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A Comparison of Three Frailty Indices in Predicting Morbidity and Mortality After On-Pump Aortic Valve Replacement

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Abstract

BACKGROUND: Aortic valve replacement is a high-risk surgery (3%–5%, 30-day mortality) performed on approximately 30,000 elderly patients a year in the United States. Currently, preoperative risk assessment is based on a composite of medical examination and a subjective evaluation for frailty (“eyeball test”). Objective frailty assessment using validated indices has the potential to improve risk stratification. The purpose of this study was to (1) establish whether frailty can predict 30-day mortality and composite morbidity in patients undergoing aortic valve replacement and (2) compare the predictive ability of 3 frailty indices in this population.

METHODS: This study was a retrospective cohort study of 3088 patients 65 years old and older undergoing aortic valve replacement surgery (based on current procedure terminology codes) between the years 2006 and 2012 extracted from the American College of Surgeons National

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DISCLOSURES

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Surgical Quality Improvement Program database. Frailty was assessed using the modified frailty index, risk analysis index, and Ganapathi indices. Outcomes measured were 30-day mortality and composite morbidity (myocardial infarction, cardiac arrest, pulmonary embolism, pneumonia, reintubation, renal insufficiency, coma >24 hours, urinary tract infections, sepsis, deep vein thrombosis, deep wound surgical site infection, superficial site infection, and reoperation).

RESULTS: Frailty was a better predictor of mortality than morbidity, and it was not markedly different among any of the 3 indices. Frailty was associated with an increased risk of 30-day mortality and longer lengths of stay.

CONCLUSIONS: Frailty can predict mortality in patients undergoing aortic valve replacement. Choice of frailty index does not make a difference in this patient population.

Aortic valve replacement is a high-risk surgery (3%–5%, 30-day mortality) performed on approximately 30,000 elderly patients a year in the United States.¹ Currently, preoperative risk assessment is based on a composite of medical examination that incorporates comorbidities and a subjective evaluation for frailty (“eyeball test”) in which the physician determines if the patient appears frail simply by looking at the patient.²

Frailty is a biological syndrome reflecting a limited physiologic reserve and ability to withstand stressors.³ Formal frailty screening is a scientific approach which has been shown in surgical populations to improve prediction of morbidity and mortality in elderly patients.^{4–7} In fact, frailty has been shown to predict postoperative mortality after cardiac surgery.⁸ However, frailty, as judged by formal geriatric evaluation, has not been widely implemented into clinical practice, in many cases due to time constraints and availability of trained assessors.⁹ Frailty screening tools vary in their composition, but are generally comprised of a patient’s disease burden plus markers of function/disability. There are several tools currently described in the literature that are quick and straightforward to administer.

In this study, we address the predictive ability of 3 short-form frailty screening indices in elderly aortic valve patients. We performed a retrospective cohort study of patients from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database and compared 3 of the more common and easy to use frailty indices and their ability to predict 30-day mortality and composite morbidity. Additionally, because surgery itself can impact patient postoperative outcomes, we investigated the degree of improvement in predictability of outcomes by adding surgical operating time. If preoperative frailty can identify the highest risk patients, then this information may assist clinicians in choosing between transcatheter aortic valve replacement (TAVR) and open surgery. Frailty may also identify patients who could benefit from additional care and resources in the perioperative period.

METHODS

Study Population

ACS NSQIP Participant Data Use Files from 2006 to 2012 were requested for this study, and permission for use was obtained via the institutional NSQIP official from the ACS. This research was granted exemption status from the institutional review board. We included

patients 65 years old and older who underwent nonemergent open aortic valve replacement surgery identified using the following Current Procedural Terminology codes: 33405, 33406, 33410, 33411, 33412, and 33413. Data on TAVR procedures were not available in the NSQIP database and were not analyzed in this study. Exclusion criteria were as follows: American Society of Anesthesiologists status of >4 and emergency surgery. We did not include patients undergoing valve replacement and coronary artery bypass graft to facilitate extrapolation of our data for the situation where a surgeon is choosing between open valve replacement and TAVR.

