Relative Importance of Preoperative Health Status Versus Intraoperative Factors in Predicting Postoperative Adverse Outcomes in Geriatric Surgical Patients

Jacqueline M. Leung, MD, MPH, and Samir Dzankic, MD

OBJECTIVES: To determine the prevalence and predictors of adverse postoperative outcomes in older surgical patients undergoing noncardiac surgery.

DESIGN: Prospective cohort study of consecutive patients undergoing noncardiac surgery in 1997.

SETTING: A medical school–affiliated teaching community hospital.

PARTICIPANTS: Patients age 70 and older undergoing noncardiac surgery. Patients presenting for surgery requiring only local anesthesia or monitored anesthesia care were excluded.

MEASUREMENTS: Potential pre- and intra-operative risk factors were measured and evaluated for their association with the occurrence of predefined in-hospital postoperative adverse outcomes. Univariate predictors of postoperative outcomes were first measured using the chi-square or Fisher's exact tests followed by multivariate logistic regression. Odds ratios (OR) with 95% confidence interval (CI), and two-sided *P*-values were reported.

RESULTS: Five hundred forty-four consecutive patients were studied. Overall, 21% of patients developed one or more postoperative adverse outcomes and 3.7% died during the in-hospital postoperative period. Of all the adverse outcomes, cardiovascular complications (10.3%) were the leading cause of morbidity, followed by neurological (7.7%) and pulmonary complications (5.5%). By multivariate logistic regression analysis, American Society of Anesthesiologists (ASA) classification (OR = 2.7, CI = 1.6–4.4), emergency surgery (OR = 2.0, CI = 1.1–3.4), and intraoperative tachycardia (OR = 3.8, CI = 1.9–7.6) were the most important predictors of postoperative adverse outcomes. Of all the preoperative physical symptoms and signs, decreased functional status (OR = 3.0, CI = 1.4–6.4) and clinical signs of congestive heart failure (OR = 2.1, CI = 1.1–5.1) were the two most important predictors of postoperative adverse neurological and cardiac outcomes, respectively. The median hospital stay was 4 days. The patients who developed postoperative adverse outcomes had significantly longer median hospital stays (9 days) than those without complications (3 days), ($P < .0001$).

CONCLUSION: Our study demonstrates that the postoperative mortality rate in geriatric surgical patients undergoing noncardiac surgery is low. Despite the prevalence of preoperative chronic medical conditions, most patients do well postoperatively. The ASA classification (a reflection of the severity of preoperative comorbidities), emergency surgery, and intraoperative tachycardia increase the odds of developing any postoperative adverse events. Future studies aimed at modifying some of the potentially reversible risk factors, such as preoperative heart function and intraoperative heart rate are warranted. **J Am Geriatr Soc 49:1080–1085, 2001.**

Key words: geriatric; outcomes; predictors; surgery

Perioperative management of geriatric surgical patients is becoming an increasingly important component of surgical and anesthetic practice in the 21st century. This phenomenon is due to the fact that people age 65 and older constitute the fastest growing segment in the population.[1] This change in patient demographics results in more older patients presenting for surgery. Furthermore, advances in perioperative practice and introduction of minimally invasive surgical approaches have enabled sicker patients to be eligible for surgery. To develop strategies to improve the perioperative care for geriatric patients, we undertook a prospective investigation of perioperative morbidity and mortality rates to identify factors associated with adverse postoperative outcomes.

In a previous study, we examined the prevalence and predictors of adverse perioperative outcomes by means of a retrospective study involving 367 consecutive patients, age 80 and older undergoing noncardiac surgery.[2] We found

From the Department of Anesthesia and Perioperative Care, University of California, San Francisco, California.

A portion of the data was presented in abstract form at the 2000 Annual Meeting of the International Anesthesia Research Society, Honolulu, Hawaii. This project was supported in part by institutional funds and the National Institutes of Health, Grant #1K24A600948-01AZ.

Address correspondence to Dr. Leung, University of California, San Francisco, Mount Zion Medical Center, Department of Anesthesia and Perioperative Care, 1600 Divisadero Street, CA 94143.

