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

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ABSTRACT

Background: The effects of the mode of anesthesia on major adverse postoperative outcomes in geriatric patients are still inconclusive. The authors hypothesized that a neuraxial anesthetic (NA) rather than a general anesthetic (GA) would yield better in-hospital postoperative outcomes for geriatric patients undergoing hip surgery.

Methods: The authors used data from Taiwan's 1997–2011 in-patient claims database to evaluate the effect of anesthesia on in-hospital outcomes. The endpoints were mortality, stroke, transient ischemic stroke, myocardial infarction, respiratory failure, and renal failure. Of the 182,307 geriatric patients who had hip surgery, a GA was given to 53,425 (29.30%) and an NA to 128,882 (70.70%). To adjust for baseline differences and selection bias, patients were matched on propensity scores, which left 52,044 GA and 52,044 NA patients.

Results: GA-group patients had a greater percentage and higher odds of adverse in-hospital outcomes than did NA-group patients: death (2.62 *vs.* 2.13%; odds ratio [OR], 1.24; 95% CI, 1.15 to 1.35; $P < 0.001$), stroke (1.61 *vs.* 1.38%; OR, 1.18, 95% CI, 1.07 to 1.31; $P = 0.001$), respiratory failure (1.67 *vs.* 0.63%; OR, 2.71; 95% CI, 2.38 to 3.01; $P < 0.001$), and intensive care unit admission (11.03 *vs.* 6.16%; OR, 1.95; 95% CI, 1.87 to 2.05; $P < 0.001$), analyzed using conditional logistic regression. Moreover, patients given a GA had longer hospital stays (10.77 ± 8.23 *vs.* 10.44 ± 6.67 days; 95% CI, 0.22 to 0.40; $P < 0.001$) and higher costs (New Taiwan Dollars [NT$] 86,606 ± NT$74,162 *vs.* NT$74,494 ± NT$45,264; 95% CI, 11,366 to 12,859; $P < 0.001$).

Conclusion: For geriatric patients undergoing hip surgery, NA was associated with fewer odds of adverse outcomes than GA.
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HIP fracture is the second leading cause of hospitalization for the elderly and is becoming a major public health problem as the mean age of the population increases.[1–4] The incidence increases considerably with age, increasing from 22.5 (men) and 23.9 (women) per 100,000 population at age 50 to 630.2 (men) and 1,289.3 (women) per 100,000 population by age 80.[5] Moreover, hip fractures are often associated with devastating complications that create medical and financial burdens for society. The risks of fatal or life-threatening events for geriatric patients increase several-fold after hip surgery.[2,6] Many factors affect the outcomes of patients after hip surgery: age, timing of surgery, comorbidities, *etc.*[7–10] There is a debate on whether the type of anesthesia has any substantive effect on these risks.[11–13] A neuraxial anesthetic (NA) rather than a general anesthetic (GA) has the advantages of fewer incidents of deep vein thrombosis (DVT), less postoperative cognitive dysfunction, fewer cases of pneumonia, fewer fatal pulmonary embolisms, and less postoperative hypoxia.[11] Whether an

What We Already Know about This Topic

- Fracture and degenerative disease make hip surgery common in the elderly
- Previous studies suggest that neuraxial anesthetic techniques may have some advantages over general anesthesia for hip surgery

What This Article Tells Us That Is New

- Using Taiwan's in-patient claims database, the effect of anesthetic technique on in-hospital outcomes was assessed
- Neuraxial techniques were found to have lower rates of in-hospital adverse outcomes of several types including mortality, stroke, and others

Parts of the data were presented as a poster at the 2012 Euroanaesthesia Annual Meeting, Barcelona, Spain, May 31 to June 2, 2012.

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NA reduces other major complications, such as mortality, acute postoperative stroke, myocardial infarction, and renal failure, is still controversial because most studies have been limited either by small sample sizes[11–16] or by medical center records,[17–20] both of which may result in underestimating the rates of adverse outcomes in the general population. Two meta-analyses,[15,16] therefore, were unable to decide whether a GA or an NA induced more major postoperative morbidities. One recent large-scale report[21] using the New York State In-patient Database found that patients given an NA were associated with fewer pulmonary complications and less in-hospital mortality than were patients given a GA. Because the median age of the populations of most developed countries is increasing, the number of elderly (≥70 yr old) patients is growing, and the healthcare resources burden that elderly patients place on societies is increasing,[22] a conclusive answer to this question is becoming more important. More large-scale nationwide population-based studies are urgently needed before we can confidently conclude what the effects are of the mode of anesthesia on the occurrence of adverse outcomes in hip fracture surgery.

We hypothesized that an NA rather than a GA would be associated with better in-hospital outcomes for geriatric patients given hip repair surgery. We also hypothesized that the association of the mode of anesthesia with outcomes would be different between patients with different fracture types and the hospital accreditation levels. To address this issue, we used Taiwan's 14-yr nationwide population-based National Health Insurance Research Database (NHIRD) as our data source to test our hypothesis. Our primary outcome was in-hospital mortality. Moreover, we focused on five other major adverse in-hospital outcomes as our secondary endpoints: stroke, transient ischemic attack (TIA), respiratory failure, renal failure, and myocardial infarction. Furthermore, we compared the need for mechanical ventilator support, the need for prolonged intensive care unit (ICU) stays, the length of hospital stays (LOHS), and the total hospital costs between these two cohorts as our tertiary endpoints because the economic burden is another worthwhile concern.

