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Can the Risk Analysis Index for Frailty Predict Morbidity and Mortality in Patients Undergoing High-risk Surgery?

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Abstract

Objective: To determine the effectiveness of the revised Risk Analysis Index (RAI-rev), administrative Risk Analysis Index (RAI-A), cancer-corrected Risk Analysis Index [RAI-rev (cancer-corrected)], and 5-variable modified Frailty Index for predicting 30-day morbidity and mortality in patients undergoing high-risk surgery.

Background: There are several frailty composite measures, but none have been evaluated for predicting morbidity and mortality in patients undergoing high-risk surgery.

Methods: Using the National Surgical Quality Improvement Program database, we performed a retrospective study of patients who underwentcolectomy/proctectomy, coronary artery bypass graft (CABG), pancreaticoduodenectomy, lung resection, or esophagectomy from 2006 to 2017. RAI-rev, RAI-A, RAI-rev (cancer corrected), and 5-variable modified Frailty Index scores were calculated. Pearson's chi-square tests and C-statistics were used to assess the predictive accuracy of each score's logistic regression model.

Results: In the cohort of 283,545 patients, there were 178,311 (63%) colectomy/proctectomy, 38,167 (14%) pancreaticoduodenectomy, 40,328 (14%) lung resection, 16,127 (6%) CABG, and 10,602 (3%) esophagectomy cases. The RAI-rev was a fair predictor of mortality in the total cohort (C-statistic, 0.71, 95% CI 0.70–0.71, $P < 0.001$) and for patients who underwent colectomy/proctectomy (C-statistic 0.73, 95% CI 0.72–0.74, $P < 0.001$) and CABG (C-statistic 0.70, 95% CI 0.68–0.73, $P < 0.001$), but a poor predictor of mortality in all other operation cohorts. The

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RAI-A was a fair predictor of mortality for colectomy/proctectomy patients (C-statistic 0.74, 95% CI 0.73–0.74, $P < 0.001$). All indices were poor predictors of morbidity. The RAI-rev (cancer corrected) did not improve the accuracy of morbidity and mortality prediction.

Conclusion: The presently studied frailty indices are ineffective predictors of 30-day morbidity and mortality for patients undergoing high-risk operations.

Keywords

frailty; frailty assessment; morbidity; mortality; risk analysis index; surgery

Caring for complex patient populations requires effective ways to evaluate a patient's physical candidacy for surgery. Research has repeatedly shown the association of frailty and adverse outcomes after surgery, including discharge to a location other than home,[1] readmission,[2] and serious complications or mortality.[3,4] The syndrome of frailty is characterized by reduced physiologic reserve and increased vulnerability to stressors leading to early decline and increased risk of mortality.[5,6] Best practice guidelines from the American College of Surgeons (ACS) and American Geriatrics Society (AGS) include assessing and documenting frailty as a component of the preoperative evaluation of elderly patients.[7] Effective preoperative frailty screening has the potential to enhance surgical decision making, but a consensus on the ideal screening tool has not been established.

Numerous tools for identifying frailty in surgical patients have been proposed, many based on an accumulation of deficits approach to the frailty index.[8] Previous research has validated the 11-factor modified Frailty Index (mFI-11) as a robust predictor of postoperative morbidity and mortality in cohorts of surgical patients across a range of subspecialties.[9–11] The mFI-11 was developed by mapping items in the Canadian Study of Health and Aging Frailty Index to 11 corresponding preoperative variables recorded in the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) dataset.[12] However, the 2012 update to NSQIP removed 6 of 11 factors in the mFI-11, threatening the validity of using that index within NSQIP cohorts. A revised 5-factor modified Frailty Index (mFI-5) has been preliminarily validated in a national surgical cohort, but has not garnered widespread use.[13] Hall et al[14] proposed the Risk Analysis Index as a frailty tool that could be assessed both prospectively, as the clinical Risk Analysis Index, and retrospectively, as the administrative Risk Analysis Index (RAI-A). These indices were developed and validated utilizing a Veterans Affairs Surgical Quality Improvement Program (VASQIP) cohort of elective surgery patients.[14] Hall et al's initial validation found that the clinical Risk Analysis Index and RAI-A predicted postoperative morbidity and mortality with similar predictive ability to the mFI-11 in the VASQIP cohort. The same group subsequently developed a revised Risk Analysis Index (RAI-rev) by recalibrating the RAI-A to improve its predictive performance for postoperative mortality and simultaneously demonstrated the RAI-rev's external validity within a NSQIP cohort of elective, noncardiac surgery patients.[15]

The optimal frailty prediction tool for patients undergoing complex operations associated with a high risk of morbidity and mortality has yet to be determined. Mosquera et al[16] have previously shown a linear correlation between mFI-11 score and mortality risk in NSQIP data for patients who underwent high-risk operations such as colectomy, pancreatectomy,

and cardiac operations. An accurate frailty prediction tool is needed for patients undergoing high-risk operations.

