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The Effect of Anesthetic Technique on Postoperative Outcomes in Hip Fracture Repair

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Background: **The impact of anesthetic choice on postoperative mortality and morbidity has not been determined with certainty.**

Methods: **The authors evaluated the effect of type of anesthesia on postoperative mortality and morbidity in a retrospective cohort study of consecutive hip fracture patients, aged 60 yr or older, who underwent surgical repair at 20 US hospitals between 1983 and 1993. The primary outcome was defined as death within 30 days of the operative procedure. The secondary outcomes were postoperative 7-day mortality, postoperative myocardial infarction, postoperative pneumonia, postoperative congestive heart failure, and postoperative change in mental status. Numerous comorbid conditions were controlled for individually and by several comorbidity indices using logistic regression.**

Results: **General anesthesia was used in 6,206 patients (65.8%) and regional anesthesia in 3,219 patients (3,078 spinal anesthesia and 141 epidural anesthesia). The 30-day mortality rate in the general anesthesia group was 4.4%, compared with 5.4% in the regional anesthesia group (unadjusted odds ratio = 0.80; 95% confidence interval = 0.66–0.97). However, the adjusted odds ratio for general anesthesia increased to 1.08 (0.84–1.38). The adjusted odds ratios for general anesthesia *versus* regional anesthesia for the 7-day mortality was 0.90 (0.59–1.39) and for postoperative morbidity outcomes were as follows: myocardial infarction: adjusted odds ratio = 1.17 (0.80–1.70); congestive heart failure: adjusted odds ratio = 1.04 (0.80–1.36); pneumonia: adjusted odds ratio = 1.21 (0.87–1.68); postoperative change in mental status: adjusted odds ratio = 1.08 (0.95–1.22).**

Conclusions: **The authors were unable to demonstrate that regional anesthesia was associated with better outcome than was general anesthesia in this large observational study of elderly patients with hip fracture. These results suggest that the type of anesthesia used should depend on factors other than any associated risks of mortality or morbidity. (Key words: Anesthesiology; orthopaedic surgery; outcome study.)**

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THE choice of anesthetic technique is a complex medical decision that depends on many factors, including patient characteristics (*e.g.*, comorbidity, age), type of surgery performed, and risks of the anesthetic tech-

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niques. Assessment of the risks of the anesthetic technique should include consideration of technical factors (airway, establishment of regional blocks, invasive monitoring), anesthetic agent toxicities, incidence of critical intraoperative and postoperative events, and postoperative treatment of pain.

Few studies have prospectively compared the outcome of patients administered general *versus* regional anesthesia.[1] The largest randomized trial included only 423 patients, and the type of anesthesia did not appear to influence cardiac morbidity or overall mortality.[2] It has been suggested that further trials are unlikely to show important differences among the types of anesthesia,[3] although each of the published trials had limited power.

We describe the results of an analysis that evaluated the relation between type of anesthesia and postoperative morbidity and mortality in a cohort of 9,425 elderly patients undergoing surgery for hip fractures.

Methods

Study Design and Patient Population

We performed a retrospective cohort study of consecutive patients with hip fracture, aged 60 yr or older, who underwent surgical repair at 1 of 20 study hospitals between 1983 and 1993. Patients were excluded if they declined to receive blood transfusion, had metastatic cancer, or underwent a surgical procedure involving a site other than the hip because the data were collected for a study of blood transfusion and surgery.[4] The 20 participating hospitals were drawn from four metropolitan areas: New Brunswick, New Jersey; San Antonio, Texas; Philadelphia, Pennsylvania; and Richmond, Virginia. These hospitals included university and community and Veterans Administration medical centers and were selected based on willingness to allow review of medical records.

Anesthetic Technique

We compared the use of general *versus* regional anesthesia during the hip fracture repair. *General anesthesia* was defined as inhalational anesthesia or total intravenous anesthesia with use of an endotracheal tube. *Regional anesthesia* was defined as epidural or spinal anesthesia. A patient receiving spinal or epidural anesthesia plus sedation was classified in the regional anesthesia group. The anesthesia technique was defined as general plus regional if the patient received full regional anesthesia plus inhalational anesthesia. Patients who received a combination of regional and general anesthesia were excluded from these analyses, as were the small number of patients who received local anesthesia.

Primary Outcome: 30-day Mortality

The primary study outcome was 30-day postoperative mortality. The National Death Index (NDI) was used to identify deaths that occurred after discharge but within 30 days of the operation. Thirty-day mortality was the primary outcome because it is not subject to detection bias and it is an extremely important outcome, and 30 days is the standard time period to assess perioperative outcomes.

Secondary Outcome: 7-day Mortality

We evaluated 7-day mortality because the immediate postoperative period (1 week) may be more likely to reflect anesthetic-related complications. A National Death Index search was used to identify deaths.

Tertiary Outcomes: Morbidity

The morbidity outcomes were postoperative myocardial infarction, postoperative pneumonia, postoperative congestive heart failure (CHF), and postoperative confusion. We evaluated morbidity at 7 days after surgery. We used the 7-day time period because (1) we could not assess outcomes that occurred after discharge from the hospital and (2) the immediate postoperative period (1 week) may be more likely to reflect anesthetic-related complications.

Morbidity was considered to be a tertiary outcome because (1) identification was based only on information available in the medical record and it is possible these data were pursued or recorded differently among study sites and over time; (2) although unlikely, we cannot rule out the possibility of a detection bias caused by differential postoperative assessment for morbidity in patients receiving general or regional anesthesia; and (3) we could only assess events that occurred during the hospital stay. *Postoperative myocardial infarctions* were defined using Atherosclerosis Risk in Communities (ARIC) Study criteria.[5] These criteria are widely used in epidemiologic studies of myocardial infarction. A screening procedure was used to identify patients who could conceivably be classified as having a myocardial infarction using Atherosclerosis Risk in Communities Study criteria. These screening criteria included (1) postoperative chest pain and at least one postoperative electrocardiography (ECG) performed; (2) cardiac enzymes and at least one postoperative ECG performed; or (3) at least two

ECG procedures performed, with one performed during the postoperative period. In patients meeting any of these criteria, up to three ECGs were interpreted by the ECG center at the University of Minnesota.

