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Comparative Perioperative Outcomes Associated With Neuraxial Versus General Anesthesia for Simultaneous Bilateral Total Knee Arthroplasty

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Abstract

Background and Objectives—The influence of the type of anesthesia on perioperative outcomes after bilateral total knee arthroplasty (BTKA) remains unknown. Therefore, we examined a large sample of BTKA recipients, hypothesizing that neuraxial anesthesia would favorably impact on outcomes.

Methods—We identified patient entries indicating elective BTKA between 2006 and 2010 in a national database; subgrouped them by type of anesthesia: general (G), neuraxial (N), or combined neuraxial-general (NG); and analyzed differences in demographics and perioperative outcomes.

Results—Of 15,687 identified procedures, 6.8% (n = 1066) were performed under N, 80.1% (n = 12,567) under G, and 13.1% (n = 2054) under NG. Comparing N to G and NG, patients in group N were, on average, younger (63.9, 64.6, and 64.8 years; $P = 0.030$) but did not differ in overall comorbidity burden. Patients in group N required blood product transfusions significantly less frequently (28.5%, 44.7%, 38.0%; $P < 0.0001$). In-hospital mortality, 30-day mortality, and complication rates tended to be lower in group N, without reaching statistical significance. After adjusting for covariates, N and NG were associated with 16.0% and 6.0% reduction in major complications compared with G, but only the reduced odds for the requirement of blood transfusions associated with N reached statistical significance (N vs G: odds ratio, 0.52 [95% CI, 0.45–0.61], $P < 0.0001$; NG vs G: odds ratio, 0.77 [95% CI, 0.69–0.86], $P < 0.0001$).

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The authors declare no conflict of interest.

Conclusions—Neuraxial anesthesia for BTKA is associated with significantly lower rates of blood transfusions and, by trend, decreased morbidity. Although by itself the effect may be limited, N might be used within a multimodal approach to reduce complications after BTKA.

Simultaneous bilateral total knee arthroplasty (BTKA) is an increasingly used treatment modality for end-stage osteoarthritis in both knee joints.[1] Although BTKA is believed to confer a number of advantages, such as reduced overall cost, reduced recovery time, and increased patient convenience,[2] multiple studies have concluded that despite these advantages, the simultaneous bilateral approach is associated with increased perioperative morbidity and mortality.[1,3,4] In an attempt to reduce adverse events, we recently proposed appropriate patient selection based on risk factor analysis.[5] Although careful selection of appropriate candidates for this procedure may be one approach to improving outcomes, the identification of possible interventions capable of decreasing the associated risk remains critical yet largely unstudied to date.[6] In this context, potential impacts of the anesthetic technique used during the procedure have not been evaluated. Previous publications have suggested that a potential benefit of regional anesthesia over general anesthesia may be present in the orthopedic surgical setting.[7] Although some studies suggest beneficial results in terms of reduced overall morbidity and mortality, lower rates of thromboembolic phenomena, and reduced blood loss and operating time, the validity of these findings have been challenged because of limitations of small sample sizes and inclusion of historical data and data from only preferentially academic institutions.[7–13] However, the low incidence of most studied complications renders randomized controlled studies at an institutional level relatively impractical, because of the extremely large sample size that would be required to capture low-incidence complications and to reach satisfactory statistical power. Therefore, we chose to access a large national database aiming to (1) analyze the utilization of different anesthesia techniques among patients undergoing BTKA and (2) examine, by means of comparative effectiveness research, whether there were differences between types of anesthesia in outcomes such as mortality, major in-hospital complications, need for blood product transfusion or mechanical ventilation, and length of hospitalization.

We hypothesized that the use of neuraxial anesthesia would favorably impact these outcomes in patients undergoing BTKA.

METHODS

Data Source, Ethics Approval

We obtained data for the period between 2006 and 2010 from Premier Perspective, Inc (Charlotte, North Carolina), an administrative database containing discharge information from approximately 400 acute care hospitals located throughout the United States. This database aggregates information on coding histories, patient billing, and hospital cost from approximately 45 million inpatient visits (at the time this study was conducted). All data received from hospitals undergo a rigorous 7-step validation process, involving approximately 100 validity and integrity assurance cross-checks before being incorporated in the Premier data warehouse.[14] Data included are compliant with the Health Insurance Portability and Accountability Act[15]; this project was therefore exempt from requirements for consent by our institutional review board. Rigorous quality assurance and data validation checks are performed by the provider before distribution to ensure accuracy of entries.

