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Advancing Age and 30-Day Adverse Outcomes Following Non-Emergent General Surgical Operations

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Abstract

Background—While some single center studies have demonstrated that major surgical operations are safe to perform in older adults, most multicenter database studies find advancing age to independently predict adverse postoperative outcomes. We hypothesized that thirty-day postoperative mortality, complications, failure to rescue rates and postoperative length of stay will increase with advancing age.

Design—Retrospective cohort study.

Setting—Hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP)

Participants—Patients undergoing non-emergent major general surgical operations between 2005 and 2008 were studied.

Measures—Postoperative outcomes of interest were complications occurring within 30 days of the index operation, return to OR within 30 days, failure to rescue after a postoperative complication, post-surgical length of stay and 30 day mortality.

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No conflicts of interest or financial interest were declared by any of the authors.

Results—A total of 165,600 patients were studied. The rates of postoperative mortality, overall morbidity, and each type of postoperative complication increased as age increased. The rates of failure to rescue after each type of postoperative complication also increased with age. Mortality rates in patients ≥80 following renal insufficiency (43.3%), stroke (36.5%), myocardial infarction (35.6%), and pulmonary complications (25-39%) were particularly high. Median postoperative length of stay increased with age following surgical site infection, UTI, pneumonia, return to OR, and overall morbidity, but not after venous thromboembolism, stroke, myocardial infarction, renal insufficiency, failure to wean from the ventilator or reintubations.

Conclusion—Thirty-day mortality, complications and failure to rescue rates increase with advancing age following non-emergent general surgical operations. Patients over 80 years of age have especially high mortality following renal, cardiovascular, and pulmonary complications. As patient age advances, surgeons need to be more selective regarding who will benefit from the surgical intervention.

Keywords

Aging; Surgery; Postsurgical outcomes

INTRODUCTION

More than one third of all inpatient operations in the United States are currently performed on individuals 65 years and older.[1] Aging adults often have multiple chronic diseases which make their surgical care complex.[2-7] Given the demographic inevitability of the aging population, it is important to improve our understanding of the relationship of advancing age to surgical outcomes.

Current surgical literature is conflicting on the relationship of advancing age and surgical outcomes. Single center studies have established that acceptable outcomes can be achieved in patients older than 80 years following major operations.[8] In contrast, population based outcomes research has found that advancing age independently predicts adverse postoperative outcomes.[3-5,7,9,10] As a result, the operative risk and optimal perioperative medical and surgical management of these patients is not completely understood.

Older adults have diminished physiologic reserve compared to younger adults; a unique physiologic vulnerability termed frailty.[11-13] Intuitively, these diminishing physiologic reserves with advancing age likely affect our ability to salvage patients following a major postoperative complication. The relationship of failure to rescue (or the probability of a patient's death following a postoperative complication) and age is not known.

Using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, this study examined the effect of advancing age on the postoperative morbidity and mortality, failure to rescue, and postoperative length of stay in patients undergoing major non-emergent general surgical operations.

METHODS

Data source

Data for this study were obtained from the ACS-NSQIP, which assesses pre-operative risk factors, operative data, and 30-day postoperative outcomes for sampled patients undergoing major surgery at participating hospitals. A trained surgical clinical nurse collects the data from the patient's medical records. All data contained within the dataset are de-identified. On the 30th postoperative day, the nurse obtains outcome information through chart review, reports from morbidity and mortality conferences, and communication with each patient or the patient's family by letter or by telephone.[14]

Patients

The ACS-NSQIP database was used to select patients who had major non-emergent general surgical operations between 2005 and 2008. Patients included in the analysis were identified by Current Procedure Terminology (CPT) codes used to select patients whose procedure warrants more than an overnight stay. Patients were excluded if their operation was coded as an "Emergent case" (because emergent surgical operations in the elderly are not discretionary), if there was missing information for sex, race, wound classification, age, work RVU (relative value units: RVU), or if the patient had a prior operation within the past 30 days. The 'Online Table 1" lists all CPT codes used to select patients for this study. Using the methods detailed above, a total of 165,600 patients were selected. Patients were stratified by age (< 50, 50-59, 60-69, 70-79 and ≥80 years).

