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Thyroidectomy In Older Adults: An ACS-NSQIP Study Of Outcomes

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Abstract

Background—The growth of the US geriatric population coupled with the rise in thyroid nodular disease and cancer will result in an increased number of thyroidectomies performed in older adults. We aim to evaluate outcomes after thyroidectomy in older adults as compared to younger adults.

Study Design—A retrospective cohort study using the American College of Surgeons National Surgery Quality Improvement Program (ACS-NSQIP) database from 2012–2015 categorized thyroidectomy patients into three age groups: 18–64 years, 65–79 years, and ≥ 80 years. Thirty-day perioperative outcomes were analyzed using bivariate χ^2 test and multivariate logistic regression to estimate risk of outcomes.

Results—Our study identified 60,990 patients who underwent thyroidectomy: 47,855 (78.4%) patients between 18–64 years, 11,716 (19.2%) between 65–79 years, and 1,419 (2.3%) ≥ 80 years. Compared to younger adults, patients ≥ 80 years were 2.67 times more likely to develop a complication (95% confidence interval [CI]: 2.02–3.53, $p < 0.001$), 1.83 times more likely to be readmitted for any reason (95%CI: 1.40–2.38, $p < 0.001$), 1.54 times more likely to be readmitted for a reason related to the thyroidectomy (95%CI: 1.10–2.16, $p < 0.05$), and 1.66 times more likely to have an extended hospital stay (95%CI: 1.44–1.91, $p < 0.001$). Patients 65–79 years were 1.40 times more likely to develop a complication (95%CI: 1.19–1.63, $p < 0.001$).

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Conclusions—Patients 65 years have significantly higher rates of overall complications. Additionally, patients 80 years have higher rates of total and thyroidectomy-related readmissions, and extended length of hospital stay.

Keywords

Thyroidectomy; Older Patients; Geriatric; NSQIP; Epidemiology; Surgery

Introduction

According to the United States Census Bureau, the proportion of older adults is rising in the United States and around the world (1, 2). In 2012, 562 million (8.0%) of the world's population was at least 65 years old, and this increased to 617 million (8.5%) in 3 years (2). In the United States, there were an estimated 47.8 million adults 65 years or older in 2015, and this number is estimated to almost double to 88.0 million by 2050 (1, 2). For this reason, the future will bring unique healthcare challenges, as providers and public health officials begin to understand the implications of surgery on the aging population.

Studies have reported increasing age to be independently associated with increased postoperative morbidity and mortality in older patients undergoing major or high-risk elective surgery (3, 4). However, data is limited and conflicting for patients undergoing thyroidectomy, which is considered an intermediate-risk surgery (5). Multiple single-institution studies have shown that the advances in endocrine surgery and anesthesia practices have reduced the overall risks of surgery to older patients, thereby increasing the number of elective operations done in older adults over the past few years (6–8). Furthermore, the numbers of thyroidectomies performed in older adults is expected to rise due to the increase in thyroid nodular disease and cancer with age, an increase in thyroid cancer incidence over the last several decades, and growth of the geriatric population (9–11).

The data regarding the risks of thyroidectomy of surgery in the older population is conflicting. Single institution studies cite similar safety, efficacy and equivalency outcomes between older and younger patients, but some have limited power or missing data on outpatient procedures (6–8). However, population based studies have demonstrated that elderly patients undergoing thyroidectomies are at risk for long hospitalization times and major systemic complications, in addition to higher re-admission rates, but have limited comparisons of age-groups among older adults and lack the risk of specific outcomes in older adults versus younger adults (12, 13). Therefore, the goal of our study was to compare surgical outcomes of thyroidectomy performed in young adults (18 to 64 years), versus older adults (65 to 79 years) and the super-elderly (> 80 years) by analyzing the 30-day perioperative outcomes, reoperation rates, readmission rates, and length of hospital stay by using a national database with surgical outcomes from inpatient and outpatient data.

