Preoperative Evaluation Clinic Visit Is Associated with Decreased Risk of In-hospital Postoperative Mortality

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ABSTRACT

Background: As specialists in perioperative medicine, anesthesiologists are well equipped to design and oversee the preoperative patient preparation process; however, the impact of an anesthesiologist-led preoperative evaluation clinic (PEC) on clinical outcomes has yet to be fully elucidated. The authors compared the incidence of in-hospital postoperative mortality in patients who had been evaluated in their institution's PEC before elective surgery to the incidence in patients who had elective surgery without being seen in the PEC.

Methods: A retrospective review of an administrative database was performed. There were 46 deaths from 64,418 patients (0.07%): 22 from 35,535 patients (0.06%) seen in PEC and 24 from 28,883 patients (0.08%) not seen in PEC. After propensity score matching, there were 13,964 patients within each matched set; there were 34 deaths (0.1%). There were 11 deaths from 13,964 (0.08%) patients seen in PEC and 23 deaths from 13,964 (0.16%) patients not seen in PEC. A subanalysis to assess the effect of a PEC visit on deaths as a result of failure to rescue (FTR) was also performed.

Results: A visit to PEC was associated with a reduction in mortality (odds ratio, 0.48; 95% CI, 0.22 to 0.96, $P = 0.04$) by comparison of the matched cohorts. The FTR subanalysis suggested that the proportion of deaths attributable to an unanticipated surgical complication was not significantly different between the two groups ($P = 0.141$).

Conclusions: An in-person assessment at the PEC was associated with a reduction in in-hospital mortality. It was difficult to draw conclusions about whether a difference exists in the proportion of FTR deaths between the two cohorts due to small sample size. **(ANESTHESIOLOGY 2016; 125:280-94)**

VALUE-BASED management initiatives in health care have led to the expansion and transformation of the anesthesiologist's role.[1] The preoperative evaluation clinic (PEC) provides an opportunity to demonstrate expertise in perioperative patient care and systems design as perioperative medicine consultants. Many key elements of a successful perioperative surgical home can be initiated in an anesthesiologist-led PEC, such as early anesthesiologist access to patients; increased preoperative counseling by anesthesiologists; increased communication between providers and patients; anesthesiologist involvement in protocol development; and coordination of postoperative care to reduce pain, complications, morbidity, and mortality.[2–4] Previous studies of anesthesiologist-directed PECs have demonstrated that a well-designed PEC can reduce preoperative consultations, decrease surgical cancellations due to inadequate preoperative preparation, and reduce costs associated with unnecessary testing.[5–8] Furthermore, data suggest that standardized, surgery-specific clinical protocols that include a preoperative patient engagement component improve efficiency, reduce day of surgery case cancellations, decrease hospital length of stay, and reduce readmission rates, which translate to a cost savings for the institution.[5,9–16] However, these studies do not specifically address the contribution of a PEC to the improvement in clinical outcomes.

What We Already Know about This Topic

- Dedicated preoperative evaluation clinics allow for early patient access to anesthesiologists, increased preoperative counseling, increased communication between providers and patients, anesthesiologist involvement in protocol development, and coordination of postoperative care to reduce pain, complications, morbidity, and mortality
- Previous studies of well-designed anesthesiologist-directed preoperative evaluation clinics have demonstrated that these clinics can reduce preoperative consultations, decrease surgical cancellations due to inadequate preoperative preparation, and reduce costs associated with unnecessary testing

What This Article Tells Us That Is New

- An in-person assessment in an anesthesiologist-led preoperative evaluation clinic was associated with a reduction in in-hospital mortality.

Failure to rescue (FTR) is defined as death after a postoperative complication.[17] Strategies to reduce FTR mortality rely on interventions that occur in the postoperative period, after the complication has occurred and been recognized.[18] By contrast, a PEC may provide the opportunity to reduce non-FTR mortality through the preoperative identification and optimization of high-risk patients. However, whether a PEC visit can influence postoperative mortality of either type has not been determined.

This article is featured in "This Month in Anesthesiology," page 1A. This article has an audio podcast.

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Our PEC is a free-standing outpatient clinic, which serves a tertiary and quaternary care academic medical center. Moderate- to high-risk patients are referred to our institution's PEC with the goals of improving patient education and engagement and coordinating the plan of care before surgery. We hypothesized that the anesthesiologist-directed, standardized preoperative evaluation process that patients underwent in our PEC was superior to the preoperative evaluation process that occurred outside of PEC with regard to patient outcomes. We compared the incidence of in-hospital postoperative mortality in patients who were evaluated before elective surgery in our institution's PEC to the incidence in those patients who had elective surgery without being seen in the PEC. We then noted the number of FTR deaths that occurred in each cohort.

Materials and Methods

Preoperative Evaluation Clinic Structure and Activities

Our PEC is a free-standing outpatient clinic, open from 8:00 AM to 8:00 PM on weekdays; it is staffed on-site by 2 attending anesthesiologists, 1 resident anesthesiologist, 6 nurse practitioners (NPs), and 10 registered nurses (RNs), as well as 3 patient care technicians (PCTs). On Saturdays, the PEC is open from 8:00 AM to 4:00 PM and is staffed by one attending anesthesiologist, one NP, three RNs, and one PCT. Our PEC provided in-person assessments to an average of 60 patients per day on weekdays and 18 patients per day on Saturdays during the time frame studied in this analysis, which was approximately 55% of the annual surgical volume.

Patients were identified as requiring an in-person assessment in PEC through the use of a screening tool that was administered in the surgeon's office (appendix 1). The tool was readily accessible both in paper form and *via* our institution's Web site. The screening tool consisted of a list of medical comorbidities; it was created by the anesthesiologist–director of PEC and approved by the medical board at our institution. When the patient required an assessment in PEC, this was explained to the patient, and the appointment was scheduled by secretarial staff in the surgeon's office with the patient present. Whether or not the patient needed a PEC evaluation was included as a required element on the surgical case request form. If a patient who required a PEC assessment had not been evaluated in PEC by 72 h before surgery, the patient was contacted by secretarial staff in PEC to schedule an appointment. Multiple efforts were made to schedule the patient for the recommended assessment; however, whether or not to undergo a preoperative evaluation at the clinic was ultimately the patient's decision. No patients were refused a PEC clinic appointment: all self- and surgeon-referred patients were assessed in PEC.

