Patient Selection for Day Case-eligible Surgery

Identifying Those at High Risk for Major Complications

Michael R. Mathis, M.D.,* Norah N. Naughton, M.D., M.B.A.,† Amy M. Shanks, M.S.,‡ Robert E. Freundlich, M.D., M.S.,* Christopher J. Pannucci, M.D., M.S.,§ YiJia Chu, M.D.,* Jason Haus, M.D.,* Michelle Morris, M.S.,‡ Sachin Kheterpal, M.D., M.B.A.‖

ABSTRACT

Background: Due to economic pressures and improvements in perioperative care, outpatient surgical procedures have become commonplace. However, risk factors for outpatient surgical morbidity and mortality remain unclear. There are no multicenter clinical data guiding patient selection for outpatient surgery. The authors hypothesize that specific risk factors increase the likelihood of day case-eligible surgical morbidity or mortality.

Methods: The authors analyzed adults undergoing common day case-eligible surgical procedures by using the American College of Surgeons' National Surgical Quality Improvement Program database from 2005 to 2010. Common day case-eligible surgical procedures were identified as the most common outpatient surgical Current Procedural Terminology codes provided by Blue Cross Blue Shield of Michigan and Medicare publications. Study variables included anthropometric data and relevant medical comorbidities. The primary outcome was morbidity or mortality within 72 h. Intraoperative complications included adverse cardiovascular events; postoperative complications included surgical, anesthetic, and medical adverse events.

Results: Of 244,397 surgeries studied, 232 (0.1%) experienced early perioperative morbidity or mortality. Seven independent risk factors were identified while controlling for surgical complexity: overweight body mass index, obese body mass index, chronic obstructive pulmonary disease, history of transient ischemic attack/stroke, hypertension, previous cardiac surgical intervention, and prolonged operative time.

Conclusions: The demonstrated low rate of perioperative morbidity and mortality confirms the safety of current day case-eligible surgeries. The authors obtained the first prospectively collected data identifying risk factors for morbidity and mortality with day case-eligible surgery. The results of the study provide new data to advance patient-selection processes for outpatient surgery.

What We Already Know about This Topic

- Risk factors for major morbidity and mortality from outpatient surgery are not clearly defined

What This Article Tells Us That Is New

- In a review of approximately 250,000 cases in the National Surgery Quality Improvement Program, early perioperative morbidity and mortality occurred in approximately 1:1,000 patients
- Predictors for morbidity and mortality were overweight or obesity, chronic obstructive pulmonary disease, history of transient ischemic attack/stroke, hypertension, previous cardiac surgical intervention, and prolonged operative time

OVER the past 3 decades, the proportion of surgeries performed in an outpatient setting has increased dramatically, comprising 16% of all surgeries in 1980 and steadily growing to include over 50% in the 1990s and over 60% by 2007.[1,2] This drive toward outpatient surgery can be attributed to several factors. Improvements in anesthetic care, including innovations such as shorter-acting anesthetic agents and improved cardiopulmonary monitoring, have allowed for fewer adverse anesthetic effects. Innovations in minimally invasive surgical techniques have decreased the need for inpatient hospitalization.[3] Economic pressures have also influenced increased adoption of outpatient surgery.

* Anesthesiology Resident, † Associate Professor, ‡ Research Associate, ‖ Assistant Professor, Department of Anesthesiology, Center for Perioperative Outcomes Research, § Plastic Surgery Chief Resident, Department of Surgery, University of Michigan Medical School, Ann Arbor, Michigan.

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Address correspondence to Dr. Mathis: Department of Anesthesiology, University of Michigan Medical School, 1H247 UH, SPC 5048 1500 East Medical Center Drive, Ann Arbor, Michigan 48109-5048. mathism@med.umich.edu.

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Estimates have determined charges per visit for surgical procedures to be approximately five times less for outpatient *versus* inpatient surgery although unadjusted for length-of-stay or procedural complexity.[4]

Patient selection and these advances in perioperative care have allowed outpatient surgical procedures to be performed at an exceedingly low rate of morbidity or mortality.[5–8] However, concern over patient safety remains, as the outpatient surgical population has increased not only in volume but also in age and complexity, necessitating improved preoperative screening.[9–12] In addition, the explosion of ambulatory surgery centers (ASCs) has created a need to identify patients suitable for receiving surgical procedures on an ambulatory basis. There are no national, prospectively collected data regarding optimal patient selection for ASC procedures.[13,14] Patient selection is largely guided by administrative data, focused on risk of "readmission" or incidence of complications.[5–8,15]

Although data are available regarding the incidence of morbidity and mortality after outpatient surgery, there are no prospectively collected clinical data to guide the outpatient surgery–selection processes. Risk factors for adverse outcomes have been proposed,[16–18] and calls for such a study have been made, as this would provide valuable information to a clinician determining a patient's eligibility for surgery on an ambulatory basis.[12,19,20] We hypothesize that specific patient history and surgical characteristics place patients scheduled for common day case-eligible surgeries at a greater risk of major morbidity and mortality within 72 h after such procedures.

Materials and Methods

Clinical information on all adult patients (aged ≥18 yr) who underwent surgical procedures from 2005 to 2010 was obtained from the Participant Use Data File of the American College of Surgeons' National Surgical Quality Improvement Program (ACS-NSQIP). Within this dataset, data are deidentified, contain no protected health information, and are made publicly available. As a result, the proposed analysis was performed under an existing institutional review board exemption (University of Michigan, Ann Arbor, Michigan, HUM22030). Patient consent was waived because no protected health information was available in the dataset.