Study Sample

We queried the database for entries with 2 occurrences of the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) procedure code for total knee arthroplasty (81.54) showing the same date of service, which has been considered a valid approach for identifying BTKA records in numerous studies.[1,3,5,16] Only records indicating routine admission for elective surgery were included. The entries were separated into 3 groups using billing data: those for patients who underwent the procedure under general (G), neuraxial (N), or combined general and neuraxial anesthesia (NG). Records without indication of type of anesthesia were included in a separate group for the purpose of missing data analysis. The impact of missing data was assessed by performing a sensitivity analysis that consisted of (1) the inclusion and (2) the exclusion of patients with missing entries for type of anesthesia.[17] No significant differences in results were observed.

Demographic Variables

We compared the characteristics of patients undergoing surgery under the different types of anesthesia. Patient-related characteristics were analyzed. Patient demographics included age, sex, and race (white, black, Hispanic, and other). The prevalence of comorbidities and overall comorbidity burden were assessed using the method described by Deyo et al.[18]

Complication Variables

For each group, the proportions of patients with major complications were computed by identifying cases that had *ICD-9-CM* diagnosis codes listed, consistent with such diagnosis (Appendix 1). The incidence of in-hospital as well as 30-day mortality was computed. Complications analyzed included wound infection, pulmonary embolism, cerebrovascular event, pulmonary compromise, cardiac complications (except myocardial infarction), pneumonia, other infectious complications, acute renal failure, gastrointestinal complications, and acute myocardial infarction.

Furthermore, the incidence of the use of blood product transfusion and mechanical ventilation was recorded using *ICD-9* and billing codes (Appendix 1). Differences in length of hospital stay were analyzed. The length of hospital stay was also dichotomized based on 75th percentile. Entries above the 75th percentile were categorized as prolonged hospitalization.

Statistical Analysis

The study goal was to analyze whether the type of anesthesia is associated with differences in perioperative outcomes. All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, North Carolina). The weighting procedure developed by Centers for Medicare and Medicaid Services and made available by Premier was utilized to derive nationally representative estimates from the available data.[14] To facilitate analysis of weighted data, SAS procedures SURVEYMEANS, SURVEYFREQ, SURVEYREG, and SURVEYLOGISTIC were utilized for descriptive analyses and modeling efforts.

Univariate Analysis

Weighted means and percentages were described for continuous and categorical variables, respectively. For variables that had a skewed distribution, median and interquartile range were estimated. For a continuous variable, 95% confidence intervals (CIs) were shown as a measure of variability. χ^2 Test was performed to evaluate the association of 2 categorical variables. One-way analysis of variance F test was used to compare means for a continuous variable between more than 2 groups. The logistic regression was performed to assess the association between anesthesia type and outcomes, and unadjusted odds ratio (OR), 95% CI, and *P* values were reported.

Multivariate Regression Analysis

Binary outcomes of incidence of complications, use of blood product transfusion, mechanical ventilation, and prolonged length of hospital stay as defined above were considered. For the purpose of the evaluation of major complications, a combined outcome variable was created, which included the complications listed above. For each outcome, logistic regression was used to evaluate its association with the type of anesthesia, while controlling for age, sex, race, and comorbidity burden. Adjusted ORs, 95% CI, and *P* values were reported. A test of model discrimination using the C-statistic and a test of model calibration using the Hosmer-Lemeshow (H-L) test were performed for each model.[19] The conventional threshold of statistical significance (ie, 2-sided *P* G 0.05) was used to determine significance of variables.

RESULTS

We identified 22,253 entries of patients undergoing simultaneous BTKA and indicating routine admission: 29.5% (n = 6566) did not have information on anesthesia type (Fig. 1). Of the remaining 70.5% (n = 15,687), 6.8% (n = 1066) were performed under N, 80.1% (n = 12,567) under G, and 13.1% (n = 2054) under N+G anesthesia, respectively. Table 1 details the patient and health care systemYrelated demographics of patients by anesthesia type utilized.

Patients in group N were, on average, younger than those operated on under G or N+G. There were no significant differences in overall comorbidity burden or the prevalence of individual comorbidities (Table 2).