Not every patient in PEC met with an anesthesiologist; certain low- and intermediate-risk patients were preassigned to meet with a NP who had received training in preoperative assessment and anesthesia care. The patient's electronic health record was reviewed by our NP staff 3 days before the scheduled PEC visit. Using an algorithm created by the anesthesiologist–director of PEC, the NP assigned patients to one of three groups: preoperative evaluation with an anesthesiologist, preoperative evaluation with a NP, or "fast-track" status: the patient will meet only with an RN and PCT. The algorithm included the complexity of the patient's preoperative comorbidities and medication list and the severity of the planned surgical procedure (appendices 2 and 3). When the electronic health record contained insufficient data, or a patient arrived at PEC as an "add-on," the patient was assigned to be evaluated by an anesthesiologist. All patients who visited the clinic were subjected to a standardized preoperative evaluation process and patient education methods, which had been developed by the anesthesiologist–director of PEC. During the time period analyzed, the PEC utilized protocols for the preoperative workup of preexisting cardiac conditions, cardiac stents and implantable cardiac devices, the preoperative workup and management of diabetes and hypertension, and the preoperative management of antiplatelet and anticoagulation medications. These protocols were devised by an anesthesiologist-led hospital committee that consisted of anesthesiologists, surgeons, medical subspecialists, and nursing leadership. The determination of a patient as not a surgical candidate due to the severity of preexisting medical conditions was a joint decision between the anesthesiologist evaluating the patient in PEC, the surgeon, and the patient.

Patients who were not evaluated in the PEC received their preoperative instructions and education from their surgeon and/or primary medicine physician, who also coordinated the plan of care. For these patients, exposure to an in-person preanesthesia evaluation by an anesthesiologist was limited to an assessment and discussion with the anesthesiologist assigned to the case immediately before surgery. This is consistent with the traditional, sequential model of perioperative care described in the literature.[19] No comorbidity-specific or procedure-specific enhanced recovery protocols were in place for the intraoperative or postoperative phase of care during the time interval used for our analysis.

Data

We performed a retrospective review of an administrative database that had been stripped of patient identifiers; the only charts reviewed were of deceased persons. The institutional review board at our institution determined that this analysis did not constitute human subject research. The database consisted of 76,601 patients who had procedures between June 2011 and June 2013 at a single, urban academic medical center and contained information including date of procedure, procedure type, emergency status, certain preoperative comorbidities (coronary artery disease [CAD], history of stroke, congestive heart failure, diabetes mellitus, hypertension, atrial fibrillation, obesity, dementia, cancer, human immunodeficiency virus, and chronic obstructive pulmonary disease), gender, age, American Society of

Anesthesiologists (ASA) physical classification score, Johns Hopkins surgical grade, in-hospital mortality, and whether or not the patient was seen in the PEC before the procedure. In-hospital mortality referred to any patient who died in the hospital after a procedure. Diagnoses were determined based on *International Classification of Diseases*, Ninth Revision codes, which were obtained from coded discharge data. Codes for preoperative diagnoses were able to be entered by any clinician responsible for the patient's care in the perioperative period, including the surgeon and his or her clinical staff, clinicians in PEC, clinical staff in the preoperative area on the day of surgery, the anesthesiologist assigned to the case, clinical staff responsible for the patient's postoperative care, and the patient's medical doctor(s) or referring physician. The only missing data points were in cases that did not have an assigned Johns Hopkins surgical grade due to being missed during the assignment process; these cases were excluded. Canceled cases and patients who underwent emergency procedures were excluded. Emergency procedures were those that were booked as emergent or those in which the patient was admitted *via* the emergency room. All elective procedures performed with anesthesia care were included in the analysis, including cases performed in the operating room and off-site locations such as the interventional radiology and endoscopy suites. Tracheotomy and percutaneous endoscopic gastrostomy (PEG) procedures that were performed on patients in the intensive care unit were included in the analysis only if the patient had undergone an elective surgery during that same hospital admission before the tracheotomy or PEG procedure. Patients who had been seen in PEC before the elective surgery that preceded the tracheotomy or PEG procedure were included in the PEC group for the analysis although they had not been reevaluated in PEC before the tracheotomy or PEG procedure.

All patients studied underwent their procedure at the same institution and were subjected to the standard of care at our urban, academic medical center.

Statistical Analysis

The Matching Package[20] for the R statistical software (version 3.1.1, The R Foundation for Statistical Computing, Austria) was utilized for propensity score matching and assessment of postmatch balance; a greedy match was performed. Propensity score for being seen at PEC was determined using logistic regression based on preoperative medical comorbidities, including CAD, history of stroke, diabetes mellitus, hypertension, atrial fibrillation, obesity, dementia, cancer, human immunodeficiency virus, and chronic obstructive pulmonary disease; age; ASA score; Johns Hopkins surgical grade; and gender. The medical comorbidity covariates were chosen due to inclusion within the Charlson Comorbidity Index.[21] Johns Hopkins surgical grade[22,23] was chosen as a measure to classify and categorize the severity of the surgical procedure. One to one nearest neighbor propensity score matching without replacement using Mahalanobis distance metric weighting and a caliper width of 0.2 SDs was performed based on the derived propensity scores, using a visit to PEC as the treatment variable and estimating the average treatment effect on the treated (appendix 4). Match balance was considered adequate for standardized mean difference less than 0.1 and by visualizing q-q plots when applicable for continuous variables. Univariate logistic regression was performed on the matched set using a visit to PEC as the independent variable and in-hospital mortality as the dependent variable. Using univariate logistic regression allowed specific identification of the dependent and independent variables, as opposed to a Pearson chi-square test. In order to consider the possibility that the matched pairs are derived from the same multivariate distribution, McNemar chi-square test was also conducted. To confirm that no additional confounder was present due to the referral patterns of certain surgical services, an additional analysis by surgical service was performed. Additional analysis by specific surgeon could not be performed due to the large number of surgeons in the database.

An additional subanalysis involved assessment of whether the death was as a result of an intraoperative or postoperative complication that could not have been anticipated preoperatively, and thus could not be mitigated by preoperative interventions. Designation as a FTR death, defined as an in-hospital death after an adverse occurrence such as a major surgical complication,[3,17] was assigned *post hoc* to the subset of deceased patients. The following diagnoses were used to define a major surgical complication: shock or cardiac arrest, respiratory arrest or failure, pneumonia, upper gastrointestinal bleeding, sepsis, and venothromboembolism.[24] Three separate reviewers performed chart reviews to assign FTR, all of whom were blinded as to PEC status. To minimize the effect of sicker patients visiting the PEC, this subanalysis was performed on the matched cohorts, and McNemar chi-square test was used.