All operative procedures performed with general, spinal, or epidural anesthesia from more than 250 medical centers across the country are eligible for inclusion in this dataset. Procedures at each contributing site are recorded in 8-day cycles, with the first 40 operations within each cycle included in the database. To ensure data heterogeneity, an 8-day cycle is used to favor each day of the week equally when beginning data collection on subsequent cycles; in addition, high-volume, low-risk cases (*e.g.*, cholecystectomy, inguinal hernia repair) are capped at five cases per cycle. To ensure fidelity of data collection, clinical nurses trained in data collection are assigned at each site, with interrater reliability measurements taken through periodic site reviews. All sites with interrater reliability less than 95% are excluded from the database. Currently, fidelity of data collection has been demonstrated to be excellent, with sites showing less than 1.5% variable disagreement during annual audits.[21] Patients included in the database underwent a variety of operations, including general, orthopedic, plastic, urologic, obstetric, gynecologic, and vascular surgical procedures. Patients were followed through their operative course until postoperative day 30. Trained nurses then performed a patient chart review at the institution where the surgical procedure was performed and made direct patient contact to further identify complications diagnosed and treated at other institutions. The methodology for prospective data collection within this database, demonstrating high degrees of accuracy and reproducibility, has been described in previous literature.[21–23]

For this study, all adult patients who were scheduled as outpatient were eligible for inclusion. Outpatient status for each procedure was determined at participating institutions in compliance with federal guidelines. As confirmed among reviewers across several NSQIP-participating sites, a surgical procedure is defined as "outpatient" if the patient arrived to the ASC or hospital-based facility on the same day as the procedure performed and was discharged the same day; this applied to patients planned for both same-day discharge and "23-h observation" intended for overnight stay, but then discharged before overnight stay.# In addition, this excluded same-day admission patients planned for hospital admission for one or more nights after surgery, patients who underwent surgery on a hospital day subsequent to hospital admission, and finally patients admitted from the emergency department undergoing surgery the same day, and possibly discharged the same day (each defined as "inpatient").

The ACS-NSQIP Participant Use Data File dataset includes data from freestanding ASCs, ASCs attached to acute care hospitals, and acute care hospitals; there are no data elements allowing differentiation of location of care. "Common" day case-eligible surgeries were defined as the 100 most frequently used Current Procedural Terminology (CPT) codes for which outpatient surgery claims were billed to Blue Cross Blue Shield, Michigan Liability, regular business (commercial Preferred Provider Organization) during the 2010 calendar year, in conjunction with 50 commonly performed procedures in ASCs as determined *via* a national claims review of Medicare beneficiaries during the 2010 calendar year (fig. 1).[24] Day case-eligible surgical patients in the NSQIP-Participant Use Data File file were then filtered to only include these commonly performed CPT codes. A summary of the most commonly observed surgical procedures are listed in table 1. To improve validity of the final

Electronic-mail communication with NSQIP data entry nurse specialists and trainers, July 2013.

analytical dataset, we then excluded cases clearly inappropriately coded as outpatient by removing patients who were ventilator dependent, American Society of Anesthesiologists physical status 5 or 6, experiencing preoperative sepsis, or did not have surgery on the recorded admission date. In addition, due to a low incidence, we excluded patients who had received preoperative transfusions within 72 h of operation or had a tumor involving the central nervous system (fig. 1). A summary of all ACS-NSQIP variables used as inclusion/exclusion criteria are detailed in appendix 1.

Within the study population, perioperative patient data collected included anthropometric data and the presence of a number of chronic diseases detailed in table 2; specific definitions for these perioperative variables are detailed in appendix 2 and reflect the standard ACS-NSQIP definitions. Among the risk factors selected for the study, many have been previously considered as risk factors for adverse outcomes related to ambulatory surgery, including age,[11,15,25,26] sex,[25,27] body mass index (BMI),[11,28] type of surgery,[11,25,27] surgical duration,[11,15,25,26,29] and presence of comorbidities including diabetes mellitus,[11] chronic obstructive pulmonary disease (COPD),[11] congestive heart failure,[11,25] previous myocardial infarction,[11] previous cardiac surgery,[17] hypertension,[11] angina,[11] peripheral vascular disease,[15] renal failure,[11] cancer,[15] history of stroke,[11,15] history of smoking,[11,17] and recent surgical admission.[10,16] The ACS-NSQIP dataset also included other salient risk factors, such as recent significant weight loss, steroid use, heavy alcohol intake, paraplegia/quadriplegia, and pregnancy. Age was converted from a continuous variable to categorical by establishing age ranges by decade with 18–30 yr considered the reference group. BMI was calculated using the height and weight as reported; only values within a valid range of 10–80 were used for analysis. After BMI calculation, patients were categorized based on the World Health Organization classifications for underweight, normal weight (reference group), overweight, and obese.[30] In addition, distinct ACS-NSQIP variables addressing a single clinical concept were collapsed for the purposes of this study. Diabetes mellitus requiring insulin treatment and requiring oral treatment were combined into diabetes. Acute renal failure and current dialysis were combined into renal failure. History of transient ischemic attacks (TIA) and history of cerebrovascular accident (CVA) were combined into history of TIA/CVA. Cancer was defined as a diagnosis of disseminated cancer, radiotherapy within 90 days, and/or chemotherapy within 30 days of operation. Previous percutaneous coronary intervention (PCI) and history of cardiac surgery were combined into previous cardiac surgical intervention.

We defined prolonged operative time as any case duration greater than the CPT code-specific 75th percentile for each surgical case included in the study, as previously defined by