The frailty indices we chose for this paper were the modified frailty index (mFI),¹⁰ risk analysis index (RAI),¹¹ and Ganapathi index.¹² The mFI is a comorbidity index; unlike the other 2 indices, it does not directly contain a measure of function. We have included it as a sensitivity analysis since it has been shown in the NSQIP database to be an important predictor of complications and death.^{10,13–15} The mFI was derived from the Canadian Study of Health and Aging Frailty Index, a well-established frailty index that uses history and physical examination to assess disease and quantify accumulating deficits to predict survival. It is comprised of variables that assess the patient's functional status, medical history, and mental status. The RAI is an index that is a simplification of the 6-month mortality index by Porock et al.¹⁶ It has been validated retrospectively and prospectively and is associated with mortality after 30, 180, and 365 days after surgery.¹¹ It includes a combination of demographic information, medical history, functional status, and lab data. The Ganapathi index uses a score consisting of 6 components of history and laboratory data shown to be objective indicators of frailty. The variables included are age, body mass index, anemia, stroke history, low albumin, and functional status. The Ganapathi index has been used previously for aortic surgeries,¹² and it has been shown to be predictive of outcomes in this population. Supplemental Digital Content 1, Table, <http://links.lww.com/AA/B959>, shows the variables and scoring for each frailty index used in this study.

Outcomes

Thirty-day mortality and major postoperative morbidity were the primary outcomes for the study. Major post-operative morbidity was defined as a composite using the variables from Robinson et al¹⁷ and included myocardial infarction, cardiac arrest, pulmonary embolism, pneumonia, reintubation, renal insufficiency, coma >24 hours, urinary tract infections, sepsis, deep vein thrombosis, deep wound surgical site infection, superficial site infection, and reoperation. Postoperative length of stay was evaluated as a secondary outcome.

Statistical Analysis

We described the demographics, comorbidities, and proportions of observed complications of the population as percentage, median, or mean as appropriate.

Frailty.—We investigated frailty defined as (1) continuous scores, (2) multilevel categories, and (3) binary (frail or not frail). For each index, we fitted a logistic regression model of 30-day mortality using each frailty score as the sole predictor. Then we used the rate of predicted versus observed outcomes to assess sensitivity and specificity. We compared C-

statistics between models and based on this chose to represent frailty using a categorical score for all 3 indices.²⁹

Multivariate logistic regression models were created for our primary outcomes morbidity and mortality, and Poisson modeling was used for secondary outcome length of stay. The models included age, gender, and race either within the frailty index or as independent predictors if not included in the index. Receiver operating characteristic curves were constructed for the models. Statistical significance was defined as P value $< .05$. A post hoc power calculation was performed to detect a clinically significant difference in 30-day mortality.

Analysis was done using SAS software (Version 9.3; SAS Institute, Cary, NC).

RESULTS

Baseline Characteristics

A total of 2,320,920 ACS NSQIP user files were reviewed for this study. Of these, 3088 met the criteria for inclusion (Figure 1). Patient demographics and baseline characteristics including a breakdown of how each frailty index classifies patients are shown in Table 1. Mean age was 69.24 ± 13 years. A total of 37.7% of the total cohort were female, and 43.9% were Caucasian. Six procedural variations of aortic valve replacement were included. Supplemental Digital Content 2, Table, <http://links.lww.com/AA/B960>, shows the distribution of aortic valve replacement procedures by Current Procedural Terminology code.

Outcomes

One hundred fifteen patients (4%) of the cohort died within 30 days of surgery. Major morbidity was seen in 675 (22%); the most common morbidity was reoperation ($n = 250$), pneumonia ($n = 134$), and reintubation ($n = 132$). Of the patients with major morbidity, 82 (12%) had 30-day mortality. Thirty-day mortality was associated with totally dependent functional status (11.3% vs 0%; $P < .001$), American Society of Anesthesiologists IV (83.5% vs 77.3%; $P < .001$), and malnutrition (34.8% vs 11.6%; $P < .001$). The 30-day mortality group also showed a significantly higher percentage of comorbidities including transient ischemic attack (10.4% vs 4.6%; $P < .05$), hypertension (85.2% vs 75.7%; $P < .05$), chronic obstructive pulmonary disease (19.1% vs 8.1%; $P < .001$), insulin-dependent diabetes (20.9% vs 8.8%; $P < .001$), and congestive heart failure (46.1% vs 18.7%; $P < .001$).