Definitions of outcomes of interest

Postoperative outcomes of interest were complications occurring within 30 days of the index operation, return to OR within 30 days, failure to rescue after a postoperative complication, post-surgical length of stay and 30 day mortality. Post-operative complications included: surgical site infection (SSI, including superficial and deep wound infections, wound disruptions); cardiovascular, pulmonary, renal and central nervous system complications; and return to operating room. In addition, we also grouped complications to form a composite pulmonary outcome (CPO: pneumonia, failure to wean from ventilator > 48 hrs or re-intubation for cardio-respiratory failure) and a composite vascular complications (stroke/cerebrovascular accident, myocardial infarction). An overall composite outcome was created by combining SSI, pulmonary, and vascular complications.

Statistical analyses

Baseline patient characteristics were compared among the age groups using chi-square tests of association for categorical variables and analysis of variance for continuous variables. A chi-square test was used to compare the overall number of postoperative complications and the rates of each type of complication between the age groups. Logistic regression analysis was used to compare the rates of failure to rescue after each type of complication between the age groups, adjusting for operation type. Multiple linear regression analysis was used to compare postoperative lengths of stay for patients with and without each type of complication between the age groups, adjusting for operation type.

Failure to rescue (FTR) rates were computed for each type of complication and the age groups by computing the 30-day mortality rates for those patients who developed each type of postoperative complication. These FTR rates were compared between various age groups by the Cochran-Mantel-Haenszel method. For example, the FTR rate for surgical site infection is calculated as the number of patients who have a postoperative surgical site infection and die within 30 days following the operation divided by the total number of patients who develop a postoperative surgical site infection.

All analyses were performed using SAS® software, Version 9.3 (SAS Institute Inc., Cary, North Carolina). A p-value of ≤ 0.05 was considered to be statistically significant.

RESULTS

A total of 165,600 who underwent elective major general surgical operations from 2005-2008 were studied. Patient characteristics for all age groups are shown in Table 1. The frequency of medical co-morbidities increased with advancing age. Older patients were less likely to be independent in their activities of daily living. Preoperative hematocrit and albumin values decreased with advancing age. Preoperative BUN increased with advancing age. Older patients had significantly higher ASA class. Elderly patients were less likely to have an upper gastrointestinal procedure performed and more likely to have a colo-rectal-appendix operation.

The frequencies of patients with multiple complications increased as patient age increased (Online Table 2).

The incidence of postoperative complications by type of complication and age group is presented in Table 2. For all ages, SSI (6.9%), return to OR (5.1%) and UTI (2.6%) were the most frequent postoperative complications. While the top two complications in terms of frequency remained the same for all ages (SSI and return to OR), the third most frequent complication was UTI for patients under age 60 and pulmonary complications for patients over the age of 60. For just about every type of complication, there was a monotonically increasing rate of complication as age increased.

Failure to rescue (FTR) rates, or mortality rates following a complication were the highest for renal complications (27%), myocardial infarction (26%) and reintubation (25.6%) for the entire sample (Table 3). There were differences in the mortality impact of the postoperative complications in the different age groups. The most lethal complications in patients under age 50 and between 50-59 years were MI (22 and 26%), renal complications (20% and 19%) and CVA (18% and 19%). The highest mortality complication was renal complications in patients over age 60 and with significantly increasing mortality with advancing age (24% for 60-69; 32% for ages 70-79 and 43% for ages 80 and over). The second highest mortality was attributable to reintubations (21%, 30%, and 39%) in all three of the most senior age groups. The third highest mortality was from failure to wean from the ventilator in patients aged 60-69 and 70-79, with stroke coming third in patients over 80. While in general there was a steady increase in mortality with advancing age for almost every type of postoperative

complication studied, the most striking was the significantly elevated FTR for all complications in patients over 80 (from 5.75% for SSI to 43.3% for renal insufficiency)

The association of complications and post-operative length of stay by age group is presented in Online Table 3. SSI increased post surgical length of stay in all age groups. In addition, there was an age dependent steady increase in length of stay in patients with SSI from a median of 6 days in patients below 50 years of age to over 9 days for patients over 80 years. Similarly, pneumonia increased postoperative length of stay in all age groups from 12 days in patients below 50 to 17 days in patients above 80. UTI resulted in progressively increasing length of stay in patients 69 years of age or below, but the effect leveled off in patients over 70 years of age with UTI. Unplanned return to the OR was associated with increased length of stay, which also increased with advancing age, although the effect diminished in those over 80 years of age. Failure to wean and reintubations were associated with the longest post surgical length of stay in all age groups when these patients were compared with patients not having the complication. Interestingly, patients over age 80 developing the above mentioned pulmonary complications spent shorter time in the hospital. There were no statistically significant differences in length of stay by age groups in patients experiencing the postoperative complications of thromboembolism, stroke, myocardial infarction, renal insufficiency or reintubation.