Materials and Methods

Database

Taiwan launched a single-payer National Health Insurance (NHI) program on March 1, 1995. The NHI offers comprehensive medical care coverage to all Taiwan residents. As of 2011, approximately 22.60 million (>99%) of Taiwan's 22.96 million legal residents (citizens and noncitizens) were enrolled in this program. The NHIRD provides encrypted patient identification numbers, sex, date of birth, dates of admission and discharge, the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes of diagnoses (up to five) and procedures (up to five), details of prescriptions, and costs covered and paid for by the NHI.

We used the in-patient claims database for 1997 to 2011 because almost all patients with hip fractures in Taiwan are hospitalized. The dataset was released with deidentified secondary data for public research. The Taiwan National Health Research Institutes approved the current study. Moreover, because all types of personal identification were encrypted to secure patient privacy, the current study was granted an exemption from a full ethical review by the Chi Mei Hospital Institutional Review Board (Tainan, Taiwan).

Selection of Patients and Variables

The inclusion criteria were that all patients had to be 65 yr old or older, have an ICD-9-CM principal discharge diagnosis code of 820.X, have been surgically treated and assigned at least one of the following treatment codes: (1) closed reduction of fracture with internal fixation (ICD-9-CM 79.1), (2) open reduction of fracture with internal fixation (ICD-9-CM 79.3), (3) total hip arthroplasty (ICD-9-CM 81.5), or (4) hemiarthroplasty (ICD-9-CM 81.4). We excluded patients coded as treated with both a GA and an NA, only a local anesthetic, or no anesthetic. We focused on osteoporosis-related fracture; therefore, patients diagnosed with pathological fractures (codes 733.14 and 733.15), and patients who presented with a code (or codes) other than a hip fracture, which indicated multiple trauma (appendix 1), were also excluded (fig. 1). In addition, to prevent repeating the calculation, patients with repeated admissions under the same main diagnostic codes within 30 days were considered to have a single admission, and the length of stay was determined by adding the days of these admissions, that is, the days of the first admission plus the days of the second admission.

The participants were then stratified into two groups according to the type of anesthetic used for the surgery: (1) GA (order codes 96020C-96022C) and (2) NA: spinal anesthesia (order codes 96007C and 96008C) and epidural anesthesia (order codes 96005C and 96006C).

We also recorded the comorbidities of hypertension (ICD-9-CM codes 401 to 405), diabetes mellitus (ICD-9-CM code 250, 357.2, and 362.0), hyperlipidemia (ICD-9-CM code 272), chronic obstructive pulmonary disease (ICD-9-CM codes 490 to 496), heart disease (ICD-9-CM codes 393 to 398 and 424), dementia (ICD-9-CM codes 290, 294, and 331), and renal disease (ICD-9-CM codes 582, 583, 585, 586, and 588) (appendix 2). A modified Charlson Comorbidity Index (CCI)[23] was used to infer the health status of each patient: higher sums of weighted scores indicated greater disease severity; therefore, the CCI was used as a surrogate for the American Society of Anesthesiologists (ASA) physical status classification system.[24]

The accreditation levels of hospitals were also recorded in the database. According to the Taiwan Joint Commission on Hospital Accreditation, hospitals are classified as medical centers, regional hospitals, and local hospitals. Generally, medical centers in Taiwan have 1,000 to 2,500 beds and

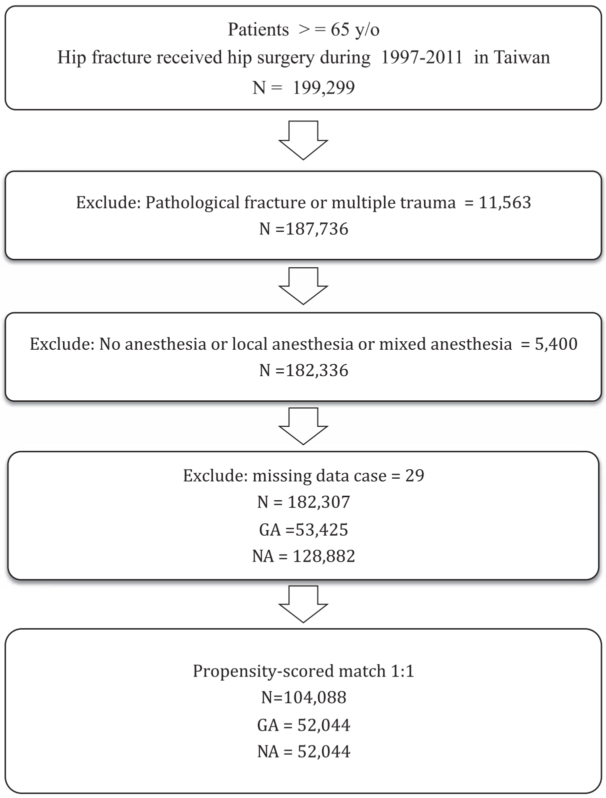

Fig. 1. Flow chart of the creation of the study sample. GA = general anesthesia; NA = neuraxial anesthesia.

provide tertiary care. Regional hospitals have 301 to 999 beds and provide secondary care. Local hospitals have fewer than 300 beds and provide primary care. In addition, medical centers do more staff training than do regional hospitals and local hospitals, which provide medical care to local areas and do not have a great training burden.[25]

Propensity Score Matching

We used propensity score–matched analyses to reduce the selection bias and potential baseline differences between the GA and NA groups. Propensity scores were computed using modeling a logistic regression model in which the dependent variable was whether the patient was given an NA. The independent variables were age, sex, baseline comorbidities, the modified CCI score, fracture type (intracapsular and extracapsular: further subdivided into trochanteric, intertrochanteric, and subtrochanteric), surgery type (total hip replacement, hemiarthroplasty, revision hip replacement, and internal fixation), and hospital type (medical center, regional hospital, and local hospital). These selected variables were based on prior subject matter knowledge and empirical observation.[7–10]

The multivariate regression model of propensity for patients given an NA had a *C*-statistic of 0.64. Before matching, patients managed with an NA (n = 128,882) had a median propensity score of 0.285475 (Q1~Q4: 0.183218~0.351895), and those managed with a GA (n = 53,425) had a median propensity score of 0.334389 (Q1~Q4: 0.268511~0.398691).