Pneumonia was determined to be present in patients based on the following criteria: (1) Postoperative chest radiograph was consistent with infiltrate or pneumonia was diagnosed by a physician and (2) the patient was treated using an antibiotic.

Congestive heart failure was determined to be present in patients who had (1) either a physician diagnosis of CHF or a chest radiograph that was consistent with new CHF and (2) treatment with diuretics, digoxin, or angiotensin-converting enzyme inhibitor. *Postoperative confusion* was defined as a postoperative change in mental status that included new episodes of syncope, seizure, loss of consciousness, disorientation, agitation, somnolence, and lethargy.

We also evaluated intraoperative events, including hypotension, use of vasopressors, and arrhythmias. *Hypotension* was defined as a systolic blood pressure less than 90 mmHg. *Intraoperative arrhythmia* was defined as the presence of new onset of atrial fibrillation or flutter, ventricular fibrillation, more than five premature ventricular contractions/min, or ventricular tachycardia.

Other outcomes of an *a priori* interest, including postoperative stroke and postoperative deep venous thrombosis or pulmonary embolism, were not studied because they were rare outcomes in the study population.

Data Collection

A retrospective chart review was conducted using standardized, pretested forms and an explicit abstraction process. The data collection instrument included questions regarding anesthetic technique and significant intraoperative and postoperative events. Research nurses received extensive training by the investigators. Quality assurance was performed by reviewing a random sample of medical records.

We collected information regarding demographic characteristics (age, gender, race, insurance, preadmission residence, hospital admission year), comorbid conditions (see next paragraph), habits (smoking, alcohol use), medications used before admission and during the preoperative and postoperative time periods, preoperative physical examination (vital signs, cardiac examination, mental status, motor strength, whether patient was malnourished or cachectic, presence of a decubitus ulcer), laboratory results (electrocardiogram, chest radiograph, arterial blood gas, echocardiogram, glucose, creatinine, liver enzymes, coagulation tests), cointerventions (preoperative admission to the intensive care unit, thromboembolism prophylaxis, antibiotic prophylaxis, preoperative transfusions, physical therapy, respiratory therapy, preoperative consultations), and hip fracture treatment (type of hip fracture, surgical procedure).

Information regarding the presence of many comorbid conditions was collected. *Cardiovascular disease* was defined as history of any of the following: myocardial infarction, angina or ischemic chest pain, coronary artery disease, coronary artery bypass surgery, percutaneous transluminal coronary angioplasty, CHF, or peripheral vascular disease. *Chronic pulmonary disease* was defined as history of any of the following: chronic obstructive pulmonary disease, asthma, primary pulmonary hypertension, chronic pulmonary embolism, or other chronic pulmonary disorder. Data were collected about the following other comorbid conditions: history of valvular heart disease, arrhythmia, hypertension, diabetes mellitus, dementia, stroke or transient ischemic attach, thromboembolism, malignancy, gastrointestinal bleeding, swallowing disorder, liver disease, arthritis, hospital admission within the preceding month, and hip fracture.

We also calculated several multivariate indices, including the Charlson Comorbidity index,[6] the acute physiology score (APS) subscore of the Acute Physiology and Chronic Health Evaluation (APACHE) II index,[7] and the 30-day Sickness at Admission scale.[8] The APACHE II index is predictive of in-hospital mortality for critically ill patients.[9] The Charlson Index incorporates many common, serious comorbid conditions in its final score and is a predictor of mortality for medical in-patients. The 30-day Sickness at Admission scale was developed specifically to predict mortality in hip fracture patients. In addition, we collected data regarding the American Society of Anesthesiologists' (ASA) physical status classification system, which predicts postoperative mortality.[10,11] The acute physiology score was analyzed as a continuous variable; the Charlson Index was analyzed as a dichotomous variable (no points *vs.* any points) because it was not linearly associated with outcome; the 30-day Sickness at Admission Scale was divided into quartiles; and the ASA physical status was grouped into three categories (I or II; III; IV or V).

Statistical Analysis

For each outcome, we first assessed the unadjusted relations with type of anesthesia and potential confounders using an independent sample *t* test or chi-square test.[12] We calculated the unadjusted odds ratio for the