Table 3 depicts the incidence of in-hospital and 30-day mortality, major in-hospital complications, incidence of blood product transfusion, mechanical ventilation, and the median length of stay. No difference was found in regard to in-hospital mortality or 30-day mortality between groups. Despite trends toward lower morbidity for studied complications, no significant differences in the unadjusted rates of major in-hospital complications were recorded across the groups. However, patients in group N required blood product transfusion significantly less frequently. Although the requirement for mechanical ventilation was lower in patients in the N and N+G groups, the difference did not reach statistical significance. Compared with G, N and N+G were associated with shorter length of stay.

Tables 4 and 5 show the results of the univariate and multivariate regression analyses, respectively. In the logistic regressions, unadjusted and adjusted ORs of anesthesia type were similar. Specifically, in the multivariate analysis, N and NG were associated with lower, although insignificantly reduced, odds for major complications compared with G. However, the adjusted risk for blood product transfusion was significantly lower in patients receiving N or N+G (OR, 0.52 [CI, 0.45–0.61] for N vs G, $P < 0.0001$; OR, 0.77 [CI, 0.69–0.86] for NG vs G, $P < 0.0001$). Moreover, a trend toward decreased risk for mechanical ventilation became apparent in N and N+G. The odds for increased length of hospitalization (above the 75th percentile) were not different between groups. When analyzing outcomes by including the group with unknown anesthesia type, the results did not change significantly.

The C-statistics were 0.64, 0.62, 0.63, and 0.61, and *P* values for H-L goodness of fit were 0.21, 0.02, 0.10, and 0.01 for cumulative complication, transfusion, mechanical ventilation, and prolonged length of stay, respectively.

DISCUSSION

When considering a large national patient sample, the utilization of neuraxial anesthesia for BTKA is associated with trends toward decreased rates and risk of perioperative major complications, without reaching statistical significance, however. We found decreased rates and odds for perioperative blood product transfusion among neuraxial anesthesia recipients compared with those receiving general anesthesia. There was no impact of the choice of anesthetic technique on the need for mechanical ventilation or the length of hospitalization.

The potential impact of anesthetic technique on complication incidence seems limited in our sample. However, our results indicate an overall trend toward beneficial impact of neuraxial anesthesia over the general approach. This might indicate that, despite the comparatively large number of subjects included, an even larger sample size would have been required to achieve statistical significance. Although to our knowledge, no study has focused on this issue in the setting of BTKA, some evidence indicates advantages of the neuraxial technique with regard to complication incidence and mortality. Two of the largest studies, a meta-analysis by Rodgers et al[7] including 141 trials with a total of 9559 patients, and an administrative database analysis by Wijeysundera et al,[8] retrospectively examining 259,037 patient records, found various small overall benefits for regional anesthesia compared with general anesthesia. Whereas Rodgers et al[7] detected a mortality reduction by about one third in patients receiving epidural anesthesia, the difference in the second study mentioned was not significant. Unfortunately, despite the large sample sizes, these studies were not adequately powered to allow for subgroup analysis toward specific surgical specialties or procedures.[7,8] In addition, the latter did not analyze the incidence of perioperative complications, except the need for mechanical ventilation.

Two meta-analyses by Mauermann et al[10] and Hu et al[9] subsequently limited their scope to outcomes after elective hip and, respectively, hip or knee replacement only. Although they were able to demonstrate advantages of neuraxial anesthesia with regard to perioperative complications (most notably reduced incidence of thromboembolic phenomena, reduced operating time, and lower blood loss), criticisms about these studies include issues regarding publication bias, small sample sizes, inclusion of data from small specialized centers, analysis of limited outcomes, and inclusion of studies that do not reflect current medical practice.[9,10]

The majority of patients in our sample received general anesthesia during their surgeryVonly 6.8% of patients underwent surgery under neuraxial anesthesia alone, and 13.1% received a combination of neuraxial and general anesthesia. Interestingly, the odds for most outcomes of the combined N+G group lie between those of G only and N only, suggesting an intrinsic positive effect of neuraxial anesthesia. However, it must be noted that some complication rates are unchanged or minimally higher in the N+G group. Yet, these observations raise the question of whether the observed benefits in outcome can be associated with the performance of neuraxial anesthesia itself, the avoidance of general anesthesia, or a combination of both. The positive impact of neuraxial anesthesia can probably be partly attributed to some of its described beneficial effects. With regard to reduced rates of thromboembolic complications, including myocardial infarction, deep venous thrombosis, or pulmonary embolism, antithrombotic properties of regional anesthesia come to mind, especially in light of the predominance of this complication entity among the orthopedic population. [10,19] Conversely, neuraxial anesthesia appears capable of reducing not only thromboembolism but also bleeding and thus the demand for blood product transfusion.