An SAS (SAS Institute, USA) matching macro, "%OneToManyMTCH,"[26] was used for this matching. It allows propensity score matching from 1-to-1 to 1-to-N. We set a caliper for nearest-neighbor matching within the first four to eight digits; for example, two patients with propensity scores of 0.12345678 and 0.12347123 matches on the first four digits (0.1234). The macro makes the "best" matches first and the "next-best" matches next in a hierarchical sequence until no more matches can be made. If no GA patient has a propensity score that lies within a four-digit width of an NA patient's propensity score, then that NA patient is left unmatched and is not used in subsequent analyses.

Each GA patient was selected once at most. To verify the balance between the GA and NA groups, the standardized difference[27] was computed to compare the distribution of the baseline covariates between the GA and NA groups. This matching resulted in two final study cohorts of 52,044 each (fig. 1). After matching, either NA-group or GA-group patients had a median propensity score of 0.332136 (Q1~Q4, 0.268312~0.394289). For these covariates, all standardized differences were less than 0.01 after propensity score matching.

Study Endpoints

Our study endpoints were in-hospital mortality (discharge death code) and five outcomes: (1) acute stroke (ICD-9-CM codes 430 to 436 and 997.02), (2) transient ischemic stroke (ICD-9-CM code 435), (3) acute myocardial infarction (AMI) (ICD-9-CM code 410), (4) acute respiratory failure (ICD-9-CM codes 518.81 to 518.82, 518.84, and 518.5), and (5) acute renal failure (ICD-9-CM codes 584.5 to 584.9) with hemodialysis (procedure code 39.95) or peritoneal dialysis (procedure code 54.98). Because it is customary for many Taiwanese to want to "die at home," "in-hospital death" coded at discharge necessarily underestimates true hospital mortality. Therefore, except when "in-hospital death" was coded, we also presumed an in-hospital death for patients who withdrew from the NHI program within 30 days of hospital discharge because the NHI requires that expired patients be withdrawn within 30 days and because emigration, another reason for withdrawal, is highly unlikely shortly after surgery for a severe disease.

Our tertiary endpoints included (1) the need for ventilator support (order code 57001B), (2) duration of intensive care stay (order codes: 03010E, 03011F, 03012G, and 03013H), (3) LOHS, and (4) total hospital cost (New Taiwan Dollars [NT$]).

Statistical Analysis

SAS 9.3.1 for Windows (SAS Institute, Inc.) was used for this study. The differences in baseline characteristics and comorbid variables between the two cohorts were evaluated using Student *t* test for continuous variables and Pearson chi-square tests for categorical variables. The distributions of stroke type, ICU admission, and ventilator support were calculated using Pearson chi-square tests. Moreover, the odds ratio (OR) and 95% CI were calculated using conditional logistic regression without further adjustment because the potential confounding factors were bundled by propensity score matching. The differences and 95% CIs of hospital stays and the costs of the two cohorts were calculated using Student *t* test. No *a priori* power calculations were conducted because this study is a retrospective study. To account for multiple outcome testing, we used the Bonferroni correction. Significance was set at *P* value less than 0.00625 (*i.e.*, 0.05/8).

Results

Overall, 182,307 geriatric patients in Taiwan were given a GA or an NA for hip fracture repair surgery between 1997 and 2011 (table 1). The 53,425 GA-group patients (29.30%) were younger. The NA-group patients had more comorbid chronic obstructive pulmonary disease but less dementia, diabetes mellitus, hypertension, heart disease, and renal disease. The GA-group patients had a higher CCI than did the NA-group patients.

In our two propensity score–matched cohorts, GA-group patients had a greater percentage and higher odds of in-hospital mortality than did NA-group patients (2.62 *vs.* 2.13%; OR, 1.24; 95% CI, 1.15 to 1.35; *P* < 0.001), analyzed using conditional logistic regression (table 2). Moreover, for major adverse outcomes, the incidence and odds of acute stroke were higher in GA-group patients (1.61 *vs.* 1.38%; OR, 1.18; 95% CI, 1.07 to 1.31; *P* = 0.001). Most of the strokes in both groups were ischemic: 594 of 840 strokes (70.71%) in the GA group and 545 of 717 strokes (76.01%) in the NA group; only 91 strokes (10.83%) in the GA group and 47 strokes (6.56%) in the NA group were hemorrhagic; however, the incidence of TIAs was not significantly different between these two cohorts (GA *vs.* NA: 0.17 *vs.* 0.18%; OR, 0.95; 95% CI, 0.71 to 1.27; *P* = 0.71). Furthermore, GA-group patients had a significantly higher percentage and odds of acute respiratory failure than did NA-group patients (1.67 *vs.* 0.63%; OR, 2.71; 95% CI, 2.38 to 3.08; *P* < 0.001). The incidence and odds of in-hospital AMI (GA *vs.* NA: 0.36 *vs.* 0.32%; OR, 1.11; 95% CI, 0.90 to 1.37; *P* = 0.31) and renal failure that required acute dialysis (0.15 *vs.* 0.11%; OR, 1.40; 95% CI, 0.99 to 1.98; *P* = 0.06) were not significantly different.