DISCUSSION

The present report is one of the largest studies on the complication rates and short term outcomes of non-emergent general surgical operations in elderly patients. Older patients had more co-morbidities and higher ASA scores preoperatively. In general, older patients had a higher rate of postoperative morbidity and mortality compared to their younger counterparts. The most frequent post-operative complication was SSI in all age groups, followed by return to OR and UTI. Advancing age was also associated with more patients having multiple complications simultaneously. Once a complication occurred, elderly patients were less likely to survive this event compared with their younger counterparts. Most striking was the substantially increased mortality for every postoperative complication studied in patients over 80 years of age. Patients under age 60 were most likely to die following an MI (the number of events in these age groups was low), while patients over 60 years of age were most likely to die from renal complications. Increasing age resulted in progressively increasing postoperative length of stay in all age groups for all patients without a complication. Patients with any complication had an increased postoperative stay when compared to patients within their age groups without any complication. Increasing age resulted in progressively increasing post surgical length of stay following surgical site infections, UTI, pneumonia, and return to OR. In contrast, there were no statistically significant differences in postoperative length of stay by age groups for patients having the postoperative complications of thromboembolism, strokes, MI, renal insufficiency, and unplanned intubation. A lack of statistically significant differences for the latter complications could be due to early withdrawal of care in the elderly age groups when these complications occurred.

Surgeons routinely do risk benefit ratio discussions with patients preoperatively. Defining an actual risk remains a difficult task, especially in older adults. The unspoken expectation from the surgeon is to provide outcomes similar to those in younger patients. Traditional preoperative risk stratification for aging adults may include several preoperative risk factors beyond patient age.[15] Geriatric surgery patients have a unique physiologic vulnerability resulting from reduced physiologic reserves associated with aging.[11]

A frail individual has limited reserves to withstand health stressors.[12-13] With a continued increase in the number of operations performed in patients with advancing age, improved preoperative identification of predictors for poor postoperative outcomes is important.

Population studies have consistently found that older patients have increased risk of postoperative adverse events, longer length of stay and higher rate of death following major general surgical operations. Al-Refaie et al.[5] studied patients over 80 years of age undergoing colorectal surgery and found elderly patients to be prone to major complications (17%), prolonged length of stay (29%) and increased risk of 30-day mortality (6%). In their study, multivariable analysis demonstrated that older age independently predicted worse postoperative outcomes in the oldest old. These findings were similar to findings from our study, where patients over 80 had the highest rate of complications, (24%), as well as the highest overall mortality (6.3%). Massarweh[3] studied patients over 65 years of age undergoing commonly performed abdominal surgery in Washington State and examined complication and mortality rates in various age groups with 5 year increments. The ninety day cumulative complication rate was over 17% with 5.4 % mortality. Similar to findings from our study, the odds of postoperative death increased significantly with advancing age in adjusted analysis.

The great majority of patients in this study using the ACS-NSQIP data had no documented postoperative complication in the non-emergent general surgery setting. This is true for patients of all ages, including the oldest old (over 80 years of age), suggesting that surgical interventions can be safely performed in all age groups for the majority of our patient population. On the other hand, we noted a progressively increasing FTR rate with advancing age in all complications studied. This suggests that an older adult has diminished physiologic reserve reducing their ability to withstand complications and decreases the clinician’s ability to rescue the patient once a complication occurs. While MI, renal insufficiency and stroke with neurological deficit are rare postoperative events; the mortality rate for these complications is 17-43%. Admittedly, the high mortality rate following MI and stroke has to be interpreted with caution given the low number of events in younger age groups.