We determined the accuracy of the RAI-rev, RAI-A, and mFI-5 frailty indices for predicting postoperative morbidity and mortality in patients undergoing 5 high-risk operations: colectomy/proctectomy, coronary artery bypass graft (CABG), pancreaticoduodenectomy, lung resection, and esophagectomy. We hypothesized that the RAI-rev and RAI-A would be stronger predictors of postoperative morbidity and mortality than the mFI-5. We further hypothesized that correcting the 3-factor cancer variable of the RAI-rev to International Classification of Diseases 9th Revision (ICD-9) diagnosis codes for select primary cancer diagnoses would improve the RAI-rev's effectiveness for predicting adverse postoperative outcomes after these high-risk operations, many of which are commonly performed for malignancy.

METHODS

Patient Selection

We conducted a retrospective cohort study of patients who underwent 5 high-risk operations using the American College of Surgeons NSQIP Participant Use Data Files from 2006 through 2017. NSQIP collects data from participating institutions nationwide on perioperative variables and 30-day postoperative morbidity and mortality. We used Current Procedural Terminology codes (Supplemental Table 1, http://links.lww.com/SLA/C765) to select patients who underwent 5 select cancer and cardiovascular operations that have been associated with increased morbidity and mortality risk and have been evaluated for regionalization and volume-based referral by the Leapfrog Group[17,18]: colectomy/proctectomy, CABG, pancreaticoduodenectomy, lung resection, and esophagectomy.

Patients younger than 18 years of age or those with insufficient data to calculate the RAI-rev, RAI-A, and mFI-5 frailty indices or determine 30-day morbidity and mortality were excluded. This study was exempt from review by the University of California, Davis Institutional Review Board.

Calculation of Frailty Scores

The RAI-A, RAI-rev, and mFI-5 scores were calculated for each patient. As per Hall et al,[14] the RAI-A score ranged from 0 to 81 and was calculated as a composite score based on age, sex, cancer status, unintentional weight loss, renal failure, chronic/congestive heart failure, poor appetite, dyspnea at rest, residence in noninde-pendent setting, activities of daily living, and cognitive status. The RAI-rev score was calculated according to Arya et al's recalibrated scoring system of the RAI-A and also ranged from 0 to 81.[15] As described by Subramaniam et al,[13] the mFI-5 was calculated as a value between 0 and 1 based on the following factors: diabetes, history of chronic obstructive pulmonary disease, history of congestive heart failure, hypertension requiring medication, and functional status of partially or totally dependent.

In the RAI-A, the cancer diagnosis variable is constructed as an interaction term combined with age that holds significant weight in the calculation of the RAI-A score. In the RAI-rev,

cancer remains an interaction term with age and holds even further weight in the composite score calculation. The RAI-A and RAI-rev use 3 VASQIP variables to identify a patient with cancer: presence of disseminated cancer, chemotherapy for malignancy within 30 days before surgery, and radiotherapy for malignancy within 90 days before surgery.[14] As we hypothesized that this methodology would significantly under-represent the true prevalence of cancer within our cohort, we corrected the cancer indicator variable utilizing ICD-9 diagnosis codes for a primary diagnosis of colorectal, pancreatic, biliary, small bowel, lung, or esophageal cancer. We then implemented this corrected cancer variable to calculate an updated RAI-rev score, labeled as RAI-rev (cancer corrected), for each patient, replacing the RAI-rev's variables for cancer status with the presence of any of the aforementioned ICD-9 codes. Of note, analysis of the RAI-rev (cancer corrected) index's predictive ability for the CABG subgroup was not performed as the primary cancer diagnoses selected were not an indication for this procedure.