Within the propensity score–matched cohorts, GA-group patients had a significantly higher percentage and odds of ICU admissions (11.03 *vs.* 6.16%; OR, 1.95; 95% CI, 1.87 to 2.07; *P* < 0.001), more GA-group patients had significantly longer ICU stays (≥3 days: 2.32 *vs.* 0.79%; *P* < 0.001), needed significantly more postoperative ventilator support (7.70 *vs.* 1.44%; OR, 6.08; 95% CI, 5.59 to 6.61; *P* < 0.001), had a significantly longer LOHS (10.77 ± 8.23 *vs.* 10.44 ± 6.67 days; 95% CI, 0.22 to 0.40%; *P* < 0.001), and had significantly higher total hospital expenditures (NT$86,606 ± NT$74,162 *vs.* NT$74,494 ± NT$45,263; 95% CI, 11,366 to 12,859; *P* < 0.001) (table 3).

Regardless of whether their hip fracture was intracapsular or extracapsular, GA-group patients were always associated with higher odds for in-hospital mortality, respiratory failure, ICU admission, and the need for ventilator support than were NA-group patients. Moreover, patients with extracapsular hip fractures who underwent surgery with a GA had higher odds for an in-hospital stroke (estimated OR, 1.33; 95% CI, 1.14 to 1.53; *P* < 0.001). However, for intracapsular hip fracture patients, a GA was not associated with higher odds for a stroke than was an NA (OR, 1.07; 95% CI, 0.92 to 1.24; *P* = 0.37). In addition, neither the postoperative odds for in-hospital acute renal failure nor the odds for an in-hospital AMI for intracapsular or extracapsular hip fracture patients who underwent surgery with a GA or an NA were significantly different (table 4).

Regardless of whether patients underwent hip surgery in a medical center, regional hospital, or local hospital, GA-group patients had higher odds for in-hospital mortality, acute respiratory failure, ICU admission, and the need for mechanical ventilator support. However, for patients treated in a medical center or local hospital, the odds for an acute stroke were not significantly different between the GA and NA groups (medical center: OR, 0.99; 95% CI, 0.83 to 1.18; *P* = 0.89; local hospital: OR, 1.22, 95% CI, 0.938 to 1.60; *P* = 0.15) (table 5). This result was different for patients treated in a regional hospital, in which GA-group patients were estimated to have 1.33 times higher odds (95% CI, 1.15 to 1.54; *P* < 0.001) for an in-hospital stroke. The odds for a TIA, AMI, or renal failure, however, were not different regardless of the type of hospital.

We divided the study periods into two subperiods (1997–2004 and 2005–2011) to analyze the temporal effect on the association of anesthesia and bad outcomes. We found that, in both subperiods, GA was associated with higher odds of in-hospital death, acute respiratory failure, ICU admission, and ventilator support than with NA. Although GA was associated with higher odds of acute stroke between 1997 and 2004 (OR, 1.39; 95% CI, 1.13 to 1.51; *P* = 0.002), it was not between 2005 and 2011 (OR, 1.22; 95% CI, 1.00 to 1.48; *P* = 0.046) (table 6).

Discussion

We found that in-hospital mortality, stroke, and acute respiratory failure were more likely outcomes for elderly patients given a GA for hip fracture repair surgery than for those given an NA. In particular, patients with an extracapsular hip fracture, and those treated in regional hospitals and given a GA, had greater odds for postoperative stroke than did patients

Table 1. Demographic and Clinical Characteristics of Patients Diagnosed with a Hip Fracture and Given Hip Repair Surgery

	Before Propensity Score Matching (n = 182,307)				After Propensity Score Matching (n = 104,088)*			
	GA	NA	*P* Value	Standardized Difference	GA	NA	*P* Value	Standardized Difference
n (%)	53,425 (29.30)	128,882 (70.70)			52,044 (50.00)	52,044 (50.00)		
Age (yr)†	78.26 ± 7.07	79.29 ± 7.10	<0.001	0.15	78.32 ± 7.13	78.26 ± 7.07	0.15	0.01
65–69	6,682 (12.51)	12,467 (9.67)	<0.001	0.09	6,197 (11.91)	6,197 (11.91)	1.00	<0.01
70–74	10,328 (19.33)	21,902 (16.99)		0.06	9,963 (19.14)	9,979 (19.17)		<0.01
75–79	13,377 (25.04)	31,069 (24.11)		0.02	13,116 (25.20)	13,116 (25.20)		<0.01
80–84	12,345 (23.11)	32,165 (24.96)		0.04	12,209 (23.46)	12,227 (23.49)		<0.01
>85	10,693 (20.01)	31,279 (24.27)		0.10	10,559 (20.29)	10,525 (20.22)		<0.01
Sex								
Male	19,308 (36.14)	51,014 (39.58)	<0.001	0.07	18,853 (36.23)	18,860 (36.24)	0.96	<0.01
Female	34,117 (63.86)	77,868 (60.42)		0.07	33,191 (63.77)	33,184 (63.76)		<0.01
Comorbidities								
CCI 0	25,255 (47.27)	63,758 (49.47)	<0.001	0.04	24,965 (47.97)	25,015 (48.07)	0.67	<0.01
CCI 1	16,131 (30.19)	37,670 (29.23)		0.02	15,596 (29.97)	15,663 (30.10)		<0.01
CCI ≥2	12,039 (22.53)	27,454 (21.30)		0.03	11,483 (22.06)	11,366 (21.84)		0.01
Dementia								
No	49,716 (93.06)	120,812 (93.74)	<0.001		48,603 (93.39)	48,647 (93.47)	0.58	
Yes	3,709 (6.94)	8,070 (6.26)		0.03	3,441 (6.61)	3,397 (6.53)		<0.01
Diabetes mellitus								
No	39,286 (73.53)	97,496 (75.65)	<0.001		38,378 (73.74)	38,339 (73.67)	0.78	
Yes	14,139 (26.47)	31,386 (24.35)		0.05	13,666 (26.26)	13,705 (26.33)		<0.01
Hypertension								
No	30,938 (57.91)	76,915 (59.68)	<0.001		30,189 (58.01)	30,178 (57.99)	0.94	
Yes	22,487 (42.09)	51,967 (40.32)		0.04	21,855 (41.99)	21,866 (42.01)		<0.01
Hyperlipidemia								
No	52,448 (98.17)	126,659 (98.28)	0.12		51,104 (98.19)	51,042 (98.07)	0.16	
Yes	997 (1.83)	2,223 (1.72)		0.01	940 (1.81)	1,002 (1.93)		0.01
Heart disease								
No	50,946 (95.36)	124,027 (96.23)	<0.001		49,846 (95.78)	49,957 (95.99)	0.08	
Yes	2,479 (4.64)	4,855 (3.77)		0.04	2,198 (4.22)	2,087 (4.01)		0.01
Renal disease								
No	50,490 (94.51)	122,607 (95.13)	<0.001		49,386 (94.49)	49,494 (95.10)	0.12	
Yes	2,935 (5.49)	6,275 (4.87)		0.03	2,658 (5.11)	2,550 (4.90)		0.01
COPD								
No	48,435 (90.66)	113,961 (88.42)	<0.001		47,221 (90.73)	47,371 (91.02)	0.11	
Yes	4,990 (9.34)	14,921 (11.58)		0.07	4,823 (9.27)	4,673 (8.98)		0.01
Fracture type			<0.001				0.32	
Intracapsular	27,271(51.05)	65,056 (50.48)		0.01	26,631 (51.17)	26,709 (51.32)		<0.01