Table 1. Patient Characteristics by Type of Anesthesia

Description	General Anesthesia (n = 6,206) No.	%	Regional Anesthesia (n = 3,219) No.	%	P*
Age (yr)					≤ 0.001
60–69	910	14.7	325	10.1	
70–79	1,918	30.9	881	27.4	
80–89	2,602	41.9	1,452	45.1	
90+	776	12.5	561	17.4	
Female gender	4,978	80.2	2,437	75.7	≤ 0.001
White race	5,402	87.2	2,748	85.8	0.07
History of					
Cardiovascular disease	2,537	40.9	1,533	47.6	≤ 0.001
Valvular disease	286	4.6	201	6.2	≤ 0.001
Atrial fibrillation	575	9.3	424	13.2	≤ 0.001
Hypertension	2,865	46.2	1,529	47.5	0.22
Chronic pulmonary disease	869	14.0	864	21.3	≤ 0.001
Confusion or disorientation not precipitated by fracture	1,624	26.2	851	26.4	0.78
Stroke or transient ischemic attack	987	15.9	577	17.9	0.01
Prior hospital stay within 1 month of admission	269	4.3	144	4.5	0.76
Smoking	1,433	23.1	860	26.7	≤ 0.001
Physician diagnosis of malnourished or cachectic	355	5.7	210	6.5	0.12
Described as obese at physical examination	501	8.1	179	5.6	≤ 0.001
Charlson comorbidity index (any points)	3,142	50.6	1,766	54.9	≤ 0.001
Sickness at admission scale for 30-day mortality					≤ 0.001
≤ 3.00	1,669	26.9	730	22.7	
3.01–5.4	1,545	24.9	779	24.2	
7.5–8.6	1,544	24.9	835	25.9	
> 8.6	1,448	23.3	875	27.2	
ASA physical status					≤ 0.001
I or II	1,698	28.4	560	18.1	
III	3,666	61.3	2,097	67.8	
IV or V	618	10.3	438	14.1	
Preoperative transfusion	489	7.9	216	6.7	0.04
Surgery delayed for medical reasons	663	10.7	324	10.1	0.35
Fracture type intertrochanteric or subtrochanteric	3,272	52.7	1,667	51.8	0.39
Procedure type					≤ 0.001
Total arthroplasty or hemiarthroplasty	2,327	37.6	1,153	35.8	
Internal fixation, other than pinning	3,367	54.4	1,851	57.6	
Internal fixation, pinning	495	8.0	212	6.6	
Preadmission residence was nursing home/psychologic facility	1,260	20.3	657	20.4	0.90

* Chi-square statistic.

effect of type of anesthesia instead of the relative risk, so it could be compared with the adjusted odds ratio generated by a logistic-regression model. The odds ratio should be the same for uncommon outcomes except confusion.

Logistic regression was used to describe the effect of type of anesthesia on outcome after adjusting for potential confounders. Potential confounding variables included characteristics that met all of the following criteria: (1) a statistically significant univariate relation with outcome ($P \geq 0.05$), (2) presence in at least 5% of the population, and (3) no expected value less than 5 in the contingency-table analysis. All variables maintaining a P value of 0.10 or less were included in the final model. All variables included in the tables or described in the data collection section of the article were evaluated for inclusion in the models. We did not control for intraoperative or postoperative factors (*i.e.*, intraoperative hypotension) that might influence mortality or morbidity because these might actually represent outcomes that occurred during or after the time anesthesia was administered.

The ASA physical status score was missing in 348 (3.7%) patients. We present the unadjusted odds ratios for both the entire study population (N = 9,425) and the subset of the population with an available ASA physical status score (n = 9,067). Adjusted odds ratios are pre-

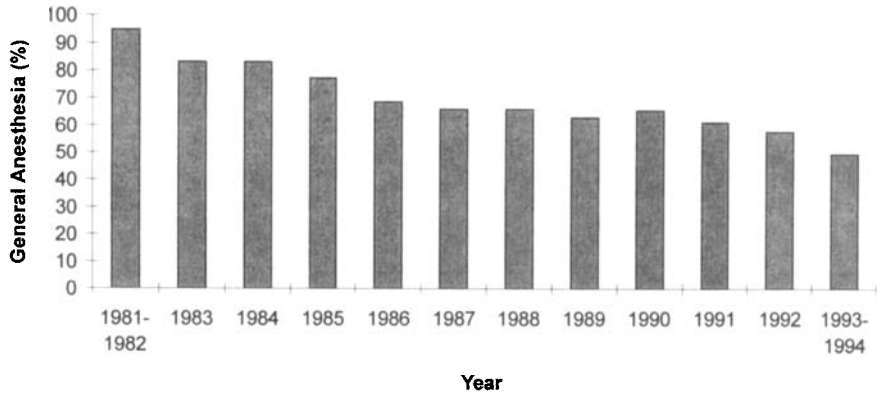

Fig. 1. Decreasing rate of general anesthesia by year.

sented for the population with an available ASA physical status score because the ASA physical status is included in all the multivariate models. The results of logistic-regression models that included all patients (therefore not controlling for ASA physical status) were very similar and had no effect on the interpretation of the results, except where noted in the Results section.

In addition to controlling for confounding in the logistic-regression model as described previously, we performed an analysis using propensity scores, which stratified patients based on their predicted probability of receiving general anesthesia. The first step in this analysis was to develop a predictive model for general anesthesia. Independent predictors (demographic characteristics, comorbid conditions, habits, preoperative physical findings, hospital) were entered into a logistic model. The C statistic was used to assess the adequacy of the ability of the predictive models to discriminate between those who received general *versus* regional anesthesia. The probability of receiving general anesthesia (the "propensity score") was generated for each patient, based on the model, and patients were grouped into quintiles of predicted probability. Thus, within each of the five strata defined by predicted probability, all patients had a similar likelihood (based on clinical and demographic characteristics) of receiving general anesthesia, although some did and others did not actually receive general anesthesia. This stratification is an attempt to eliminate confounding by the variables that went into calculating the propensity score.[13] The odds ratio for anesthesia type *versus* 30-day mortality was calculated, with a 95% confidence interval, separately within each of the five strata defined by the propensity scores. We used the Breslow-Day test among quintiles of predicted probability of receiving general anesthesia to assess homogeneity of odds ratios,[14] and then calculated the common odds ratio using the Mantel-Haenzsel procedure.[15] All analyses were performed using Statistical Analysis Software (SAS) version 6.12.[16]

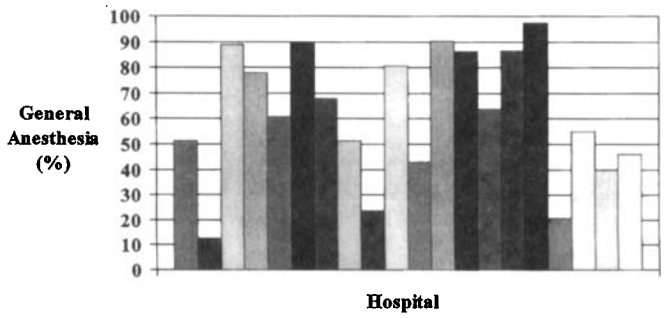

Fig. 2. Variation in general anesthesia by hospital.

