The Effect of Anesthetic Type on Outcomes of Hip Fracture Surgery

A Nationwide Population-Based Study

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Abstract: Hip fractures are a global public health problem. During surgery following hip fractures, both general and regional anesthesia are used, but which type of anesthesia offers a better outcome remains controversial. There has been little research evaluating different anesthetic types on mortality and readmission rates for hip fracture surgery using nationwide population-based data.

We used nationwide population-based data to examine the effect of anesthetic type on mortality and readmission rates for hip fracture surgery. Retrospective observational study.

General acute care hospitals throughout Taiwan.

A total of 17,189 patients hospitalized for hip fracture surgery in 2011.

Generalized estimating equation models with propensity score weighting were performed after adjustment for patient, surgeon, and hospital characteristics to examine the associations of anesthesia type with 30-day all-cause mortality, 30-day all-cause readmission, and 30-day specific-cause readmission (including surgical site infection, sepsis, acute respiratory failure, acute stroke, acute myocardial infarction, acute renal failure, deep vein thrombosis, pneumonia, and urinary tract infection).

Of 17,189 patients, 11,153 (64.9%) received regional anesthesia and 6036 (35.1%) received general anesthesia. Overall, the 30-day mortality rate was 1.7%, and the 30-day readmission rate was 12.3%. Regional anesthesia was not associated with decreased 30-day all-cause mortality (odds ratio [OR] 0.89, 95% confidence interval [CI] 0.67–1.18, \( P = 0.409 \)), but associated with decreased 30-day all-cause readmission and surgical site infection readmission relative to general anesthesia (OR 0.83, 95% CI 0.75–0.93, \( P = 0.001 \) and OR 0.69, 95% CI 0.49–0.97, \( P = 0.031 \)).

Regional anesthesia is not associated with 30-day mortality, but is associated with lower 30-day all-cause and surgical site infection readmission compared with general anesthesia for hip fracture surgery. (Medicine 95(14):e3296)

INTRODUCTION

Hip fractures are a global public health problem. It is estimated that about 1.6 million hip fractures occur worldwide each year, and 2.6 million will occur worldwide annually by 2025.1 Hip fractures can lead to death and severe disability.2,3 With an aging population, hip fractures have been increasing, causing hip fracture-related healthcare costs to rise. Regional anesthesia for hip fracture surgery may reduce postoperative complications.4,5 Practice guidelines have advocated broader use of regional anesthesia for hip fracture surgery.7–9 To our knowledge, findings regarding an association between anesthetic types and mortality were inconclusive, and there has been little research evaluating different anesthetic types on readmission rates for hip fracture surgery using nationwide population-based data.

The Agency for Healthcare Research and Quality has regarded hip fracture mortality as an inpatient quality indicator.10 Both 30-day mortality and 30-day readmission rates are regarded as important outcome indicators for evaluating hospital care.11 Starting October 1, 2012, the Hospital Readmissions Reduction Program, under the Affordable Care Act, requires the Centers for Medicare & Medicaid Services to reduce payments to hospitals with excessive readmission ratio for applicable conditions.12 Moreover, the Bundled Payments for Care Improvement initiative for Medicare patient’s medical conditions (including hip fracture) was launched in 2013. Thus, it is important to discover which factors are associated with 30-day mortality or 30-day readmission rates for hip fracture patients.

Anesthesia type is hypothesized to be related to mortality among patients undergoing hip fracture surgery, but the influence of anesthesia type on mortality is certainly a controversial issue in the literature. Regional anesthesia has significantly reduced incidences of deep vein thrombosis, surgical site infections, and pulmonary complications. On the other hand, general anesthesia is beneficial in that it has a lower incidence of...
hypotension and cerebrovascular accidents. To date, there is not enough evidence to show which anesthesia type can best improve outcomes for patients undergoing hip fracture surgery. For hip fracture surgery, a few observational studies have focused on the relationship between anesthesia type and mortality. Some of these studies found that the use of regional anesthesia was associated with reduced mortality, and others found no difference in mortality between regional and general anesthesia. Additionally, only 3 studies have attempted to compare readmissions between regional and general anesthesia for hip fracture surgery.

The aim of this study was to use nationwide population-based data from Taiwan to examine the associations of anesthesia type with 30-day mortality and readmission rates for hip fracture surgery. We hypothesized that regional anesthesia would be associated with better outcomes compared with general anesthesia.

MATERIALS AND METHODS

Database

We collected data from the National Health Insurance Research Database (NHIRD), provided by the National Health Insurance Administration (NHIA) and managed by the National Health Research Institutes. The NHIRD is a national database that contains patient-level demographic, diagnostic, and administrative information across Taiwan. This study was approved by the Institutional Review Board of the National Taiwan University Hospital.