Statistical Analysis

The primary outcome was 30-day postoperative mortality. The secondary outcome was 30-day postoperative morbidity. Morbidity was defined as any postoperative complication captured by NSQIP excluding urinary tract infections and superficial surgical site infections, as defined by Hall et al.[14]

Demographic and clinical variable proportions, median age, and morbidity and mortality rates were calculated to characterize the cohort. Frailty score distributions were stratified by operation. Due to the right-skewed distribution of the RAI-rev, RAI-A, and RAI-rev (cancer corrected), and mFI-5 scores, central tendencies were described with medians (interquartile range). Chi-square contingency table and Kruskal–Wallis testing were used to compare proportions and median values between operation subgroups, respectively. Receiver operating characteristic (ROC) area under the curve calculations to determine C-statistics were used to analyze each score's ability to predict mortality and morbidity. A P value < 0.05 was statistically significant. SPSS Statistics Version 25 (IBM Corp, Armonk, NY) was used for analyses.

RESULTS

The cohort included 283,545 patients who were predominantly White (70.6%) and male (51.7%) with a median age of 64 (54–73) years (Table 1). Colectomy/proctectomy was the most common operation (62.9%), followed by lung resection (14.2%) and pancreaticoduodenectomy (13.5%). Esophagectomy patients were most likely to experience loss of appetite and weight loss. CABG patients were most likely to live nonindependently. The 30-day mortality rate for the entire cohort was 2.6% and was highest among esophagectomy patients (3.7%) and lowest among lung resection patients (1.7%). The 30-day morbidity ranged from 53.5% in CABG patients to 12.5% in lung resection patients. Correcting the cancer diagnosis variable in the RAI-rev utilizing ICD-9 diagnosis codes increased the prevalence of cancer across the operation subgroups and from 9.6% to 48.2% for the entire cohort.

The distribution of mFI-5 scores varied by subgroup (type of operation) with significant variance in median scores ($P < 0.001$). Lung resection patients showed the greatest variation in scores (Fig. 1A). The distribution of RAI-A scores by subgroup was right-skewed with significant differences in median scores ($P < 0.001$) (Fig. 1B). In the recalibrated scoring of the RAI-rev, median scores were greater than seen in the RAI-A for each subgroup ($P < 0.001$), but the distribution of scores remained similarly right-skewed (Fig. 1C). Scores from the RAI-rev (cancer-corrected) were significantly higher than the RAI-rev only in the pancreaticoduodenectomy (34.0 vs 24.0, $P < 0.001$), lung resection (34.0 vs 22.0, $P < 0.001$), and esophagectomy subgroups (36.0 vs 23.0, $P < 0.001$) (Fig. 1D).

In the ROC analysis, C-statistics for predicting 30-day mortality in the entire cohort were similar across the 4 indices (Fig. 2). RAI-rev (C-statistic 0.73, 95% CI: 0.72–0.74, $P < 0.001$) and RAI-A (C-statistic 0.74, 95% CI: 0.73–0.74, $P < 0.001$) predicted mortality best for patients undergoing colectomy/proctectomy. No differences were found between these 2 indices' performances in the other operation subgroups. In all operation subgroups, the RAI-rev (cancer corrected) did not improve performance relative to the RAI-rev.

In the analysis for the prediction of 30-day morbidity, C-statistics indicated poor performance for all 4 indices in all operation subgroups and the total cohort (Fig. 3). The RAI-A for colectomy/ proctectomy patients had the highest C-statistic at 0.60 (95% CI: 0.59–0.60, $P < 0.001$). The RAI-rev was not an improved predictor of morbidity compared with the RAI-A. The RAI-rev (cancer corrected) performed as poorly as the RAI-rev.

DISCUSSION

Our data show that the RAI-rev, RAI-A, and mFI-5 are poor predictors of morbidity and mortality in a national cohort of patients who underwent elective high-risk operations. The RAI-rev was a fair predictor of mortality for colectomy/proctectomy and CABG patients but performed poorly for all other operations, and all indices performed poorly for predicting morbidity. Correcting the variables used for cancer diagnosis in the RAI-rev to primary diagnosis by ICD-9 codes did not improve the RAI-rev's predictive ability.

The objective evaluation of patient frailty preoperatively has been investigated for a wide range of procedures across surgical specialties as consideration of the trade-off between risk and benefit to the patient is particularly important in patients with reduced reserve to recover from a physiologic insult such as an operation. The ability to accurately assess frailty and use it to predict outcomes after surgery may have a substantial impact on surgical decision making with elderly patients prior to high-risk procedures, possibly to a greater extent than prior to operations associated with lower rates of major morbidity and mortality.[19] As such, in our study we investigated the utility of 3 proposed frailty indices for the purpose of postoperative adverse event prediction before high-risk operations.