Results

Study Population

The original study cohort included 9,598 patients who underwent operative repair of a hip fracture. Patients who received local anesthesia (n = 14), a combination of regional and general anesthesia (n = 134), or whose type of anesthesia was unknown (n = 25), were excluded from this analysis. The final study population therefore included 9,425 patients. General anesthesia was used in 6,206 patients (65.8%). Of the remaining 3,219 patients, 3,078 received spinal anesthesia and 141 received epidural anesthesia. The mean age was 80.3 yr (SD = 8.7 yr) and 78.7% were women.

Table 1 shows the clinical characteristics of the study population stratified by the type of anesthesia. The regional anesthesia group was older (17.4% were older than 90 yr *vs.* 12.5% of the general anesthesia group), and somewhat more sick. For example, the regional anesthesia group was more likely to have a history of cardiovascular disease (47.6 *vs.* 40.9%) and chronic obstructive lung disease (21.3 *vs.* 14.0%), and a greater

Table 2. Description of Patient Population and Univariate Relationship with 30-day Mortality

Description	Dead		30-day Mortality	
	No.	%	Odds Ratio	95% CI
Age (yr)				
60–69	29/1,235	2.4		Baseline
70–79	87/2,799	3.1	1.33	0.86–2.09
80–89	201/4,054	5.0	2.17	1.44–3.29
90+	129/1,337	9.7	4.44	2.90–6.84
Gender			0.46	0.38–0.56
Female	285/7,415	3.8		
Male	161/2,010	8.0		
Race			0.82	0.61–1.11
Nonwhite	50/1,249	4.0		
White	394/8,150	4.8		
History of cardiovascular disease*			2.03	1.67–2.47
Present	267/4,070	6.6		
Absent	179/5,355	3.3		
History of atrial fibrillation			2.08	1.63–2.66
Present	85/999	8.5		
Absent	361/8,426	4.3		
History of valvular disease			1.50	1.04–2.16
Present	33/487	6.8		
Absent	413/8,938	4.6		
History of hypertension			0.96	0.80–1.17
Present	204/4,394	4.6		
Absent	242/5,031	4.8		
History of chronic pulmonary disease			1.46	1.16–1.84
Present	98/1,553	6.3		
Absent	348/7,872	4.4		
History of confusion or disorientation not precipitated by fracture			2.37	1.96–2.88
Present	199/2,475	8.0		
Absent	247/6,950	3.6		
History of stroke or transient ischemic attack			1.50	1.20–1.89
Present	101/1,564	6.5		
Absent	345/7,861	4.4		
Prior hospital stay within 1 month of admission			2.41	1.73–3.37
Present	42/413	10.2		
Absent	404/8,608	4.5		
History of treated diabetes mellitus			1.41	1.04–1.91
Present	50/788	6.4		
Absent	396/8,637	4.6		
Physician diagnosis of malnourished or cachectic			2.39	1.78–3.21
Present	56/565	9.9		
Absent	390/8,860	4.4		
Charlson comorbidity index			2.77	2.23–3.44
Any points	331/4,908	6.7		
No points	115/4,517	2.5		
Sickness at admission scale for 30-day mortality†				
≤ 3.00	45/2,399	1.9		Baseline
3.01–5.4	60/2,324	2.6	1.39	0.92–2.09
7.5–8.6	115/2,379	4.8	2.66	1.85–3.83
> 8.6	226/2,323	9.7	5.64	4.03–7.91
ASA physical status‡				
I or II	42/2,258	1.9		Baseline
III	265/5,763	4.6	2.54	1.81–3.59
IV or V	118/1,056	11.2	6.64	4.57–9.67
Abnormal preoperative chest radiograph§			1.77	1.46–2.14
Present	221/3,424	6.5		
Absent	225/6,001	3.8		

Table 2. Continued

Description	Dead		30-day Mortality	
	No.	%	Odds Ratio	95% CI
Type of fracture			1.25	1.11–1.64
Intertrochanteric or subtrochanteric	265/4,939	5.4		
Other	181/4,486	4.0		
Preoperative transfusion			2.45	1.87–3.20
Present	70 /705	9.9		
Absent	376/8,720	4.3		
Surgery delayed for medical reasons			2.04	1.58–2.64
Present	83 /987	8.4		
Absent	363/8,438	4.3		
Procedure type				
Internal fixation, pinning	15 /707	2.1		Baseline
Total arthroplasty or hemiarthroplasty	161/3,480	4.6	2.24	1.28–3.98
Internal fixation, other than pinning	265/5,218	5.1	2.47	1.43–4.34
Preadmission residence			1.94	1.57–2.39
Nursing home/psychologic facility	144/1,917	7.5		
Other	302/7,508	4.0		
Admission year				
1981/1982	4 /96	4.2		
1983	14 /433	3.2		
1984	21 /507	4.1		
1985	42 /716	5.9		
1986	40 /762	5.3		
1987	29 /811	3.6		
1988	49 /929	5.3		
1989	47 /936	5.0		
1990	38/1,070	3.6		
1991	73/1,268	5.8		
1992	58/1,226	4.7		
1993/1994	31 /67	4.6		
Hospital				
1	13 /288	4.5		
2	49 /855	5.7		
3	19 /314	6.0		
4	8 /322	2.5		
5	16 /452	3.5		
6	3 /137	2.2		
7	39/1,353	2.9		
8	34 /693	4.9		
9	12 /393	3.0		
10	11 /278	4.0		
11	21 /325	6.5		
12	15 /379	4.0		
13	35 /614	5.7		
14	42 /642	6.5		
15	40 /739	5.4		
16	39 /863	4.5		
17	17 /327	5.2		
18	12 /200	6.0		
19	21 /238	8.8		
20	0 /13	0.0		

* Cardiovascular disease defined as history of myocardial infarction, angina, or ischemic chest pain, or coronary artery disease, coronary artery bypass surgery, percutaneous transluminal coronary angioplasty, or history of congestive heart failure, or history of peripheral vascular disease.