The NHIA is the sole insurer and implemented national health insurance beginning March 1, 1995. The coverage rate of National Health Insurance has reached 99.9%, and almost all healthcare facilities are National Health Insurance contracted providers. Every enrollee is free to go to any hospital or clinic. The NHIA has reimbursed providers mainly on a fee-for-service basis since the implementation of the national health insurance system. To improve efficiency and outcomes of inpatient care, certain major diagnostic categories (such as musculoskeletal system diseases) have been reimbursed mainly by bundled payments based on Taiwan diagnosis-related groups since 2010. Surgeons are employed by hospitals; thus, surgeons responsible for treating patients with musculoskeletal system diseases (eg, hip fractures) are paid by the hospital out of the bundled payment. Related readmissions for 30 days after hospital discharge are not included in the bundled payment amount. The Hospital Readmissions Reduction Program is not implemented. Therefore, Taiwan’s healthcare system provides an excellent opportunity to examine the associations of anesthesia type with 30-day mortality and readmission rates for hip fracture surgery under bundled payments.

Study Population

This study population included all patients undergoing hip fracture surgery aged 18 years and older admitted to hospitals in Taiwan in 2011. The study period (2011) was based on admission date. The major inclusion criterion was admission with a principal diagnosis of hip fracture as identified through the patient’s principal diagnosis recorded using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code 820. We included those admissions who underwent at least one of the following surgical operations based on ICD-9-CM procedure codes: total hip arthroplasty (81.51), hemiarthroplasty (81.52), and internal fixation (79.15, 79.35, 78.55). For patients with multiple hip fracture admissions, the subsequent admissions were excluded. We excluded patients treated by surgeons without cases in 2010 and admitted to hospitals without cases in 2010. We excluded patients who received local or no anesthesia and who received both general and regional anesthesia. Nevertheless, when 30-day readmission was analyzed, we excluded patients who died during hospital stay. Because patients died during hospital stay, they had no chance of being readmitted to hospital.

Variables

Dependent Variables

Outcome measures included 30-day all-cause mortality and 30-day all-cause readmission, and 30-day specific-cause readmission. Thirty-day mortality was defined as death in or out of hospital from any cause within 30 days of admission (in hospital and after discharge). Thirty-day all-cause/specific-cause readmission was defined as the occurrence of at least one hospitalization for any cause/specific cause within 30 days of discharge for those surviving to discharge. Specific causes of readmission included surgical site infection, sepsis, acute respiratory failure, acute stroke, acute myocardial infarction, acute renal failure, deep vein thrombosis, pneumonia, and urinary tract infection, which were major or common complications after hip fracture surgery. Specific-cause mortality and readmission rates are standard measurements of the outcomes of care. Readmission is chosen in addition to mortality because it is expensive to the healthcare system and commonly represents a preventable adverse event for patients.

Independent Variables

Exposure to a specific anesthesia type was defined by one or more charge codes for general or regional anesthesia. Patients were classified either as having received general anesthesia (if they had charges for general anesthesia) or as having received regional anesthesia (if they had charges for epidural or spinal anesthesia).

The covariates included patient, surgeon, and hospital characteristics. The patient characteristics were sex, age, comorbid conditions, fracture type (intracapsular, extracapsular, other), type of surgical procedure (arthroplasty, internal fixation), multiple trauma (yes/no), admission from emergency department (ED) (yes/no), intensive care unit (ICU) use (yes/no), and length of hospital stay. The age groups were divided into 5 groups: ≤50, 51–60, 61–70, 71–80, and ≥80 years of age because the transformed scale was strongly associated with patient outcomes. A modified Charlson Comorbidity Index adopted by previous studies on hip fracture surgery was used to identify patients’ comorbidities. This modified index was the sum of weighted points based on the presence or absence of 10 different medical conditions. One point was also added for each decade more than 40 years of age. In addition to a modified Charlson Comorbidity Index, individual comorbidities (including diabetes mellitus, hypertension, hyperlipidemia, chronic obstructive pulmonary disease, heart disease, dementia, and renal disease) were also included. The type of hip fracture was grouped into three major categories based on the location of the fracture as indicated by their ICD-9-CM codes. The type of surgical procedure was defined with principal procedure codes for arthroplasty and internal fixation.
### TABLE 1. Characteristics of the Study Population by Anesthesia Type