Results

After exclusion, 64,418 patients remained for analysis. Of these patients, 35,535 (55%) had been seen in PEC. There were 46 deaths (0.07%): 22 of 35,535 (0.06%) patients seen in PEC and 24 of 28,883 (0.08%) patients not seen in PEC. Before matching, univariate analysis of the association between being seen at PEC and death did not demonstrate significance ($P = 0.32$). Patients who visited PEC were older, with a mean age of 50 yr (table 1), and had a greater incidence of CAD, hypertension, and obesity than those who did not. They also underwent procedures with higher Johns Hopkins surgical grades and were more frequently ASA II or III. Patients with an ASA score of I and those with cancer were less likely to have been seen at PEC.

The median propensity score for being seen in PEC before matching was 0.67 (interquartile range, 0.27 to 0.83) and after matching was 0.50 (interquartile range, 0.48 to 0.52). After propensity score matching, there were 13,964 patients within each cohort (fig. 1); there were 34 deaths (0.1%). There were 11 deaths from 13,964 (0.08%) patients seen in

Table 1. Patient Demographics before Propensity Score Matching

Before Matching	Seen in PEC (n = 35,535)	Not Seen in PEC (n = 28,883)	Entire Cohort (n = 64,418)	Standardized Mean Difference before Matching
Age, yr (mean ± SD)	50 ± 18	45 ± 23	48 ± 21	0.31
Gender				−0.04
Male	15,591 (44)	13,266 (46)	28,857 (45)	
Female	19,944 (56)	15,617 (54)	35,561 (55)	
Coronary artery disease	2,203 (6)	1,301 (5)	3,504 (5)	0.07
History of stroke	256 (0.7)	63 (0.2)	319 (0.5)	0.06
Congestive heart failure	689 (2)	455 (2)	1,144 (2)	0.03
Diabetes mellitus	3,311 (9)	2,001 (7)	5,312 (8)	0.08
Hypertension	10,088 (28)	5,784 (20)	15,871 (25)	0.2
Atrial fibrillation	682 (2)	265 (0.9)	947 (1)	0.07
Obesity	3,165 (9)	952 (3)	4,117 (6)	0.2
Dementia	245 (0.7)	124 (0.4)	369 (0.6)	0.03
HIV	268 (0.8)	188 (0.7)	456 (0.7)	0.01
Cancer	6,254 (18)	7,046 (24)	13,299 (21)	−0.2
COPD	852 (2)	448 (2)	1,300 (2)	0.06
Johns Hopkins surgical grade				
1	1,951 (5)	5,058 (18)	7,009 (11)	−0.3
2	11,632 (33)	11,367 (39)	22,999 (36)	−0.14
3	14,625 (41)	10,450 (36)	25,075 (39)	0.1
4	5,017 (14)	1,040 (4)	6,056 (9)	0.3
5	2,310 (7)	968 (3)	3,278 (5)	0.1
eGFR (ml/min/1.73 m^2)				
> 60	25,299 (71)	5,811 (20)	31,109 (48)	1.1
31–60	2,718 (3)	940 (8)	3,658 (6)	0.16
15–30	206 (0.5)	136 (0.6)	342 (0.5)	0.01
< 15	142 (0.4)	79 (0.3)	221 (0.3)	−0.02
Unknown	7,170 (20)	21,917 (76)	29,087 (45)	−0.8
ASA score				
I	6,404 (18)	8,488 (29)	14,892 (23)	−0.30
II	19,929 (56)	14,499 (50)	34,428 (53)	0.11
III	7,778 (22)	4,242 (15)	12,019 (19)	0.17
IV	1,104 (3)	603 (2)	1,707 (3)	0.06
V	5 (0.01)	6 (0.02)	11 (0.01)	−0.005
Unknown	315 (1)	1,045 (4)	1,360 (2)	−0.16
Total	35,535 (55)	28,883 (45)	64,418 (100)	

All categories are represented as n (%) unless otherwise noted.

ASA score = American Society of Anesthesiologists physical status score; COPD = chronic obstructive pulmonary disease; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; PEC = preoperative evaluation clinic.

PEC and 23 deaths from 13,964 (0.16%) patients not seen in PEC. The balance of the covariates between cohorts improved after propensity score matching (fig. 2). Characteristics after matching can be seen in table 2 (see also appendix 5). A visit to PEC resulted in a reduction in mortality (odds ratio [OR], 0.48; 95% CI, 0.22 to 0.96, P = 0.04) by comparison of the matched cohorts using univariate logistic regression. By McNemar test, P value was less than 0.0001, and the calculated OR was 0.48 as well (95% CI, 0.23 to 0.98).

The following subspecialties were significantly less likely to utilize the PEC than other service lines: endocrine surgery, ophthalmology, gastroenterology, pulmonary medicine, pediatric surgery, and pediatric orthopedic surgery.

Characteristics of deceased patients in the matched cohorts are detailed in table 3. The FTR subanalysis on the deceased patients in the matched cohorts resulted in a P value of 0.141, suggesting that the proportion of deaths attributable to an unanticipated surgical complication was not significantly different between the two groups (table 4).

Discussion

An assessment in our PEC was associated with a reduction in in-hospital mortality. Although previous studies have demonstrated that anesthesiologist-led PECs decrease costs, improve OR efficiency, and increase patient satisfaction,[5,9–13,25–29] our study demonstrates an association between PEC and an important clinical outcome. The association with reduced mortality was noted in a broad surgical population that spanned low-risk surgery on healthy patients to high-risk surgery on high-risk patients.