Methods

Study Design

Under IRB approval, we conducted a retrospective study, using the American College of Surgeons National Surgical Quality Improvement Program database (ACS-NSQIP) from 2012 to 2015. The NSQIP database contains information gathered from over 700 enrolled healthcare institutions, providing clinical data related to operative cases and 30-day postoperative outcomes. NSQIP only began to capture readmission data in 2012. Therefore, we identified patients who underwent thyroidectomy on or after the year 2012 by using Current Procedural Terminology (CPT) codes: 60210 (partial thyroid lobectomy: unilateral; with or without isthmusectomy); 60212 (partial thyroid lobectomy with contralateral subtotal lobectomy, including isthmusectomy); 60220 (total thyroid lobectomy, unilateral with or without isthmusectomy); 60225 (total thyroid lobectomy, unilateral; with contralateral subtotal lobectomy, including isthmusectomy), 60200 (isthmusectomy); 60240 (total thyroidectomy, total or complete); 60271 (thyroidectomy-cervical approach); 60252 (thyroidectomy with limited neck dissection); 60254 (thyroidectomy with radical neck dissection); 60260 (thyroidectomy, removal of all remaining thyroid tissue following previous removal of a portion of thyroid).

Demographic information was collected, including age, sex, patient comorbidities including functional status and ASA class, body-mass-index (BMI) category, operative characteristics, postoperative complications, and postoperative diagnosis. For information on how ACS-NSQIP data are collected and a complete list of parameters followed, please refer to the ACS-NSQIP web site (<http://www.acsnsqip.org/>).

To evaluate outcomes after thyroidectomy, operative time, estimated blood loss, wound infections, hematoma requiring readmission, respiratory complications, cardiac complications, renal complications, neurologic complications, infectious complications, extended hospital stay (defined as stay >2 days), hypoparathyroidism, hypocalcemia, mortality within 30 days, and tracheostomy were identified in the database as postoperative outcomes. All complications were grouped to assess an overall complication rate. Readmission and reoperation rates, operative time, length of hospital stay, and postoperative length of stay were assessed as perioperative outcomes. Readmissions were defined in two ways: total readmissions and related readmissions to initial procedure. Related readmissions were defined by NSQIP and included only thyroid related readmissions. Reoperations were defined to include hematoma drainage (CPT10140); incision and drainage of deep abscess or hematoma (CPT 21501); planned tracheostomy (CPT 31600); emergency tracheostomy (CPT 31603); exploration of neck for postoperative hemorrhage, thrombosis, or infection (CPT 35800); exploration of chest for postoperative hemorrhage, thrombosis, or infection (CPT 35820); direct therapeutic laryngoscopy with injection into vocal cord (CPT 31571); incision and drainage of infected thyroglossal duct cyst (CPT 60000); ligation of internal jugular vein (CPT 37565); diagnostic direct laryngoscopy, with or without tracheoscopy (CPT 31525); horizontal partial laryngectomy excision (CPT 31370); incision and removal of foreign body from subcutaneous tissue (CPT 10120); incision and drainage of abscess

(CPT 10060); ligation of major artery in neck (CPT 37615); incision and drainage procedure of postoperative wound (CPT 10180).

Statistical Analysis

The data was analyzed by dividing the patients into three age groups Group A (18–64 years); Group B (65–79 years); and Group C (≥80 years). Categorical variables were analyzed using Pearson's χ^2 and continuous variables comparing age groups were analyzed using t-test. Multivariable logistic regression was performed to adjust for important covariates, and odds ratios were obtained to evaluate the risk of developing any one of the four perioperative outcomes identified. Based on the results of univariable associations between each covariate and age group (Table 1 and 2), covariates with a p -value <0.20 were entered into the multivariable logistic regression model. A second regression analysis was then performed including only covariates with a p -value <0.10 in the first model. This process was repeated for each outcome. Age and sex were always retained in the final model. A series of stratified bivariable logistic analyses was performed to assess whether age differences were consistent across gender and surgical pathology. Statistical analysis was performed using Stata 14 (College Station, TX), and statistical significance was defined as a p -value <0.05 .