0002-8614/01/$15.00

that 25% of the patients developed postoperative adverse outcomes involving either the neurological, cardiovascular, or pulmonary systems, and that the overall postoperative in-hospital mortality rate was 4.6%. By multivariate analysis, it was found that a history of neurological disease, congestive heart failure (CHF), or dysrhythmia increased the odds of developing any postoperative adverse events.

To confirm and expand these results, we carried out a prospective cohort study with the goal of determining predictors of postoperative adverse outcomes that may be modifiable by perioperative management in geriatric surgical patients undergoing noncardiac surgery.

METHODS

Approval was obtained from the institutional Committee on Human Research. The study was exempted from the requirement of obtaining informed consent from patients because it involved the collection of existing records and diagnostic data that were publicly available. During a 1-year period in 1997, consecutive patients age 70 and older undergoing elective or emergent noncardiac surgery requiring general or regional anesthesia at one of the teaching hospitals of the University of California, San Francisco Medical Center (Mount Zion Medical Center), were studied.

Patients who were scheduled for surgery requiring local anesthesia or monitored anesthesia care (local anesthesia supplemented with intravenous sedation) were excluded. Medical records of each patient were reviewed to obtain data on their preoperative health status and intraoperative management. Potential perioperative risk factors were selected based on their known influence on major organ function and overall health, and also the feasibility of measurement of the risk factors through medical record review and routine preoperative clinical testing. The potential preoperative predictors of in-hospital morbidity included a history of hypertension, diabetes mellitus, smoking, coronary artery disease, previous cardiac interventions, valvular heart disease, CHF, dysrhythmias/conduction defects, vascular disease, pulmonary disease, renal disease, neurological disease including stroke and transient ischemic attack, liver disease, past surgical procedure(s), and medication use and type. Preoperative physical examination data measured included vital signs, mental status, heart murmur, wheezes on chest auscultation, and signs of heart failure. Other potential predictors of postoperative morbidity measured included general demographics, such as gender, race, age, location from where the patient was admitted (home, hospital, nursing home, skilled nursing facility), and type of admission (elective versus emergent).

Potential intraoperative risk factors measured for in-hospital morbidity included type of anesthesia (general, regional, or general/regional combined), type of surgical procedures, and hemodynamic abnormalities (>10 minutes duration of tachycardia (heart rates >100 beats per minute)), hypertension (systolic blood pressure >180 mm Hg), hypotension (systolic blood pressure <80 mm Hg), oxygen saturation <95%, dysrhythmias, American Society of Anesthesiologists (ASA) classification, type of monitoring (routine versus invasive (arterial, central venous, or pulmonary artery catheterization or transesophageal echocardiography)), use of vasoactive agents, intraoperative blood loss, and duration of anesthesia.

In-hospital course was followed daily until discharge for the new occurrence of postoperative outcomes; cardiac complications included ischemic cardiac complications (new occurrence of chest pain, electrocardiogram changes, or cardiac enzyme changes), myocardial infarction, dysrhythmias, or heart failure. Respiratory complications included pulmonary edema, tracheal re-intubation, pulmonary consolidation on chest X-ray, pneumothorax, or pleural effusion. Renal complications were defined as the new requirement of dialysis postoperatively or elevation of serum creatinine. Neurological complications were defined as the new occurrence of transient ischemic attack or stroke, delirium, or confusion. Infection required documentation of a positive culture. Gastrointestinal complications were defined as bowel ischemia, perforation, bleeding, cholecystitis, pancreatitis, or elevated postoperative liver enzymes with or without postoperative jaundice. Thromboembolic events were defined as deep venous thrombosis or pulmonary embolism. Other postoperative outcomes measured included death, surgical complications, and re-operation during the same hospitalization.