|                               | Total            | Regional Anesthesia | General Anesthesia | P     |
|-------------------------------|------------------|---------------------|--------------------|-------|
|                               | N   | %    | N   | %    | N   | %    |       |
| No. of patients               | 17,189 | 100.0 | 11,153 | 100.0 | 6036 | 100.0 | —     |
| Patient characteristics       |      |      |      |      |      |      |       |
| Male sex                      | 6982 | 40.6 | 4558 | 40.9 | 2424 | 40.2 | 0.366 |
| Age, y                        |      |      |      |      |      |      |       |
| ≤50                           | 1063 | 6.2  | 471  | 4.2  | 592  | 9.8  | <0.001|
| 51–60                         | 1325 | 7.7  | 747  | 6.7  | 578  | 9.6  |       |
| 61–70                         | 2205 | 12.8 | 1366 | 12.2 | 839  | 13.9 |       |
| 71–80                         | 5640 | 32.8 | 3695 | 33.1 | 1945 | 32.2 |       |
| ≥81                           | 6956 | 40.5 | 4874 | 43.7 | 2082 | 34.5 |       |
| Modified Charlson Comorbidity Index |      |      |      |      |      |      |       |
| ≤3                            | 5708 | 33.2 | 3351 | 30.0 | 2357 | 39.0 | <0.001 |
| 4                             | 4581 | 26.7 | 3136 | 28.1 | 1445 | 23.9 |       |
| ≥5                            | 6900 | 40.1 | 4666 | 41.8 | 2234 | 37.0 |       |
| Diabetes mellitus             | 4647 | 27.0 | 3048 | 27.3 | 1599 | 26.5 | 0.238 |
| Hypertension                  | 7652 | 44.5 | 5037 | 45.2 | 2615 | 43.3 | 0.021 |
| Hyperlipidemia                | 144  | 0.8  | 97   | 0.9  | 47   | 0.8  | 0.532 |
| COPD                          | 1037 | 6.0  | 755  | 6.8  | 282  | 4.7  | <0.001|
| Heart disease                 | 506  | 2.9  | 307  | 2.8  | 199  | 3.3  | 0.044 |
| Dementia                      | 963  | 5.6  | 637  | 5.7  | 326  | 5.4  | 0.398 |
| Renal disease                 | 356  | 2.1  | 236  | 2.1  | 120  | 2.0  | 0.574 |
| Fracture type                 |      |      |      |      |      |      |       |
| Intracapsular                 | 1712 | 10.0 | 1062 | 9.5  | 650  | 10.8 | 0.021 |
| Extracapsular                 | 8087 | 47.0 | 5302 | 47.5 | 2785 | 46.1 |       |
| Other                         | 7390 | 43.0 | 4789 | 42.9 | 2601 | 43.1 |       |
| Type of surgical procedure    |      |      |      |      |      |      |       |
| Arthroplasty                  | 6192 | 36.0 | 4096 | 36.7 | 2096 | 34.7 | 0.009 |
| Internal fixation             | 10,997 | 64.0 | 7057 | 63.3 | 3940 | 65.3 |       |
| Multiple trauma               | 1068 | 6.2  | 417  | 3.7  | 651  | 10.8 | <0.001|
| Admission from ED             | 12,069 | 70.2 | 7666 | 68.7 | 4403 | 72.9 | <0.001|
| Length of stay, d             |      |      |      |      |      |      |       |
| ≤6                            | 6280 | 36.5 | 3869 | 34.7 | 2411 | 39.9 | <0.001|
| 7–8                           | 5270 | 30.7 | 3569 | 32.0 | 1701 | 28.2 |       |
| ≥9                            | 5639 | 32.8 | 3715 | 33.3 | 1924 | 31.9 |       |
| Surgeon characteristics       |      |      |      |      |      |      |       |
| Surgeon volume                |      |      |      |      |      |      |       |
| Low                           | 5882 | 34.2 | 4014 | 36.0 | 1868 | 30.9 | <0.001|
| Medium                        | 6010 | 35.0 | 3920 | 35.1 | 2090 | 34.6 |       |
| High                          | 5297 | 30.8 | 3219 | 28.9 | 2078 | 34.4 |       |
| Orthopedic surgeon            | 16,794 | 97.7 | 10,942 | 98.1 | 5852 | 97.0 | <0.001|
| Surgeon age, y                |      |      |      |      |      |      |       |
| ≤40                           | 5613 | 32.7 | 3627 | 32.5 | 1986 | 32.9 | <0.001|
| 41–50                         | 7485 | 43.5 | 4751 | 42.6 | 2734 | 45.3 |       |
| ≥51                           | 4091 | 23.8 | 2775 | 24.9 | 1316 | 21.8 |       |
| Hospital characteristics      |      |      |      |      |      |      |       |
| Hospital volume               |      |      |      |      |      |      |       |
| Low                           | 5867 | 34.1 | 4521 | 40.5 | 1346 | 22.3 | <0.001|
| Medium                        | 5642 | 32.8 | 3484 | 31.2 | 2158 | 35.8 |       |
| High                          | 5680 | 33.0 | 3148 | 28.2 | 2532 | 41.9 |       |
| Hospital level                |      |      |      |      |      |      |       |
| Academic medical center       | 5206 | 30.3 | 2940 | 26.4 | 2266 | 37.5 | <0.001|
| Regional                      | 8644 | 50.3 | 5482 | 49.2 | 3162 | 52.4 |       |
| District                      | 3339 | 19.4 | 2731 | 23.4 | 608  | 10.1 |       |
| Teaching                      | 14,740 | 85.8 | 9239 | 82.8 | 5501 | 91.1 | <0.001|
| Location                      | 5212 | 30.3 | 3969 | 35.6 | 1243 | 20.6 | <0.001|
The surgeon characteristics included surgeon volume (low, medium, high), orthopedic surgeon (yes/no), and age. The hospital characteristics included hospital volume (low, medium, high), hospital level (academic medical center, regional, district), teaching status (yes/no), and hospital location (Taipei, northern, central, southern, Kao-Ping, eastern). Surgeon volume was calculated as the number of cases a given surgeon performed in the calendar year before the year of the patient’s admission. Hospital volume was calculated as the number of cases a given hospital performed in the calendar year before the year of the patient’s admission. These volumes were then divided into tertiles, as has been done in previous studies.32–34

Statistical Analysis

We used generalized estimating equation logistic regression models and propensity score weighting, adjusted for all patient, surgeon, and hospital characteristics, to examine the association of anesthesia type with 30-day all-cause mortality, 30-day all-cause readmission, and 30-day specific-cause readmission for hip fracture surgery.35–43 The patient was the unit of analysis. Patient outcomes are correlated within surgeons that are, in turn, correlated within hospitals. We used generalized estimating equation models that accounted for the clustering of patients within surgeons and surgeons within hospitals to reduce the potential for biased standard errors and conclusions about the statistical significance.36–38 We modeled 30-day outcomes as a function of anesthesia type, patient sex, age, comorbid conditions, fracture type, type of surgical procedure, multiple trauma, admission from ED, ICU use, length of stay, surgeon volume, orthopedic surgeon, surgeon age, hospital volume, hospital level, teaching status, and geographic location.