Prediction of Mortality and Morbidity

Models of mortality and major morbidity are shown in Tables 2 and 3. The odds ratios for major morbidity and 30-day mortality increased with the increasing number of frailty characteristics, regardless of which index was utilized. Increasing frailty was also significantly associated with longer postoperative length of stay. Predictors of major morbidity were as follows: frailty score and Asian/Pacific Islander race. Thirty-day mortality was associated with higher frailty scores and Asian/Pacific Islander race.

Prediction of mortality was overall much better than for morbidity; the covariates-adjusted C-statistic for mortality ranged from 0.68 to 0.73 for mortality, not significantly different between indices. In contrast, the C-statistic for morbidity ranged from 0.57 to 0.61, which was significantly different; the mFI outperformed the RAI but not Ganapathi index (Figure 2).

Post Hoc Power Calculation

Comparing the incidence of 30-day mortality (2.5%) in non-frail patients as defined by the Ganapathi index, we would have 85% power to detect a clinically significant odds ratio of mortality of 2. Given that frailty (defined by any of the 3 indices) was associated with an odds ratio of >2 , we were sufficiently powered to detect a clinically significant difference in 30-day mortality.

DISCUSSION

In this study, we found that patients who were more frail were also more likely to have a major complication, 30-day mortality, and extended postoperative length of stay after aortic valve replacement. Frailty was a better predictor for mortality than morbidity as a composite outcome. For mortality, there was no advantage to using 1 frailty index over another.

Our study suggests that simple frailty indices (Ganapathi, mFI, and RAI) can be used to predict mortality in cardiac surgery patients, which may benefit institutions with minimal or limited access to geriatricians. The frailty index utilized in this study showed increased risk for early (in-hospital or 30-day) mortality consistent with the previous cardiac frailty model by Lee et al¹⁸ and Herman et al.¹⁹ Both studies used impairment defined by Katz's activities of daily living, ambulation, and dementia to assess frailty and found that frailty was an independent predictor of mortality, major cardiac adverse events, institutional discharge, and long-term mortality (up to 3 years). Preoperative frailty also increased the odds of postoperative complications, a similar trend to the findings of Afilalo et al⁶ who used slow gait speed to determine frailty and showed that gait speed was an incremental predictor of major morbidity in elderly patient undergoing cardiac surgery. Additionally, this trend was seen in a study by Robinson et al²⁰ who used a preoperative frailty score consisting of 7 characteristics that included physical and cognitive tasks, medical history, and laboratory data to predict risk for postoperative complications in a mixed cardiac and general surgery population. The predictive power of our 30-day mortality modeling was comparable to the previous frailty models by Amrock et al²¹ who used simplified geriatric-specific models to predict 30-day postoperative mortality with similar accuracy to formal geriatric evaluation in a general surgery population.

Each index we examined in this paper has benefits but also has certain limitations. The mFI is a comorbidity composite that does not include functional status, and is controversial whether it truly captures frailty. The RAI is widely studied, has been validated both prospectively and retrospectively, and includes functional measures but requires information that is often not routinely collected. The Ganapathi index is similar to the other indices and brings the added benefit of only requiring approximately half the number of variables. Given that our data show that all 3 indices have similar predictive value in this population, an index

may be selected based on ease of implementation in the specific clinical situation. While the mFI, RAI, and Ganapathi indices are all good initial screening tools for patients, they are by no means a comprehensive tool and would likely need to be supplemented by other geriatric assessments to identify specific areas that are amenable to intervention to optimize patients and minimize the surgical risk. These data should be collected prospectively and can be used to make clinical decisions or target patients for interventions. For instance, a patient who is identified as frail may be directed toward more conservative management (TAVR/surgical aortic valve replacement) or may be referred for prehabilitation. This concept is demonstrated in a recent prospective study by Hall et al²² which showed that using the RAI to inform surgical decision-making was associated with a significant decrease in mortality for frail patients at 30, 180, and 365 days.