† Cut points for categories chosen to create approximately equal quartiles.

‡ American Society of Anesthesiologist physical status classification missing for 348 patients.

§ Abnormal chest radiograph defined as consistent with congestive heart failure, cardiomegaly, or chronic obstructive pulmonary disease.

‖ Intraoperative tachycardia defined as pulse > 100 beats/min for at least 10 min.

Intraoperative arrhythmia includes ventricular fibrillation, ventricular tachycardia, > five premature ventricular contractions, atrial fibrillation, atrial flutter, superventricular tachycardia, paroxysmal atrial tachycardia, multifocal atrial tachycardia, or intraoperative cardiopulmonary resuscitation.

ASA = American Society of Anesthesiologists; CI = Taylor-based confidence interval.

Table 3. Unadjusted and Adjusted Relations between General Anesthesia and Outcome

	General Anesthesia Patients (n = 6,206)		Regional Anesthesia Patients (n = 3,129)		Unadjusted		Fully Adjusted	
Outcome	No.	%	No.	%	Odds Ratio	95% CI	Odds Ratio	95% CI
30-day mortality	272	4.4	174	5.4	0.80	0.66–0.97	1.08	0.84–1.38*
7-day mortality	82	1.3	53	1.6	0.80	0.56–1.13	0.90	0.59–1.39†
7-day myocardial infarction	122	2.0	61	1.9	1.04	0.76–1.42	1.17	0.80–1.70‡
7-day congestive heart failure	288	4.6	133	4.1	1.13	0.92–1.39	1.04	0.80–1.36§
7-day pneumonia	174	2.8	84	2.6	1.07	0.83–1.40	1.21	0.87–1.68‖
7-day change in mental status	1,565	25	1,114	34	0.64	0.58–0.70	1.08	0.95–1.22#

* Variables included in the final model were gender, history of cardiovascular disease, history of atrial fibrillation, history of confusion, history of hospitalization 1 month before admission, malnourished or cachectic on physical examination, abnormal preoperative chest radiograph, acute physiological score, Charlson comorbidity scale (any *vs.* no points), age (divided into four groups), preoperative transfusions, type of fracture, delay of surgical repair of fracture for medical reasons, 30-day Sickness at Admission Scale (quartiles), hospital, and ASA score.

† Variables included in the final model were gender, history of cardiovascular disease, history of hospitalization 1 month before admission, malnourished or cachectic on physical examination, acute physiological score, Charlson comorbidity scale (any *vs.* no points), age (divided into four groups), delay of surgical repair of fracture for medical reasons, hospital, and ASA score. There were no cases of 7-day mortality at one of our study hospitals. Therefore, patients from this hospital were excluded from the multivariate analysis (n = 137).

‡ Variables in final model were race, gender, history of cardiovascular disease, fracture type, admission year, age, hospital, and ASA score.

§ Variables included in final model were race, gender, admission year, history of cardiovascular disease, history of hospitalization 1 month before admission, history of treated diabetes mellitus, abnormal preoperative chest radiograph, preoperative transfusion, 30-day Sickness at Admission Scale (quartiles), age, delay of surgical procedure for medical reasons, hospital, and ASA score.

‖ Variables included in final model were gender, history of confusion, any history of smoking, abnormal preoperative chest radiograph, Charlson comorbidity scale, 30-day Sickness at Admission score, age, hospital, and ASA score. There were no cases of postoperative pneumonia at one of our study hospitals. Therefore, patients from this hospital were excluded from the multivariate analysis (n = 137).

Variables included in the final model were gender, history of cardiovascular disease, history of stroke, abnormal preoperative chest radiograph, type of surgical repair, age, hospital, and ASA score.

CI = confidence interval.

percentage of patients had a higher score on the Sickness at Admission scale and a higher ASA physical status classification. The relative percentages of patients receiving regional anesthesia increased progressively ($P < 0.001$) beginning in 1988 (fig. 1). There was considerable difference among study hospitals in the percentage of cases performed during general *versus* during regional anesthesia ($P < 0.001$), ranging from 12.6 to 97.3% (fig. 2). Only 0.2% of the general anesthesia group and 1.6% of the regional anesthesia group underwent postoperative epidural anesthesia.

Primary Outcome: 30-Day Mortality

The clinical characteristics of the study population and the univariate association with mortality is described in table 2. There were no significant differences in mortality by admission year ($P = 0.20$). Mortality varied by hospital ($P < 0.001$). Many clinical characteristics were associated with 30-day mortality.

Table 3 describes the unadjusted and adjusted analyses for each outcome and the variables included in the final model. The unadjusted 30-day mortality rate was 4.4% in the general anesthesia group and 5.4% in the regional anesthesia group (odds ratio = 0.80, 95% confidence interval = 0.66-0.97; table 3). The adjusted odds ratio for general anesthesia was 1.08 (95% confidence interval, 0.84-1.38).

We performed an additional analysis that stratified patients by probability of receiving general anesthesia (table 4). The results of the Breslow-Day test for homogeneity of the odds ratio were not significant ($P = 0.50$). The common odds ratio was 1.03 (0.81-1.32).