In addition, we used propensity score analyses to reduce the selection bias and the potential baseline differences between the regional anesthesia and general anesthesia groups. Propensity scores were computed by modeling a logistic regression model in which the dependent variable was whether the patient received regional anesthesia. The independent variables were the above-mentioned covariates. Then, each patient was weighted by the inverse propensity score when performing generalized estimating equation models to reduce the selection bias.39–43

In sensitivity analysis to examine the robustness of our results, we used Cox proportional hazard models with robust sandwich variance estimates (also called clustered Cox proportional hazard models or clustered survival analysis) and propensity score weighting, adjusted for all patient, surgeon,

| TABLE 2. Patient Outcomes by Anesthesia Type |
|-----------------|-----------------|-----------------|
|                | Total           | Regional Anesthesia | General Anesthesia |
|                | N   | %   | N   | %   | N   | %   | P   |
| No. of patients| 17,189 | 100.0 | 11,153 | 100.0 | 6036 | 100.0 | —   |
| 30-Day mortality| 293   | 1.7  | 189   | 1.7  | 104  | 1.7  | 0.891|
| No. of patients| 17,122 | 100.0 | 11,112 | 100.0 | 6010 | 100.0 | —   |
| 30-Day readmission | All-cause | 2103 | 12.3 | 1332 | 12.0 | 771 | 12.8 | 0.109|
|                | Specific-cause |                  |                  |                  |                  |
| Surgical site infection | 202 | 1.2 | 117 | 1.1 | 85 | 1.4 | 0.037|
| Sepsis          | 145   | 0.8  | 96   | 0.9  | 49  | 0.8  | 0.740|
| Acute respiratory failure | 67 | 0.4 | 42 | 0.4 | 25 | 0.4 | 0.704|
| Acute stroke    | 53    | 0.3  | 36   | 0.3  | 17  | 0.3  | 0.644|
| Acute myocardial infarction | 20 | 0.1 | 10 | 0.1 | 10 | 0.2 | 0.162|
| Acute renal failure | 15 | 0.1 | 11 | 0.1 | 4 | 0.1 | 0.494|
| Deep vein thrombosis | 10 | 0.1 | 6 | 0.1 | 4 | 0.1 | 0.745|
| Pneumonia       | 218   | 1.3  | 159 | 1.4  | 59  | 1.0  | 0.012|
| Urinary tract infection | 202 | 1.2 | 128 | 1.2 | 74 | 1.2 | 0.646|

COPD = chronic obstructive pulmonary disease, ED = emergency department, ICU = intensive care unit.
and hospital characteristics, to examine the association between anesthesia type and 30-day mortality and readmission.43,44 The models focused on time from admission until death, and time from discharge until the first rehospitalization date during the 30 days of follow-up. Patients were censored on date of death, or 30 days postadmission/postdischarge, whichever came first. All analyses were adjusted for clustering at the surgeon and hospital level with the use of robust sandwich variance estimates.43,44 The SAS 9.3 (SAS Institute, Cary, NC) was used for the analysis. All statistical testing was 2-sided at a significance level of 0.05.

RESULTS

We identified 19,971 patients undergoing hip fracture surgery aged 18 years and older admitted to hospitals in 2011, of which 1744 were removed for the second admission and thereafter. Data were excluded from patients treated by surgeons without cases in 2010 (N = 784) and admitted to hospitals without cases in 2010 (N = 201). We excluded 19 patients who received local or no anesthesia, and 34 patients who received both general and regional anesthesia. The final dataset consisted of 17,189 patients from 896 physicians and 239 hospitals. Nevertheless, when 30-day readmission was analyzed, we excluded 67 patients who died during hospital stay.

The study population characteristics are reported in Table 1. Of all patients, 64.9% received regional anesthesia, and 35.1% received general anesthesia. In the univariate analysis, Pearson Chi-square analysis showed the comparison of the patients who received regional anesthesia to those who received general anesthesia. Baseline characteristics that differed between the regional anesthesia and general anesthesia groups were patient age, comorbid conditions, fracture type, type of surgical procedure, multiple trauma, admission from ED, ICU use, length of stay, surgeon volume, orthopedic surgeon, surgeon age, hospital volume, hospital level, teaching status, and geographic location.

Patient outcomes are reported in Table 2. The 30-day mortality rate was 1.7%, and the 30-day readmission rate was 12.3%. Pearson Chi-square analysis showed no association of anesthesia type with 30-day mortality and readmission. However, 30-day surgical site infection and pneumonia readmission rates were different between the 2 anesthesia groups. As shown in Figure 1, the Kaplan–Meier analysis and log-rank test showed that patients receiving regional anesthesia had a similar survival rate, but had a marginally significantly higher readmission-free rate compared with patients receiving general anesthesia (P = 0.097).