We found that frailty strongly predicted mortality but was less predictive for morbidity. This is a phenomenon seen in previous studies²⁰ and may be due to the differences in how morbidity is defined and which morbidities are actually collected and documented. Our composite score included a wide variety of complications, not all of which may correlate with frailty. For example, reintubation may be more common in frail patients with muscle wasting; however, wound infection may not be affected by frailty status. Future studies may benefit from subanalysis of individual morbidities to understand whether frailty can predict some better than others.

Overall, these frailty indices can help clinicians preoperatively identify the highest risk patients and assist clinicians in choosing between less invasive procedures such as TAVR and open surgery. Additionally, screening for frailty at an early stage of treatment may help identify patients who could benefit from additional care and resources in the perioperative period.

There are several limitations to this study. First, this study used NSQIP data which represents approximately 10% of US hospitals and mainly large academic centers.²³ However, this population does represent a spectrum of socioeconomic and racial diversity which allows extrapolation to the greater population of surgical patients. Second, frailty was not defined according to the traditional frailty phenotype of Fried et al²⁴ which requires examination by a geriatrician but rather was based on surrogate elements of the frailty phenotype.^{15,25–28} This was done intentionally, and the indices we used are well validated and have the advantage of simplicity needed for the perioperative arena while still retaining predictive value.

We were unable to compare our risk score with Society of Thoracic Surgeons (STS) or European System for Cardiac Operative Risk Evaluation (EuroSCORE) risk for this cohort as the variables necessary to assess this risk are not available in the NSQIP database and approximating a second composite (frailty is the first) would add an undesired complexity to our modeling. However, previous studies have shown frailty to be an independent predictor of risk or to add predictive value to these risk scores.⁷ A prospective study would do well to collect cardiac risk score data since the literature suggests that a combination of risk score plus frailty gives the best prediction. Future studies may include validation of brief frailty screening measures in a prospective cohort to assess its feasibility as a clinical tool. The

addition of a physical measure such as grip strength or walk speed may also prove useful by potentially adding additional predictive ability to the frailty indices investigated in this study. In all cases, the incorporation of operating time into models will likely improve predictive ability.^{30,31}

CONCLUSIONS

We demonstrated that 3 simple frailty screens can predict mortality and morbidity in patients undergoing aortic valve replacement. Frailty was a better predictor of 30-day mortality than composite morbidity. There was no significant difference in prediction of mortality among the 3 different frailty indices we used. Since there is minimal advantage between 1 index and another, investigators should choose the index that is most feasible for testing based on the population being studied and the ability to collect the necessary data. Future studies should investigate whether patient selection, optimization, and targeted perioperative resources for the most frail patients have the potential to reduce mortality and some types of morbidity in this population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Study design. A total of 2,320,920 ACS NSQIP participant use files from 2005 to 2012 were reviewed. Of these, 3088 were ≥ 65 y old and met CCS and CPT code criteria for inclusion. ACS NSQIP indicates American College of Surgeons National Surgical Quality Improvement Program; CCS, clinical classifications software; CPT, Current Procedural Terminology.

Figure 2. ROC curves for (A) 30-d mortality and (B) morbidity for logistic model with frailty plus covariates. ROC indicates receiver operating characteristic.

Table 1.