Results

Cohort Identification

Our study identified 60,990 patients who underwent thyroidectomy. The median age was 51.7 years (range 18–90 years), and the majority of patients were female. Among our cohort, 47,855 (78.4%) patients were between 18–64 years, 11,716 (19.2%) were between 65–79 years, and 1,419 (2.3%) were ≥80 years (Table 1). Outpatient procedures were performed in 39,111 (64.1%) whereas inpatient procedures were performed in 21,879 (35.9%) patients. The most common indication for thyroidectomy was a malignant neoplasm of the thyroid gland (ICD-9 code 193, 18,055; 29.6%). The most common procedure performed was a total thyroidectomy (CPT code 60240, 27,257; 44.7%). On final pathology, 42,471 (69.6%) patients had benign disease and 18,519 patients (30.4%) had malignant disease (Table 1).

Group C had a significantly greater proportion of inpatients ($p<0.05$). However, no difference in rate of malignancy was observed in patients >80 years as compared to that in younger patients.

Comparison of Age Groups

To identify confounding risk factors for complications, functional status, ASA status, and BMI were stratified and compared among age groups (Table 1). Of our cohort, 116 (0.2%) patients had a 'totally dependent' functional status and 210 (0.4%) were partially dependent. There was a statistically significant higher percentage of adults in Group C who were totally dependent (1.2%) as compared to Group A and B (0.1% and 0.4%, respectively, all $p<0.001$).

Of our patient population, 4,529 (7.4%) patients were classified as ASA class 1, 37,270 (61.2%) as ASA class 2, and 19,110 (31.4%) as ASA class 3 or greater. Of the 19,110 patients with an ASA class of 3 or greater, 12,228 (25.6%) were in Group A, 5,947 (50.8%) were in Group B, and 935 (65.9%) were in Group C ($p < 0.001$).

Finally, according to BMI, there were a total of 27,567 (45.2%) who were obese, 18,495 (30.3%) overweight, and 606 (1.0%) underweight. There was a significant difference in the proportion of obese patients between the three groups: 45.8% in Group A, 44.4% in Group B and 30.0% in Group C ($p < 0.001$). On the contrary, Group C had significantly more underweight patients (1.8%) as compared to Groups A (1.0%) and B (0.8%), all $p < 0.001$. Therefore, the proportion of patients with a 'totally dependent' functional status, ASA class 3 or greater, and those who were underweight significantly increased with age 80 years.

Outcomes

Complications—Our study identified 904 (1.5%) complications, which were grouped into broader categories (Table 3). Wound complications including superficial and deep incisional surgical site infections (SSI), organ space SSIs, and wound disruption occurred in 278 (31.1%) patients. Pulmonary complications including pneumonia, pulmonary embolisms, and unplanned intubations occurred in 342 (37.8%) patients. Renal complications, which included urinary tract infections, renal insufficiency, and renal failure, were identified in 154 (17.0%) of patients. Cardiovascular complications including cardiac arrest requiring CPR, myocardial infarctions, and DVT/Thrombophlebitis occurred in 90 (10.0%). Neurologic complications including strokes/CVA (with, without, and no mention of neurological deficit), and peripheral nerve injury were identified in 83 (9.2%). Finally, there were 79 (8.7%) cases of sepsis.

There was a significantly higher complication rate of 4.8% in those >80 years as compared to 1.2% in younger patients ($p < 0.001$) (Table 4) including pulmonary, wound, renal, and cardiac complications. Neck hematomas requiring readmission occurred in 71 patients (5.1%), of which 47 (4.6%) were in group A 21 (7.0%) in group B, and 3 (4.4%) in group C ($p = 0.24$). There was no significant difference in neck hematoma rates in those >80 years as compared that in younger patients.

Re-operations—Unplanned reoperations were identified in 477 (0.8%) of cases (Table 4). The most common reoperation performed was exploration of neck for postoperative hemorrhage, thrombosis, or infection (CPT 35800, 21501, 10140), which occurred in 389 cases (81.6%). The second most common reoperation procedure included planned tracheostomy (CPT 31600) in 40 cases (8.4%) followed by emergency tracheostomy (CPT 31603) in 19 cases (4.0%).