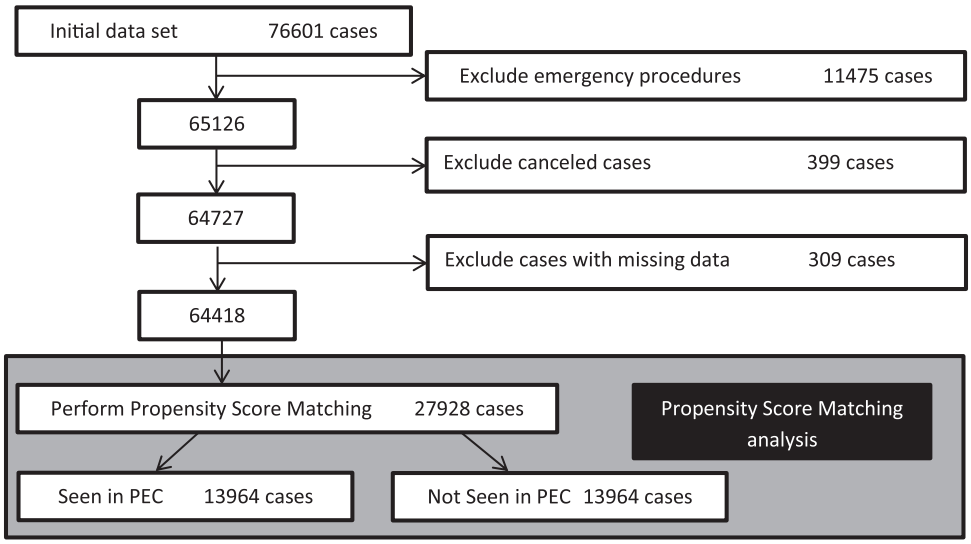

Fig. 1. Exclusion criteria and identification of cohorts for analyses. PEC = preoperative evaluation clinic.

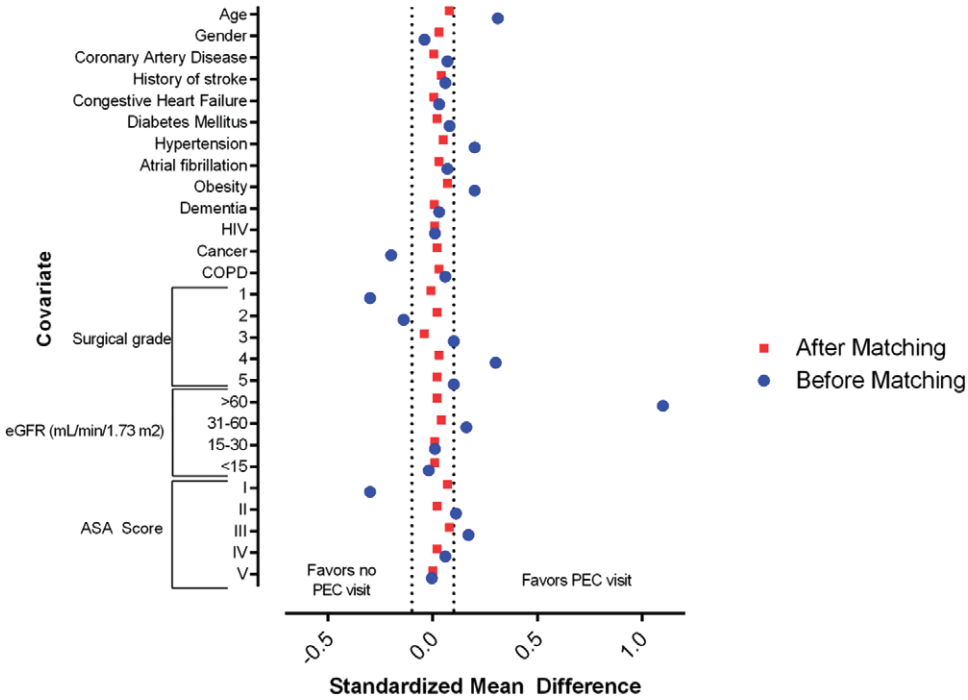

Fig. 2. Standardized mean differences before and after propensity score matching. Standardized mean difference with absolute value less than 0.1 was considered adequate reduction in match imbalance. *Dashed lines* indicate standardized mean differences of −0.1 and 0.1. ASA score = American Society of Anesthesiologists physical status score; COPD = chronic obstructive pulmonary disease; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; PEC = preoperative evaluation clinic; Surgical grade = Johns Hopkins surgical grade.

Although there are institution-specific variations, Vetter *et al.*[3] have identified *patient engagement and shared decision-making, cross-continuum team collaboration,* and *health information exchange* as the necessary elements for successful perioperative care coordination.[30] Our PEC focused on early patient engagement strategies and detailed perioperative care plans that were created with input from an interdisciplinary team and documented in the electronic health record. Patient engagement strategies used in PEC included the following: an individualized typewritten visit summary was provided for each patient; participation was encouraged in patient-modifiable risk factors such as smoking cessation and nonpharmacologic anxiety reduction; and comprehension of the presented information was evaluated using the teach-back method. Every visit summary included certain elements: standardized information about the surgery and postoperative recovery, instructions on

Table 2. Patient Demographics after Propensity Score Matching

After Matching	Seen in PEC (n = 13,964)	Not Seen in PEC (n = 13,964)	Entire Cohort (n = 27,928)	Standardized Mean Difference after Matching
Age, yr (mean ± SD)	49 ± 21	48 ± 22	49 ± 22	0.08
Gender				–0.03
Male	5,655 (40)	5,915 (42)	11,570 (41)	
Female	8,309 (60)	8,049 (58)	16,358 (59)	
Coronary artery disease	961 (7)	942 (7)	1,903 (7)	0.005
History of stroke	96 (0.7)	50 (0.4)	146 (0.5)	0.04
Congestive heart failure	356 (3)	367 (3)	723 (3)	–0.005
Diabetes mellitus	1,145 (8)	1,208 (9)	2,353 (8)	–0.02
Hypertension	3,563 (26)	3,278 (23)	6,841 (24)	0.05
Atrial fibrillation	301 (3)	237 (3)	538 (2)	0.03
Obesity	955 (7)	691 (5)	1,646 (6)	0.07
Dementia	103 (0.7)	96 (0.7)	199 (0.7)	0.006
HIV	104 (0.7)	90 (0.6)	194 (0.7)	0.01
Cancer	3,234 (23)	3,136 (22)	6,370 (23)	0.02
COPD	380 (3)	305 (2)	685 (2)	0.03
Johns Hopkins surgical grade				
1	1,214 (9)	1,692 (12)	2,906 (10)	–0.01
2	5,305 (38)	4,680 (34)	9,985 (36)	0.02
3	5,352 (38)	5,727 (41)	11,079 (40)	–0.04
4	1,274 (9)	952 (7)	2,226 (8)	0.03
5	819 (6)	913 (7)	1,732 (6)	0.02
eGFR (ml/min/1.73 m^2)				
> 60	5,624 (40)	5,794 (41)	11,418 (41)	–0.02
31–60	1,079 (8)	932 (7)	2,011 (7)	0.04
15–30	139 (1)	126 (0.9)	265 (0.9)	0.009
< 15	90 (0.6)	74 (0.5)	164 (0.6)	0.01
Unknown	7,032 (50)	7,038 (50)	14,070 (50)	0
ASA score				
I	2,826 (20)	3,206 (23)	6,032 (22)	–0.07
II	7,209 (52)	7,315 (52)	14,524 (52)	–0.02
III	3,163 (23)	2,693 (19)	5,856 (21)	0.08
IV	545 (4)	492 (4)	1,037 (4)	0.02
V	4 (0.03)	4 (0.03)	8 (0.03)	0
Unknown	217 (2)	254 (2)	471 (2)	–0.02
Total	13,964 (50)	13,964 (50)	27,928 (100)	

All categories are represented as n (%) unless otherwise noted.