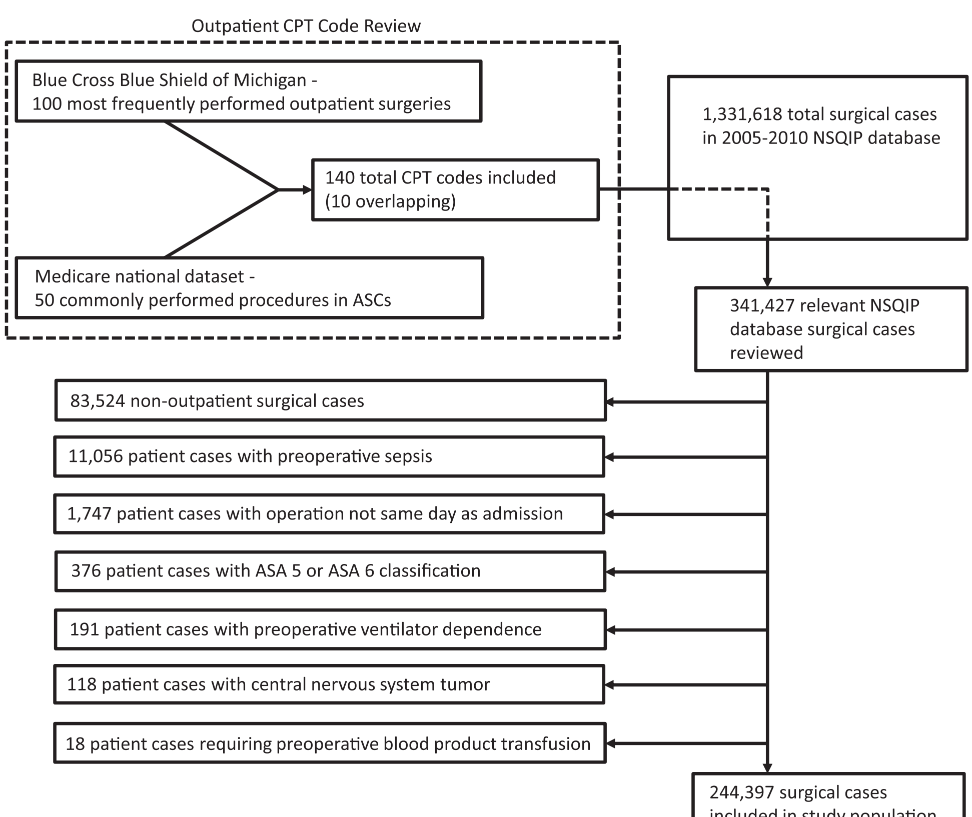

Fig. 1. Patient population derivation. ASA = American Society of Anesthesiologists; ASC = ambulatory surgery center; CPT = current procedural terminology; NSQIP = National Surgical Quality Improvement Program.

Table 1. Most Commonly Performed (>1,000) Surgical Cases by CPT Code within Study Population

Primary CPT Code	Procedures Performed (% of Population)	Description	Frequency of Perioperative Mortality <72 h	Frequency of Perioperative Morbidity <72 h
47562	43,952 (18.0)	Laparoscopic cholecystectomy	5	67
49505	42,082 (17.2)	Inguinal hernia repair	4	26
19125	20,343 (8.3)	Excision of breast lesion	1	7
49585	20,063 (8.2)	Umbilical hernia repair	0	12
19301	17,811 (7.3)	Partial mastectomy	0	13
19120	17,692 (7.2)	Removal of breast lesion	0	7
49560	13,046 (5.3)	Abdominal wall hernia repair	3	21
49650	12,857 (5.3)	Femoral/inguinal hernia repair	0	14
47563	12,300 (5.0)	Laparoscopic cholecystectomy	1	11
43770	7,498 (3.1)	Laparoscopic gastric band placement	0	6
29881	5,422 (2.2)	Knee arthroscopy with meniscectomy	0	2
19302	4,051 (1.7)	Partial mastectomy with under-arm lymph node removal	0	2
57288	3,145 (1.3)	Repair of bladder defect	0	1
42826	2,691 (1.1)	Tonsillectomy over age 12	1	3
19318	2,222 (0.9)	Reduction of large breast	0	5
29826	2,137 (0.9)	Shoulder arthroscopy, bone shaving	1	1
29827	1,930 (0.8)	Shoulder arthroscopy, rotator cuff repair	0	0
29880	1,877 (0.8)	Knee arthroscopy with meniscectomy	0	0
29888	1,825 (0.7)	Knee arthroscopy with anterior cruciate ligament repair	0	0
63030	1,639 (0.7)	Low back disk repair	0	3
52648	1,451 (0.6)	Laser vaporization of prostate	0	3
52234	1,289 (0.5)	Cystoscopy, removal of small tumor	1	1
52235	1,163 (0.5)	Cystoscopy, removal of medium tumor	1	3

CPT = current procedural terminology.

the Centers for Disease Control methodology.[31,32] To risk-adjust based on the inherent risk of each type of surgery, we computed a surgical complexity score based on a previously established technique using primary CPT code.[33] This technique results in one continuous score based on a logistic regression model. As applied to our study, each CPT code was placed into the model with our primary outcome as the dependent variable. Resulting adjusted odds ratios (AORs) were calculated for each CPT code, converted to logarithmic scale, and applied to each surgical case included in our study. The surgical complexity score was then included as a continuous variable for all statistical models used.

The primary outcome studied was composite perioperative morbidity/mortality, defined as the occurrence of any intraoperative or postoperative major complication occurring within 72 h of surgery, as detailed in table 3. Specific definitions for variables comprising the primary outcome are detailed in appendix 3. Consistent with previous outpatient surgery literature,[5] a 72-h outcome window was selected to identify patients experiencing morbidities who may have potentially benefitted from postoperative inpatient monitoring and treatment before any scheduled outpatient postoperative follow-up appointment. Timing of major complications included in the primary outcome definition was defined as the time of definitive diagnosis.

In addition, a secondary outcome studied was unplanned admission, defined as a hospital length-of-stay greater than 1 day—despite being scheduled as outpatient, as prerequisite for inclusion in the patient population studied. This secondary outcome was chosen on the basis that previous literature has focused on this outcome to guide outpatient surgical selection.[15,34]

To ensure validity of the cases in the final analytical dataset, each of the cases meeting the primary or secondary outcome was manually reviewed by two of the study investigators (M.R.M., M.M., or S.K.) to confirm that no preoperative or postoperative attributes suggested misclassification of the case as outpatient. Specifically, the primary procedure code, additional procedure codes, preoperative comorbidity data, and duration of procedure were reviewed.