Secondary Outcome: 7-Day Mortality

The rate of postoperative 7-day mortality in the general anesthesia group was 1.3%, compared with 1.6% in the regional anesthesia group (unadjusted odds ratio = 0.80, 95% confidence interval = 0.56-1.13). The adjusted odds ratio for 7-day mortality in patients administered general anesthesia *versus* regional anesthesia was 0.90 (95% confidence interval, 0.59-1.39).

Tertiary Outcomes: Morbidity

Table 3 shows the relation between anesthesia and morbidity. None of the outcomes were associated with type of anesthesia after adjusting for risk factors.

Table 4. Analysis Stratified by Probability of Receiving General Anesthesia

Probability of General Anesthesia Quintile*	Patients Receiving General Anesthesia		Death Rate in Those Receiving General Anesthesia		Death Rate in Those Receiving Regional Anesthesia		Odds Ratio	95% Confidence Interval
	No.	%	No.	%	No.	%		
1	354/1,806	19.6	24/354	6.8	87/1,452	6.0	1.41	0.72–1.82
2	951/1,807	52.6	52/591	5.5	51/856	6.0	0.91	0.61–1.36
3	1,333/1,807	73.8	50/1,333	3.8	20/474	4.2	0.89	0.52–1.50
4	1,582/1,807	87.5	70/1,582	4.4	5/225	2.2	2.04	0.81–5.10
5	1,737/1,806	96.2	56/1,737	3.2	3/69	4.5	0.73	0.22–2.24

Breslow-Day test for homogeneity of the odds ratio was not significant ($P = 0.50$). Overall summary odds ratio, 1.03; 95% confidence interval, 0.81–1.32.

* The variables included in the predictive model of anesthesia were age, gender, race, hospital admission year (added as 11 indicator variables), hospital (added as 19 indicator variables), transfer from an acute care hospital, surgical procedure (divided into three groups: internal fixing with pinning, internal fixation other than pinning, total or hemiarthroplasty), history of cardiovascular disease, valvular heart disease, atrial fibrillation, hypertension, stroke, malignancy, arthritis, chronic pulmonary disease, Charlson comorbidity index (any points *vs.* no points), APS (continuous), 30-day Sickness at Admission Scale (quartiles), ASA status (1 or 2 points, 3 points, 4 or 5 points), smoking, malnourished or cachectic, preoperative transfusion. Model discrimination was excellent (C index = 0.85).

Intraoperative hypotension (16.3% regional, 12.4% general; $P < 0.001$), use of vasopressors (42.6% regional, 14.3% general; $P < 0.001$), and intraoperative arrhythmia (3.3% regional, 1.6% general; $P < 0.001$) occurred more commonly in the regional anesthesia group than in the general anesthesia group. The association between intraoperative arrhythmia and anesthesia was not quite significant after adjusting for confounding variables (odds ratio = 0.70, 95% confidence interval 0.5–1.04).

Discussion

This study of 9,425 patients is the largest analysis that we are aware of that evaluated the effect of the type of anesthesia on mortality and morbidity. As might be predicted from clinical practice, we found that older patients and those who are more ill were more likely to be administered regional anesthesia. However, after controlling for differences in patient characteristics, we found no association between type of anesthesia and mortality or morbidity. This finding suggests that unadjusted differences in outcome between general anesthesia and regional anesthesia are mainly a result of concomitant disease, and not any protective effect of one anesthetic technique *versus* another.

Each of the intraoperative events we evaluated—hypotension, use of vasopressors, and arrhythmia—was associated with the use of regional anesthesia. The increased incidence of hypotension and use of vasopressors were expected findings, resulting from a loss of vascular tone in patients who were administered regional anesthesia.

Our analysis also shows that regional anesthesia was used more frequently in recent years. In 1981–1982, the first year of our study, general anesthesia was used in 94.8% of patients. By 1993–1994, general anesthesia was used in only 49.6% of patients. The reasons for the increased use of regional anesthesia cannot be determined from these data. However, there was considerable variability in the use of regional anesthesia among institutions, ranging from 12.6 to 97.3%. This variation in practice is consistent with many other medical interventions.[17] Importantly, we adjusted for year of surgery and hospital in the analysis.

Many clinical factors influence the risk of mortality and morbidity after anesthesia. Studies have suggested increasing age, cardiovascular disease, pulmonary disease, diabetes mellitus, and poor general medical status are associated with an increased risk of death during anesthesia, regardless of anesthesia type.[18–23] Indices that incorporate multiple medical problems, such as the Charlson comorbidity index, Sickness at Admission scale, and acute physiologic score from the APACHE II scale have also been shown to be associated with mortality after surgery. Predictors of postoperative ischemia include evidence of cardiovascular disease (including hypertension), symptoms of ischemia, and CHF and diabetes.[24] Age older than 60 yr, male gender, obesity, diabetes mellitus, and history of chronic obstructive pulmonary disease, renal disease, and smoking are associated with increased risk of critical respiratory events after general anesthesia.[25] The ASA physical status has been shown to predict perioperative mortality and morbidity.[26–28]

Previous studies have not reliably established whether the type of anesthesia influences mortality and morbidity from nonvascular surgery. The largest clinical trial in-

cludes only 423 patients randomized to general, spinal, or epidural anesthesia.[2] The type of anesthesia did not appear to influence cardiac morbidity or overall mortality; however, the study was discontinued early because the outcomes were infrequent and the study was unlikely to show differences between the groups. In total, approximately 1,400 patients have been included in randomized clinical trials.[25,29-37] Few of these studies found differences in mortality or morbidity, although most had limited power because of small sample size. One small study in 53 patients found lower mortality and morbidity in high-risk patients administered epidural anesthesia and postoperative analgesia.[37] A second study showed more postoperative confusion in patients administered general anesthesia,[25] although a study of 262 patients evaluated postoperative cognition using standardized neuropsychological tests and found no difference in function.[38] Our study also found that the type of anesthesia did not affect postoperative cognition.