ASA score = American Society of Anesthesiologists physical status score; COPD = chronic obstructive pulmonary disease; eGFR = estimated glomerular filtration rate; HIV = human immunodeficiency virus; PEC = preoperative evaluation clinic.

perioperative medication management, patient-specific preoperative fasting recommendations, and a contact name and phone number for PEC. The evaluation process and methods utilized in our PEC are consistent with those previously established at another teaching hospital.[7] Although we are unable to confirm an improvement in the level of patient preparation due to the written instructions provided in our PEC, a previous study demonstrated increased patient compliance with preoperative instructions when the patient received medication management recommendations in writing.[31] When applicable, smoking cessation strategies, the phone number for a smoker's quit line,[32] and advice on nonpharmacologic anxiety reduction methods[33,34] including positive imagery and meditation techniques were also provided. These components of a comprehensive preoperative patient preparation process are not new. PECs have previously been identified as an opportunity to encourage smoking cessation,[35] and a previous study on the benefit of an in-person assessment with an anesthesiologist before the day of surgery demonstrated a reduction in preoperative anxiety on the day of surgery.[36,37] The "teach-back" method[38–40] was utilized to assess and enhance the level of patient comprehension of preoperative instructions. This entails asking the patient to explain the instructions back to the clinician to close the communication gap and to confirm that the patient has an accurate understanding of the information.[39,40] When possible, the preoperative discussion with the patient was held with a family member present in the room to enhance retention of the information. Our preoperative efforts were facilitated by enhancements that were made to the electronic health record at our institution during this same time interval: the visit summary was accessible within the electronic health record for review by all members of the perioperative team and included a care plan summary line written by the clinician in PEC.

Table 3. Demographics of Deceased Patients in the Matched Cohorts

	Seen in PEC	Not Seen in PEC
ASA		
I	0	0
II	3 (27)	4 (17)
III	4 (36)	8 (35)
IV	4 (36)	10 (43)
V	0	1 (4.3)
Age, yr (mean ± SD)	66 ± 27	62 ± 24
Gender: Male, n (%)	7 (64)	16 (70)
Johns Hopkins surgical grade		
1	0	0
2	2 (18)	4 (17)
3	4 (36)	7 (30)
4	2 (18)	4 (17)
5	3 (27)	8 (35)
Cause of death		
Sepsis	4 (36)	7 (30)
Respiratory failure	3 (27)	7 (30)
Cardiac arrest	2 (18)	2 (8)
Intraoperative hemorrhage	1 (9)	5 (21)
Uncal herniation	1 (9)	0
Multiorgan failure	0	1 (4)
Metastatic cancer	0	1 (4)
Surgical procedure		
Cardiac surgery	2	4
Transcatheter aortic valve replacement	1	1
Mitral valve repair	1	1
Coronary artery bypass graft		1
Left ventricle–pulmonary artery conduit		1
ASD-VSD repair		
General Surgery	4	2
Gastrectomy	1	1
Exploratory laparoscopy	1	1
Insertion of mediport	1	
Laparoscopic colectomy	1	
Laparoscopic cholecystectomy		
Vascular surgery	0	3
Endovascular aortic aneurysm repair		2
Above-knee amputation		1
Thoracic surgery	0	4
Thoracoscopy		3
Thoracentesis		1
Orthopedic surgery	1	2
Total hip replacement	1	1
Total knee replacement		1
Repair of hip fracture		
Plastic surgery	2	0
Cleft lip repair	1	
Microvascular free flap	1	
Gynecologic surgery	1	0
Repair of rectovaginal fistula	1	
Neurosurgery	1	0
Aneurysm clipping	1	
Gastroenterology	0	8
ERCP		1
PEG placement		1
EGD		4
Colonoscopy		2

All categories are represented as n (%) unless otherwise noted.

ASA = American Society of Anesthesiologists physical status score; ASD-VSD = atrial septal defect-ventricular septal defect; EGD = esophagogastroduodenoscopy; ERCP = endoscopic retrograde cholangiopancreatography; PEC = preoperative evaluation clinic; PEG = percutaneous endoscopic gastrostomy.

Table 4. Number of Deaths Attributed to Failure to Rescue in Each Cohort Postpropensity Score Matching

	Seen in PEC (n = 11)	Not Seen in PEC (n = 23)
Failure to rescue (n = 17)	8 (73)	9 (39)
Non failure to rescue (n = 17)	3 (27)	14 (61)

All categories are represented as n (%). $P = 0.141$.

PEC = preoperative evaluation clinic.

Previous studies on the effect of an in-person preoperative evaluation by an internal medicine physician have failed to demonstrate a positive effect on postoperative outcomes.[41,42] A preoperative evaluation by a physician not specifically trained in perioperative medicine has been associated with an increased length of stay and increased postoperative mortality,[43] whereas a PEC run by hospitalists was associated with lower mortality rates at one institution,[44] and attendance at an anesthesiologist-run PEC at another was independently associated with a lower incidence of postoperative mortality in patients undergoing colon surgery.[45] The difference in results between the studies on preoperative assessments by internists and those of anesthesiologist or hospitalist-directed assessments in a PEC may be due to the perioperativist's ability to improve coordination of care along the entire perioperative continuum, as well as the anesthesiologist's in-depth knowledge of the proposed surgery and anesthetic.