Statistical Analysis

Statistical analysis of data was performed using RStudio and SPSS version 21.0 (IBM, Somers, NY). Basic descriptive statistics were calculated for demographic and anthropometric data. Pearson chi-square or Fisher exact tests (for categorical

Table 2. Perioperative Patient Characteristics—Univariate Analyses

Potential Risk Factor Category	Did Not Experience Perioperative Morbidity/Mortality N = 244,165 (%)	Experienced Perioperative Morbidity/Mortality N = 232 (%)	*P* Value*	Odds Ratio (95% CI)	% Cases with Complete Data
Male sex	101,064 (42)	109 (47)	0.09	1.25 (0.96–1.62)	99.8
Age, yr					
18–30	26,717 (11)	18 (7.8)	Reference		100
31–40	34,354 (14)	16 (6.9)	0.28	0.69 (0.35–1.36)	
41–50	52,365 (21)	44 (19)	0.43	1.25 (0.72–2.16)	
51–60	55,034 (23)	51 (22)	0.24	1.38 (0.80–2.36)	
61–70	41,787 (17)	39 (17)	0.25	1.39 (0.79–2.42)	
71–80	24,161 (9.9)	37 (16)	0.003	2.27 (1.29–3.99)	
81+	9,747 (4.0)	27 (12)	<0.001	4.11 (2.26–7.47)	
BMI					
Normal (BMI 18.5–24.9)	66,074 (28)	39 (17)	Reference		98.5
Underweight (BMI <18.5)	3,087 (1.3)	2 (0.9)	0.71	1.10 (0.27–4.55)	
Overweight (BMI 25–29.9)	79,267 (33)	77 (34)	0.01	1.65 (1.12–2.42)	
Obese BMI (BMI ≥30)	92,008 (38)	112 (49)	<0.001	2.06 (1.43–2.97)	
Diabetes mellitus	17,451 (7.3)	34 (15)	<0.001	2.24 (1.56–3.23)	98.2
Current smoker	44,130 (18)	43 (19)	0.86	1.03 (0.74–1.44)	100
Alcohol use	4,877 (2.0)	2 (0.9)	0.34	0.43 (0.11–1.72)	100
COPD	5,227 (2.1)	19 (8.2)	<0.001	4.08 (2.55–6.53)	100
CHF	220 (0.1)	1 (0.4)	0.19	4.80 (0.67–34.4)	100
MI within 6 months of operation	208 (0.1)	0 (0.0)	1.00	0.99 (0.99–0.99)	100
Previous PCI or cardiac surgery	13,252 (5.4)	37 (16)	<0.001	3.31 (2.33–4.70)	100
Angina within 1 month before operation	635 (0.3)	1 (0.4)	0.45	1.66 (0.23–11.9)	100
Hypertension requiring medication	85,998 (35.2)	136 (58.6)	<0.001	2.61 (2.01–3.38)	100
History of revascularization or amputation	1,248 (0.5)	2 (0.9)	0.33	1.69 (0.42–6.82)	100
Acute renal failure or current dialysis	962 (0.4)	4 (1.7)	0.01	4.44 (1.65–11.9)	100
History of TIA/CVA	6,884 (2.8)	24 (10)	<0.001	3.98 (2.61–6.07)	100
Paraplegia/quadriplegia	415 (0.2)	2 (0.9)	0.06	5.11 (1.27–20.6)	100
Disseminated cancer or current therapy for cancer†	1,568 (0.6)	4 (1.7)	0.06	2.71 (1.01–7.30)	100
Current steroid use	3,006 (1.2)	9 (3.9)	0.003	3.24 (1.66–6.31)	100
Recent weight loss >10%	934 (0.4)	0 (0.0)	1.00	0.99 (0.99–0.99)	100
Pregnant	306 (0.1)	1 (0.5)	0.25	3.55 (0.50–25.4)	87.2
Previous operation within 30 days	2,659 (1.2)	1 (0.5)	0.53	0.40 (0.06–2.86)	93.9
Prolonged operative time‡	62,841 (26)	86 (37)	<0.001	1.70 (1.30–2.22)	100

* *P* values calculated using either Pearson chi-square or Fisher exact test as appropriate. † Defined as history of disseminated cancer, history of radiotherapy within 90 days of operation, or history of chemotherapy within 30 days of operation. ‡ Defined as any surgical duration greater than the 75th percentile for each specific CPT.

BMI = body mass index; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; MI = myocardial infarction; PCI = percutaneous coronary intervention; TIA = transient ischemic attack.

variables) were used to assess baseline univariate clinical differences between patients who did and did not demonstrate the primary outcomes of interest.

Before developing a prediction model to determine independent risk factors, all variables in table 2 were tested for collinearity by investigating the condition index. If the condition index was greater than 30, then pairwise Pearson correlation matrices were constructed to determine which variables were highly correlated. If the condition index was less than 30, then no collinearity was detected, and all variables were eligible for regression model entry. Variables from table 2 which demonstrated a univariate *P* value of less than 0.20 or clinical relevance were entered into a semi-parsimonious logistic regression model to identify independent predictors of measured outcomes. A multivariate *P* value of less than 0.05 was considered statistically

Table 3. NSQIP Variables Comprising Perioperative Morbidity and Mortality Primary Outcome

Morbidity Type	Specific Morbidity	Frequency by Postoperative Day			
		POD 0	POD 1	POD 2	Total
Intraoperative morbidities	Intraoperative occurrence—cardiac arrest requiring CPR	0	0	0	0
	Intraoperative occurrence—myocardial infarction	0	0	0	0
Postoperative occurrences—surgical	Deep surgical site infection	0	0	1	1
	Organ-space surgical site infection	0	2	0	2
	Wound disruption	7	13	5	25
Postoperative occurrences—anesthetic	Unplanned intubation	30	5	2	37
	On ventilator >48 h	1	0	1	2
Postoperative occurrences—medical	Pneumonia	1	16	29	46
	Pulmonary embolism	0	3	4	7
	Progressive renal insufficiency	0	1	5	6
	Acute renal failure	1	0	3	4
	Stroke/CVA with neurologic deficit	3	6	6	15
	Cardiac arrest requiring CPR	6	1	1	8
	Myocardial infarction	7	3	5	15
	Bleeding requiring transfusion	8	7	6	21
	Graft/prosthesis/flap failure	1	2	2	6
	DVT/thrombophlebitis	3	1	6	10
	Sepsis	2	3	14	19
	Septic shock	2	3	5	10
Mortality	Postoperative death within 72 h	9	7	5	21

CPR = cardiopulmonary resuscitation; CVA = cerebrovascular accident; DVT = deep venous thrombosis; NSQIP = National Surgical Quality Improvement Program; POD = postoperative day.

significant and an independent predictor. Measures of effect size were reported as AORs and 95% CIs. Goodness-of-fit was assessed using the Omnibus Tests of Model Coefficients as well as the Hosmer and Lemeshow Test. Overall predictive capability of each model was assessed using the c-statistic. In addition, the model was validated using bootstrapping, performed in RStudio using the bootcov function with 1,000 replacements. A *P* value of less than 0.05 was considered statistically significant and an independent predictor in the bootstrapped dataset.