There is a clear need to further refine our preoperative patient selection tools especially in elderly individuals. Based on our and some other studies, chronologic age remains an important variable in predicting postsurgical complications and mortality. However, in the era of individualized health care additional variables will also play an important role in achieving a better patient selection process for high risk surgical procedures in elderly individuals.

Previous studies have shown a clear volume outcome relationship for some of the most complex elective general surgical operations performed across the US.[7,9,16] The volume outcome relationship may be even more important for elderly patients, as occurrence of a postoperative adverse event clearly increases FTR rates in aging adults in our study. Several papers [2,6,17] developed risk assessment tools using easily identifiable preoperative variables besides age, such as cognition, nutritional status, number of falls, hematocrit, dependence in activities related to daily living and comorbidities. Living in a nursing home as a measure of preoperative function, or being discharged to one postoperatively, has also been clearly demonstrated to predict significantly worse postsurgical outcomes.[18,19] The best prediction tool will likely come from combining variables identified in the above mentioned studies and should be a subject of carefully planned, prospectively performed studies in the future.

Our study has several limitations. The database that we used and the analyses that were conducted contain a large number of different types of general surgical operations. With the exception of SSI, all other complications studied were non-surgical complications. The follow-up in the ACS-NSQIP is limited to 30 days. As a result, long-term complications, discharge to facility and mortality could not be studied. We could not explore volume-outcome relationship, as the dataset does not have any information on hospital volume. The number of adverse events in certain age groups was low (MI, stroke), potentially influencing FTR results. We attributed decreasing length of stay in patients over the age of 80 following certain complications (stroke, MI, failure to wean, unplanned intubation) to possibly sooner withdrawal of care in older individuals; however, we do not have enough data to better study this hypothesis.

In summary, we found that patients with advancing age undergoing non-emergent general surgical operations in ACS-NSQIP hospitals have a longer postoperative length of stay, elevated risk of postoperative complications and higher death rates compared to their younger counterparts. Based on our study, age alone currently remains an important predictor of adverse postoperative events in the general surgical population. The significantly elevated risk of postoperative complications and death deserves an in depth discussion with elderly patients and their families preoperatively. In addition to pushing for a more realistic informed consent acknowledging the possibility of higher mortality, complications, and post complication mortality in this patient population, we should also emphasize and develop new preoperative geriatric assessment tools, pre-habilitation and improve post-operative geriatric pathways to reduce postsurgical adverse events in the oldest old. Some of these prospective studies are currently underway at our institution.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Geriatric Review Syllabus: A core curriculum in geriatric medicine. 6. New York NY: American Geriatric Society; 2006.
2. Robinson TN, Eiseman B, Wallace JI, et al. Redefining geriatric preoperative assessment using frailty, disability and co-morbidity. Ann Surg. 2009; 250:449–455. [PubMed: 19730176]
3. Massarweh NN, Legner VJ, Symons RG, et al. Impact of advancing age on abdominal surgical outcomes. Arch Surg. 2009; 144:1108–1114. [PubMed: 20026827]
4. Al-Refaie WB, Parsons HM, Henderson WG, et al. Major Cancer surgery in the elderly. Ann Surg. 2010; 251:311–318. [PubMed: 19838107]
5. Al-Refaie WB, Parsons HM, Habermann EB, et al. Operative outcomes beyond 30-day mortality. Ann Surg. 2011; 253:947–952. [PubMed: 21490452]
6. Robinson TN, Wu DS, Stiegmann GV, et al. Frailty predicts increased hospital and six-month healthcare cost following colorectal surgery in older adults. Am J Surg. 2011; 202:511–514. [PubMed: 21890098]
7. Finlayson E, Fan Z, Birkmeyer JD. Outcomes in octogenerians undergoing high-risk cancer operation: A national study. J Am Coll Surg. 2007; 205:729–734. [PubMed: 18035254]
8. Makary MA, Winter JM, Cameron JL, et al. Pancreaticoduodenectomy in the very elderly. J Gastrointest Surg. 2006; 10:347–356. [PubMed: 16504879]
9. Riall TS, Reddy DM, Nealon WH, Goodwin JS. The effect of age on short-term outcomes after pancreatic resection. Ann Surg. 2008; 248:459–467. [PubMed: 18791366]
10. Morris EJA, Taylor EF, Thomas JD, et al. Thirty-day postoperative mortality after colorectal cancer surgery in England. Gut. 2011; 60:806–813. [PubMed: 21486939]
11. Buchner DM, Wagner EH. Preventing frail health. Clin Geriatr Med. 1992; 8:1–17. [PubMed: 1576567]
12. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: Evidence for a phenotype. J Gerontol a Biol Sci Med Sci. 2001; 56:M146–M156. [PubMed: 11253156]
13. Mitniski AB, Mogilner AJ, MacKnight C, et al. The mortality rate as a function of accumulated deficits in a frailty index. Mech Ageing Dev. 2002; 123:1457–1460. [PubMed: 12425952]
14. Khuri SF, Henderson WG, Daley J, et al. The patient safety in surgery study: Background, study design, and patient populations. J Am Coll Surg. 2007; 204:1089–1102. [PubMed: 17544068]
15. Fleisher LA, Beckman JA, Brown KA, et al. ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery: Executive summary. Circulation. 2007; 116:1971–1996. [PubMed: 17901356]
16. Finlayson E, Birkmeyer JD. Effects of hospital volume on life expectancy after selected cancer operations in older adults: A decision analysis. J Am Coll Surg. 2003; 196:410–417. [PubMed: 12648693]
17. Robinson TN, Wu DS, Pointer LF, et al. Preoperative cognitive dysfunction is related to adverse postoperative outcomes in the elderly. J Am Coll Surg. 2012; 215:12–18. [PubMed: 22626912]
18. Finlayson E, Wang L, Landefeld CS, et al. Major abdominal surgery in nursing home residents: A national study. Ann Surg. 2011; 254:921–926. [PubMed: 22020197]
19. Legner VJ, Massarweh NN, Symons RG, et al. The significance of discharge to skilled care after abdominopelvic surgery in older adults. Ann Surg. 2009; 249:250–255. [PubMed: 19212178]