In our study, neuraxial anesthesia was indeed associated with a highly significantly decreased incidence of perioperative blood product transfusion. Substantial blood loss is recognized as a very common complication during BTKA. Although various methods to reduce or compensate for blood loss have been proposed, including administration of erythropoietin, tranexamic acid, or topical hemostatic agents, the requirement for intraoperative and postoperative allogeneic or autologous blood transfusions remains disproportionately high when compared with unilateral procedures.[20–23] In a previous study, the incidence of posthemorrhagic anemia was found to be as high as 28.6% after BTKA, compared with 15.3% after unilateral TKA.[16] In the previously mentioned study by Rodgers et al,[7] a comparable reduction in incidence of blood product transfusion was noticed.[7] A meta-analysis by Guay,[24] including 24 studies on surgical blood loss and blood transfusion requirements after different types of surgery, similarly concluded that neuraxial anesthesia confers a highly significant reduction in blood loss and transfusion incidence when utilized for total hip replacement and spinal fusion, but not for other procedures such as hip fracture surgery, lumbar disk surgery, peripheral vascular surgery, prostatectomy, cesarean delivery, or bowel surgery.[24] Reasons for this finding have to remain speculative. Associations with improved analgesia, sympathicolysis, decreased vascular tone, and, subsequently, decreased blood pressure in the lower extremities seem intuitive, yet there is no conclusive evidence available to this date.

Large administrative databases are increasingly used to explore a wide variety of different questions in anesthesiology research. The specific advantage of the Premier Perspective database is its relatively high level of detail, allowing for the distinction of perioperative management techniques, including the type of anesthesia used. To ensure adequate validity, data undergo rigorous integrity inspection by the vendor before it is added to the data set.[14] A large number of published studies across various medical specialties demonstrate the high level of confidence in this database.[25–27] In addition, we performed extensive model diagnostics to ensure the validity of our methodology. Nonetheless, our study is limited by a number of factors that are related to secondary database analysis. First, we were not able to capture intraoperative events such as total amount of blood loss or medications administered to the subjects, including anticoagulants or cardioprotective agents. The outcomes are, however, evaluated under realistic settings rather than in an experimental setup and therefore reflect “real world” level of care as demanded by comparative effectiveness research standards. Second, because of the nature of the database, post-discharge events, except death within 30 days, cannot be taken into consideration because only events recorded during the index admission in which the surgery was performed are recorded. Third, as comorbidities and complications were identified using *ICD-9-CM* codes (see Appendix 1), there is a possibility that some of the events are not adequately captured because of coding errors or inconsistencies, despite quality checks by the vendor. However, this effect is presumably attenuated by the equal distribution of this coding bias across the entire data collection construct. Finally, we did not analyze anesthesia-related complications, including postdural puncture headache, blood vessel and nerve damage, damages to oropharyngeal structures during intubation, or failed intubation because they are not provided in the database. Although anesthesia-associated morbidity is known to be very low in comparison to other complications studied, contraindications to either method can certainly prevail and obviate the utilization of a particular technique, for instance, regional anesthesia in anticoagulated patients or general anesthesia in those suffering from pulmonary comorbidity.

In conclusion, to our best knowledge, our study is the first to analyze the impact of various types of anesthesia on perioperative outcomes after BTKA.We were able to depict some of the advantages of neuraxial or combined neuraxial-general versus general anesthesia alone during BTKA. Being considered a high-risk procedure, careful patient selection and perioperative management have proven useful tools to improve outcomes. Although by itself the impact of neuraxial anesthesia on outcomes may be limited, it may be considered as one part of various interventions to reduce complications after simultaneous BTKA. With approximately only 1 in 5 patients receiving some form of neuraxial anesthesia, a tremendous potential for growth becomes apparent. Our data support the promotion of the use of neuraxial anesthesia for the management of BTKA patients, but also point out the demand for further research to quantify the magnitude of its beneficial effects.