Data Analysis

Univariate preoperative and intraoperative predictors of postoperative outcomes were measured using the chi-square or Fisher's exact tests (Stata 5.0, College Station, TX). Variables that had significant association with postoperative adverse outcomes on univariate analysis (P-value = .1) were entered in a stepwise multivariate logistic regression model (STATA statistical software Version 5.0, Stata Corporation, College Station, TX). Using this statistical model, each variable was examined for association with postoperative adverse outcomes while controlling for all other confounding variables. The contribution of each risk factor was assessed by testing the regression coefficient against zero. Risk factors were removed from the model in a stepwise fashion; the risk factor showing the smallest contribution was deleted at each step. The model building was stopped when all risk factors remaining in the model had regression coefficients significantly different from zero. P-values and odds ratios (ORs) with 95% confidence intervals (CIs) were reported. P-value <.05 was considered statistically significant.

Comparison of median hospital stay between patients with and without postoperative adverse outcomes was performed using the two-sample Wilcoxon rank-sum (Mann-Whitney) test.

RESULTS

Six hundred one surgical procedures were performed in 544 consecutive patients. For those patients who underwent more than one surgical procedure during the study period, only the first surgical procedure was included in this analysis.

The mean age of the patients was 78 ± 6 (range 70–100). Forty-four percent of the patients were male and 56% were female. The racial distribution of the patients was white, 82%, black, 7.9%, Hispanic, 3.8%, and Asian/Pacific Islander, 6.0%. 86.4% of the operations were elective and 13.6% were urgent or emergent. The preoperative

Table 1. Preoperative Chronic Health Conditions

Preoperative Conditions	Proportion of Patients (%)
Diabetes mellitus	14.9
Hypertension	58.1
History of angina pectoris	16.4
History of myocardial infarction	9.1
History of vascular disease	17.7
Coronary artery bypass graft	5.9
Percutaneous transluminal coronary angioplasty	3.7
History of congestive heart failure	7.8
History of dysrhythmias	19.6
History of valvular disease	5.7
Pulmonary disease	21.9
History of smoking	39.9
Current smoking	6.9
History of neurologic disease	22.4
History of renal disease	7.6
0 preoperative conditions	16
1 Preoperative condition	27.5
2 Preoperative conditions	26.9
≥3 Preoperative conditions	29.3

health data are summarized in Table 1. More than half of the study cohort had a history of hypertension. The other cardiac risk factors that were prevalent in this cohort included a history of smoking, diabetes mellitus, and a history of vascular disease. A history of coronary artery disease, which included either a history of angina pectoris, previous myocardial infarction, or status postcardiac interventions such as coronary artery bypass graft surgery or percutaneous transluminal coronary angioplasty, was also prevalent (Table 1). Other prevalent chronic conditions included a history of dysrhythmias and pulmonary and neurological disease. Overall, 84% of the patients had one or more preoperative comorbid condition. The functional status, ASA classification, types of preoperative medications, and the location from which the patients were admitted are shown in Table 2. The reasons listed for limitation of activities (functional status = 3) were heterogeneous, including orthopedic (most common reason), dyspnea, chest pain, claudication, general fatigue, and a history of stroke.

The majority of the operations were general (24%), followed by orthopedic (18%), neurological (13%), urological (13%), head and neck (9%), gynecological (9%), vascular (8%), thoracic (5%), and cosmetic surgeries (1%). Four hundred five patients (74.5%) received general anesthesia, 85 (15.6%) received regional anesthesia, and 54 (9.9%) received combined general and regional anesthesia. Sixty-seven percent of patients had standard noninvasive monitoring and 33% had invasive monitoring (32% direct arterial pressure, 5.7% central venous pressure, 0.6% pulmonary artery catheter and 1.7% transesophageal echocardiographic monitoring).

Adverse events occurring in the intraoperative period are listed in Table 3. The majority of patients (77.6%) had no intraoperative adverse events. The most common hemodynamic abnormality observed in the intraoperative period was systolic hypertension.