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Table 1

Patient Characteristics by Age Category

			Age Category					
		Total n=165,600	**<50 n=60,043**	**50-59 n=36,720**	**60-69 n=31,887**	**70-79 n=23,568**	**>=80 n=13,382**	**p-value**
Patient Demographics								
Race	American Indian or Alaska Native	0.7% (1,084)	0.8% (473)	0.7% (255)	0.5% (175)	0.6% (143)	0.3% (38)	<0.001
	Asian or Pacific Islander	1.9% (3,207)	1.8% (1,066)	1.8% (659)	2.1% (661)	2.4% (563)	1.9% (258)	
	Black, Not of Hispanic Origin	9.9% (16,448)	12.7% (7,607)	10.4% (3,826)	8.2% (2,605)	7.0% (1,640)	5.8% (770)	
	Hispanic, Black	0.1% (191)	0.2% (126)	0.1% (29)	0.1% (19)	0.1% (14)	0.0% (3)	
	Hispanic, Color Unknown	2.9% (4,769)	4.5% (2,717)	2.1% (782)	1.9% (608)	1.9% (454)	1.6% (208)	
	Hispanic, White	2.7% (4,407)	3.9% (2,327)	2.1% (755)	1.9% (591)	2.1% (496)	1.8% (238)	
	Unknown	7.5% (12,500)	8.1% (4,837)	7.3% (2,668)	7.3% (2,329)	7.3% (1,711)	7.1% (955)	
	White, Not of Hispanic Origin	74.3% (122,994)	68.1% (40,890)	75.6% (27,746)	78.1% (24,899)	78.7% (18,547)	81.5% (10,912)	
Gender	Male	40.6% (67,183)	34.8% (20,870)	41.4% (15,187)	46.1% (14,699)	46.8% (11,033)	40.3% (5,394)	<0.001
	Female	59.4% (98,417)	65.2% (39,173)	58.6% (21,533)	53.9% (17,188)	53.2% (12,535)	59.7% (7,988)	
Age (years, truncated at 90), mean (sd)		55.4 (16.8)	37.4 (8.6)	54.5 (2.9)	64.3 (2.9)	74.3 (2.9)	84.1 (3.2)	<0.001
Preoperative Status								
Diabetes mellitus with oral agents or insulin		16.5% (27,347)	10.2% (6,141)	18.8% (6,913)	22.2% (7,065)	21.0% (4,959)	17.0% (2,269)	<0.001
Functional health status Prior to Surgery	Independent	93.9% (155,536)	97.1% (58,325)	95.8% (35,164)	93.9% (29,953)	90.3% (21,276)	80.8% (10,818)	<0.001
	Partially Dependent	4.5% (7,479)	1.9% (1,168)	3.1% (1,123)	4.4% (1,396)	7.4% (1,745)	15.3% (2,047)	
	Totally Dependent	1.6% (2,585)	0.9% (550)	1.2% (433)	1.7% (538)	2.3% (547)	3.9% (517)	
History of severe Chronic Obstructive Pulmonary Disease		4.7% (7,719)	1.1% (663)	3.6% (1,337)	6.8% (2,177)	9.8% (2,315)	9.2% (1,227)	<0.001
Current pneumonia		0.6% (1,036)	0.4% (244)	0.6% (212)	0.6% (201)	0.9% (218)	1.2% (161)	<0.001
Congestive heart failure (CHF) in 30 days before surgery		0.8% (1,281)	0.2% (116)	0.4% (154)	0.8% (265)	1.6% (376)	2.8% (370)	<0.001
History of myocardial infarction 6 mos prior to surgery		0.4% (721)	0.1% (50)	0.3% (105)	0.5% (173)	1.0% (234)	1.2% (159)	<0.001
History of angina in 1 month before surgery		0.6% (969)	0.2% (114)	0.4% (161)	0.8% (258)	1.1% (255)	1.4% (181)	<0.001
Hypertension requiring medication		47.0% (77,879)	24.0% (14,437)	48.4% (17,784)	60.4% (19,272)	69.6% (16,403)	74.6% (9,983)	<0.001
History of transient ischemic attacks (TIA)		2.1% (3,453)	0.4% (229)	1.3% (459)	2.4% (776)	4.5% (1,072)	6.9% (917)	<0.001
CVA*/Stroke with neurological deficit		1.7% (2,867)	0.4% (255)	1.3% (466)	2.2% (714)	3.4% (807)	4.7% (625)	<0.001
CVA*/Stroke with no neurological deficit		1.6% (2,613)	0.4% (241)	1.0% (371)	1.9% (591)	3.3% (771)	4.8% (639)	<0.001
Prior Operation within 30 days		2.4% (4,005)	2.0% (1,200)	2.3% (839)	2.6% (839)	3.1% (739)	2.9% (388)	<0.001