Results

Through a review of the Michigan Blue Cross Blue Shield and the national Medicare 2010 databases, a total of 140 CPT codes were identified as common day case-eligible surgical procedures. Within the NSQIP database, we identified 341,427 cases with one or more matching CPT codes, of which 257,903 were scheduled on an outpatient basis. Among these cases, 244,397 cases met the inclusion criteria for this study as detailed in figure 1. Exactly 241,600 cases (98.9%) involved a length-of-stay less than or equal to 1 day, and data completion rate was noted to be 98% or greater for all but two variables: previous operation within 30 days (94%) and pregnancy (87%).

Within this study population, primary outcome analysis identified 232 cases experiencing an event: a total of 21 mortalities and 234 perioperative morbidities (multiple morbidities in some cases) within 72 h postoperatively. This corresponded to an incidence of 0.095%, or approximately 1 in 1,053 cases. It was noted that no intraoperative deaths occurred; nine occurred on the day of surgery, seven on postoperative day 1, and five on postoperative day 2. Of the 232 cases experiencing an event, 195 (84%) were discharged within 23 h of surgery. Of the 234 perioperative morbidities, the most common events included pneumonia (46), unplanned postoperative intubation (37), wound disruption (25), postoperative bleeding (21), and sepsis (19).

A variety of patient comorbidities were identified as significant univariate predictors of 72-h perioperative morbidity or mortality, as described in table 2. On multivariable analysis, collinearity diagnostics did not demonstrate any condition indices greater than 30, and therefore, no variables were removed from the analysis. All variables in table 2 meeting logistic regression model inclusion criteria plus the surgical complexity score were subsequently entered into the semi-parsimonious logistic regression model. Through multivariable analysis of primary outcome, seven independent predictors of perioperative morbidity or mortality were identified while controlling for surgical complexity: overweight BMI (AOR, 1.6; 95% CI, 1.1–2.3), obese BMI (AOR, 2.0; 95% CI, 1.4–3.0), prolonged operative time (AOR, 1.7; 95% CI, 1.3–2.2), previous PCI/cardiac surgery

(AOR, 1.7; 95% CI, 1.2–2.6), COPD (AOR, 2.4; 95% CI, 1.4–4.0), hypertension (AOR, 1.7; 95% CI, 1.2–2.3), and history or TIA/CVA (AOR, 2.1; 95% CI, 1.4–3.4). These independent predictors are shown in figure 2. The Omnibus Tests of Model Coefficients demonstrated a chi-square value of 155, 24 degrees of freedom, and a *P* value less than 0.001. The Hosmer and Lemeshow Test demonstrated a chi-square value of 8.12, 8 degrees of freedom, and a *P* value of 0.42. The c-statistic was 0.72 (95% CI, 0.69–0.76). All seven of the independent predictors were validated using bootstrapping with 1,000 samples with replacement. The Somers Dxy was 0.4646 for the original data set, 0.4901 for the training set, and 0.4175 for the test set. The optimism was 0.0726 and the bias-corrected Somers Dxy was 0.3920.[35]

Secondary outcome analysis recognized 2,797 cases (1.1%) described as unplanned admission. An additional multivariable regression model identified 17 independent predictors: male sex (AOR, 0.77; 95% CI, 0.71–0.85), age 51–60 yr (AOR, 1.2; 95% CI, 1.0–1.4), age 61–70 yr (AOR, 1.4; 95% CI, 1.2–1.7), age 71–80 yr (AOR, 1.6; 95% CI, 1.3–2.0), age 81–90 yr (AOR, 2.4; 95% CI, 1.9–3.0), underweight BMI (AOR, 2.0; 95% CI, 1.5–2.7), obese BMI (AOR, 1.4; 95% CI, 1.2–1.6), prolonged operative time (AOR, 3.1; 95% CI, 2.8–3.3), diabetes mellitus (AOR, 1.3; 95% CI, 1.1–1.5), COPD (AOR, 1.4; 95% CI, 1.2–1.8), previous PCI/cardiac surgery (AOR, 1.3; 95% CI, 1.2–1.5), hypertension (AOR, 1.1; 95% CI, 1.0–1.2), renal failure/dialysis (AOR, 2.3; 95% CI, 1.6–3.4), history of TIA/CVA (AOR, 1.5; 95% CI, 1.2–1.8), paraplegia or quadriplegia (AOR, 2.7; 95% CI, 1.5–4.9), current steroid use (AOR, 1.6; 95% CI, 1.2–2.0), and previous operation within 30 days (AOR, 0.58; 95% CI, 0.35–0.94). A chi-square value of 1,158, 30 degrees of freedom, and a *P* value less than 0.001 were determined by the Omnibus Tests of Model