Our results suggest that the RAI-rev, RAI-A, and mFI-5 indices are not equipped for discriminatory prediction of morbidity and mortality outcomes for patients undergoing high-riskoperations. There may be component factors of frailty that these indices do not effectively capture, limiting their performance. The performance of the RAI-rev and RAI-A

may be inferior for our cohort by the limitations inherent in the variables available within the VASQIP database. In both the RAI-rev and RAI-A, cognitive decline is constructed as an interaction term combined with activities of daily living. The indices use 3 VASQIP/NSQIP variables to approximate cognitive deterioration over the previous 90 days before surgery: impaired sensorium, coma, and stroke with neurological deficits.[14,15] Although Hall et al may have been limited in their selection of these variables by those available within the VASQIP/NSQIP datasets, these variables more often represent acute disease processes uncommon among patients undergoing elective high-risk surgery. Additionally, a “stroke with neurological deficits” is a nonspecific term that could represent post-stroke motor dysfunction with no actual effect on cognitive function. As such, the RAI-rev and RAI-A do not capture milder forms of cognitive impairment such as chronic cognitive decline or dementia that may have significant impact on a patient’s postoperative recovery.

The cancer diagnosis risk factor in the RAI-rev and RAI-A is also constructed as an interaction term, in this case combined with age. Three VASQIP/NSQIP variables were selected to capture the presence of advanced cancer: disseminated cancer, chemotherapy for malignancy within 30 days before surgery, and radiotherapy for malignancy within 90 days before surgery. Capturing advanced stage metastatic cancer in a surgical frailty index is ideologically flawed, as surgical resections are seldom performed for advanced stage cancer patients. For our cohort in particular, surgical resections are not done for advanced metastatic esophageal, lung, pancreatic, biliary, small bowel, and colorectal cancers. This limitation may be demonstrated in our study by the increase in cancer prevalence that was seen across the cohort after correcting the above 3 advanced cancer variables to ICD-9 codes for primary diagnosis, which suggests a high prevalence of cancer within the cohort that is not being identified and adjusted for accurately by the RAI-rev and RAI-A methodologies. That correcting these variables to ICD-9 diagnosis codes did not improve the predictive ability of the RAI-rev for our cohort may indicate a flawed initial calibration of the RAI-rev and RAI-A wherein cancer was defined as advanced malignancy only. The importance of malignancy in the frailty phenotype has been well demonstrated. Malnutrition from cancer-associated cachexia represents a significant risk factor for postoperative complications.[20] Additionally, toxicities associated with neoadjuvant or adjuvant therapies for cancer can affect postoperative complications after cancer resec-tion.[21]

The mFI-5 may be limited for our cohort by the low number of factors included in this index, which may hinder its discrimination. Since its proposal, the mFI-5 has not been extensively studied. Recent work has shown that mFI-5 is independently associated with morbidity and mortality in orthopedic procedures, but these studies did not evaluate the ability of the mFI-5 to discriminate between patients that would or would not have adverse outcomes.[22–24] Our results show that mFI-5 discrimination for adverse outcomes is poor for our cohort.

The poor performance of the indices in our study suggests that frailty may best be used as a component of a preoperative assessment. Although frailty is itself a composite risk factor, using frailty as a predictor of postoperative outcomes may be more effective when considered as one of several factors of a predictive model rather than a sole predictor. In the first study to examine the association between preoperative frailty and surgical

outcomes, Makary et al[3] showed that predictive models with frailty added to established preoperative risk assessment tools, namely the American Society of Anesthesiologists score, Lee's revised cardiac risk index, and Eagle score, performed better than models with those tools alone for predicting postoperative complications and discharge location. They did not assess the predictive ability of frailty alone compared with American Society of Anesthesiologists, Lee, and Eagle scores, but their results underline the potential value of frailty as a constituent element of a high-performing risk assessment model.