Table 2. Functional Status, ASA Classification, Preoperative Medications, and Locations Before Admission

Preoperative Conditions	Percentage of Patients (%)
Functional status*	
1	47.2
2	18.6
3	17.9
4	14.9
5	1.3
ASA classification†	
I	1.7
II	45.0
III	48.0
IV	4.8
V	0.55
Taking ≥1 medications preoperatively	92.3
Diuretics	23.4
Nitrates	8.3
ACE inhibitors	17.7
Beta blockers	14.2
Calcium channel blockers	21.1
Antiarrhythmics	12.1
Anti-thrombotics	26.8
Anti-depressants	6.3
Hypoglycemic agents	9.7
Pulmonary medications	7.2
NSAIDS	19.7
Narcotics	9.6
Admission from	
Home	93.5
Hospital	1.3
Nursing home	4.4
Skilled nursing facility	0.7

*Functional status classification (1 = no limitation of activities, 2 = intermittent limitation of activities, 3 = mild limitation of activities, 4 = moderate limitation of activities, 5= severe limitation of activities).

American Society of Anesthesiologists (ASA) classification (1 = no organic, physiologic, biochemical, or physical disturbance, 2 = mild to moderate systemic disturbance that may or may not be related to the reason for surgery, 3 = severe systemic disturbance that may or may not be related to the reason for surgery, 4 = severe systemic disturbance that is life threatening with or without surgery, 5 = moribund patient who has little chance of survival but is submitted to surgery as a last resort).

ACE = angiotensin converting enzyme; NSAIDS = nonsteroidal anti-inflammatory drugs.

The types and prevalence of postoperative adverse outcomes are listed in Table 4. Twenty-one percent of patients developed one or more postoperative adverse events and 3.7% of patients died during the in-hospital postoperative period. Of all the adverse outcomes, cardiovascular complications were the leading causes of morbidity, followed by neurological and pulmonary complications. The results of the multivariate logistic regression are shown in Table 5. Five separate models were constructed, respectively, for the following outcomes: any postoperative adverse outcome; death; and cardiac, neurological, and pulmonary complications, the last three being the most prevalent types of postoperative complications demonstrated in this study. In the multivariate logistic regression models, the ASA classification (OR = 2.7, CI = 1.6–4.4), emergency

Table 3. Adverse Intraoperative Events

Intraoperative Events	Proportion of Patients with Events (%)
Heart rate >100 bpm	7.5
Systolic blood pressure <80 mmHg	0.55
Systolic blood pressure >180 mmHg	14.7
Intraoperative desaturation (O_2 saturation < 95%)	2
Use of neosynephrine or ephedrine	56
Use of other vasoactive agents*	4.2
Use of beta blockers	24
0 Intraoperative events	77.6
1 Intraoperative event	20.0
2 Intraoperative events	2.4
Total patients/total events	122/135

See text for detailed definitions of hemodynamic abnormalities.
*Other vasoactive agents = calcium, dobutamine, dopamine or epinephrine.

surgery (OR = 2.0, CI = 1.1–3.4), and intraoperative tachycardia (OR = 3.8, CI = 1.9–7.6) were the most important predictors of postoperative adverse outcomes (Table 5). Although several predictors of postoperative death were identified, including emergency surgery, history of percutaneous transluminal coronary angioplasty, preoperative wheezing, use of intraoperative invasive monitor, and race (black), the CIs for the ORs were large (Table 5) because the number of patients who died during the in-hospital follow-up period was small.

In separate analyses examining the specific predictors for adverse outcomes involving different organ systems, we found that ASA classification (OR = 2.7, CI = 1.4–5.2) and clinical signs of CHF (OR = 2.1, CI = 1.1–5.1) increased the odds of an adverse cardiac event. The odds of an adverse pulmonary event were increased with a history of CHF (OR = 5.7, CI = 2.1–15.1), use of invasive monitors (OR = 9.7, CI = 3.7–25.4), or emergency surgery (OR = 3.6, CI = 1.6–8.3); and the odds of an adverse neurological event were increased for nursing home patients (OR = 6.5, CI = 1.8–23.2), decreased functional status (=3) (OR = 3.0, CI = 1.4–6.4), intraoperative tachycardia (OR = 3.6, CI = 1.4–9.4), use of invasive monitors (OR = 5.2, CI = 2.5–11.1), and race (black) (OR = 3.4, CI = 1.3–8.9).