(*Continued*)

Table 1. *(Continued)*

	Before Propensity Score Matching (n = 182,307)				After Propensity Score Matching (n = 104,088)*			
	GA	NA	*P* Value	Standardized Difference	GA	NA	*P* Value	Standardized Difference
Extracapsular	26,154 (48.95)	63,826 (49.52)			25,413 (48.83)	25,335 (48.78)		
Trochanteric	1,172 (2.19)	3,498 (2.71)		0.03	1,066 (2.05)	1,019 (1.96)		0.01
Intertrochanteric	23,219 (43.46)	56,893 (44.14)		0.01	22,775 (43.76)	22,828 (43.86)		<0.01
Subtrochanteric	1,763 (3.30)	3,435 (2.67)		0.01	1,572 (3.02)	1,488 (2.86)		0.01
Surgery type			<0.001				0.79	
THR	303 (0.57)	524 (0.41)		0.02	208 (0.40)	193 (0.37)		<0.01
Hemiarthroplasty	22,191 (41.54)	50,875 (39.47)		0.04	21,679 (41.66)	21,740 (41.77)		<0.01
Revision HR	152 (0.28)	157 (0.12)		0.04	51 (0.10)	45 (0.09)		<0.01
Internal fixation	30,779 (57.61)	77,955 (60.21)		0.06	30,106 (57.85)	30,066 (57.77)		<0.01
Hospital type‡			<0.001				0.92	
Medical center	21,360 (39.98)	31,217 (24.22)		0.34	20,257 (38.92)	20,270 (38.95)		<0.01
Regional hospital	23,662 (44.29)	54,995 (42.67)		0.03	23,436 (45.03)	23,470 (45.10)		<0.01
Local hospital	8,403 (15.73)	42,670 (33.11)		0.41	8,351 (16.05)	8,304 (15.96)		<0.01

* The following variables were entered into the model: age, sex, listed baseline comorbidities, modified CCI score, fracture type, surgery type, and hospital type. † Mean ± SD. ‡ According to the Taiwan Joint Commission on Hospital Accreditation, the C-statistic of the logistic regression model used to generate the propensity score was 0.64.

CCI = Charlson Comorbidity Index; COPD = chronic obstructive pulmonary disease; GA = general anesthesia; HR = hip replacement; NA = neuraxial anesthesia; THR = total hip replacement.

given an NA. Moreover, patients given a GA had longer hospital stays, a higher incidence of ICU admission, a greater need for mechanical ventilation support, and higher medical costs. Because our 14-yr data source is a nationwide population-based database, the statistical power of our analysis is stronger than that of other reports in the literature.

In the current study, the overall in-hospital mortality rate for geriatric patients given hip repair surgery between 1997 and 2011 was 2.37% (GA group: 2.61%; NA group: 2.26%). Although the difference seemed small, conditional logistic regression revealed that GA-group patients had a significantly higher OR for mortality than did NA-group patients (OR, 1.24; 95% CI, 1.15 to 1.35). Our findings are consistent with those of some other studies. A study[20] of 5,683 community-dwelling elderly men who had undergone hip fracture repair between 1998 and 2003 reported that GA was related to a significantly higher risk of mortality. This study was limited because it included only male patients. A meta-analysis of 141 trials involving 9,559 patients[28] reported that the overall mortality was approximately 30% lower in patients given an NA. However, this finding is insecure because of possible selection biases, one of the inherited limitations of meta-analyses,[29,30] in the subgroups in which this outcome was measured. To verify this controversial finding, larger studies may be required.[31]

Some studies[12,14,32,33] do not report that an NA is associated with lower mortality. For instance, a longitudinal observational study[32] that evaluated the effects of anesthetic technique on the outcomes of elderly patients after a hip fracture repair found no significant differences in postoperative mortality or morbidity for geriatric patients given an NA or a GA. However, anesthetic drugs, perioperative hemodynamic monitoring and management, and pain control have recently improved[34–36]; therefore, a new assessment of this question seems not only a good idea but also a necessary topic of research.