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APPENDIX 1

ICD-9-CM Diagnosis Codes for Major Complications

Complications	***ICD-9-CM* Diagnosis Codes**
Wound infection	998.5x
Pulmonary embolism	415.1
Cerebrovascular event	433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91, 997.02
Pulmonary compromise	514, 518.4, 518.5, 518.81, 518.82
Cardiac (non–myocardial infarction)	426.0, 427.41, 427.42, 429.4, 997.1, 427.4, 427.3, 427.31, 427.32
Pneumonia	481, 482.00- 482.99, 483, 485, 486, 507.0, 997.31, 997.39

Complications	***ICD-9-CM* Diagnosis Codes**
All infections	590.1, 590.10, 590.11, 590.8, 590.81, 590.2, 590.9, 595.0, 595.9, 599.0, 567.0
	480, 480.0, 480.1, 480.2, 480.8, 480.9, 481, 482.0, 482.1, 482.2, 482.3, 482.30, 482.31, 482.32, 482.39, 482.4, 482.40, 482.41, 482.42, 482.49, 482.5, 482.8, 482.81, 482.82, 482.83, 482.84, 482.89, 482.9, 483, 483.0, 483.1, 483.8, 485, 486, 487, 997.31
	038, 038.0, 038.1, 038.10, 038.11, 038.12, 038.19, 038.2, 038.3, 038.4, 038.40, 038.41, 038.42, 038.43, 038.44, 038.49, 038.8, 038.9, 790.7
	998.0, 958.4, 998.5, 998.59, 998.89, 785, 785.50, 785.52, 785.59, 999.39, 999.31, 999.3
Acute renal failure	584, 584.5, 584.9
Gastrointestinal complication	997.4, 560.1, 560.81, 560.9, 536.2, 537.3
Acute myocardial infarction	410.XX
Blood transfusion	99.0, 99.01, 99.02, 99.03, 99.04, 99.05, 99.06, 99.07, 99.08, 99.09 (HCPCS codes) P9010, P9011, P9012, P9016, P9017, P9019, P9020, P9021, P9022, P9023, P9031, P9032, P9033, P9034, P9035, P9036, P9037, P9038, P9039, P9040
Mechanical ventilation	93.90, 96.7, 96.70, 96.71, 96.72 (CPT code) 94002, 94656, 94003, 94657

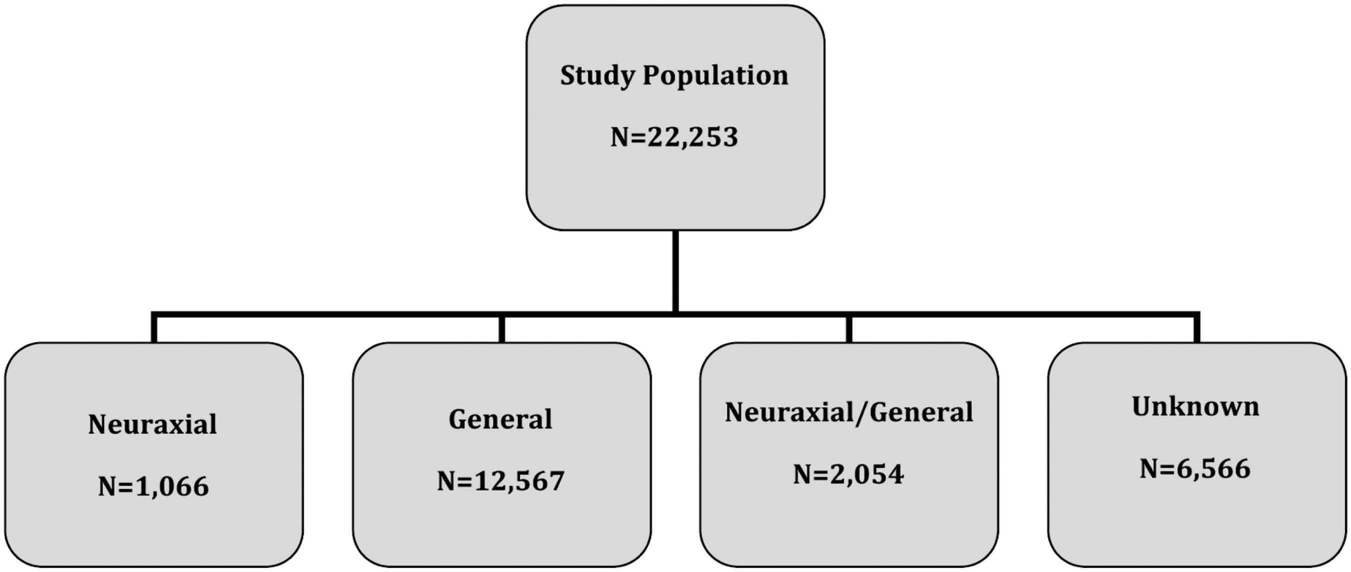

FIGURE 1.
The flowchart depicts the study population and subgroup distribution.