			Age Category					
		Total n=165,600	**<50 n=60,043**	**50-59 n=36,720**	**60-69 n=31,887**	**70-79 n=23,568**	**>=80 n=13,382**	**p-value**
Pre-operative hematocrit, mean (sd)		38.3 (5.3)	38.8 (5.1)	39.0 (5.2)	38.2 (5.4)	37.3 (5.4)	35.8 (5.2)	<0.001
Pre-operative BUN,** mean (sd)		14.9 (9.0)	12.0 (6.5)	14.7 (8.2)	16.4 (9.5)	17.8 (10.4)	19.5 (11.8)	<0.001
Pre-operative serum albumin, mean (sd)		3.8 (0.7)	3.9 (0.7)	3.8 (0.7)	3.7 (0.7)	3.6 (0.7)	3.4 (0.7)	<0.001
Surgical Profile								
Wound classification	Clean	15.9% (26,347)	16.5% (9,922)	17.6% (6,452)	16.5% (5,275)	14.2% (3,357)	10.0% (1,341)	<0.001
	Clean/Contaminated	65.0% (107,566)	64.1% (38,474)	64.1% (23,545)	64.4% (20,549)	66.3% (15,626)	70.0% (9,372)	
	Contaminated	12.9% (21,354)	13.4% (8,018)	12.2% (4,482)	12.5% (3,984)	13.2% (3,102)	13.2% (1,768)	
	Dirty/Infected	6.2% (10,333)	6.0% (3,629)	6.1% (2,241)	6.5% (2,079)	6.3% (1,483)	6.7% (901)	
	Missing	0.1% (146)	0.1% (54)	0.1% (24)	0.1% (36)	0.1% (18)	0.1% (14)	
ASA*** classification	No Disturb	4.2% (6,916)	8.7% (5,236)	2.8% (1,027)	1.4% (439)	0.7% (155)	0.4% (59)	<0.001
	Mild Disturb	43.7% (72,292)	54.4% (32,667)	45.9% (16,868)	39.2% (12,507)	31.0% (7,310)	22.0% (2,940)	
	Severe Disturb	47.2% (78,174)	34.8% (20,903)	47.3% (17,365)	53.4% (17,041)	59.9% (14,121)	65.3% (8,744)	
	Life Threat	4.8% (7,959)	1.9% (1,166)	3.8% (1,412)	5.8% (1,836)	8.2% (1,938)	12.0% (1,607)	
	Moribund	0.1% (113)	0.0% (17)	0.1% (24)	0.1% (28)	0.1% (26)	0.1% (18)	
Surgical procedure	Respiratory-Thoracic	5.9% (9,738)	4.4% (2,667)	5.8% (2,130)	7.3% (2,315)	7.9% (1,858)	5.7% (768)	<0.001
	Gastric-Small Bowel-Peritoneal	33.3% (55,226)	42.5% (25,544)	36.9% (13,565)	27.3% (8,700)	20.5% (4,835)	19.3% (2,582)	
	Spleen-Laparoscopic-Hernia	18.0% (29,728)	13.5% (8,116)	19.1% (7,011)	21.5% (6,851)	21.7% (5,114)	19.7% (2,636)	
	Hepato-Biliary-Pancreatico	21.3% (35,285)	21.0% (12,591)	18.8% (6,918)	22.2% (7,074)	24.6% (5,801)	21.7% (2,901)	