A recent retrospective study[21] of 18,158 cases of hip fracture repair reported that using an NA rather than a GA was significantly associated with lower adjusted ORs for mortality and pulmonary complications. Moreover, in the subgroup analyses, they demonstrated that an NA was associated with improved survival and fewer pulmonary complications in patients with extracapsular fractures but not in patients with intracapsular fractures. However, in our study, we did not find fracture type–related outcome differences between patients given an NA and those given a GA. Regardless of whether the hip fracture was intracapsular or extracapsular, GA-group patients always had a higher OR for in-hospital mortality, respiratory failure, ICU admission, and the need for ventilator support than did NA-group patients. Our study, which contains almost six times as many patients after propensity score matching, yielded a somewhat different finding on this point. Because of our study's large sample size and small selection bias, its statistical power is more than ample to make finer discriminations than substantially smaller studies.

Table 2. Associations between GA or NA and In-hospital Adverse Outcomes for 104,088 Propensity Score–matched Patients Diagnosed with Hip Fracture and Given Hip Surgery: Taiwan, 1997 and 2011

Outcomes	GA	NA	Odds Ratio GA/NA (95% CI)	*P* Value*
In-hospital death			1.24 (1.15–1.35)	<0.001
Yes	1,363 (2.62)	1,107 (2.13)		
No	50,681 (97.38)	50,937 (97.87)		
Stroke			1.18 (1.07–1.31)	0.001
Yes	840 (1.61)	717 (1.38)		
Stroke type				0.008†
Ischemic	594 (70.71)	545 (76.01)		
Hemorrhagic	91 (10.83)	47 (6.56)		
Unspecified	155 (18.45)	125 (17.43)		
No	51,204 (98.39)	51,327 (98.62)		
Transit ischemic stroke			0.95 (0.71–1.27)	0.71
Yes	88 (0.17)	93 (0.18)		
No	51,956 (99.83)	51,951 (99.82)		
Acute myocardial infarction			1.11 (0.90–1.37)	0.31
Yes	188 (0.36)	169 (0.32)		
No	51,856 (99.64)	51,875 (99.68)		
Acute renal failure			1.40 (0.99–1.98)	0.06
Yes	78 (0.15)	56 (0.11)		
No	51,966 (99.85)	51,988 (99.89)		
Acute respiratory failure			2.71 (2.38–3.08)	<0.001
Yes	868 (1.67)	328 (0.63)		
No	51,176 (98.33)	51,716 (99.37)		
ICU admission			1.95 (1.87–2.05)	<0.001
Yes	5,743 (11.03)	3,205 (6.16)		
Days				<0.001†
>0, <3	3,905 (7.50)	2,327 (4.47)		
≥3	1,838 (3.53)	878 (1.69)		
No	46,301 (88.97)	48,839 (93.84)		
Ventilator support			6.08 (5.59–6.61)	<0.001
Yes	4,008 (7.70)	749 (1.44)		
Days				<0.001†
>0, <3	2,802 (5.38)	338 (0.65)		
≥3	1,206 (2.32)	411 (0.79)		
No	48,036 (92.30)	51,295 (98.56)		

Data are number (%).

* *P* values by conditional logistic regression analysis, unless otherwise indicated. † Chi-square test for distribution of subgroups.

GA = general anesthetic; ICU = intensive care unit; NA = neuraxial anesthetic.

Table 3. Geriatric Patients Given a GA for Hip Surgery Were Associated with a Prolonged Hospital Stay and a Higher Total Cost Than Were Patients Given an NA: Taiwan, 1997–2011

Outcome	GA	NA	Difference (95% CI)	*P* Value*
LOHS (days)	10.77 ± 8.23	10.44 ± 6.67	0.31 (0.22–0.40)	<0.001
Cost (NT$)†	$86,606.50 ± 74,161.90	$74,494.00 ± 45,263.60	$12,112.50 (11,366.1–12,859.0)	<0.001

Data are mean ± SD.

* Two-sample *t* tests of difference. † US$1 = NT$30.

GA = general anesthetic; LOHS = length of hospital stay; NA = neuraxial anesthetic; NT$ = New Taiwan Dollars.

This is also the first retrospective study to report that a GA was associated with a higher rate of stroke than with an NA in geriatric patients who had undergone surgery for a femoral fracture. One possible explanation is that an NA is significantly more efficacious at inhibiting blood clot formation and reducing the incidence of DVT.[37–39] DVT increases the risk of ischemic stroke for patients who have a patent foramen ovale, which is present in approximately 15 to 25% of the adult population.[40–43] Systemic migration of emboli to the brain might also pass through extracardiac right-to-left shunts and result in stroke.[44,45]

Table 4. Associations between GA or NA and In-hospital Adverse Outcomes in Propensity Score–matched Patients Diagnosed with Intracapsular or Extracapsular Hip Fracture and Given Hip Surgery: Taiwan, 1997 and 2011