The most common reason for reoperation based on ICD-9 was a hematoma complicating a procedure (ICD-9 998.11, 998.12), which accounted for 281 cases (58.9%). There was, however, a significantly higher unplanned reoperation rate in Group C (21 unplanned reoperations, 1.5%) as compared to Group A (328 complications, 0.7%, $p < 0.001$). There was no significant difference in indication for reoperation ($p = 0.07$). However, type of operation performed ($p = 0.73$) across age groups was not significantly different.

Readmission—Overall, readmissions were required in 1,388 (2.3%) patients. Readmissions related to the initial thyroid procedure were required in 998 (1.7%) patients. Of the 998 patients, the most common reasons for readmission included hypocalcaemia in 312 cases (31.3%), hematoma in 71 cases (7.1%), and hypoparathyroidism in 22 cases (2.2%).

There was a significant increase in overall and thyroid related readmissions with increasing age. There were 1,020 (2.2%) total re-admissions in Group A, 299 (2.6%) in Group B, and 69 (4.9%) in Group C ($p<0.001$). Re-admission related to the thyroid procedure occurred in 761 (1.6%) patients in group A, 198 (1.7%) patients in group B, and 39 (2.8%) patients in group C. The related readmission rate for hypocalcemia or hypoparathyroidism in group C compared to A was significantly less ($p<0.001$).

Length of Stay—The average length of hospital stay was 1.23 days. Extended hospital stay was defined as hospital stay > 2 days. Extended hospital stay was most frequent in group C (309 patients, 21.8%) followed by group B (1,673 patients, 14.3%) and then Group A (5,852 patients, 12.2%) ($p<0.001$).

Adjustment for covariates—Odds ratios from bivariate analysis for outcomes were calculated and stratified by gender and surgical pathology (Table 5). In comparing Group C to the other groups, Group C had significantly higher odds of overall morbidity in women (OR=4.69, 95% CI=3.48–6.31) and higher morbidity due to a malignant diagnosis (OR=5.91, 95% CI=3.92–8.93) ($p<0.001$). This group also had higher odds of overall readmission in both men and women (OR=2.69, 95% CI=1.69–4.27; OR=2.20, 95% CI=1.64–2.97) as well as in both benign and malignant cases (OR=2.38, 95% CI=1.73–3.27, OR=2.24, 95% CI=1.50–3.34) ($p<0.001$).

The odds of reoperation were highest among females in group C (OR=2.36, CI=95%, 1.37–4.06), and benign cases in group C (OR=2.30, 95% CI=1.38–3.84) ($p<0.001$). Men and women in group C had approximately twice the odds of an extended hospital stay (OR male =1.92, 95% CI=1.51–2.43 and OR female=1.97, 95% CI=1.69–2.30). Odds of extended hospital stay was also increased for both benign (OR=1.79, 95% CI=1.51–2.11) and malignant (OR=2.41, 95% CI=1.96–2.96) pathology in group C ($p<0.001$). Therefore, Group C had significantly higher odds of overall morbidity, overall readmission, requiring a re-operation, and extended length of hospital stay. Odds ratio of outcomes when comparing Group B to Group A are tabulated in Table 7.

Using multivariate analysis, we estimated the risk of developing an outcome including overall complication, overall and related re-admission, re-operation, hematoma, or extended hospital stay > 2 days. Despite controlling for variables listed in Table 2 and 4 including BMI, ASA class, functional status, gender, pathology, and type of operation, the risk of developing a complication, requiring re-admission, requiring a re-operation, and having extended LOS still significantly increased with age (Table 6).

In comparing the oldest group (C) to the youngest group (Group A), group C had an increased risk of developing an overall complication (OR=2.67, 95% CI=2.02–3.53,

$p<0.001$), having an overall readmission (OR=1.83, 95% CI=1.40–2.38, $p<0.001$), having a thyroid related readmission (OR=1.54, 95% CI=1.10–2.16, $p<0.05$), and having an extended hospital stay (OR=1.66, 95% CI=1.44–1.91, $p<0.001$) (Table 6). The risk of developing an overall complication was also significantly higher in group B when compared to group A (OR=1.40, 95% CI=1.19–1.63, $p<0.001$). However, when compared to group A, there was no increased risk in group B for an overall readmission, related readmission, or extended hospital stay. There was no statistically significant difference in the risk of re-operation or neck hematoma requiring readmission between groups.