	Colon-Appendix-Rectum	21.0% (34,698)	18.0% (10,832)	18.7% (6,856)	21.1% (6,741)	24.8% (5,843)	33.1% (4,426)	
	Skin-Node Dissections-Head/Neck	0.6% (925)	0.5% (293)	0.7% (240)	0.6% (206)	0.5% (117)	0.5% (69)	
Work Relative Value Unit, mean (sd)		21.6 (10.0)	20.6 (9.4)	22.1 (9.9)	22.5 (10.7)	22.6 (11.0)	21.4 (9.2)	<0.001
Total operation time in minutes, mean (sd)		144.0 (100.0)	130.3 (90.9)	152.0 (102.9)	158.7 (108.6)	154.5 (106.7)	129.9 (87.3)	<0.001

* CVA, Cerebro Vascular Accident

** Blood Urea Nitrogen

*** ASA, American Society of Anesthesiology

Table 2

Complication Frequencies (n, %) by Age Category and Complication for Non-Emergent General Surgeries (N=165,600)

Age Category	SSI	VTE	CVA	MI	Renal	UTI	Pneum	Fail to Wean	Unplanned intubation	Combined Pulmonary Outcome	Combined Vascular Outcome	Return to OR	Overall Morbidity	Mortality
	11,377 6.9%	**2,426 1.5%**	**320 0.2%**	**289 0.2%**	**1,556 0.9%**	**4,336 2.6%**	**4,028 2.4%**	**4,228 2.6%**	**3,338 2.0%**	**7,566 4.6%**	**2,977 1.8%**	**8,396 5.1%**	**26,800 16.2%**	**2,685 1.6%**
< 50 yrs 60,043 36.3%	3,190 5.3%	457 0.8%	22 0.0%	9 0.0%	246 0.4%	963 1.6%	683 1.1%	751 1.3%	450 0.8%	1,293 2.2%	488 0.8%	2,470 4.1%	6,758 11.3%	217 0.4%
50-59 yrs 36,720 22.2%	2,778 7.6%	433 1.2%	37 0.1%	35 0.1%	315 0.9%	819 2.2%	724 2.0%	791 2.2%	559 1.5%	1,362 3.7%	499 1.4%	1,928 5.3%	5,779 15.7%	336 0.9%
60-69 yrs 31,887 19.3%	2,587 8.1%	611 1.9%	69 0.2%	69 0.2%	407 1.3%	912 2.9%	938 2.9%	1029 3.2%	827 2.6%	1,782 5.6%	729 2.3%	1,857 5.8%	5,935 18.6%	548 1.7%
70-79 yrs 23,568 14.2%	1,935 8.2%	564 2.4%	96 0.4%	86 0.4%	348 1.5%	928 3.9%	956 4.1%	992 4.2%	861 3.7%	1,790 7.6%	731 3.1%	1,381 5.9%	5,121 21.7%	742 3.2%
>= 80 yrs 13,382 8.1%	887 6.6%	361 2.7%	96 0.7%	90 0.7%	240 1.8%	714 5.3%	727 5.4%	665 5.0%	641 4.8%	1,339 10.0%	530 4.0%	760 5.7%	3,207 24.0%	842 6.3%
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