	Intracapsular Fracture (n = 53,340)			Extracapsular Fracture (n = 50,748)		
	OR (95% CI)			OR (95% CI)		
Outcomes	GA	NA	*P* Value	GA	NA	*P* Value
In-hospital death	1.27 (1.127–1.43)	1.000	<0.001	1.23 (1.10–1.38)	1.000	<0.001
Acute stroke	1.07 (0.92–1.24)	1.000	0.37	1.32 (1.14–1.53)	1.000	<0.001
Transient ischemic attack	1.18 (0.79–1.77)	1.000	0.41	0.77 (0.48–1.18)	1.000	0.22
Acute myocardial infarction	1.06 (0.78–1.44)	1.000	0.70	1.10 (0.81–1.48)	1.000	0.54
Acute renal failure	1.78 (1.07–2.97)	1.000	0.03	1.00 (0.61–1.63)	1.000	1.00
Acute respiratory failure	2.60 (2.16–3.13)	1.000	<0.001	2.68 (2.23–3.23)	1.000	<0.001
ICU admission	2.00 (1.87–2.13)	1.000	<0.001	1.91 (1.79–2.04)	1.000	<0.001
Ventilator support	6.05 (5.36–6.82)	1.000	<0.001	6.18 (5.48–6.98)	1.000	<0.001

Intracapsular fracture: transcervical fracture; Extracapsular fracture: trochanteric, intertrochanteric, and subtrochanteric fractures.
GA = general anesthetic; ICU = intensive care unit; NA = neuraxial anesthetic; OR = odds ratio.

Table 5. Associations between GA or NA and In-hospital Adverse Outcomes in Propensity Score–matched Patients Diagnosed with Hip Fracture Having Hip Surgery in Medical Center, Regional Hospital, or Local Hospital: Taiwan, 1997 and 2011

	Medical Center (n = 40,527)			Regional Hospital (n = 46,906)			Local Hospital (n = 16,655)		
	OR (95% CI)			OR (95% CI)			OR (95% CI)		
Outcome	GA	NA	*P* Value	GA	NA	*P* Value	GA	NA	*P* Value
In-hospital mortality	1.35 (1.17–1.55)	1.000	<0.001	1.12 (0.99–1.26)	1.000	0.06	1.39 (1.15–1.69)	1.000	<0.001
Acute stroke	0.99 (0.83–1.18)	1.000	0.8946	1.33 (1.15–1.55)	1.000	<0.001	1.22 (0.93–1.60)	1.000	0.15
TIA	0.78 (0.48–1.27)	1.000	0.3186	0.93 (0.61–1.42)	1.000	0.75	1.78 (0.79–4.02)	1.000	0.17
AMI	0.97 (0.69–1.37)	1.000	0.8618	1.22 (0.90–1.65)	1.000	0.19	0.90 (0.48–1.7)	1.000	0.75
Acute renal failure	2.46 (1.29–4.69)	1.000	0.0062	1.08 (0.69–1.70)	1.000	0.73	0.67 (0.19–2.36)	1.000	0.53
Acute respiratory failure	2.79 (2.23–3.49)	1.000	<0.001	2.70 (2.24–3.26)	1.000	<0.001	2.31 (1.68–3.17)	1.000	<0.001
Intensive care unit admission	1.88 (1.73–2.05)	1.000	<0.001	1.96 (1.84–2.10)	1.000	<0.001	2.00 (1.80–2.24)	1.000	<0.001
Ventilator support	6.69 (5.82–7.70)	1.000	<0.001	6.05 (5.36–6.83)	1.000	<0.001	4.60 (3.69–5.73)	1.000	<0.001

AMI = acute myocardial infarction; GA = general anesthetic; NA = neuraxial anesthetic; OR = odds ratio; TIA = transient ischemic attack.

Interestingly, in our subgroup analyses, an NA was associated with a lower risk of acute stroke only in patients with an extracapsular fracture, but not in patients with an intracapsular fracture. Extracapsular fractures have higher rates of postoperative DVT than do intracapsular fractures.[46] However, the risk of postoperative stroke between extracapsular and intracapsular fractures is never reported.

Another new finding of the current study is the association of in-hospital stroke with both the type of anesthesia and the hospital level. For patients treated in a medical center or local hospital, the odds for an acute stroke were not significantly different between the GA and NA groups. However, for patients treated in a regional hospital, the GA group had a higher risk for an in-hospital stroke. We urge additional study to confirm this finding.

Other findings of the current study were that the GA group was associated with higher odds of respiratory failure and had a higher ICU admission rate, a greater need for ventilator support, and more frequent prolonged hospital stays. However, a recent prospective study[47] of 194 patients who underwent internal fixation for intertrochanteric hip fractures between 2005 and 2010 found no significant differences in the number of wound infections or LOHSs. Because our sample was much larger than the sample in that study, a significant difference was revealed. Although it was merely a mean of 0.31 days longer (10.77 *vs.* 10.44 days), we think this is clinically important and cannot be overlooked because it ultimately translates into a vast amount of extra and perhaps unnecessary medical resources, both human and financial. In our study, medical costs were NT$12,112 (approximately US$403) lower per person for patients given an NA. Because medical costs are increasing worldwide, the economic aspect of health care is especially important for governments that provide NHI.

Limitations

Our findings need to be interpreted in the context of some inherent limitations of administrative datasets.