Perhaps more importantly, the results of our study suggest that frailty is poorly measured by tools constructed from retrospective or administrative data. The RAI and mFI-5 were developed from administrative datasets and validated retrospectively within these datasets. Although administrative datasets may be convenient sources of data for developing predictive models due to their accessibility and large volume of data, the effectiveness of models developed from these data is limited by the available variables that may not accurately capture a complex syndrome such as frailty. The clinical features such as grip strength and gait speed that are components of the Fried 5-factor phenotypic definition of frailty adopted by the ACS and AGS do not have equivalent variables in the NSQIP or VASQIP datasets. Variables that capture cognitive decline are present and included in the RAI-rev and RAI-A, but, as described above, the blunt measures of acute disease processes may not be appropriate in representing the frailty associated with the deterioration of more chronic problems such as stroke and dementia. Other components of the RAI-rev and RAI-A along with the 5 factors that comprise the mFI-5, all taken from the VASQIP/NSQIP datasets, represent comor-bidities that do not occur in all patients deemed frail, and commonly occur in otherwise non-frail patients. As such, models that rely on administrative datasets may measure comorbidity but miss frailty, which may accompany comorbidity but is a distinct clinical syn-drome.[25]

Our results are inconsistent with the initial validations of the indices, which found stronger predictive performance for all 3. The RAI-A was validated in a cohort of all elective surgery patients in a single VA medical center.[14] The RAI-rev was validated in a VASQIP cohort of all elective, noncardiac surgery patients.[15] The mFI-5 was validated in a cohort of all surgery patients found in the NSQIP dataset from a single year.[13] These cohorts consisted of patients who underwent operations of varying complexity, including operations associated with lower morbidity and mortality than patients in this study. The stronger performance in the validation studies may have been influenced by the proportion of patients who underwent lower risk operations within the study cohorts. We hypothesize that preoperative frailty may have a greater effect on postoperative outcome in patients undergoing high-risk operations than low-risk operations. Thus, the initial calibration of the RAI-A and RAI-rev to cohorts of a wide range of procedures may have rendered them less effective predictors of outcome when studied in a cohort of exclusively high-risk procedures.

Recent studies have used the RAI-A and RAI-rev to demonstrate a positive association between severity of frailty and rate of postoperative mortality in both low- and high-risk procedures.[26,27] These studies indicate that the presence of frailty increases the risk of adverse outcome after any operation regardless of physiologic stress. In a NSQIP cohort of patients who underwent inpatient general, vascular, thoracic, cardiac and orthopedic

surgery, Shah et al[26] found a dose–response relationship between RAI-A score and failure to rescue after both low-risk (30-day mortality rate ≤1%) and high-risk (30-day mortality rate >1%) operations. Although the distribution of RAI-A scores in our cohort is similar to the high-risk operation cohort in the Shah et al study, a significant proportion of the patients in that study (18%) underwent emergency surgery. Given emergency circumstances, surgeons may be more likely to operate on a patient than if the operation were elective, especially if surgery is the only possible treatment option. Our cohort of patients undergoing elective surgery differs in that many had cancer. Cancer patients are assessed by surgeons to determine surgical candidacy and if the patient is deemed too frail for surgery, there are other treatment options such as chemotherapy and radiotherapy. Therefore, these frailty indices may not have performed as well for our cohort because patients who were too frail for surgery were already excluded as they did not have an operation. Similarly, regardless of diagnosis, all patients in our cohort underwent elective operations and therefore may not include patients who were deemed too frail for high-risk surgery.

The VASQIP cohorts in the validation studies of the RAI-A and RAI-rev were more homogeneous with respect to age, sex, and race than our NSQIP cohort, and this variation may account for some differences in the indices' performance between our study and the validation studies. The RAI-rev was developed by recalibrating the RAI-A to a sample of VASQIP elective surgery patients, then was internally validated in the VASQIP cohort, before undergoing external validation in a NSQIP cohort of elective, noncardiac surgery patients. As such, it was likely to perform well on internal validation in a cohort very similar to the recalibration cohort. The NSQIP cohort that the RAI-rev was externally validated within is dissimilar to our cohort, patients who underwent high-risk cardiac and oncologic operations. Of note, the recalibration resulted in increasing the weight of the cancer diagnosis factor in the composite score in the RAI-rev compared with RAI-A.[15] As discussed above, the initial conception of the cancer diagnosis factor within the RAI-A may have been flawed. Therefore, increasing its weight in the RAI-rev is a likely reason for the latter's further limited performance in our cohort of patients with a high prevalence of malignancy.

Our study is limited by the scope of the NSQIP dataset. As NSQIP does not record postoperative data beyond 30 days, we are unable to compare the indices' ability to predict long-term outcomes. Additionally, NSQIP does not include detailed oncological data that may allow more specific characterization of cancer diagnoses beyond ICD-9 codes in the RAI-rev (cancer corrected). The retrospective nature of this study precludes an accurate assessment of frailty and the risk associated with it.