The most important limitation of this retrospective observational cohort study is that it is possible that we were unable to identify and adjust for important prognostic differences between groups even though we controlled for ASA status, hospital, many individual diseases, and several comorbidity indices. A randomized clinical trial would eliminate this limitation but would need to be very large to adequately assess mortality and morbidity outcomes. For example, a trial in patients with hip fracture with 30-day mortality as the primary outcome (assuming 80% power, 4.8% mortality, and ability to detect 25% difference) would necessitate a sample size of approximately 13,000-14,000 patients. If the primary outcome for the trial was 7-day mortality (a time period some would argue is more likely to be related to anesthesia than 30-day mortality), 38,000 patients would be needed because mortality is much lower at 7 days than at 30 days. Alternatively, a smaller trial could be performed using a combined mortality and morbidity outcome.

The precision of this study can be evaluated by evaluating the 95% confidence intervals.[39] For fully adjusted 30-day mortality analysis, the 95% confidence interval of 0.84-1.38 means that the observed data are statistically compatible with an increase in risk of death no greater than 38% and a decrease in the risk of death no greater than 16%. This is equivalent to a difference in mortality from 4.03 to 6.6% when compared to a baseline of 4.8%, which suggests this study has reasonable power to detect clinically important differences in 30-day mortality. The study has less power to evaluate risk of myocardial infarction and pneumonia.

The results of the analysis of morbidity outcomes must be interpreted cautiously. We used data recorded in the medical record to identify patients with a morbidity outcome. It is likely that not all of the events were captured in the medical record, either because the diagnostic tests were not ordered or the because symptoms were subtle and therefore went unrecognized. Postoperative confusion may be especially difficult to determine reliably from the medical record. Some of the criteria used for morbidity outcomes were based on physician diagnosis and these may not always be accurate. It is probable that diagnostic information was not recorded consistently among the 20 hospitals or during the time of the study. Although unlikely, we cannot rule out the possibility that there was differential assessment for postoperative morbidity in patients receiving general or regional anesthesia. Therefore, we classified the morbidity endpoints as tertiary outcomes.

This study has several other potential limitations. We did not control for intraoperative or postoperative factors (*e.g.*, intraoperative hypotension, postoperative analgesic management) that might influence mortality or morbidity because these might actually represent outcomes occurring during or after the time anesthesia was administered. The benefit of regional anesthesia may be partially mediated by the use of epidural anesthesia, which was used too infrequently to study in this study population. We did not collect information about the specific anesthetic drug and dose.

We were unable to demonstrate any clinically important influence on major outcomes from surgery in this very large study in patients with hip fracture who were administered general *versus* regional anesthesia after differences in clinical characteristics were considered. The study was large enough to exclude up to a 38% difference in mortality and a 22-70% difference in morbidity. During the period of the study, the use of regional anesthesia for hip fracture surgery increased by 30%, and there was great variability among hospital centers in the choice of anesthesia. Combined with other work in the field, this study suggests that choice of anesthesia should be dependent on factors other than influence on postoperative mortality or morbidity.

References

1. Liu S, Carpenter RL, Neal JM: Epidural anesthesia and analgesia. Their role in postoperative outcome. ANESTHESIOLOGY 1995; 82:1474-506

2. Bode RH, Lewis KP, Zarich SW, Pierce, ET, Roberts, M, Kowal-

chuk, GJ, Satwicz, PR, Gibbons, G, Hunter, JA, Espanola, CC, Nesto, RW: Cardiac outcome after peripheral vascular surgery. Comparison of general and regional anesthesia. ANESTHESIOLOGY 1996; 84:3-13

3. Go AS, Browner WS: Cardiac outcomes after regional or general anesthesia. Do we have the answers? ANESTHESIOLOGY 1996; 84:1-2

4. Carson JL, Duff A, Berlin JA, Lawrence, VA, Posis, RM, Huber, EC, O'Hara, DA, Noveck, H, Strom, BL: Influence of perioperative blood transfusion on postoperative mortality. JAMA 1998; 279:199-205

5. Crow RS, Prineas R, Jacobs DR, Blackburn H: A new epidemiologic classification system for interim myocardial infarction from serial electrocardiographic changes. Am J Cardiol 1989; 64:454-61

6. Charlson ME, Pompei P, Ales KL, MacKenzie CR: A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chron Dis 1987; 40:373-83

7. Knaus WA, Draper EA, Wagner DP, Zimmerman JE: APACHE II: A severity of disease classification system. Crit Care Med 1985; 13:818-29

8. Keeler EB, Kahn KL, Draper D, Sherwood MJ, Rubenstein LV, Reinisch EJ, Kosecoff J, Brook, RH: Changes in sickness at admission following the introduction of the prospective payment system. JAMA 1990; 264:1962-8

9. Knaus WA, Draper EA, Wagner DP, Zimmerman JE: An evaluation of outcome from intensive care in major medical centers. Ann Intern Med 1986; 104:410-8

10. Dripps RD, Lamont A, Eckenhoff JE: The role of anesthesia in surgical mortality. JAMA 1961; 178:261-6

11. American Society of Anesthesiologists: New classification of physical status. ANESTHESIOLOGY 1963; 24:111

12. Feinberg SE: The Analysis of Cross Classified Data. Cambridge, The MIT Press, 1977, p 9

13. Rubin B: Estimating causal effects from large data sets using propensity scores. Ann Intern Med 1997; 127:757-63

14. Beslow NE, Day NE: Statistical Methods in Cancer Res, Volume 1: The Analysis of the Case-Control Studies. Lyon, International Agency for Research on Cancer, 1980 p 142