Table 6. Associations between GA or NA and In-hospital Adverse Outcomes in Propensity Score–matched Patients Diagnosed with Hip Fracture and Given Hip Surgery between 1997 and 2004 and between 2005 and 2011 in Taiwan

	1997–2004 (n = 47,381)			2005–2011 (n = 56,707)		
	OR (95% CI)			OR (95% CI)		
Outcomes	GA	NA	*P* Value	GA	NA	*P* Value
In-hospital death	1.29 (1.09–1.51)	1.000	0.003	1.28 (1.10–1.49)	1.000	0.002
Acute stroke	1.39 (1.13–1.74)	1.000	0.002	1.22 (1.00–1.48)	1.000	0.046
Transient ischemic stroke	1.06 (0.54–2.10)	1.000	0.86	1.20 (0.74–1.95)	1.000	0.46
Acute myocardial infarction	0.73 (0.46–1.17)	1.000	0.19	1.58 (1.08–2.32)	1.000	0.019
Acute renal failure	2.00 (0.75–5.33)	1.000	0.17	1.64 (0.96–2.78)	1.000	0.07
Acute respiratory failure	2.62 (1.95–3.52)	1.000	<0.001	2.67 (2.14–3.34)	1.000	<0.001
ICU admission	2.21 (1.98–2.46)	1.000	<0.001	1.89 (1.75–2.04)	1.000	<0.001
Ventilator support	4.83 (4.05–5.76)	1.000	<0.001	8.46 (7.22–9.92)	1.000	<0.001

GA = general anesthetic; ICU = intensive care unit; NA = neuraxial anesthetic; OR = odds ratio.

First, with cross-sectional analyses, it is not possible to determine the temporal relation between surgery and observed events. However, from standard clinical practice, the probability of a patient being hospitalized because of an AMI, a stroke, respiratory failure, or renal failure and then to have to undergo hip fracture repair surgery immediately after treatment for one of these acute diseases during the same admission is very low.

Second, identifying these cases, comorbidities, and complications was completely dependent upon the correctness of the ICD-9-CM coding. These codes were reviewed and validated by auditors of medical records for the insurance system to ensure the accuracy of the claims. However, the NHI started using the ICD-9-CM coding scheme in 2000. Diagnoses in the NHIRD before 2000 used the "A-code" system from 1997 to 1999; therefore, codes used before 2000 may misclassify some diseases and conditions.

Third, although propensity score matching was used to reduce the selection bias, we still cannot entirely exclude the possibility that unobserved differences may have existed between the groups. For instance, individual data for lifestyle behaviors, cigarette smoking and alcohol drinking habits, body mass index, the severity of comorbid and preoperative functional disabilities, and ASA physical status are not available in the NHIRD. Therefore, we could not adjust for these variables as contributing factors in the propensity score model. However, we used the CCI as a surrogate for the ASA physical status: a satisfactory correlation of their ability to predict complications and mortality has recently been reported.[24] Moreover, the details of intraoperative hemodynamics, such as body temperature change, blood pressure stability, and cardiac output fluctuations, are also lacking, which might affect the analyses of complications and mortality to some extent.

Fourth, because we worried that preoperative stroke, AMI, renal failure, and respiratory failure would confound our analysis, all hip fracture repair surgery patients who had these conditions before this hospitalization were excluded from this study; therefore, our results might not be generalizable to all geriatric patients. Because our study population was mainly ethnic Chinese, not all of our results will be directly generalizable to other ethnic groups.

Fifth, the NHI did not cover any postoperative continuous regional analgesia technique for pain control; therefore, we did not know how many patients continuously underwent postoperative regional analgesia. The benefits of an NA over a GA might actually have come from postoperative analgesia rather than from the choice of the type of anesthetic itself.

Conclusions

We conclude that for geriatric patients undergoing hip repair surgery, an NA rather than a GA has several advantages: NAs are associated with lower incidences of and risks for the adverse in-hospital outcomes of stroke, respiratory failure, and death. Moreover, the ICU admission rate, LOHSs, and total medical costs are also lower for patients given an NA.

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Competing Interests

The authors declare no competing interests.

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Appendix 1: ICD-9 CM Codes Indicating Trauma

Part of Trauma	ICD-9 CM Code
Head	
Fracture of skull	800–804
Intracranial injury	850–854
Chest trauma	
Fracture of ribs, sternum, larynx, and trachea	807
Traumatic pneumothorax and hemothorax	860
Injury to heart and lung	861
Injury to other and unspecified intrathoracic organs	862
Abdominal trauma	
Injury to gastrointestinal tract	863
Injury to liver	864
Injury to spleen	865
Injury to other intraabdominal organs	868
Injury to kidney	866
Pelvic trauma	
Fracture of pelvis	808
Injury to pelvic organs	867
Extremities trauma	
Fracture of upper limb	810–819
Fracture of lower limb except hip	823–829

ICD-9 CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*.

Appendix 2: Major Comorbidities and Corresponding ICD-9 CM Codes

Comorbidities	ICD-9 CM Code
Hypertensive disease	
Essential hypertension	401
Hypertensive heart disease	402
Hypertensive chronic kidney disease	403
Hypertensive heart and chronic kidney disease	404
Secondary hypertension	405
Diabetes mellitus	
Diabetes mellitus	250
Polyneuropathy in diabetes	357.2
Diabetic retinopathy	362.0
Hyperlipidemia	272
Chronic obstructive pulmonary disease	
Bronchitis	490–491
Emphysema	492
Asthma	493
Bronchiectasis	494
Extrinsic allergic alveolitis	495
Chronic airway obstruction, not elsewhere classified	496
Heart disease	
Chronic rheumatic heart disease	393–398
Pulmonary heart disease	415–417
Valvular heart disease	424.0–424.3
Endocarditis	424.9
Renal disease	
Chronic glomerulonephritis	582
Nephritis and nephropathy, not specified as acute or chronic	583
Chronic kidney disease	585
Disorders resulting from impaired renal function	588
Dementia	
Dementias (senile, presenile, and vascular dementia)	290
Persistent mental disorders due to conditions classified elsewhere	294
Cerebral degeneration (such as Alzheimer disease, *etc.*)	331

ICD-9 CM = *International Classification of Diseases, Ninth Revision, Clinical Modification*.