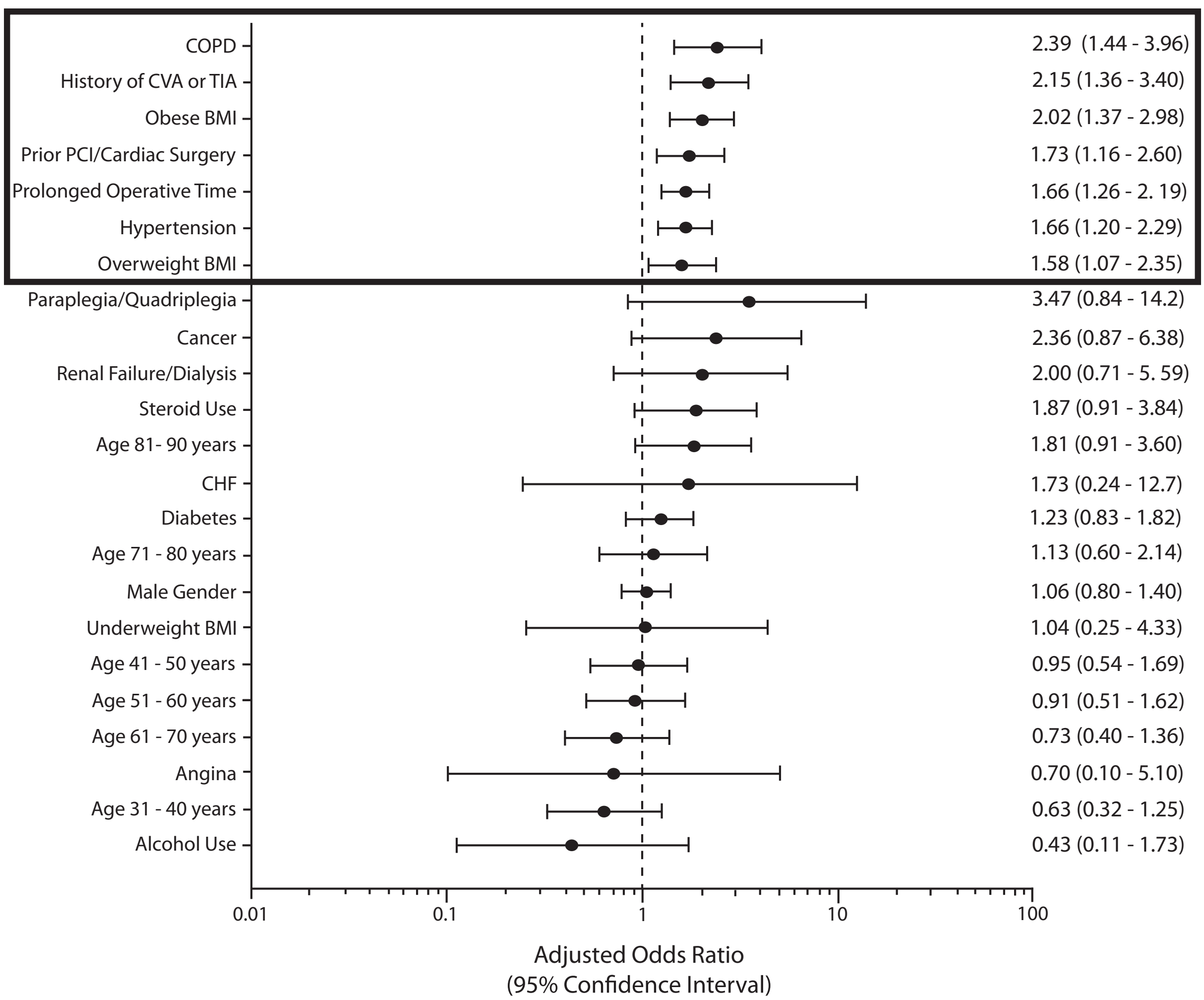

Fig. 2. Primary outcome logistic regression model covariates. Significant predictors of morbidity or mortality after same-day case-eligible surgery were chronic obstructive pulmonary disease (COPD), history of cerebrovascular accident (CVA) or transient ischemic attack (TIA), obese body mass index (BMI), previous percutaneous coronary intervention (PCI)/cardiac surgery, prolonged operative time, hypertension, and overweight BMI. These predictors are depicted at the top of this figure. Other covariates evaluated, but not found to be statistically significant, are also depicted in the figure. Reference age range = 18–30 yr; reference BMI = normal BMI (18.5–24.9). CHF = congestive heart failure.

Coefficients. The Hosmer and Lemeshow Test revealed a chi-square value of 14.4, 8 degrees of freedom, and a P value of 0.07. The c-statistic was 0.70 (95% CI, 0.69–0.71).

Discussion

The expansion of outpatient surgery across the United States is sharply contrasted by a shortage of outcomes data for patients undergoing procedures in this care setting. Current knowledge is limited to case series, single-center data, and administrative data analyses, and this continues to create a demand for evidence-based research to direct future initiatives. To this end, our study sought out specific patient populations for whom the day-case surgical model may pose significant risks. Given the paucity of outpatient data overall—and in particular for ASC patients—these outpatient data serve as a critical starting point for research focused on the ASC care model.

In our study, the incidence of perioperative morbidity or mortality was 0.095% among 244,397 adult outpatients undergoing common day case-eligible surgical procedures, corresponding to 1 in 1,053 cases. We identified seven independent predictors of perioperative morbidity or mortality when controlled for surgical complexity: overweight BMI, obese BMI, prolonged operative time, COPD, hypertension, previous PCI/cardiac surgery, and history of TIA/CVA. Early postoperative pneumonia, unplanned postoperative intubation, and wound disruption were among the most common morbidities identified.

The incidence of perioperative morbidity/mortality identified in our study is consistent with previous single-center literature, which notes major morbidity rates from 0.09 to 0.60% through the perioperative period among common ambulatory surgical procedures.[5,7,8] The low rate confirms the relative safety of day case-eligible surgical procedures, aided by current patient-selection processes—although nonuniform—which continue to evolve with emerging literature. Such selection processes have cited case series and single-center analyses suggesting that poorly stabilized cardiopulmonary status, obstructive sleep apnea, advanced age, increased surgical invasiveness, and recent hospitalizations are characteristics placing patients at high risk for major morbidity, death, or hospital admission after outpatient surgery.[10,11,16,18] An administrative analysis performed by Fleisher *et al.*[15] did note a 0.58% rate of hospital admission after outpatient surgery characterized by similar risk factors identified in our study although nonspecific for cause of readmission. Our prospectively collected clinical data provide validation to the existing retrospective administrative or single-center literature, with some identified risk factors confirming previous hypotheses, and others perhaps newly elucidated.

In addition to modest discriminating capacity (c-statistic of 0.72), the model demonstrates clinical relevancy because each independent predictor had an AOR of 1.6 or greater for perioperative morbidity within 72 h. Many of the independent predictors had even higher AORs, such as COPD or a history of TIA/CVA. Because the underlying rate of the primary outcome is low, this does not translate to a large absolute risk increase. However, in the current environment of limited clinical data to guide patient selection, these data serve to provide a previously unavailable evidence basis for this process.