The median hospital stay was 4 days. The patients who developed postoperative adverse outcomes had a significantly longer median hospital stay (9 days) than those without complications (3 days), $P = .0001$. Postoperatively, the majority of the patients were discharged to home (73.5%). Other destinations included another hospital (1.7%), nursing home (2%), and skilled nursing facility (19.1%).

DISCUSSION

Study Population

Our study involves unselected, consecutive patients from a community medical center providing health care to a heterogeneous group of older patients living in the San Francisco area. The preoperative health status and the postoperative morbidity and mortality rates of our patients were comparable to those reported from previous studies.[3–6]

Table 4. Adverse Postoperative Events

Types of postoperative adverse outcomes	Number (%) of patients
Death	20 (3.7)
Cardiac complications	56 (10.3)
Ischemic complications	29 (5.3)
Myocardial infarctions	10 (1.8)
Heart failure	18 (3.3)
Dysrhythmia	32 (5.9)
Hepatic/gastrointestinal	3 (0.5)
Infection	27 (4.9)
Neurological complications	42 (7.7)
Delirium	37 (6.8)
CVA/TIA	5 (0.9)
Pulmonary complications	30 (5.5)
Respiratory failure	18 (3.3)
Aspiration pneumonia	6 (1.1)
Pleural effusion	7 (1.2)
Renal complications	14 (2.6)
Reoperation	19 (3.5)
Surgical complications	21 (3.9)
Thrombo-embolic events	6 (1.1)
Others*	12 (2.2)
Total patients/total events	112/250
0 Postoperative adverse outcomes	432 (79.4)
1 Postoperative adverse outcome	61 (11.2)
2 Postoperative adverse outcomes	21 (3.9)
3 Postoperative adverse outcomes	30 (5.5)

Some patients had more than one type of complication (e.g., both cardiac and pulmonary complications), and that within one type of complication, they might also have had more than one subtype of complications (e.g., myocardial infarction and heart failure).
CVA = cerebrovascular accident; TIA = transient ischemic attack.
*vocal cord paralysis, clinically significant hypertension and hypotension, hypovolemic shock, etc.

Interpretation of Results

Our present results confirm several findings from our previous study in surgical patients age 80 and older.[2] Specifically, preoperative comorbidities were common. However, many of the conditions associated with aging such as hypertension and coronary artery disease were not associated with postoperative adverse outcomes. A history or the presence of clinical signs of CHF continues to be independent predictors of postoperative adverse outcomes involving the pulmonary and cardiac systems. In contrast to previous reports[5,7] chronological age alone is less important a prognosticator than the severity of preoperative comorbidities, because age was not a significant predictor of adverse postoperative outcomes in the final multivariate model (Table 5). The most prevalent types of postoperative complications were cardiac, neurological, and pulmonary morbidities, identical to what we previously reported.[2]

Despite the potentially varied nature of each study patient population, several factors continue to be identified as major predictors of surgical outcomes as demonstrated by our present results and those from previous studies. These in-

Table 5. Multivariate Analysis of Pre- and Intraoperative Predictors of Adverse Postoperative Events

Preoperative and Intraoperative Predictors	Postoperative Event	Odds Ratio (confidence interval)	*P*-value
ASA class ≥3	any adverse postoperative event	2.7 (1.6–4.4)	<.0001
Emergency surgery	any adverse postoperative event	2.0 (1.1–3.4)	.014
Intraoperative tachycardia	any adverse postoperative event	3.8 (1.9–7.6)	<.0001
Emergency surgery	death	22.0 (6.2–78.0)	<.0001
History of PTCA	death	7.1 (1.3–39.2)	.024
Preoperative wheezing	death	12.9 (2.1–77.6)	.005
Use of invasive monitor	death	13.4 (3.3–55.0)	<.0001
Race (black)	death	9.2 (2.2–37.9)	.002
ASA class ≥ 3	adverse cardiac event	2.7 (1.4–5.2)	.003
Signs of heart failure	adverse cardiac event	2.1 (1.1–5.1)	.034
Emergency surgery	adverse pulmonary event	3.6 (1.6–8.3)	.003
History of heart failure	adverse pulmonary event	5.7 (2.1–15.5)	.001
Use of invasive monitor	adverse pulmonary event	9.7 (3.7–25.4)	<.0001
From nursing home	adverse neurologic event	6.5 (1.8–23.2)	.004
Functional status ≥ 3	adverse neurologic event	3.0 (1.4–6.4)	.004
Intraoperative tachycardia	adverse neurologic event	3.6 (1.4–9.4)	.009
Use of invasive monitor	adverse neurologic event	5.2 (2.5–11.1)	<.0001
Race (black)	adverse neurologic event	3.4 (1.3–8.9)	.015