Table 3 presents the results of the generalized estimating equation logistic regression analysis of 30-day mortality and readmission, with weighting by the inverse propensity score of receiving regional anesthesia for adjusting selection bias. Regional anesthesia was not associated with decreased 30-day all-cause mortality (odds ratio [OR] = 0.89, 95% confidence interval [CI]: 0.67–1.18). However, there were significant associations of anesthesia type with 30-day all-cause readmission and 30-day surgical site infection readmission. Patients receiving regional anesthesia had 17% lower odds of 30-day all-cause readmission and 31% lower odds of 30-day surgical site infection readmission compared with those receiving general anesthesia (OR = 0.83, 95% CI: 0.75–0.93 and OR = 0.69, 95% CI: 0.49–0.97, respectively). In sensitivity analysis, our overall results did not change significantly.

DISCUSSION AND CONCLUSIONS

This study was the first research using nationwide population-based data to evaluate the association of anesthesia type with 30-day all-cause mortality, 30-day all-cause readmission, and 30-day specific-cause readmission under bundled payments. We found that regional anesthesia was associated with decreased 30-day all-cause readmission and 30-day surgical site infection readmission, after adjusting for patient sex, age, comorbid conditions, fracture type, type of surgical procedure, multiple trauma, admission from ED, ICU use, length of stay, surgeon volume, orthopedic surgeon, surgeon age, hospital volume, hospital level, teaching status, and geographic location.

In Taiwan, about 65% of patients hospitalized for hip fracture surgery received regional anesthesia. The rate of receiving regional anesthesia in Taiwan was higher than that in the United States (about 10%).21 The result is possible because all hospitals in Taiwan are closed systems and are reimbursed for inpatient hip fracture surgery by bundled payments based on Taiwan diagnosis-related groups. Physicians only employed by hospitals can be allowed to treat inpatients, and hospitals also use variable pay to encourage staff physicians to provide efficient inpatient services under bundled payments.
| Outcomes                              | Univariate Analysis |                  |                  |                  | Multivariate Analysis |                  |                  |                  |                  |
|--------------------------------------|---------------------|------------------|------------------|------------------|-----------------------|------------------|------------------|------------------|------------------|
|                                      | Logistic            | Logistic         | GEE Logistic     | Clustered Cox    |                      |                  |                  |                  |                  |
|                                      | Regression          | Regression       | Regression       | Proportional     |                      |                  |                  |                  |                  |
|                                      | OR (95% CI)         | OR (95% CI)      | OR (95% CI)      | HR (95% CI)      | P                     | P                | P                | P                | P                |
| 30-Day mortality (N = 17,189)        | 0.98 (0.77–1.25)    | 0.99 (0.76–1.29) | 0.89 (0.67–1.18) | 0.90 (0.68–1.19) | 0.891                 | 0.930            | 0.409            | 0.447            | 0.447            |
| 30-Day readmission (N = 17,122)      | 0.93 (0.84–1.02)    | 0.87 (0.79–0.97) | 0.83 (0.75–0.93) | 0.85 (0.77–0.94) | 0.109                 | 0.100            | 0.001            | 0.002            |                  |
| All-cause                            |                     |                  |                  |                  |                       |                  |                  |                  |                  |
| Specific-cause                       |                     |                  |                  |                  |                       |                  |                  |                  |                  |
| Surgical site infection              | 0.74 (0.56–0.98)    | 0.74 (0.55–1.01) | 0.69 (0.49–0.97) | 0.68 (0.47–0.98) | 0.037                 | 0.055            | 0.031            | 0.037            | 0.037            |
| Sepsis                               | 1.06 (0.75–1.50)    | 0.95 (0.65–1.37) | 0.78 (0.51–1.20) | 0.77 (0.49–1.20) | 0.704                 | 0.711            | 0.258            | 0.250            | 0.250            |
| Acute respiratory failure            | 0.91 (0.55–1.49)    | 0.91 (0.53–1.55) | 0.92 (0.55–1.57) | 0.94 (0.55–1.58) | 0.016                 | 0.014            | 0.001            | 0.002            |                  |
| Acute stroke                         | 1.15 (0.64–2.04)    | 1.05 (0.57–1.93) | 0.98 (0.53–1.81) | 1.01 (0.56–1.83) | 0.644                 | 0.873            | 0.937            | 0.967            | 0.967            |
| Acute myocardial infarction          | 0.54 (0.23–1.30)    | 0.51 (0.20–1.33) | 0.53 (0.20–1.43) | 0.56 (0.20–1.53) | 0.169                 | 0.168            | 0.213            | 0.254            |                  |
| Acute renal failure                  | 1.49 (0.47–4.68)    | 1.16 (0.34–3.98) | 1.28 (0.40–4.09) | 1.34 (0.52–3.44) | 0.496                 | 0.809            | 0.683            | 0.542            | 0.542            |
| Deep vein thrombosis                 | 0.81 (0.23–2.88)    | 0.86 (0.22–3.33) | 1.02 (0.28–3.69) | 1.10 (0.32–3.82) | 0.746                 | 0.832            | 0.976            | 0.876            |                  |
| Pneumonia                            | 1.46 (1.08–1.98)    | 1.35 (0.97–1.87) | 1.24 (0.85–1.83) | 1.25 (0.85–1.84) | 0.013                 | 0.074            | 0.266            | 0.254            |                  |
| Urinary tract infection              | 0.94 (0.70–1.25)    | 0.86 (0.63–1.17) | 0.83 (0.60–1.16) | 0.84 (0.60–1.17) | 0.646                 | 0.339            | 0.279            | 0.295            |                  |

CI = confidence interval, GEE = generalized estimating equation, HR = hazard ratio, OR = odds ratio.