A 2009 multicenter study on the effect of an outpatient preoperative anesthesia consultation before major noncardiac surgery failed to demonstrate a reduction in 30-day and 1-yr mortality rates.[46] Details of the components of the preoperative anesthesia consultations were not provided, and consultations were not standardized between the participating centers; therefore, it is difficult to compare the results of that multicenter study with our single-institution analysis, or the previous single-institution study of patients undergoing colon surgery.[45]

Although we do not capture the rate of postdischarge mortality in our analysis, mortality after elective surgery has previously been established to occur most commonly during the hospital admission.[47] Our reported in-hospital mortality rate of 0.07% after elective surgery during the time frame studied is consistent with the rate reported by authors from other academic medical centers.[48,49]

Despite similar postoperative complication rates between the highest and lowest performing hospitals in the United States,[3,50,51] postoperative mortality varies widely from institution to institution.[50] This disparity is attributed to FTR: lack of timely recognition of the complication and appropriate management. Because efforts to reduce FTR deaths involve interventions that are enacted in a "wait and see fashion" after the complication has occurred and been recognized,[16,18,52] PEC should have little influence over the FTR rate. By contrast, the preoperative identification of patients at a high mortality risk may reduce non-FTR deaths by selection of appropriate surgical candidates, preoperative optimization, and enhanced care coordination. The proportion of

FTR deaths/non-FTR deaths was not statistically different between the postmatch cohorts. However, given the small sample size, it is difficult to draw conclusions regarding whether our PEC may be affecting the incidence of death after major perioperative complication.

Limitations of this study include the retrospective nature of the analysis and the possible presence of confounders that were not accounted for during propensity score matching. Propensity score matching is only as efficient as the variables chosen for matching: missing important variables limits the conclusions that can be made, and using excess or irrelevant variables limits the eventual power of the conclusion by the potential reduction in sample size. As in most retrospective analyses, we cannot determine causation. Although it did not ultimately demonstrate a significant association with a visit to PEC, *post hoc* assignment of the FTR designation is an additional source of error, as this may have led to the potential for confirmation bias. Patients were referred to PEC for evaluation if they were known to have multiple or significant medical comorbidities or were scheduled for a high-risk surgery. Multiple efforts were made to schedule the patient for the recommended assessment; however, the decision about whether or not to undergo a preoperative evaluation at the clinic was ultimately the patient's decision. Therefore, there may be an undetected difference between the patients who chose to come for a scheduled preoperative evaluation and those who did not. Because we did not directly control for this factor, this difference in patient characteristics may have also contributed to the differences in outcome observed in our study despite the large number of covariates chosen for matching. We are unable to provide data to demonstrate whether or not patients who comply with recommendations to attend PEC have a higher level of medical literacy or socioeconomic status as a group compared with those who do not, because this was not a metric that we were tracking during the time frame in which this retrospective analysis was performed. Due to the low-risk nature of the majority of procedures performed by the surgical services that underutilized PEC, we do not believe that subspecialty referral patterns have introduced a significant systemic bias.

An additional confounding factor is the timing of PEC evaluation relative to surgery. Timing between the date of PEC evaluation and date of surgery was not standardized and varied from 2 months before surgery to the day before. Some patient engagement strategies, meanwhile, may be more effective at a certain time interval before surgery, such as smoking cessation or practicing preoperative meditation to reduce anxiety.

While we hypothesize that the decrease in mortality in patients seen in PEC was due to better patient engagement, interdisciplinary team communication, and care coordination, further investigation is required to determine which elements of the PEC assessment are actually responsible for the observed association. Furthermore, whether or not these results are generalizable to other institutions with potentially different patient populations will need to be determined in future studies.

An in-person assessment at our PEC was associated with a reduction in in-hospital mortality. We believe that the value of a PEC lies in its ability to improve the quality of the perioperative process through the creation of a more robust system of preoperative assessment and preparation.

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Competing Interests

Dr. Jain disclosed the following relationships: Dopf, P.C. (New York, New York), Schiavetti, Corgan, DiEdwards, Weinberg & Nicholson, LLP (New York, New York). The other authors declare no competing interests.

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Appendix 1: Screening Tool Used in Surgeons' Offices to Determine Whether or not a Patient Would Be Referred for an Evaluation in the Preoperative Evaluation Clinic

*Patients Must Go to New York University Langone Medical Center Preadmission Testing if They Meet Any of the following Criteria**

- History of coronary artery disease, cardiac stents, myocardial infarction, congestive heart failure, cardiomyopathy, pacemaker/implantable cardioverter defibrillator, valvular heart disease
- Poorly controlled hypertension (systolic blood pressure more than 160 mmHg, diastolic blood pressure more than 110 mmHg)
- History of severe chronic obstructive pulmonary disease or severe asthma
- Severe pulmonary hypertension
- +STOP BANG, history of obstructive sleep apnea, or currently use continuous positive airway pressure, bilevel positive airway pressure, or home oxygen
- Diabetic requiring insulin therapy
- Liver failure
- Renal failure or significant renal insufficiency (creatinine more than 2 mg/dl)
- History of organ transplant (kidney or liver)
- Morbid obesity with body mass index more than 50 kg/m^2
- Severe peripheral vascular disease
- History of anesthetic complications
- History of cerebrovascular accident
- History of chronic pain

*Please refer to surgical classification grid. Patients undergoing category 1 or 2 surgeries may not need to be evaluated by an anesthesiologist preoperatively while in preadmission testing.

Surgical Classification System

Category 1

1. Minimal risk to the patient independent of anesthesia
2. Minimally invasive procedure with little or no blood loss
3. Often done in an office setting with the operating room used principally for anesthesia and monitoring

Includes	Excludes
Breast biopsy	Open exposure of internal body organs
Excision of minor skin or subcutaneous lesions	Repair of vascular or neurologic structures
Myringotomy tubes	Placement of prosthetic devices
Hysteroscopy	Entry into the abdomen, thorax, neck, cranium, or extremities
Cystoscopy	Postoperative monitored care setting (intensive care unit, step-down unit)
Vasectomy	Resection of major body organs
Cataract extraction with lens insertion	
Circumcision	
Fiberoptic bronchoscopy	

Category 2

1. Minimal to moderately invasive procedure
2. Blood loss less than 500 ml
3. Mild risk to patient independent of anesthesia