Discussion

In summary, our study demonstrated that overall complication rate, overall and thyroid related readmission rates, and extended hospital stay all significantly increase with age. Our study represents one of the largest national studies evaluating outcomes after thyroidectomy in older adults as compared to younger adults, includes operations performed as an outpatient and also incorporates readmission data, which was not previously available (12). Unlike other studies, our study is unique as it subdivides older adults into two groups to understand the effect on age on outcomes, incorporates outpatient thyroidectomies, and examines re-admission rates (12, 14–17).

An overall complication rate of 1.5% is consistent with that reported in the literature (12, 16, 17). A population-based study between 2005–2008 reported an overall complications rate of 1.4% among 3,459 patients with older adults more likely to experience complications (12). Furthermore, existing patient co-morbidities increased the risk of complications. However, admission status (inpatient versus outpatient) and re-admission data, was not assessed in this study. A retrospective single institution study by Mekel *et al* including 332 thyroidectomy patients (90 patients ≥ 80 years) between July 2001 and October 2007 reported that octogenarians had an associated higher rate of developing complications (23.3% vs. 9.1%) and higher morbidity than younger patients, though this was not shown independently possibly due to a low octogenarian population (15).

However, there are a number of studies that have noted limited associations between increasing age and outcome due to thyroidectomy (8, 18, 19). A prospective study by Seybt *et al* including 86 and 44 thyroidectomy patients aged 21–35 years and ≥ 65 years, respectively, showed no difference in complication rates between older and younger patients (8). Despite, higher readmission rates occurring with older age, the authors concluded that thyroidectomy is safe in older adults. However, the study's results may not be generalizable due to its small sample size.

We did not find significant differences in hematoma risk among the different age groups, though an association between age and hematoma risk has been well described in the literature (19–22). A national study by Weiss *et al* among patients who underwent thyroidectomy from 1998 to 2010 reported an overall hematoma rate of 1.25% among 150,012 patients with age >45 significantly associated with an increased risk (OR = 1.44; 95% CI: 1.06–1.96) (20). Similarly, a retrospective study by Bergenfelz *et al* of 3,660 thyroidectomies between 2004 and 2006 found an increased difference in age among

patients who had a hematoma versus those who did not (OR 1.037; 95% CI 1.0206–1.0542) (22). The reason for no observed difference among our cohort may be due to the more recent patient cohort (2012 – 2015), which may reflect advances in surgical technique and technology resulting in improvements of hematoma rates.

In addition to increased readmission rates with increasing age, our results show older patients having an extended hospital length of stay. Longer length of hospital stay among older adults has been consistently reported in the literature (18). A SEER-Medicare longitudinal study by Tuggle *et al* of 2,127 elderly (≥ 65 years) patients who had undergone thyroidectomies due to a cancer diagnosis between 1996 and 2002 showed an 8% unplanned readmission rate due to mostly endocrine-specific complications (13). Furthermore, readmission was also found to have a statistically significant association with death at 1 year, compared to non-readmitted patients.

A systematic method of assessing which patients are at increased risk of surgical complications or poor outcomes is needed. A number of methods have been described in the literature including independent comorbidities, ASA index, BMI, and a frailty index (12). Data used to calculate a modified frailty index are not routinely collected in recent versions of the NSQIP database.

Our study has several limitations. One of the inherent weaknesses in this study is its retrospective nature. Moreover, the NSQIP database does not include long-term patient follow up (outcomes only up to 30 days), pre-operative diagnosis information, surgeon volume and patient co-morbidity data. Therefore, it is impossible to discern whether or not a diagnosis such as hypercalcemia identified as an ICD-9 code on post-operative diagnosis was present before surgery, or as a result of overtreatment with calcium supplementation after thyroidectomy. Moreover, the rate of hypocalcemia is likely an underestimate since the information available is only for that of the purpose of the hospital admission. For this reason, only patient hypocalcemia requiring readmission was recorded in the NSQIP database. The lack of patient co-morbidity data prevented the calculation and evaluation of its relationship with surgical outcome and thus ASA class was used as a surrogate. Due to the database's wide scope, there was limited surgery-specific information including hypocalcemia and recurrent laryngeal nerve paralysis. It may be beneficial to use an endocrine-specific database to analyze these outcomes.