ASA = American Society of Anesthesiologists.
PTCA = percutaneous transluminal coronary angioplasty.

clude ASA classification and emergency surgery.[8,9] Emergency surgery, rather than the specific type of surgery, as reported by some previous studies, continues to be a major risk factor for postoperative complications for the older patient.[5,6]

The association between nursing home patients and postoperative neurological complications is consistent with findings from a retrospective study by Keating et al.[10] demonstrating that neuropsychiatric complications were the most frequent postoperative complications in patients coming from nursing homes.

No previous study has examined the influence of race on postoperative complications. Our results suggest that blacks have an increased likelihood of developing postoperative neurological complications. Black race independently increased the odds of an adverse neurological event (OR = 3.4, 95% CI = 1.3–8.9) in the multivariate model (Table 5). This association does not appear to be related to the interaction of black race with other predictors of postoperative neurological complications. Further studies would be necessary to identify the etiology for such an association.

Of all the preoperative physical signs and symptoms measured, decreased functional status and clinical signs of CHF were the two most important predictors of postoperative adverse neurological and cardiac outcomes. In our study, 34% of the patients had moderate to severe limitation of activity. These individuals likely would be further physically incapacitated in the postoperative period because of the effect of surgery. Because the majority of the postoperative neurological complications in our previous[2] and present studies were cases of delirium, these results suggest that limitation of physical activities and postoperative delirium may be causally related, as reported in general medical patients.[11,12]

The strong association between clinical signs of CHF and postoperative complications emphasizes the importance of preoperative optimization of heart function in the elective surgical patient. The adequacy and accuracy of preoperative assessment of heart function is a critical area of future investigation. In addition, aggressive management in the postoperative period with regard to fluid management, monitoring, and pharmacological therapy in the patient with either a history or clinical signs of CHF is also important. Furthermore, older patients with CHF frequently present with normal left ventricular ejection fraction,[13] suggesting the importance of diastolic dysfunction in this age group. The prognostic significance of diastolic function assessment, such as with preoperative Doppler echocardiography in patients with a history of heart failure remains to be determined.

Although many of the intraoperative factors were significant predictors by univariate analysis, only intraoperative tachycardia and the use of invasive monitors were predictive of postoperative adverse outcomes. Other intraoperative factors, such as the type of anesthesia (regional vs general), duration of anesthesia, blood loss, and type of surgery, were not significant predictors in the final model. Although not proven by the current data, it is likely that the association of intraoperative invasive monitors with adverse outcomes likely represented sicker patients needing more extensive monitoring, rather than the monitoring itself having a cause and effect relationship with postoperative adverse outcomes.

Our study demonstrates that the prevalence of intraoperative hypotension was low, probably secondary to the frequent administration of neosynephrine or ephedrine to increase blood pressure. In contrast, intraoperative systolic hypertension was more frequent (14.7%), but it was not associated with any postoperative adverse events. Intraoperative tachycardia was infrequent (7.5%), which may have been attributable to perioperative blockade (17.7% of patients received preoperative and 24% received intraoperative beta blockade). However, in contrast to a previ-

ous study in patients age 50 and older undergoing elective noncardiac surgery,[14] we found intraoperative tachycardia to be associated with adverse neurological outcomes. Further studies are necessary to elucidate why intraoperative tachycardia increased the odds of developing postoperative adverse neurological outcomes.