1The models were adjusted for patient sex, age, comorbid conditions, fracture type, type of surgical procedure, multiple trauma, admission from emergency department, intensive care unit use, length of hospital stay, surgeon volume, specialty, and age, hospital volume, hospital level, teaching, and geographic location.

2The models were weighted by the inverse of a propensity score.
As a result, patients are more likely to receive regional anesthesia in Taiwan.

The finding of no association between anesthesia type and 30-day mortality for hip fracture surgery is consistent with that of 4 previous studies using 30-day mortality as an outcome measure, 6,22–24 and that of 2 previous studies using in-hospital mortality. 18,21 Nevertheless, 1 previous study using 30-day mortality, 18 and 2 previous studies using in-hospital mortality, 16,19 found an association between regional anesthesia and lower mortality. One reason for the differences in the findings is that in-hospital mortality is more subject to detection bias than 30-day mortality. 6 Because some patients might have been discharged from the hospital before the potential death. 23,42,45 Research has shown that in-hospital mortality measures systematically favor hospitals with shorter lengths of stay. 46 Thirty days is a standard time frame that can be strongly influenced by hospital care; therefore, the 30-day outcome time frame is necessary so that outcomes for each patient are measured consistently. 11 The result of outcomes research using 30-day mortality is more valid than that using in-hospital mortality.

Another reason is whether selection bias from observational studies is corrected. Only 1 observational study using 30-day mortality found the association between regional anesthesia and lower mortality. 18 The limitation of Radcliff et al’s study was the lack of a correction for selection bias due to the nonrandom selection of patients for one form of anesthesia or another. 22 To overcome the limitation, recent related studies used propensity score methods to correct for the selection bias and provide more valid analysis results. 15,16,19,20,22,24,27 Regarding the studies using 30-day mortality and a propensity score method, the finding of this study is consistent with that of the other studies. 22,24 If a beneficial impact of regional anesthesia on short term mortality exists, it is likely to be more modest than previously reported. 21

The notable finding was that regional anesthesia was associated with lower 30-day all-cause readmission. This finding of an association between regional anesthesia and lower 30-day readmission is consistent with Mesko et al’s 47 regarding total hip and knee arthroplasty. Mesko et al’s inference that the mechanism underlying the association is through lower 30-day complications based on previous studies finding an association between regional anesthesia and reduced complications. However, the finding is inconsistent with 3 previous studies. 18,20,24 In Radcliff et al’s and Le-Wendling et al’s studies, 18,20 there may be a measurement bias because 30-day readmission was determined by whether patients were admitted to a Veterans Health Administration hospital and the same hospital, respectively, rather than any hospital. Basques et al’s study population was patients aged 70 years and older in participating hospitals 42,44 rather than the nationwide population, so whether the finding generalizes to the nationwide population is uncertain.

This finding of an association between regional anesthesia and lower 30-day surgical site infection readmission is consistent with Radcliff et al’s 18 using 30-day complications, and Chang et al’s 15 regarding 30-day surgical site infection for total hip or knee replacement. Based on Chang et al’s reason for the association between regional anesthesia and lower 30-day surgical site infection, 15 they proposed that compared with general anesthesia, regional anesthesia has a sympathetic blocking effect that improves tissue perfusion and oxygenation, 18,49 increases polymorphonuclear cells at surgical sites, 49 and can better maintain regional normothermia. 51 Thus, regional anesthesia could still contribute to an environment strengthening the host defense against surgical pathogens, leading to reduced 30-day surgical site infection. 15 Therefore, regional anesthesia might be more effective in preventing 30-day surgical site infection readmission for hip fracture surgery.

Our study has 2 limitations. First, in common with other hip surgery studies using administrative databases, 15,16,19,21,22 no information on certain relevant clinical details (eg, body mass index, operation time) 17,24,25 was available for risk adjustment. Nevertheless, we controlled for patient sex, age, comorbid conditions, admission from ED, and ICU use, which are also important when adjusting for the complexity of the illness. 15,16,19,21,22 Second, because we lacked detailed intraoperative data, we could not examine the degree to which regional anesthesia outcomes might vary based on the type of block performed or the depth of sedation. 52,53

Anesthetic type does not affect 30-day mortality for hip fracture surgery, but hip fracture surgery patients receiving regional anesthesia have a lower risk of 30-day all-cause readmission and 30-day surgical site infection readmission than those receiving general anesthesia. These findings may support the notion that recent practice guidelines have advocated greater use of regional anesthesia for hip fracture surgery. 7–9 Thirty-day readmission is an important indicator when evaluating hospital care. Higher readmission rates signal concerns about outcomes of hospital care. The management of hip fracture surgery using regional anesthesia may offer benefits in terms of 30-day readmission, especially under the implementation of bundled payments including related readmissions for 30 days after hospital discharge, or the Hospital Readmissions Reduction Program.