In conclusion, our study provides national data for adults undergoing thyroidectomy as an inpatient or outpatient procedure. Our results show that co-morbidities along with age should be considered prior to surgery and patients counseled appropriately. Despite the study's limitations, we found significantly higher rates of complications, higher rates of overall and related readmission, and extended length of hospital stay in patients ≥ 80 years. In patients 65–79 years, we reported higher rates of complications. Further prospective studies are needed to stratify patients and identify those at risk for worse thyroid specific outcomes.

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Table 1

Demographic Characteristics of the Cohort Stratified by Age Group

	Total (%)	Group A (%)	Group B (%)	Group C (%)	P (Ref Group A)
Number of patients in each group	60,990 (100%)	47,855 (78.4%)	11,716 (19.2%)	1,419 (2.3%)	<i>P</i> =0.025
Demographic variables					
Sex					<i>P</i> <0.001
<i>Female</i>	48,517 (79.6%)	38,890 (81.3%)	8,587 (73.3%)	1,040 (73.3%)	
<i>Male</i>	12,473 (20.5%)	8,965 (18.7%)	3,129 (26.7%)	379 (26.7%)	
In/OutPatient Status					<i>P</i> <0.001
<i>Inpatient</i>	21,879 (35.9%)	16,971 (35.5%)	4,272 (36.5%)	636 (44.8%)	
<i>Outpatient</i>	39,111 (64.1%)	30,884 (64.5%)	7,444 (63.5%)	783 (55.2%)	
Final Pathology					<i>P</i> <0.001
<i>Benign</i>	42,471 (69.6%)	32,887 (68.7%)	8,623 (73.6%)	961 (67.7%)	
<i>Malignant</i>	18,519 (30.4%)	14,968 (31.3%)	3,093 (26.4%)	458 (32.3%)	
Pre-Operative Characteristics					
Functional Status					<i>P</i> <0.001
<i>Independent</i>	60,340 (99.5%)	47,448 (99.2%)	11,525 (98.4%)	1,367 (96.3%)	
<i>Partially dependent</i>	210 (0.4%)	112 (0.2%)	72 (0.6%)	26 (1.8%)	
<i>Totally dependent</i>	116 (0.2%)	52 (0.1%)	46 (0.4%)	18 (1.3%)	
<i>Unknown</i>	324 (0.01%)	243 (0.5%)	73 (0.6%)	8 (0.6%)	
ASA Class					<i>P</i> <0.001
<i>1-No Disturb</i>	4,529 (7.4%)	4,370 (9.1%)	152 (1.3%)	7 (0.5%)	
<i>2-Mild Disturb</i>	37,270 (61.2%)	31,194 (65.2%)	5,600 (47.8%)	476 (33.5%)	
<i>3-Severe Disturb, 4-Life Threat, 5-Moribund</i>	19,110 (31.4%)	12,228 (25.6%)	5,947 (50.8%)	935 (65.9%)	
<i>Unknown</i>	81 (0.1%)	63 (0.1%)	17 (0.2%)	1 (0.1%)	
BMI Categories					<i>P</i> <0.001
<i>Underweight (<18.5)</i>	606 (1.0%)	487 (1.0%)	93 (0.8%)	26 (1.8%)	
<i>Normal (18.5-24.9)</i>	14,322 (23.5%)	11,497 (24.0%)	2,391 (20.4%)	434 (30.6%)	
<i>Overweight (25-29.9)</i>	18,495 (30.3%)	13,933 (29.1%)	4,029 (34.4%)	533 (37.6%)	
<i>Obese (30 or higher)</i>	27,567 (45.2%)	21,938 (45.8%)	5,203 (44.4%)	426 (30.0%)	

