines identify as a contraindication to neuraxial anesthesia for 7 days after the last dose.[32] Our findings of a strong influence of physician- and hospital-level factors on variation are also consistent with other perioperative studies. For example, the median odds of testing and preoperative consultations vary 3-fold between physicians and hospitals before surgery;[5,33] odds of certain operative treatments for cancer may vary more than 2-fold between surgeons and hospitals.[34,35] Estimating variance from these median odds ratios suggests that in other perioperative settings, similar to our study, between 20 to 40% of variation may be explained by non–patient factors.

Reasons for this hospital- and anesthesiologist-level variation are likely multifactorial. First, although many guidelines do recommend the use of neuraxial anesthesia over general anesthesia for hip fracture surgery (including current guidelines in Ontario),[36–39] this is not true of all guidelines.[40] Furthermore, the evidence base supporting the superiority of neuraxial anesthesia *versus* general anesthesia is heterogeneous. This is consistent with existing evidence that demonstrates that variability is highest for therapies where there is limited consensus on what is superior.[41] What the evidence does suggest, however, is that unexplained variation is often associated with adverse patient outcomes. Therefore, strategies to address unexplained variation, including for hip fracture anesthesia care,[17] will need to consider all aspects of the healthcare system.

As we await the results of ongoing trials that may help to build consensus around best anesthesia practice for hip fracture surgery,[31] anesthesiologists should recognize that if future efforts are needed to change practice, we will need to address the local context, using strategies with proven efficacy to promote behavior change in these settings. Our data do provide some insights into areas of focus at the health system level, as teaching and low-volume hospitals were less likely to use neuraxial anesthesia. Hospitals that performed shorter surgeries on average were also less likely to use neuraxial anesthesia, with the effect size for the shortest surgery duration hospitals approximating that of some patient-level contraindications to neuraxial anesthesia, such as coagulopathy and metastatic cancer (odds ratio, 0.76 *vs.* 0.79 and 0.76, respectively). Mechanisms underlying this association will require further study, as the effect of expected case duration was relatively large, would be influenced by a multitude of patient-, physician-, and hospital-level factors, and as the limited data available (which comes from elective hip surgery) suggests an association between use of neuraxial anesthesia and *decreased* time in the operating room.[42] However, health administrative data do not provide a complete and granular description of hospital characteristics. Similarly, while the anesthesiologists with the highest case volumes tended to use more neuraxial anesthesia, we had limited ability to capture anesthesiologist-level variables, and had no data on the beliefs or intentions of anesthesiologists, which may strongly influence practice patterns.[43] Future research will be needed to provide an accurate and in-depth understanding of the specific contributors to hospital- and physician-level anesthesia practice, as this should allow mapping of evidence-based change strategies to identified barriers.

Finally, at the patient level, the significant predictors of neuraxial anesthesia use were not surprising. Older patients and patients with a higher expected risk of death were more likely to receive a neuraxial anesthesia, while patients with comorbidities associated with abnormal coagulation status (such as liver disease, blood loss anemia, coagulopathy, and dialysis), or who were on medications that interfere with coagulation (such as anticoagulants and antiplatelet agents) were less likely to receive a neuraxial anesthesia. Chronic obstructive pulmonary disease and its associated therapies (inhaled bronchodilators and corticosteroids) were positive predictors of neuraxial anesthesia use, which may reflect a belief and evidence that postoperative pulmonary complications are reduced when neuraxial anesthesia is used.[44] Conditions that may make placement of a neuraxial anesthesia more challenging (obesity, rheumatic disease, metastatic cancer) or that may increase the risk of adverse hemodynamic consequences (cardiac valvular disease) were also negative predictors. Finally, it is important to note that female patients were less likely to receive a neuraxial anesthesia, which suggests that there may be gender inequalities in the provision of perioperative hip fracture care.

Strengths and Limitations

This study features several strengths. Our use of population-based health administrative data allowed us to study practice across a single health system that cares for a population of more than 13 million people. Furthermore, our exposures and outcomes were defined using variables that have been reabstracted to ensure their accuracy and reliability. We were also able to consider hospital- and physician-level predictors of practice variation in addition to simply measuring attributable variation. The limitations of this study should also be considered. Health administrative data are not initially collected for research purposes. Most important, while we were able to account for measured predictors, there are patient-level predictors (such as physiologic, laboratory, cognitive, and functional measures, as well as acute delirium and level of consciousness), hospital-level variables, and specific anesthesiologist variables (such as fellowship training in regional anesthesia or experience with neuraxial techniques) that we could not measure directly. While we did include a variable reflecting the average operating time in each hospital, surgeon-specific variables, (which we could not capture) such as preference for neuraxial anesthesia *versus* general anesthesia and the specific impact of each surgeon on expected duration of surgery, could influence anesthesia decision making and should be considered when available. Patient-preference should contribute to warranted variation, and we had no ability to measure this attribute. While we were unable to identify any existing studies of patient preference for anesthesia type in hip fracture surgery, patients do have varying preferences around other aspects of their hip fracture care.[45–47] The generalizability of our findings to other jurisdictions is uncertain.