Limitations

Several potential limitations exist. First, we did not evaluate the nutritional status of our patients because laboratory testing relating to nutritional status is not routinely measured in the preoperative setting. A Veterans Affairs surgical risk study showed evidence that preoperative albumin level may be an important predictor of postoperative morbidity and mortality in.[9] Second, our postoperative surveillance was limited to the in-hospital period. As a result, the postoperative morbidity and mortality rates may have been underestimated in our study.

Clinical Implications

Our results suggest that if an illness requiring surgical intervention develops in a relatively healthy older patient (such as those with ASA classification = 2), it should be managed expeditiously, before an emergency develops. Although the exact mechanism of how emergency surgery increases surgical risk is unclear, for the older patient with severe systemic disease (such as those with ASA classification = 3) who presents with an illness requiring elective surgery, allowance of adequate time to stabilize preoperative medical status and planning of postoperative monitoring and therapy are recommended.

The combined results from our previous study in patients age 80 and older[2] and the present study confirm that the severity of preoperative comorbidities is a more important predictor of postoperative adverse outcomes than intraoperative factors. Two potentially modifiable predictors of postoperative adverse outcomes are preoperative heart function and intraoperative heart rate. Future studies directed at optimization of preoperative heart function, including the assessment of diastolic function and determination of the etiology linking intraoperative tachycardia to postoperative neurological dysfunction, are warranted.

ACKNOWLEDGMENTS

The authors thank Darwin Pastor and Carlos Gonzalez, MD, for assistance in data collection.

REFERENCES

1. U.S. Census Bureau. Projections of the Total Resident Population by 5-Year Age Groups, and Sex with Special Age Categories: Middle Series, 2025 to 2045. Washington, DC: Population Projections Program, Population Division, U.S. Census Bureau, 2000.
2. Liu L, Leung J. Predicting adverse postoperative outcomes in patients aged 80 years or older. J Am Geriatr Soc 2000;48:405–412.
3. Seeman T, Charpentier P, Berkman L et al. Predicting changes in physical performance in a high functioning elderly cohort: MacArthur studies of successful aging. J Gerontol 1994;49:M97–M108.
4. Pedersen T, Eliasen K, Henriksen E. A prospective study of risk factors and cardiopulmonary complications associated with anaesthesia and surgery: Risk indicators of cardiopulmonary morbidity. Acta Anaesthesiol Scand 1990;34: 144–155.
5. Pedersen T, Eliasen K, Henriksen E. A prospective study of mortality associated with anaesthesia and surgery: Risk indicators of mortality in hospital. Acta Anaesthesiol Scand 1990;34:176–182.
6. Reiss R, Deutsch A, Nudelman I. Surgical problems in octogenarians: Epidemiological analysis of 1,083 consecutive admissions. World J Surg 1992;16: 1017–1021.
7. Cohen M, Duncan P, Tate R. Does anesthesia contribute to operative mortality? JAMA 1988;260:2859–2863.
8. Hosking M, Warner M, Lobdell C et al. Outcomes of surgery in patients 90 years of age and older. JAMA 1989;261:1909–1915.
9. Gibbs J, Cull W, Henderson W et al. Preoperative serum albumin level as a predictor of operative mortality and morbidity. Arch Surg 1999;134:36–42.
10. Keating III J. Major surgery in nursing home patients: Procedures, morbidity, and mortality in the frailest of the frail elderly. J Am Geriatr Soc 1992;40:8–11.
11. Jarrett P, Rockwood K, Carver D et al. Illness presentation in elderly patients. Arch Intern Med 1995;155:1060–1064.
12. Ackermann R, Vogel R, Johnson L et al. Surgery in the nonagenarians: Morbidity, mortality and functional outcome. J Fam Pract 1995;40:129–135.
13. Aronow W, Ahn C, Kronzon I. Normal left ventricular ejection fraction in older persons with congestive heart failure. Chest 1998;113:867–869.
14. Marcantonio E, Goldman L, Orav E et al. The association of intraoperative factors with the development of postoperative delirium. Am J Med 1998; 105:380–384.