SSI Surgical site infection
VTE Venous thromboembolism
CVA Cerebro vascular accident
MI Myocardial infarction
Renal Renal insufficiency
Pneum Pneumonia
Fail to wean Failure to wean from ventilator
Return to OR Return to operating room

Table 3

Failure to Rescue by Age Category and Complication for Non-Emergent General Surgeries Adjusted for Procedure (N=165,600)

Complication	Age Category						p-value
	< 50 yrs n=60,043	50-59 yrs n=36,720	60-69 yrs n=31,887	70-79 yrs n=23,568	>= 80 yrs n=13,382	All Ages n=165,600	
Surgical Site Infection	n=19/3,190 0.6%	n=35/2,778 1.3%	n=57/2,587 2.2%	n=83/1,935 4.3%	n=51/887 5.8%	n=245/11,377 2.2%	<0.001
Pulmonary Embolism or DVT/ Thrombophlebitis	n=9/457 2.0%	n=23/433 5.3%	n=42/611 6.9%	n=58/564 10.3%	n=52/361 14.4%	n=184/2,426 7.6%	<0.001
Stroke/CVA with Neurological Deficit	n=4/22 18.2%	n=7/37 18.9%	n=12/69 17.4%	n=20/96 20.8%	n=35/96 36.5%	n=78/320 24.4%	0.01
Myocardial Infarction	n=2/9 22.2%	n=9/35 25.7%	n=12/69 17.4%	n=20/86 23.3%	n=32/90 35.6%	n=75/289 26.0%	0.09
Combined Vascular Outcome	n=15/488 3.1%	n=36/499 7.2%	n=60/729 8.2%	n=92/731 12.6%	n=109/530 20.6%	n=312/2,977 10.5%	<0.001
Renal Insufficiency	n=48246 19.5%	n=60/315 19.1%	n=99/407 24.3%	n=110/348 31.6%	n=104/240 43.3%	n=421/1,556 27.1%	<0.001
Urinary Tract Infection	n=11/963 1.1%	n=18/819 2.2%	n=39/912 4.3%	n=44/928 4.7%	n=52/714 7.3%	n=164/4,336 3.8%	<0.001
Pneumonia	n=36/683 5.3%	n=63/724 8.7%	n=116/938 12.4%	n=157/956 16.4%	n=182/727 25.0%	n=554/4,028 13.8%	<0.001
Failure to Wean	n=77/751 10.3%	n=107/791 13.5%	n=194/1,029 18.9%	n=262/992 26.4%	n=230/665 34.6%	n=870/4,228 20.6%	<0.001
Unplanned Intubation	n=71/450 15.8%	n=102/559 18.3%	n=175/827 21.2%	n=260/861 30.2%	n=248/641 38.7%	n=856/3,338 25.6%	<0.001
Combined Pulmonary Outcome	n=118/1,293 9.1%	n=168/1,362 12.3%	n=306/1,782 17.2%	n=421/1,790 23.5%	n=414/1,339 30.9%	n=1,427/7,566 18.9%	<0.001
Return to OR	n=80/2,470 3.2%	n=86/1,928 4.5%	n=158/1,857 8.5%	n=186/1,381 13.5%	n=142/760 18.7%	n=652/8,396 7.7%	<0.001
Overall Morbidity	n=151/6,758 2.2%	n=225/5,779 3.9%	n=390/5,935 6.6%	n=519/5,121 10.1%	n=531/3,207 16.6%	n=1,816/26,800 6.8%	<0.001

DVT Deep venous thrombosis
CVA Cerebro vascular accident
Fail to wean Failure to wean from ventilator
Return to OR Return to operating room