Table 2

Patient Co-morbidities Stratified By Age Group

Patient Co-Morbidities	Total (%)	Group A (%)	Group B (%)	Group C (%)	P (Ref Group A)
Steroid Use for chronic condition	1,433 (2.4%)	984 (2.1%)	403 (3.4%)	46 (3.3%)	$P<0.001$
Systemic sepsis w/in 48 hours prior to surgery	201 (0.4%)				$P<0.001$
<i>SIRS</i>	187 (0.3%)	140 (0.3%)	33 (0.3%)	14 (1.0%)	
<i>Sepsis</i>	8 (0.01%)	4 (0.01%)	2 (0.02%)	2 (0.1%)	
<i>Septic Shock</i>	6 (0.01%)	4 (0.01%)	2 (0.02%)	0 (0.0%)	
Ascites w/in 30 days prior to surgery	29 (0.1%)	21 (0.04%)	7 (0.06%)	1 (0.07%)	$P=0.719$
Ventilator Dependent	83 (0.1%)	43 (0.1%)	30 (0.3%)	10 (0.7%)	$P<0.001$
Disseminated Cancer	562 (0.92%)	330 (0.7%)	192 (1.6%)	40 (2.8%)	$P<0.001$
Diabetes	7,981 (13.1%)				$P<0.001$
<i>Non-Insulin Dep.</i>	5,490 (9.0%)	3,502 (7.3%)	1,807 (15.4%)	181 (12.8%)	
<i>Insulin Dep.</i>	2,491 (4.1%)	1,670 (3.5%)	761 (6.5%)	61 (4.3%)	
CHF 30 days prior to surgery	169 (0.3%)	107 (0.2%)	47 (0.4%)	15 (1.1%)	$P<0.001$
Smoker (Current w/in 1 year)	8,855 (14.5%)	7,824 (16.4%)	997 (8.5%)	34 (2.4%)	$P<0.001$
Currently on dialysis (pre-op)	260 (0.4%)	190 (0.4%)	63 (0.5%)	7 (0.5%)	$P=0.103$
History of severe COPD	1,398 (2.3%)	752 (1.6%)	569 (4.9%)	77 (5.4%)	$P<0.001$
Dyspnea	3,560 (5.8%)				$P<0.001$
<i>W/mod. Exertion</i>	3,218 (5.3%)	2,046 (4.3%)	1,012 (8.6%)	160 (11.3%)	
<i>At rest</i>	342 (0.6%)	233 (0.5%)	88 (0.8%)	21 (1.5%)	
Hypertension requiring medication	23,629 (38.8%)	14,456 (30.2%)	8,049 (68.7%)	1,124 (79.2%)	$P<0.001$
History of Acute Renal Failure	33 (0.05%)	23 (0.05%)	9 (0.08%)	1 (0.07%)	$P=0.470$
<10% weight loss body weight in last 6 months	323 (0.5%)	228 (0.5%)	75 (0.6%)	20 (1.4%)	$P<0.001$

Table 3

Postoperative Complications in our Patient Cohort

Complication Type	Frequency (%)	Group A (18–64) (%)	Group B (65–79) (%)	Group C (80) (%)
Pulmonary Complications	342 (37.8%)	211 (36.9%)	102 (38.5%)	29 (43.3%)
Wound Complications *	278 (31.1%)	217 (38.4%)	47 (17.7%)	13 (19.4%)
Renal Complications *	154 (17.0%)	84 (14.7%)	52 (19.6%)	18 (26.9%)
Cardiac Complications *	90 (10.0%)	44 (7.7%)	37 (14.0%)	9 (13.4%)
Neurological Complications *	83 (9.2%)	34 (5.9%)	45 (17.0%)	4 (6.0%)
Sepsis Complications	79 (8.7%)	44 (7.7%)	31 (11.7%)	4 (6.0%)