Includes	Excludes
Diagnostic laparoscopy	Open exposure of internal body organs
Dilation and curettage	Repair of vascular or neurologic structures
Fallopian tube ligation	Placement of prosthetic devices
Arthroscopy	Postoperative monitored care setting (intensive care unit, step-down unit)
Inguinal hernia repair	Open exposure of the abdomen, thorax, neck, cranium
Laparoscopic lysis of adhesions	Resection of major body organs
Tonsillectomy/adenoidectomy	
Umbilical hernia repair	
Vitrectomy, scleral buckle procedure	
Septoplasty/rhinoplasty	
Laparoscopic cholecystectomy	
Extensive superficial procedures	

Category 3

1. Moderately to significantly invasive procedures
2. Blood loss potential 500 to 1,500 ml
3. Moderate risk to patient independent of anesthesia

Includes	Excludes
Thyroidectomy	Open thoracic or intracranial procedure
Hysterectomy	Major procedure on the oropharynx
Myomectomy	Major vascular, skeletal, neurologic repair
Cystectomy	
Laminectomy	
Open cholecystectomy	
Hip/knee replacement	
Nephrectomy	
Major laparoscopic surgeries	
Resection, reconstructive surgery of the digestive tract	

Category 4

1. Highly invasive procedure
2. Blood loss greater than 1,500 ml
3. Major risk to the patient independent of anesthesia

Includes
Major orthopedic or spinal reconstruction
Major reconstruction of the gastrointestinal tract
Major genitourinary surgery (radical retropubic prostatectomy)
Major vascular surgery without postoperative intensive care unit stay

Category 5

1. Highly invasive procedure
2. Blood loss greater than 1,500 ml
3. Critical risk to the patient independent of anesthesia
4. Usual postoperative intensive care unit stay with invasive monitoring

Includes
Cardiothoracic procedure
Intracranial procedure

Appendix 2.

Patient Name:_____

Medical Record Number:_____

NYU Hospitals Center

Pre-Admission Testing Patient Screening Form

Patient Name:			**Date of Birth:**		
Primary Care Provider Dr.: **Phone:**			**Cardiologist/Specialist Dr.:** **Phone:**		
Surgical Procedure*: **Date of Surgery:**			**Surgeon:** **Phone**		
BP: **HR:** Wheelchair bound? Bedridden?			Height: Weight:		
YES	**NO**		**YES**	**NO**	
☐	☐	Being treated for high blood pressure? *If yes, how many years?*	☐	☐	Had a cardiac valve replacement or repair?
☐	☐	Has chest pain with walking/normal activity? With exercise?	☐	☐	Has a pacemaker or defibrillator?
☐	☐	Had a coronary bypass or angioplasty?	☐	☐	Has an aortic aneurysm?
☐	☐	Had a heart attack? *If yes, how many?: When?:*	☐	☐	Has peripheral vascular disease?
☐	☐	Has a cardiac stent(s)? *If yes, how many?: When?:*	☐	☐	Ever had a stress test? *If yes, where?: When?: Why?:*
☐	☐	Has congestive heart failure (CHF))?	☐	☐	Ever had an echocardiogram? *If yes, where?: When?: Why?:*
☐	☐	Has an arrythmia?	☐	☐	Ever had a cardiac catheterization? *If yes, where?: When?: Why?*
☐	☐	Has a heart murmur or valve disease?			
☐	☐	Takes daily medication for asthma?	☐	☐	Has difficulty breathing?
☐	☐	Has a history of COPD?	☐	☐	Uses supplemental oxygen?
☐	☐	Current smoker? *If yes, how many packs / day?:* *How may years have you been a smoker?:*	☐	☐	Has a history of sleep apnea? CPAP-Continuous Positive Airway Pressure?
☐	☐	Had a recent cold, fever or flu symptoms?	☐	☐	Ever been witnessed to stop breathing while asleep?
☐	☐	Has diabetes? *If yes, for how many years?: Complications?:*	☐	☐	Takes insulin?
☐	☐	Has kidney disease (other than kidney stones)?	☐	☐	Had a history of Hepatitis A / B / C / D? (circle)
☐	☐	Has liver disease?			
☐	☐	Drinks alcohol every day? *If yes, how many drinks/day?:*	☐	☐	Uses recreational drugs? *If yes, specify:*

Please Turn Over To Continue

Appendix 2. (*Continued*)

Patient Name:_____

Medical Record Number:_____

NYU Hospitals Center

Pre-Admission Testing Patient Screening Form

YES	NO		YES	NO	
☐	☐	Has a history of anemia?	☐	☐	Has a history of sickle cell disease or trait?
☐	☐	Takes any blood thinners?	☐	☐	Has a history of cancer?
☐	☐	Takes Aspirin or Ibuprofen regularly?	☐	☐	Is currently on chemotherapy?
☐	☐	Has a seizure disorder or takes anti-seizure medications?	☐	☐	Has neuromuscular disease (Parkinson's, ALS etc)?
☐	☐	Ever had a stroke(CVA) or TIA? *If yes, when?:*	☐	☐	Has a brain tumor, brain aneurysm or other vascular lesion of the brain?
☐	☐	Has a history of difficult intubation?	☐	☐	Has a history of severe reaction to anesthesia?
☐	☐	Has a history of malignant hyperthermia?	☐	☐	Suffers from chronic pain?
☐	☐	Has a history of severe nausea and vomiting after anesthesia?	☐	☐	Is possibility pregnant? *LMP:*
☐	☐	Has an autoimmune disease (e.g. Rheumatoid Arthritis, Sarcoidosis or Lupus)?	☐	☐	Other medical comorbidities not otherwise mentioned? *If yes, specify:*

EKG results good for 6 months. Chemistry lab results good for 30 days

Current medication list:

Medication: _____ Dose: _____

Medication: _____ Dose: _____

Medication: _____ Dose: _____

Medication: _____ Dose: _____

Medication: _____ Dose: _____

Medication: _____ Dose: _____

Medication: _____ Dose: _____

Appendix 3: Decision Grid Utilized in the Preoperative Evaluation Clinic to Assign Patients to PEC Providers

No. of Dark Boxes Checked YES on Form	Surgical Class				
	1	2	3	4	5
0	Fast track*	Fast track*	Fast track*	PAT visit	PAT visit
1	Fast track*	Fast track*	Medical evaluation†	PAT visit	PAT visit
2	Medical evaluation†	PAT visit + anesthesia NP and medical evaluations†	PAT visit + anesthesia NP and medical evaluations†	PAT visit + anesthesiologist evaluation	PAT visit + anesthesiologist evaluation
≥ 3	Medical evaluation†	PAT visit + anesthesia NP and medical evaluations†	PAT visit + anesthesia NP and medical evaluations†	PAT visit + anesthesiologist evaluation	PAT visit + anesthesiologist evaluation

This grid was modified from the version used at the Cleveland Clinic, Cleveland, Ohio. Surgical classification system is outlined in appendix 1. Patient screening form is provided in appendix 2.