ACKNOWLEDGMENTS

The interpretation and conclusions contained herein do not represent those of National Health Insurance Administration, Ministry of Health and Welfare and National Health Research Institutes.

REFERENCES

1. Gullberg B, Johnell O, Kanis J. World-wide projections for hip fracture. Osteoporos Int. 1997;7:407–413.
2. Johnell O, Kanis J. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. Osteoporos Int. 2006;17:1726–1733.
3. Parker M, Johansen A. Hip fracture. BMJ. 2006;333:27–30.
4. Parker MJ, Handoll HH, Griffiths R. Anaesthesia for hip fracture surgery in adults. Cochrane Database Syst Rev. 2004:CD000521.
5. UK National Clinical Guideline Centre. The Management of Hip Fracture in Adults. London, England: UK National Clinical Guideline Centre; 2011.
6. O’Hara DA, Duff A, Berlin JA, et al. The effect of anesthetic technique on postoperative outcomes in hip fracture repair. Anesthesiology. 2000;92:947–957.
7. Griffiths R, Alper J, Beckingsale A, et al. Management of proximal femoral fractures 2011: association of Anaesthetists of Great Britain and Ireland. Anaesthesia. 2012;67:85–98.
8. Boulton C, Currie C, Griffiths R, et al. National Hip Fracture Database: Anaesthesia Sprint Audit of Practice London, England: Royal College of Physicians; 2014.
9. Scottish Intercollegiate Guidelines Network. Management of Hip Fracture in Older People. Edinburgh, Scotland: Scottish Intercollegiate Guideline Network; 2009.
10. Agency for Healthcare Research and Quality. Inpatient quality indicators: technical specifications. 2015. Available at: http://www.qualityindicators.ahrq.gov/Modules/IQI_TechSpec.aspx. Accessed March 31, 2015.

11. Centers for Medicare and Medicaid Services. CMS publicly reported risk-standardized outcome measures. 2015. Available at: http://www.qualitynet.org/dcs/ContentServer?cidd=1228774681760&Filename=QNetPublic%2FPage%2FQnetTier4&c=Page. Accessed May 10, 2015.

12. Centers for Medicare and Medicaid Services. Readmissions Reduction Program. 2012. Available at: http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html. Accessed August 15, 2014.

13. Rodgers A, Walker N, Schug S, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. BMJ. 2000;321:1–12.

14. Luger TJ, Kammerlander C, Gosch M, et al. Neuroaxial versus general anaesthesia in geriatric patients for hip fracture surgery: does it matter? Osteoporos Int. 2010;21:S55–S57.

15. Chang CC, Lin HC, Lin HW, et al. Anesthetic management and surgical site infections in total hip or knee replacement: a population-based study. Anesthesiology. 2010;113:279–284.

16. Neuman MD, Silber JH, Elkassabany NM, et al. Comparative effectiveness of regional versus general anesthesia for hip fracture surgery in adults. Anesthesiology. 2012;117:72–92.

17. Rashid RH, Shah AA, Shakoor A, et al. Hip fracture surgery: does type of anesthesia matter? J Biomed Res Int. 2013;2013:252–356.

18. Radcliff TA, Henderson WG, Stoner TJ, et al. Patient risk factors, operative care, and outcomes among older community-dwelling male veterans with hip fracture. J Bone Joint Surg Am. 2008;90:34–42.

19. Chu CC, Weng SF, Chen KT, et al. Propensity score-matched comparison of postoperative adverse outcomes between geriatric patients given a general or a neuraxial anesthetic for hip surgery: a population-based study. Anesthesiology. 2015;123:136–147.

20. Le-Wendling L, Bihorac A, Baslanti TO, et al. Regional anesthesia as compared with general anesthesia for surgery in geriatric patients with hip fracture: does it decrease morbidity, mortality, and health care costs? Results of a single-centered study. Pain Med. 2012;13:948–956.

21. Paterno E, Neuman MD, Schneeweiss S, et al. Comparative safety of anesthetic type for hip fracture surgery in adults: retrospective cohort study. BMJ. 2014;348:g4022.

22. Neuman MD, Rosenbaum PR, Ludwig JM, et al. Anesthesia technique, mortality, and length of stay after hip fracture surgery. JAMA. 2014;311:2508–2517.

23. White SM, Moppett IK, Griffiths R. Outcome by mode of anaesthesia for hip fracture surgery. An observational audit of 65 535 patients in a national dataset. Anaesthesia. 2014;69:224–230.

24. Basques BA, Bohl DD, Golivaux NS, et al. General versus spinal anaesthesia for patients aged 70 years and older with a fracture of the hip. Bone Joint J. 2015;97-B:689–695.

25. Miller BJ, Lu X, Cram P. The trends in treatment of femoral neck fractures in the Medicare population from 1991 to 2008. J Bone Joint Surg Am. 2013;95:e132.