In conclusion, our study showed that 3 proposed surgical frailty indices are not suitable for assessing preoperative risk of morbidity and mortality for a national cohort of patients who underwent high-risk operations. Because incorporating frailty assessments into preoperative evaluations can augment shared decision-making discussions with elderly patients considering high-risk operations, an effective tool to quickly assess frailty developed from retrospective data would be helpful to better risk stratify patients. As our study highlights, administrative datasets may not contain the specific variables to accurately capture frailty. The ACS and AGS recommend using the Fried 5-factor phenotypic model

to assess for preoperative frailty in elderly patients.[7] Given this recommendation, routine collection of these variables and their documentation in NSQIP could yield valuable data both for future research and for immediate use in decision-making discussions with patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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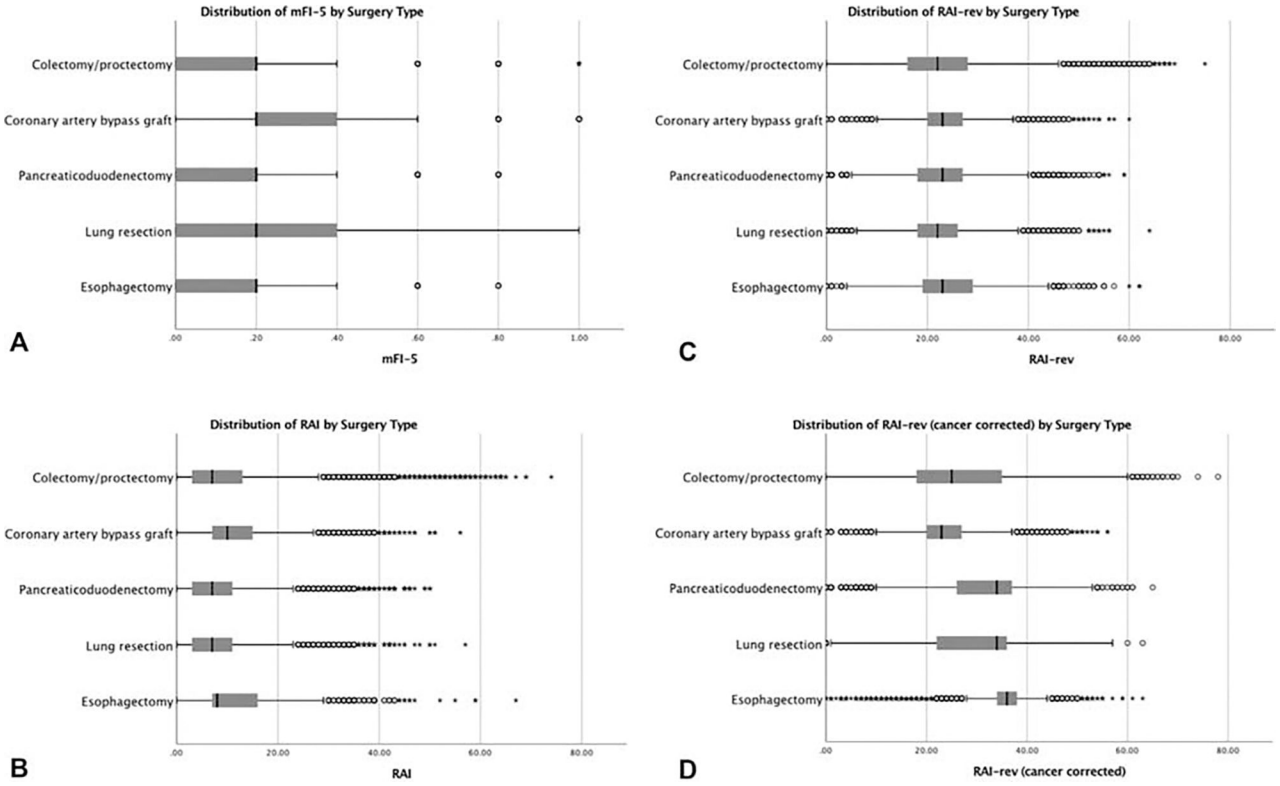

FIGURE 1.

A–D, Distribution of mFI-5 (A), RAI-A (B), RAI-rev (C), and RAI-rev (cancer corrected) (D) stratified by surgery type.