Administrative data analyses focused on a readmission outcome have previously noted prolonged operative duration, cerebrovascular disease, obesity, and cardiac disease to increase the risk after outpatient surgery.[15,34] Our prospectively collected clinical data confirm similar observations that, until now, were only noted in administrative data. In addition, we have noted hypertension requiring medications and COPD requiring medications as additional risk factors previously not reported in clinical literature. These represent additional preoperative characteristics which a medical director should consider when screening for appropriateness of day case-eligible surgery at an ASC. Interestingly, however, our multivariate regression analysis reported that many variables were not independently associated with an increased risk of perioperative morbidity/mortality: these included sex, advanced age, paraplegia/quadriplegia, cancer, renal failure, steroid use, congestive heart failure, diabetes mellitus, underweight BMI, angina, and heavy alcohol intake.[11,15,16] However, due to the low event rate, we may not have been able to observe statistically significant relationships despite an underlying clinically meaningful relationship.

Although our analysis dataset does not specifically identify which cases were performed at an ASC *versus* acute care hospital, the data do offer incremental insight for an ASC medical director attempting to establish objective criteria for patient selection. Many ASC criteria are based on subjective patient risk assessments such as the American Society of Anesthesiologists physical status classification, which has poor interrater reliability and can be manipulated.[36] Although physical status classification has been demonstrated to be an important statistical tool for risk adjustment, its use for clinical decision making has never been established. Our comorbidity-driven analysis provides specific disease definitions usable for a more transparent patient-selection process. The data must be interpreted with caution given the low absolute risk increases involved. Our data do not offer definitive, comprehensive selection criteria for ASC patient selection. Clearly, the low event rate noted in our dataset demands further research using databases specifically designed for analysis of outpatient surgery populations or requires that a specific database of high-risk outpatient surgery patients be created.

Our secondary analysis evaluated the incidence and predictors of unplanned admission after day case-eligible surgery. We observed 2,797 patients (1.1%) required an unplanned admission. Unfortunately, the dataset does not describe the specific event or issue that necessitated an admission, and we do not wish to conjecture using the postoperative events. However, these data are consistent with existing administrative or single-center data evaluating the incidence of admission. The risk model also had modest discriminating capacity with a c-statistic of 0.70 and likely encompasses a wide range of admission reasons. The factors identified are consistent with previous administrative literature.

Our study has several limitations. We sought to achieve an appropriate balance between generalizability and focused clinical results by using the Michigan Blue Cross Blue Shield and Medicare databases to identify common surgeries performed on an outpatient basis. However, given the heterogeneity of outpatient surgery centers throughout the United States, clinicians must use caution in applying these findings. In addition, the central limitation of our study was that although the procedures were scheduled as outpatient, the ACS-NSQIP dataset does not identify whether they were performed at an ASC. Nevertheless, the identified high-risk patient characteristics are still of value to ASC medical directors seeking objective patient-selection criteria. Variations in procedures and data-collection methods may have existed across ACS-NSQIP institutions although it should be noted that this was limited through the use of specific, highly enforced, rigorously validated data-collection protocols. Although attempts to minimize sources of misclassification have included using a database excluding hospital sites with suboptimal interrater reliability, developing exclusion criteria filtering invalid data, and finally a manual review of all primary outcomes included in the dataset, the authors acknowledge that it is possible that inaccuracies in data collection not detectable by any means using all other case data recorded for each primary outcome may have existed. In addition, our study shared the limitations of any observational trial. Within the ACS-NSQIP database, variables are recorded for quality improvement and research purposes, and data beyond this scope are not available. Perioperative risk factors assessed in this study were limited to existing ACS-NSQIP definitions, and those chosen were limited to those hypothesized in previous literature. In addition, ACS-NSQIP definitions do not discriminate severity within a given preoperative comorbidity. The risk factors evaluated were also limited in number as to avoid multivariable regression model overfitting. As demonstrated by c-statistic of 0.72, our multivariable model shows modest predictive capability, with other risk predictors not accounted for. Finally, as data are unavailable as to whether day case-eligible surgical cases included in the study were performed at a hospital-based facility or ASC, overreporting of patient complications may have existed, as it is possible that medical directors within the NSQIP database scheduled procedures as outpatient with the knowledge that outpatient procedures would be performed at a hospital-based facility (with increased access to healthcare resources, and thus higher acceptable patient risk) rather than ASC. Although a consistent method of classifying surgical procedures as "inpatient" *versus* "outpatient" was verified across multiple institutions, the authors acknowledge that nurses trained in data entry at other participating sites not contacted may have reasonably classified same-day admissions as "outpatient"; for this reason, further overreporting of patient complications may have existed.

Despite these limitations, our study remains the first national clinical analysis assessing risk factors for specific major morbidities and mortality after day case-eligible surgery. In accomplishing this goal, our results can provide ASC medical directors with information beyond just the incidence of these outcomes. In addition, in providing data on specific perioperative morbidities, information more tangible than a risk of inpatient admission can be provided to medical directors. In this sense, our study provides a broader evidence base for patient screening and allows for more specific patient counseling on perioperative risks.

In conclusion, we report major perioperative morbidities or mortalities to occur once in every 1,053 day case-eligible surgical cases in our study population, and they were independently associated with overweight BMI, obese BMI, prolonged operative time, previous PCI/cardiac surgery, hypertension, COPD, and a history of TIA/CVA. In the midst of a rapidly growing, increasingly complex outpatient population, the risk factors identified in our study provide evidence upon which an ASC medical director's patient-screening decisions can be based.

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Appendix 1. NSQIP Data Fields Used for Inclusion and Exclusion Criteria—Sensitivity Analyses

	Specific Data Field	Description	Data Format
Inclusion criteria category			
Outpatient surgery/admit day of procedure	#7 INOUT	Inpatient/outpatient	Inpatient/outpatient
	#8 TRANST	Patient transfer status	Admitted directly from home/acute care hospital/VA acute care hospital/chronic care facility/VA chronic care facility/other
Common outpatient surgical procedure (in Medicare/Blue Cross Blue Shield databases)	#5 CPT	CPT code	Number
Exclusion criteria category			
Preoperative sepsis	#58 PRSEPIS	Preoperative systemic sepsis	SIRS/sepsis/severe sepsis/septic shock/none
Preoperative ventilator dependence	#26 VENTILAT	Preoperative ventilator dependent	Yes/no
Moribund/deceased patient	#151 ASACLAS	ASA classification (5 or 6)	1/2/3/4/5/6
Hospital admission not same day as operation	#166 HtoODay	Days from hospital admission to operation (days)	Number
Preoperative blood transfusion	#55 TRANSFUS	Transfused >4 units of packed erythrocytes 72 h before surgery	Yes/no
Tumor involving the CNS	#47 TUMORCNS	Space-occupying lesion of the brain or spinal cord	Yes/no

ASA = American Society of Anesthesiologists; CNS = central nervous system; CPT = current procedural terminology; NSQIP = National Surgical Quality Improvement Program; SIRS = systemic inflammatory response syndrome; VA = Veterans Affairs.