26. Krumholz HM, Merrill AR, Schone EM, et al. Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. Circ Cardiovasc Qual Outcomes. 2009;2:407–413.

27. Basques BA, Toy JO, Bohl DD, et al. General compared with spinal anesthesia for total hip arthroplasty. J Bone Joint Surg Am. 2015;97:455–461.

28. D’Hoore W, Bouckaert A, Tilquin C. Practical considerations on the use of the Charlson comorbidity index in administrative data bases. J Clin Epidemiol. 1996;49:1429–1433.

29. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic mortality in longitudinal studies: development and validation. J Chronic Dis. 1987;40:373–383.

30. D’Hoore W, Sicotte C, Tilquin C. Risk adjustment in outcome assessment: the Charlson comorbidity index. Methods Inf Med. 1993;32:382–387.

31. Gruskay JA, Basques BA, Bohl DD, et al. Short-term adverse events, length of stay, and readmission after iliac crest bone graft for spinal fusion. Spine. 2014;39:1718–1724.

32. Ho V, Aloia T. Hospital volume, surgeon volume, and patient costs for cancer surgery. Med Care. 2008;46:718–725.

33. Murata A, Matsuda S, Kusabara K, et al. An observational study using a national administrative database to determine the impact of hospital volume on compliance with clinical practice guidelines. Med Care. 2011;49:313–320.

34. Tung YC, Chang GM, Chien KL, et al. The relationships among physician and hospital volume, processes, and outcomes of care for acute myocardial infarction. Med Care. 2014;52:519–527.

35. Bulka CM, Shotwell MS, Gupta RK, et al. Regional anesthesia, time to hospital discharge, and in-hospital mortality: a propensity score matched analysis. Reg Anesth Pain Med. 2014;39:381–386.

36. Teeenrenstra S, Lu B, Preisser JS, et al. Sample size considerations for GEE analyses of three-level cluster randomized trials. Biometrics. 2010;66:1230–1237.

37. Austin PC. A comparison of the statistical power of different methods for the analysis of cluster randomization trials with binary outcomes. Stat Med. 2007;26:3550–3565.

38. Agresti A. An Introduction to Categorical Data Analysis. Hoboken, NJ: Wiley-Interscience; 2007.

39. Hirano K, Imbens GW, Radder G. Efficient estimation of average treatment effects using the estimated propensity score. Econometrica. 2003;71:1161–1189.

40. Huang IC, Frangakis C, Dominici F, et al. Application of a propensity score approach for risk adjustment in profiling multiple physician groups on asthma care. Health Serv Res. 2005;40:253–278.

41. Yang G, Stemkovski S, Saunders WB. A review of propensity score application in healthcare outcome and epidemiology. 2007Available at: http://www.lexjansen.com/pharmasug/2007/pr/pr02.pdf. Accessed February 18, 2015.

42. Tung YC, Chang GM, Chen YH. Associations of physician volume and weekend admissions with ischemic stroke outcome in Taiwan: a nationwide population-based study. Med Care. 2009;47:1018–1025.

43. Chang HY, Zhou M, Tang W, et al. Risk of gastrointestinal bleeding associated with oral anticoagulants: population based retrospective cohort study. BMJ. 2015;350:h1585.

44. Pahayo R, Kawachi I, Munenig P. Political party affiliation, political ideology and mortality. J Epidemiol Community Health. 2015;69:423–431.

45. Centers for Medicare and Medicaid Services. Frequently asked questions (FAQs): implementation and maintenance of CMS mortality measures for AMI & HF. 2007. Available at: https://www.cms.gov/HospitalQualityInitiatives/downloads/HospitalMortalityAboutAMI_HF.pdf. Accessed January 1, 2016.

46. Drey E, Normand SL, Wang Y, et al. Comparison of hospital risk-standardized mortality rates calculated by using in-hospital and 30-day models: an observational study with implications for hospital profiling. Ann Intern Med. 2012;156:19–26.

47. Mesko NW, Bachmann KR, Kovacevic D, et al. Thirty-day readmission following total hip and knee arthroplasty—a preliminary
single institution predictive model. *J Arthroplasty.* 2014;29:1532–1538.

48. Kabon B, Fleischmann E, Treschan T, et al. Thoracic epidural anesthesia increases tissue oxygenation during major abdominal surgery. *Anesth Analg.* 2003;97:1812–1817.

49. Treschan TA, Taguchi A, Ali SZ, et al. The effects of epidural and general anesthesia on tissue oxygenation. *Anesth Analg.* 2003;96:1553–1557.

50. Mauermann WJ, Nemergut EC. The anesthesiologist’s role in the prevention of surgical site infections. *Anesthesiology.* 2006;105:413–421.

51. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. *N Engl J Med.* 1996;334:1209–1215.

52. Sieber FE, Zakriya KJ, Gottschalk A, et al. Sedation depth during spinal anesthesia and the development of postoperative delirium in elderly patients undergoing hip fracture repair. *Mayo Clin Proc.* 2010;85:18–26.

53. Brown CHt, Azman AS, Gottschalk A, et al. Sedation depth during spinal anesthesia and survival in elderly patients undergoing hip fracture repair. *Anesth Analg.* 2014;118:977–980.