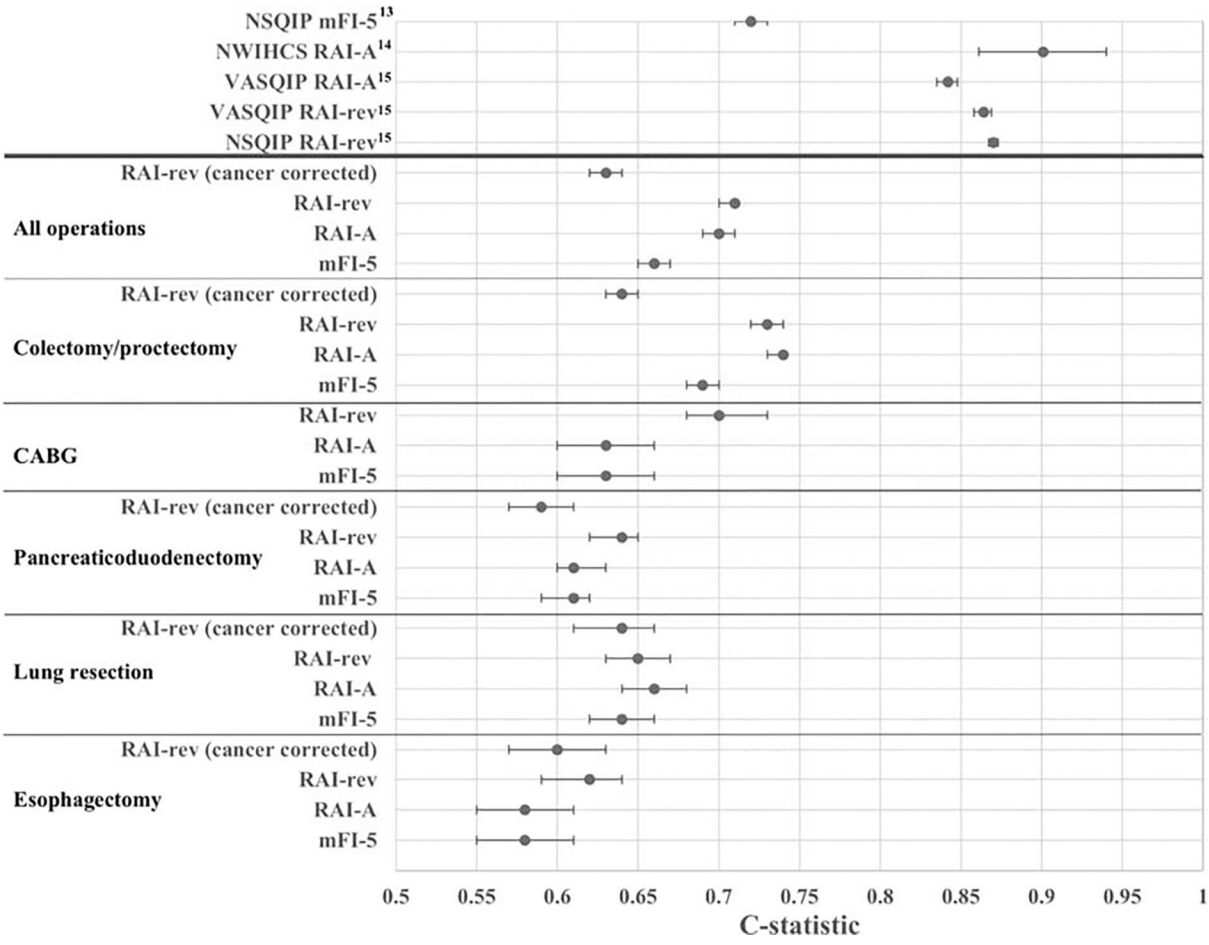

FIGURE 2.

Receiver operating characteristic analysis of RAI-rev (cancer corrected), RAI-rev, RAI-A, and mFI-5 for postoperative 30-d mortality stratified by surgical cohort.