15. Mantel N, Haenszel W: Statistical aspects of the analyses of data from retrospective studies of disease. From retrospective chart reviews. J Nat Cancer Inst 1959; 22:719

16. SAS Procedures Guide, Release 6:03 Edition. Cary, NC, SAS Institute, 1988, p 441

17. Wennberg JE, Freeman JL, Shelton RM, Bubolz TA: Hospital use and mortality among Medicare beneficiaries in Boston and New Haven. N Engl J Med 1989; 321:1168-73

18. Mangano DT, Browner WS, Hollenberg M, London MJ, Tubau JF, Tateo IM: Association of perioperative myocardial ischemia with cardiac morbidity and mortality in men undergoing noncardiac surgery. The Study of Perioperative Ischemia Research Group, N Engl J Med 1990; 323:1781-8

19. Goldman L: Cardiac risk in noncardiac surgery: An update. Anesth Analg 1995; 80:810-20

20. Goldman L, Caldera DL, Nussbaum SR, Southwick FS, Krogstad D, Murray B, Burke DS, O'Malley TA, Goroll AH, Caplan CH, Nolan J, Carabello B, Slater EE: Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med 1977; 297:845-50

21. Fleisher LA, Barash PG: Preoperative cardiac evaluation for noncardiac surgery: a functional approach. Anesth Analg 1992; 74:586-98

22. Detsky AS, Abrams HB, McLaughlin JR, Drucker DJ, Sasson Z, Johnston N, Scott JG, Forbath N, Hilliard JR: Predicting cardiac complications in patients undergoing noncardiac surgery. J Gen Intern Med 1986; 1:211-9

23. Larsen SF, Olesen KH, Jacobsen E, Nielsen H, Nielsen AL, Pietersen A, Jensen OJ, Pedersen F, Waaben J, Kehlet H: Prediction of cardiac risk in non-cardiac surgery. Eur Heart J 1987; 8:179-85

24. Hollenberg M, Mangano DT, Browner WS, London MJ, Tubau JF, Tateo IM: Predictors of postoperative myocardial ischemia in patients undergoing noncardiac surgery. JAMA 1992; 268:205-9

25. Hole A, Terjesen T, Breivik H: Epidural versus general anaesthesia for total hip arthroplasty in elderly patients. Acta Anaesth Scand 1980; 24:279-87

26. Rose DK, Cohen MM, DeBoer DP: Cardiovascular events in the postanesthesia care unit. ANESTHESIOLOGY 1996; 84:772-81

27. Wolters U, Wolf T, Stutzer H, Schroder T: ASA classification and perioperative variables as predictors of postoperative outcome. Br J Anaesth 1996; 77:217-22

28. Prause G, Ratzenhofer-Comenda B, Pierer G, Smolle-Juttner F, Glanzer H, Smolle J: Can ASA grade or Goldman's cardiac risk index predict peri-operative mortality? Anaesthesia 1997; 52:203-6

29. Cook PT, Davies MJ, Cronin KD, Moran P: A prospective randomized clinical trial comparing spinal anesthesia using hyperbaric cinchocaine with general anaesthesia for lower limb vascular surgery. Anesth Intensive Care 1986; 14:373-80

30. Damask MC, Weissman C, Todd G: General versus epidural anesthesia for femoral popliteal bypass surgery. J Clin Anesth 1990; 2:71-5

31. Jayr C, Thomas H, Rey A, Farhat F, Lasser P, Bourgain JL: Postoperative pulmonary complications. Epidural analgesia using bupivacaine and opioids versus parenteral opioids. ANESTHESIOLOGY 1993; 78:666-76

32. Jellish WS, Thalji Z, Stevenson K, Shea J: A prospective randomized study comparing short- and intermediate-term perioperative outcome variables after spinal or general anesthesia for lumbar disk and laminectomy surgery. Anesth Analg 1996; 83:559-64

33. Shir Y, Raja SN, Frank SM: The effect of epidural versus general anesthesia on postoperative pain and analgesic requirements in patients undergoing radical prostatectomy. ANESTHESIOLOGY 1994; 80:49-56

34. Christopherson R, Beattie C, Frank SM, Noris EJ, Meinert CL, Gottlieb SO, Yates H, Rock P, Parker SD, Perler BA, Williams GM: Perioperative morbidity in patients randomized to epidural or general anesthesia for lower extremity vascular surgery. ANESTHESIOLOGY 1993; 79:422-34

35. Rosenfeld BA, Beattie C, Christopherson R, Norris EJ, Frank SM, Breslow MJ, Rock P, Parker SD, Gottlieb SO, Perler BA, Williams GM, Seidler A, Bell W: The effects of different anesthetic regimens on fibrinolysis and the development of postoperative arterial thrombosis. ANESTHESIOLOGY 1993; 79:435-43

36. Williams-Russo P, Sharrock NE, Haas SB, Insall J, Windsor RE, Laskin RS, Ranawat CS, Go G, Ganz SB: Randomized trial of epidural versus general anesthesia: Outcomes after primary total knee replacement. Clin Ortho Rel Res 1996; 331:199-208

37. Yeager MP, Glass DD, Neff RK, Brinck-Johnsen T: Epidural anesthesia and analgesia in high-risk surgical patients. ANESTHESIOLOGY 1987; 66:729-36

38. Williams-Russo P, Sharrock NE, Mattis S, Szatrowski TP, Charlson ME: Cognitive effects after epidural vs general anesthesia in older adults. A randomized trial. JAMA 1995; 274:44-50

39. Goodman SN, Berlin JA: The use of predicted confidence intervals when planning experiments and the misuse of power when interpreting results. Ann Intern Med 1994; 121:200-6