*
p<0.05

Table 4

Univariate Analysis Of Outcomes Among Age Groups

Outcome (<i>p</i>)	Frequency (%)	Group A (18–64) (%)	Group B (65–79) (%)	Group C (80) (%)
Overall Complication Rate *	904 (1.5%)	572 (1.2%)	265 (2.3%)	67 (4.8%)
Hematoma Rate	71 (5.1%)	47 (4.6%)	21 (7.0%)	3 (4.4%)
Overall Readmissions *	1,388 (2.3%)	1,020 (2.2%)	299 (2.6%)	69 (4.9%)
Related Readmissions *	998 (1.7%)	761 (1.6%)	198 (1.7%)	39 (2.8%)
Extended Length of Stay *	7,834 (12.8%)	5, 852 (12.2%)	1, 673 (14.3%)	309 (21.8%)
Reoperation Rate *	477 (0.7%)	328 (0.7%)	128 (1.1%)	21 (1.5%)

*
p<0.05

Table 5

Multivariate Analysis of Outcomes Among Age Groups Controlling For the Following Covariates:

Outcome (<i>p</i>)	Group A (18–64) OR (95% CI)	Group B (65–79) OR (95% CI)	Group C (80) OR (95% CI)
Overall Complication Rate	Ref	1.40 [*] (1.19–1.63)	2.67 [*] (2.02–3.53)
Overall Readmissions	Ref	1.02 (0.88–1.17)	1.83 [*] (1.40–2.38)
Related Readmissions	Ref	0.98 (0.83–1.16)	1.54 [*] (1.10–2.16)
Reoperation	Ref	1.15 (0.92–1.43)	1.39 (0.88–2.21)
Hematoma Rate	Ref	1.22 (0.71–2.09)	1.35 (0.41–4.40)
Extended Stay	Ref	1.05 (0.98–1.12)	1.66 [*] (1.44–1.91)

*
p<0.05

Table 6

Bivariate Analysis Of Outcomes By Age Group Stratified By Variable

Variable	Group A (18–64)	Group B (65–79) OR (95% CI)	Group C (≥ 80) OR (95% CI)
Demographics			
Sex			
Male	Ref		
Overall Morbidity		1.71 [*] (1.31–2.23)	2.61 [*] (1.54–4.41)
Overall Readmissions		1.41 [*] (1.10–1.81)	2.69 [*] (1.69–4.27)
Related Readmissions		1.36 [*] (1.01–1.84)	2.10 [*] (1.15–3.83)
Reoperation		1.16 (0.81–1.66)	1.60 (0.74–3.47)
Extended Stay		1.10 (0.99–1.23)	1.92 [*] (1.51–2.43)
Female	Ref		
Overall Morbidity		1.91 [*] (1.60–2.28)	4.69 [*] (3.48–6.31)
Overall Readmissions		1.12 (0.96–1.30)	2.20 [*] (1.64–2.97)
Related Readmissions		0.96 (0.79–1.16)	1.62 [*] (1.10–2.40)
Reoperation		1.75 [*] (1.36–2.24)	2.36 [*] (1.37–4.06)
Extended Stay		1.19 [*] (1.11–1.28)	1.97 [*] (1.69–2.30)
Benign/Malignant Cases			
Benign	Ref		
Overall Morbidity		1.66 [*] (1.39–1.99)	3.36 [*] (2.40–4.70)
Overall Readmissions		1.23 [*] (1.05–1.44)	2.38 [*] (1.73–3.27)
Related Readmissions		1.09 (0.89–1.33)	1.67 [*] (1.08–2.57)
Reoperation		1.48 [*] (1.17–1.89)	2.30 [*] (1.38–3.84)
Extended stay		1.18 [*] (1.10–1.27)	1.79 [*] (1.51–2.11)
Malignant	Ref		
Overall Morbidity		2.66 [*] (2.05 – 3.46)	5.91 [*] (3.92–8.93)
Overall Readmissions		1.20 (0.96–1.50)	2.24 [*] (1.50–3.34)
Related Readmissions		1.06 (0.81–1.39)	1.81 [*] (1.1–2.98)
Reoperation		1.94 [*] (1.31–2.87)	1.87 (0.75–4.62)
Extended Stay		1.29 [*] (1.17–1.43)	2.41 [*] (1.96–2.96)

*
p<0.05