Appendix 2. Predictor Variables—NSQIP Definitions

Risk Factor Category	Specific Data Field	Description	Data Format
Patient demographics	#2 SEX	Sex	Male/female
	#9 AGE	Age	Number
	#16 HEIGHT	BMI	Number
	#17 WEIGHT		
Surgery-related risk factors	#4 PRNCPTX	Principal operative procedure CPT code description	Text/number
	#5 CPT	CPT code	
	#159 OPTIME	Total operation time	Number
Patient comorbidities	#18 DIABETES	Diabetes mellitus with oral agents or insulin	No/oral/insulin
	#19 SMOKE	Current smoker within 1 yr	Yes/no
	#21 EtOH	EtOH more than two drinks per day in 2 weeks before admission	Yes/no
	#27 HXCOPD	History of severe COPD	Yes/no
	#31 HXCHF	History of CHF in 30 days before surgery	Yes/no
	#32 HXMI	History of myocardial infarction 6 months before surgery	Yes/no
	#33 PRVPCI	Previous PCI	Yes/no
	#34 PRVPCS	Previous cardiac surgery	
	#35 HXANGINA	History of angina in 1 month before surgery	Yes/no
	#36 HYPERMED	Hypertension requiring medication	Yes/no
	#37 HXPVD	History of revascularization/amputation for peripheral vascular disease	Yes/no
	#39 RENAFAIL	Acute renal failure	Yes/no
	#40 DIALYSIS	Currently on dialysis (preoperatively)	
	#44 HXTIA	History of transient ischemic attacks	Yes/no
	#45 CVA	History of CVA/stroke with neurologic deficit	
	#46 CVANO	History of CVA/stroke with no neurologic deficit	
	#48 Para	Paraplegia	Yes/no
	#49 QUAD	Quadriplegia	

(*Continued*)

Appendix 2. *(Continued)*

Risk Factor Category	Specific Data Field	Description	Data Format
	#50 DISCANCR	Disseminated cancer	Yes/no
	#56 CHEMO	Chemotherapy for malignancy in ≤30 days preoperatively	
	#57 RADIO	Radiotherapy for malignancy in last 90 days	
	#52 STEROID	Steroid use for chronic condition	Yes/no
	#53 WTLOSS	>10% loss of body weight in last 6 months	Yes/no
	#59 PREGNANCY	Pregnancy	Yes/no
	#60 PROPER30	Previous major surgical procedure within 30 days	Yes/no

BMI = body mass index; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CPT = current procedural terminology; CVA = cerebrovascular accident; EtOH = alcohol; NSQIP = National Surgical Quality Improvement Program; PCI = percutaneous coronary intervention.

Appendix 3. Primary Outcome Variables—NSQIP Definitions

Specific Data Field	Description	Data Format
#160 TYPEINTOC → cardiac arrest requiring CPR	Cardiac arrest requiring CPR	Yes/no
#160 TYPEINTOC → myocardial infarction	Myocardial infarction	Yes/no
#173 WNDINFD	Deep surgical site infection	Yes/no
#174 DWNDINFD	Days from operation until deep incisional SSI	Number
#176 ORGSPCSSI	Organ/space surgical site infection	Yes/no
#177 DORGSPCSSI	Days from operation until organ/space SSI	Number
#179 DEHIS	Wound disruption	Yes/no
#180 DDEHIS	Days from operation until wound disruption	Number
#50 REINTUB	Unplanned intubation	Yes/no
#51 DREINTUB	Days from operation until unplanned intubation	Number
#191 FAILWEAN	On ventilator >48 h	Yes/no
#192 DFAILWEAN	Days from operation until on ventilator >48 h	Number
#182 OUPNEUMO	Pneumonia	Yes/no
#183 DOUPNEUMO	Days from operation until pneumonia	Number
#188 PULEMBOL	Pulmonary embolism	Yes/no
#189 DPULEMBOL	Days from operation until pulmonary embolism	Number
#194 RENAINSF	Progressive renal insufficiency	Yes/no
#195 DRENAINSF	Days from operation until progressive renal insufficiency	Number
#197 OPRENAFL	Acute renal failure	Yes/no
#198 DOPRENAFL	Days from operation until acute renal failure	Number
#203 CNSCVA	Stroke/CVA with neurologic deficit	Yes/no
#204 DCNSCVA	Days from operation until stroke/CVA	Number
#212 CDARREST	Cardiac arrest requiring CPR	Yes/no
#213 DCDARREST	Days from operation until cardiac arrest requiring CPR	Number
#215 CDMI	Myocardial infarction	Yes/no
#216 DCDMI	Days from operation until myocardial infarction	Number
#218 OTHBLEED	Bleeding requiring transfusion	Yes/no
#219 DOTHBLEED	Days from operation until bleed requiring transfusion	Number
#221 OTHGRAFL	Graft/prosthesis/flap failure	Yes/no
#222 DOTHGRAFL	Days from operation until graft/prosthesis/flap failure	Number
#224 OTHDVT	DVT/thrombophlebitis	Yes/no
#225 DOTHDVT	Days from operation until DVT/thrombophlebitis	Number
#227 OTHSYSEP	Sepsis	Yes/no
#228 DOTHSYSEP	Days from operation until sepsis	Number
#230 OTHSESHOCK	Septic shock	Yes/no
#231 DOTHSESHOCK	Days from operation until septic shock	Number
#236 DOpertoD	Death within 72 h of operation	Yes/no

CPR = cardiopulmonary resuscitation; CVA = cerebrovascular accident; DVT = deep venous thrombosis; NSQIP = National Surgical Quality Improvement Program; SSI = surgical site infection.