Conclusion

Sixty percent of variation in the provision of neuraxial anesthesia for hip fracture surgery may be warranted, as it is attributable to patient factors. However, approximately 20% of variation is attributable to each of the specific hospital and anesthesiologist. Combined with previous research demonstrating that low hospital-level use of neuraxial anesthesia for hip fracture surgery is associated with decreased risk-adjusted survival, our findings suggest that changing patterns of hip fracture anesthesia care will need to address hospital-level processes and anesthesiologists' behaviors and intentions.

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Competing Interests

The authors declare no competing interests.

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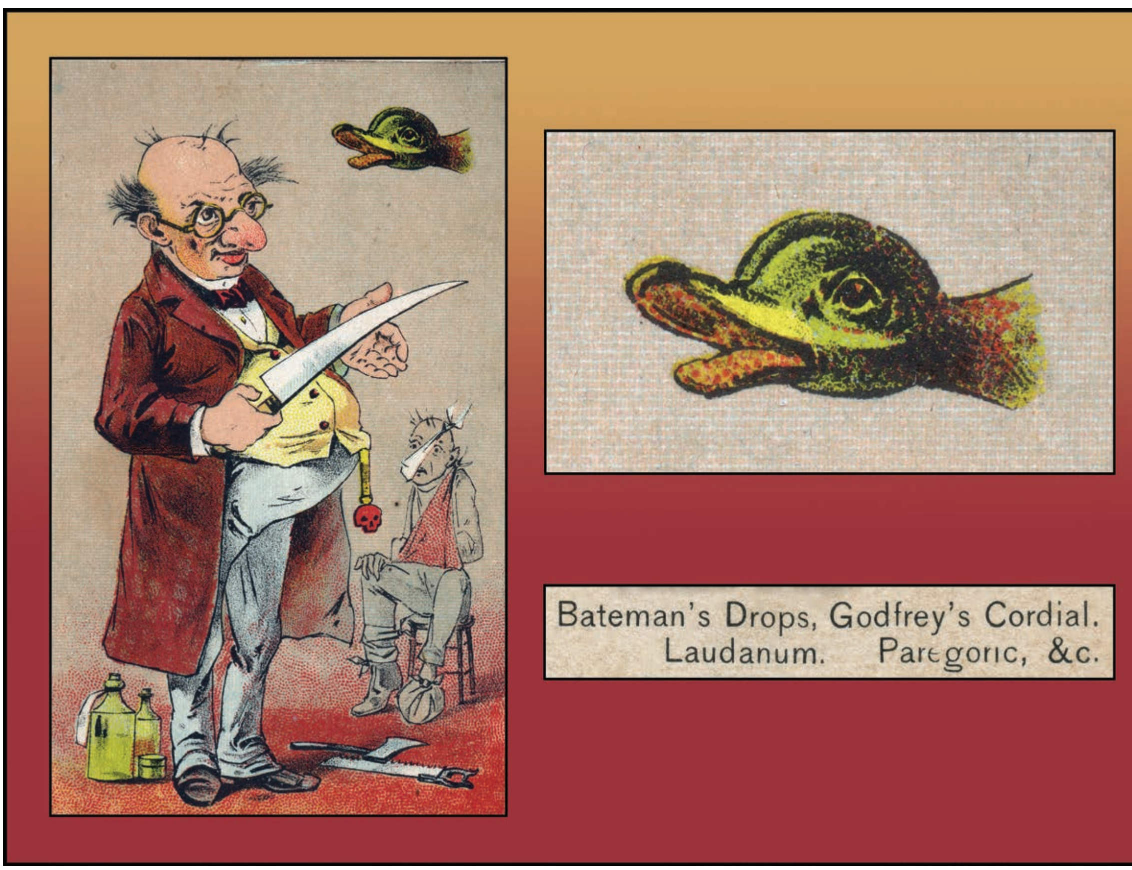
ANESTHESIOLOGY REFLECTIONS FROM THE WOOD LIBRARY-MUSEUM

Warding Off Quacks: Ward's Laudanum in Pittsburgh



Apprenticing with his pharmacist father in Pittsburgh, Pennsylvania, Robert Egbert Sumner Ward (1857 to 1936) sold laudanum as an antitussive, as an antidiarrheal, and even as an adjuvant to inhaled anesthetics. One of Ward's more popular trade cards (*left*) depicted a charlatan eyeing another quack (*upper right*, the head of a mallard drake) while testing the edge of an amputating knife. At the charlatan's feet are a hatchet, a saw, and scattered bottles. On the reverse of the trade card, druggist Ward advertised alcoholic tincture of opium (Laudanum) as well as variations of that product combined with extra alcohol, camphor, or sweet syrup (Bateman's Drops, Paregoric, or Godfrey's Cordial, respectively). Alongside all of these over-the-counter opiates, Ward advertised his culinary wares, including essences of peppermint, cinnamon, and ginger and "flavoring extracts of vanilla, lemon, &c." By 1887 the druggist was devoting more of his time to selling baker's supplies than to peddling opiates. (Copyright © the American Society of Anesthesiologists' Wood Library-Museum of Anesthesiology.)

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