*Fast-track refers to patients who will receive a phone call before the day of surgery to review their medical history and provide education. †Medical evaluation refers to any preoperative medical or specialty consultation as indicated by New York University Langone Medical Center preoperative testing policy. This consult note should be available for review ≥72 h before scheduled surgery or the in-person preadmission testing clinic (PAT; preoperative evaluation clinic) visit whenever possible.

NP = nurse practitioner; PEC = preoperative evaluation clinic.

Appendix 4: Propensity Model and Coding Used for the Analysis

```
#assign "seen at pat" as the treatment variable
Tr<-mortality$seenatpat
#determine propensity scores by logistic regression
glm.PATseen<-glm(seenatpat~ Age + GENDER + had_CHF + had_cancer + CKD_Stage + ASA_RATING + Pasternak_Score,family=binomial,data=mortality)
> summary(glm.PATseen)
Call:
glm(formula = seenatpat~ Age + GENDER + had_CHF + had_cancer +
    CKD_Stage + ASA_RATING + Pasternak_Score, family = binomial,
    data = mortality)
Deviance Residuals:
    Min 1Q Median 3Q Max
-2.3761 -0.7841 0.4441 0.6524 2.7957
```

Coefficients

	Estimate	SE	z Value	Pr(>|z|)
(Intercept)	−2.8271663	0.0865762	−32.655	< 2e-16 ***
Age	−0.0037296	0.0005491	−6.792	1.1e-11 ***
GENDERMale	−0.2267150	0.0200254	−11.321	< 2e-16 ***
had_CHFTRUE	−0.6720033	0.0790311	−8.503	< 2e-16 ***
had_cancerTRUE	−0.5541710	0.0253422	−21.867	< 2e-16 ***
CKD Stage 2	2.5461838	0.0216003	117.877	< 2e-16 ***
CKD Stage 3	2.2734332	0.0453699	50.109	< 2e-16 ***
CKD Stage 4	1.7080766	0.1194818	14.296	< 2e-16 ***
CKD Stage 5	2.0146477	0.1514618	13.301	< 2e-16 ***
ASA_RATINGI	1.0536310	0.0791061	13.319	< 2e-16 ***
ASA_RATINGII	1.2244513	0.0771413	15.873	< 2e-16 ***
ASA_RATINGIII	1.2921674	0.0795674	16.240	< 2e-16 ***
ASA_RATINGIV	0.8923236	0.1026397	8.694	< 2e-16 ***
ASA_RATINGV	−0.3403222	0.6620365	−0.514	0.607
Pasternak_Score2	0.9527839	0.0358602	26.569	< 2e-16 ***
Pasternak_Score3	1.0013711	0.0350237	28.591	< 2e-16 ***
Pasternak_Score4	1.8326468	0.0501050	36.576	< 2e-16 ***
Pasternak_Score5	1.4622910	0.0583625	25.055	< 2e-16 ***

```
Significance codes: 0 "***" 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for binomial family taken to be 1)
Null deviance: 88,614 on 64,417 degrees of freedom
Residual deviance: 64,383 on 64,400 degrees of freedom
AIC: 64419
Number of Fisher scoring iterations: 4
#perform matching
X<-glm.PATseen$fitted
rr.PATseen<-Match(Tr=Tr,X=glm.PATseen$fitted,caliper=0.
2,Weight=1,replace=FALSE)
#assess post match covariate balance
MatchBalance(seenatpat~Age+GENDER+had_AFIB+had_
CAD+had_CHF+had_CVA+had_DM+had_HTN+had_
cancer+had_HIV+had_dementia+had_COPD+had_
OBESITY+CKD_Stage+ASA_RATING+Pasternak_
Score,match.out=rr.PATseen,nboots=500,data=mortality)
```

PAT = preadmission testing clinic; PEC = preoperative evaluation clinic.

Appendix 5: Characteristics of the Patients Included in the Matched Cohort Used for Analysis and Those Who Remained Unmatched

	Matched (Included in PS Analysis)	Unmatched
Age, yr (mean ± SD)	49 ± 22	48 ± 20
Gender, n (%)		
Male	11,570 (41)	17,417 (48)
Female	16,358 (59)	19,023 (52)
Comorbidities, n (%)		
Coronary artery disease	1,903 (6.8)	1,650 (4.5)
History of stroke	146 (0.5)	176 (0.5)
Congestive heart failure	723 (3)	420 (1.1)
Diabetes mellitus	2,353 (8.4)	2,926 (8.0)
Hypertension	6,841 (24)	9,050 (25)
Atrial fibrillation	538 (1.9)	412 (1.1)
Obesity	1,646 (5.9)	2,477 (6.8)
Dementia	199 (0.7)	159 (0.4)
Human immunodeficiency virus	194 (0.7)	256 (0.7)
Cancer	6,370 (23)	6,712 (18)
COPD	685 (2.5)	619 (1.7)
Johns Hopkins surgical grade, n (%)		
1	2,906 (10)	4,054 (11)
2	9,985 (36)	13,029 (36)
3	11,079 (40)	13,993 (38)
4	2,226 (8.0)	3,919 (11)
5	1,732 (6)	1,445 (4)
eGFR (ml/min/1.73 m^2), n (%)		
> 60	11,418 (41)	19,720 (54)
31–60	2,011 (7.2)	1,635 (4.5)
15–30	265 (0.9)	75 (0.2)
< 15	164 (0.6)	57 (0.2)
Unknown	14,070 (50.4)	14,953 (41)
ASA score, n (%)		
I	6,032 (21.6)	8,877 (24.36)
II	14,524 (52)	19,830 (54.4)
III	5,856 (21)	6,155 (16.9)
IV	1,037 (3.7)	669 (1.8)
V	8 (0.03)	3 (0.008)
Unknown	471 (1.68)	906 (2.5)
Total, n (%)	27,928 (100)	36,440 (100)

ASA = American Society of Anesthesiologists physical status score; COPD = chronic obstructive pulmonary disease; eGFR = estimated glomerular filtration rate; PS = physical status.