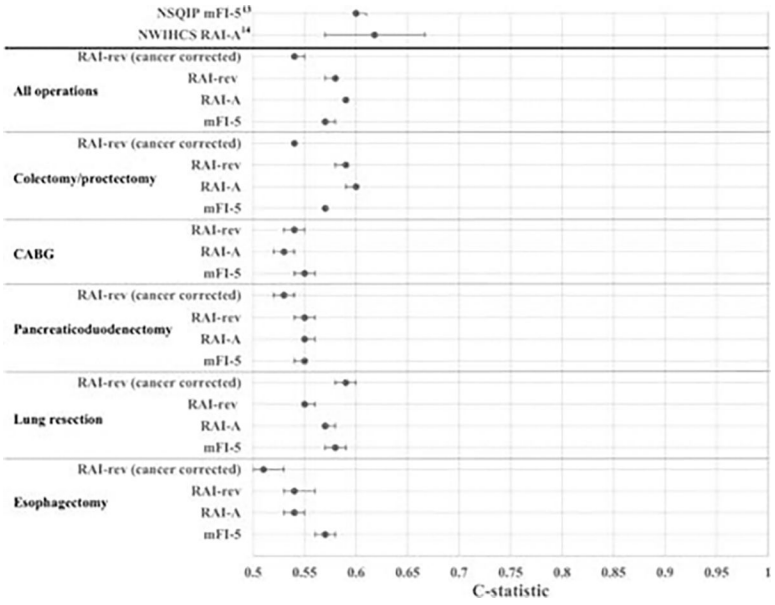

FIGURE 3.

Receiver operating characteristic analysis of RAI-rev (cancer corrected), RAI-rev, RAI-A, and mFI-5 for postoperative morbidity stratified by surgical cohort.

TABLE 1.

Patient Characteristics

	Colectomy/ Proctectomy 178,311 (62.9%)	Coronary Artery Bypass Graft 16,137 (5.7%)	Pancreatico-duodenectomy 38,167 (13.5%)	Lung Resection 40,328 (14.2%)	Esophagectomy 10,602 (3.4%)	All Patients 283,545 (100%)	*P* Value
Male sex	86,811 (48.7%)	12,285 (76.1%)	20,202 (52.9%)	18,766 (46.5%)	8483 (80.0%)	146,547 (51.7%)	< 0.001
Age, median (IQR)	63 (52–73)	66 (59–73)	66 (57–73)	66 (58–73)	64 (57–71)	64 (54–73)	< 0.001
Caucasian	122,528 (68.7%)	10,680 (66.2%)	27,324 (71.6%)	31,379 (77.8%)	8311 (78.4%)	200,222 (70.6%)	< 0.001
Cancer diagnosis	19,060 (10.7%)	41 (0.3%)	2066 (5.4%)	4871 (12.1%)	1251 (11.8%)	27,289 (9.6%)	< 0.001
Corrected cancer diagnosis	74,759 (41.9%)	1 (0.0%)	26,944 (70.6%)	25,646 (63.6%)	9212 (86.9%)	136,562 (48.2%)	< 0.001
Weight loss	11,659 (6.5%)	66 (0.4%)	6311 (16.5%)	1044 (2.6%)	2090 (19.7%)	21,170 (7.5%)	< 0.001
Renal failure	2193 (1.2%)	503 (3.1%)	150 (3.9%)	214 (5.3%)	24 (0.2%)	3084 (1.2%)	< 0.001
Congestive heart failure	2301 (1.3%)	1610 (10.0%)	132 (0.3%)	251 (0.6%)	34 (0.3%)	4328 (1.5%)	< 0.001
Poor appetite	11,659 (6.5%)	66 (0.4%)	6311 (16.5%)	1044 (2.6%)	2090 (19.7%)	21,170 (7.5%)	< 0.001
Dyspnea at rest	1586 (0.9%)	729 (4.5%)	101 (0.3%)	712 (1.8%)	40 (0.4%)	3168 (1.1%)	< 0.001
Residence other than independent living	11,079 (6.2%)	3349 (20.8%)	1281 (3.4%)	595 (1.5%)	185 (1.7%)	16,489 (5.8%)	< 0.001
Cognitive deterioration	1.852 (1.0%)	245 (1.5%)	148 (0.4%)	99 (0.2%)	46 (0.4%)	2390 (0.8%)	< 0.001
Independent on activities of daily living	168,118 (94.3%)	15,357 (95.2%)	37,565 (98.4%)	39,814 (98.7%)	10,430 (98.4%)	271,284 (95.7%)	< 0.001
30-d mortality	4856 (2.7%)	382 (2.4%)	1074 (2.8%)	687 (1.7%)	391 (3.7%)	7390 (2.6%)	< 0.001
Postoperative complication	46,380 (26.0%)	8600 (53.3%)	14,681 (38.5%)	5046 (12.5%)	4234 (39.9%)	78,941 (27.8%)	< 0.001