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TABLE 1

Patient and Health Care System–Related Characteristics by Anesthesia Type

Variable	Category	Neuraxial	General	Neuraxial/General	*P*
Unweighted n		1066	12567	2054	—
% of total		6.8%	80.1%	13.1%	—
Average comorbidity index (CI)		0.5 (0.5–0.6)	0.6 (0.5–0.6)	0.5 (0.5–0.6)	0.9911
Deyo comorbidity index categories, %	0	68.8	66.8	68.3	0.3142
	1	15.4	15.0	15.6	0.3142
	2	12.5	14.3	12.5	0.3142
	≥3	3.4	3.9	3.6	0.3142
Average age (CI), y		63.9 (63.3–64.5)	64.6 (64.4–67.8)	64.8 (64.3–65.3)	0.0298
Age group, %	≤44 y	1.2	1.4	2.0	0.032
	45–54 y	14.9	13.4	12.8	0.032
	55–64 y	37.0	34.2	31.9	0.032
	65–74 y	32.5	34.4	36.6	0.032
	≥75 y	14.3	16.5	16.8	0.032
Sex, %	Female	58.1	57.9	55.9	0.3141
	Male	41.9	42.1	44.1	0.3141
Race, %	White	77.8	75.9	74.5	<0.0001
	Black	5.6	5.4	4.6	<0.0001
	Other	0.3	5.6	0.6	<0.0001
	Missing data	16.3	13.1	20.4	<0.0001

TABLE 2

Prevalence of Preexisting Comorbidities Among Patients in the Different Types of Anesthesia Groups

	Neuraxial, %	General, %	Neuraxial/General, %	*P*
Myocardial infarction	2.4	2.5	3.4	0.0985
Peripheral vascular disease	0.9	1.2	1.3	0.6998
Dementia	0.2	0.1	0.1	0.2759
Chronic obstructive pulmonary disease	12.3	11.6	11.3	0.7097
Uncomplicated diabetes	14.5	16.8	15.0	0.0619
Complicated diabetes	0.7	1.1	0.5	0.0623
Cancer	1.2	1.5	1.9	0.2702

TABLE 3

Incidences of Complications, Use of Mechanical Ventilation, and Blood Product Transfusion, as Well as Median Length of Stay by Type of Anesthesia

	Neuraxial	**General**	**Neuraxial/General**	***P***
In-hospital mortality, %	0.1	0.1	0.1	0.9260
30-d Mortality, %	0.1	0.1	0.1	0.8222
Wound infection, %	0.1	0.1	0.1	0.6429
Pulmonary embolism, %	1.5	0.9	0.6	0.0998
Cerebrovascular event, %	0.1	0.3	0.2	0.6001
Pulmonary compromise, %	0.5	0.8	0.9	0.4865
Cardiac (non–myocardial infarction), %	5.2	5.9	5.5	0.5589
Pneumonia, %	0.7	0.9	0.8	0.6789
All infections, %	3.2	4.5	4.6	0.1515
Acute renal failure, %	1.9	2.7	2.3	0.2396
Gastrointestinal complication, %	1.1	1.3	1.3	0.8475
Acute myocardial infarction, %	0.2	0.4	0.4	0.6062
Blood transfusion, %	28.5	44.7	38.0	<0.0001
Mechanical ventilation, %	0.5	0.9	0.7	0.2171
Length of stay, median (interquartile range), d	2.8 (2.1–4.1)	3.1 (2.4–4.3)	3.1 (2.5–4.2)	<0.0001

TABLE 4

Results From the Univariate Regression, ORs, and 95% CIs (Reference = 1)

			Cumulative Complications (C-Statistics = 0.64, H-L = 0.30)		**Transfusion (C-Statistics = 0.62, H-L = 0.38)**		**Mechanical Ventilation (C-Statistics = 0.63, H-L = 0.34)**		**Length of Stay >75th Percentile (C-Statistics = 0.61, H-L = 0.94)**	
Category	**Comparison**	**Reference**	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Anesthesia technique	N	G	0.86 (0.69–1.07)	0.1710	0.49 (0.42–0.57)	<0.0001	0.49 (0.19–1.24)	0.1309	0.91 (0.77–1.07)	0.2472
	NG	G	0.99 (0.85–1.15)	0.8822	0.76 (0.68–0.84)	<0.0001	0.76 (0.42–1.38)	0.3641	0.97 (0.86–1.09)	0.5803

Cumulative complications comprise the following events: in-hospital mortality, 30-day mortality, wound infections, pulmonary embolism, cerebrovascular event, cardiac complications including myocardial infarction, pneumonia, all other infections, acute renal failure, and gastrointestinal complications.

N indicates neuraxial anesthesia; G, general anesthesia; NG, neuraxial and general anesthesia (combined).

TABLE 5

Results From the Multivariate Regression, ORs, and 95% CIs (Reference = 1)

			Cumulative Complications (C-Statistics = 0.64, H-L = 0.2174)		Transfusion (C-Statistics = 0.62, H-L = 0.0241)		Mechanical Ventilation (C-Statistics = 0.63, H-L = 0.0994)		Length of Stay >75th percentile (C-statistics = 0.61, H-L = 0.0025)	
Category	**Comparison**	**Reference**	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Anesthesia technique	N	G	0.87 (0.70–1.08)	0.2014	0.52 (0.45–0.61)	<0.0001	0.47 (0.18–1.21)	0.1161	1.07 (0.91–1.26)	0.4100
	NG	G	0.94 (0.81–1.10)	0.4432	0.77 (0.69–0.86)	<0.0001	0.71 (0.39–1.29)	0.2555	1.09 (0.97–1.23)	0.1583
Age	55–64 y	≤45	1.84 (1.07–3.19)	0.0288	1.40 (1.02–1.94)	0.039	0.38 (0.10–1.43)	0.1544	1.01 (0.70–1.47)	0.9427
	65–74 y	≤45	2.56 (1.48–4.41)	0.0008	2.02 (1.47–2.79)	<0.0001	0.47 (0.13–1.75)	0.2594	1.19 (0.82–1.72)	0.3615
	≥75 y	≤45	4.80 (2.78–8.31)	<0.0001	3.09 (2.23–4.29)	<0.0001	0.46 (0.12–1.76)	0.2541	1.69 (1.16–2.46)	0.0064
Sex	Female	Male	0.73 (0.66–0.81)	<0.0001	1.55 (1.44–1.68)	<0.0001	0.96 (0.65–1.41)	0.8259	1.02 (0.94–1.11)	0.6084
Ethnicity	Black	White	1.03 (0.81–1.30)	0.8287	1.06 (0.91–1.24)	0.4329	1.09 (0.47–2.32)	0.9077	1.02 (0.85–1.21)	0.8438
	Hispanic	White	0.66 (0.49–0.90)	0.0074	5.21 (4.20–6.46)	<0.0001	0.18 (0.03–1.33)	0.0928	12.12 (9.74–15.10)	<0.0001
	Other	White	1.29 (1.11–1.50)	0.0008	1.78 (1.59–1.99)	<0.0001	1.36 (0.79–2.34)	0.2746	1.47 (1.30–1.65)	<0.0001
Deyo index group	1	0	1.46 (1.27–1.68)	<0.0001	1.12 (1.01–1.24)	0.0357	1.90 (1.22–3.24)	0.0059	1.19 (1.06–1.34)	0.0027
	2	0	1.39 (1.20–1.60)	<0.0001	1.13 (1.02–1.26)	0.0224	1.77 (1.04–3.01)	0.0341	1.47 (1.32–1.66)	<0.0001
	≥3	0	1.74 (1.36–2.23)	<0.0001	1.15 (0.95–1.39)	0.1405	3.14 (1.54–6.39)	0.0016	1.49 (1.21–1.83)	0.0001

Cumulative complications comprise the following events: in-hospital mortality, 30-day mortality, wound infections, pulmonary embolism, cerebrovascular event, cardiac complications including myocardial infarction, pneumonia, all other infections, acute renal failure, and gastrointestinal complications.

N indicates neuraxial anesthesia; G, general anesthesia; NG, neuraxial and general anesthesia (combined).