Patient Demographics and Baseline Characteristics

Variable	Total (n = 3088)	30-d Mortality (n = 115)	No 30-d Mortality (n = 2973)	P
Demographics, n (%), mean $\pm$ SD, median [IQR]				
Age	69.24 $\pm$ 13.10	72.07 $\pm$ 12.14	69.13 $\pm$ 13.13	.018
Female	1163 (37.7)	45 (39.1)	1118 (37.6)	.816
Race				.405
Caucasian	1356 (43.9)	57 (49.6)	1299 (43.7)	
African American	52 (1.68)	3 (2.61)	49 (1.65)	
Asian or Hawaiian	15 (0.49)	1 (0.87)	14 (0.47)	
Other	1665 (53.9)	54 (47.0)	1611 (54.2)	
BMI, kg/m ²	28.66 [25.2–33.0]	28.30 [24.2–32.9]	28.69 [24.2–33.1]	.143
Preoperative status, n (%)				
ASA class				<.0001
I, II, III	674 (21.9)	14 (12.2)	660 (22.2)	
IV	2393 (77.6)	96 (83.5)	2297 (77.3)	
V	18 (0.6)	5 (4.35)	13 (0.44)	
Null	3 (0.10)	0 (0)	3 (0.10)	
Transfer status				.001
Acute care facility	321 (10.4)	19 (16.5)	302 (10.2)	
Chronic care facility	16 (0.52)	3 (2.61)	13 (0.44)	
Home	2735 (88.6)	93 (80.9)	2642 (88.9)	
Other	16 (0.52)	0 (0)	16 (0.54)	
Impaired sensorium				.183
No/null	3067 (99.3)	113 (98.3)	2954 (99.4)	
Yes	21 (0.7)	2 (1.74)	19 (0.64)	
Weight loss	35 (1.13)	3 (2.61)	32 (1.08)	.140
Malnutrition	385 (12.5)	345 (11.6)	40 (34.8)	<.001
Functional status, n (%)				<.001
Independent/null	2891 (96.1)	92 (80.0)	2799 (93.1)	
Partially/totally dependent	197 (6.4)	52 (21.7)	132 (4.44)	

Variable	Total (n = 3088)	30-d Mortality (n = 115)	No 30-d Mortality (n = 2973)	P
Baseline laboratory values, median [IQR]				
Hematocrit	38.0 [35.0–42.0]	36.00 [31.2–39.3]	39.00 [31.2–42.0]	<.001
Albumin, g/dL	4.00 [3.6–4.3]	3.60 [3.0–4.0]	4.00 [3.0–4.3]	<.001
Creatinine, mg/dL	1.00 [0.8–1.2]	1.11 [0.9–1.5]	1.00 [0.9–1.2]	<.001
Preoperative comorbidity, n (%)				
Transient ischemic attack No/null	2940 (95.2)	103 (89.6)	2837 (95.4)	.004
Yes	148 (4.79)	12 (10.4)	136 (4.57)	
CVA with deficit				.489
No/null	2970 (96.2)	112 (97.4)	2858 (96.1)	
Yes	118 (3.8)	3 (2.61)	115 (3.87)	
CVA without deficit				
No/null	2995 (97.0)	109 (94.8)	2886 (97.1)	.158
Yes	93 (3.01)	6 (5.22)	87 (2.93)	
Hypertension				.019
No/null	739 (23.9)	17 (14.8)	722 (24.3)	
Yes	2349 (76.1)	98 (85.2)	2251 (75.7)	
COPD				<.001
No	2825 (91.5)	93 (80.9)	2732 (91.9)	
Yes	263 (8.52)	22 (19.1)	241 (8.11)	
Diabetes mellitus				<.001
Insulin/oral/non-insulin	771 (25.0)	43 (37.4)	728 (24.5)	
No	2317 (75.0)	72 (62.6)	2245 (75.5)	
History of PVD				.013
No/null	3019 (97.8)	108 (93.9)	2911 (97.9)	
Yes	69 (2.2)	7 (6.1)	62 (2.1)	
History of MI	—	9 (7.83)	134 (4.51)	.097
No/null	2945 (95.4)	106 (92.2)	2839 (95.5)	
Yes	143 (4.63)	9 (7.8)	134 (4.5)	
History of PCI				.001
No/null	2672 (86.5)	87 (75.7)	2585 (87.0)	
Yes	416 (13.5)	28 (24.4)	388 (13.1)	

Variable	Total (n = 3088)	30-d Mortality (n = 115)	No 30-d Mortality (n = 2973)	P
History of angina				.010
No/null	2590 (83.9)	86 (74.8)	2504 (84.2)	
Yes	498 (16.1)	29 (25.2)	469 (15.8)	
Previous cardiac surgery				<.001
No/null	2655 (86.0)	78 (67.8)	2577 (86.7)	
Yes	433 (14.0)	37 (32.2)	396 (13.3)	
History of CHF				<.001
No	2480 (80.3)	62 (53.9)	2418 (81.3)	
Yes	608 (19.7)	53 (46.1)	555 (18.7)	
Frailty status, n (%)				
Ganapathi score 2	800 (25.92)	58 (50.43)	742 (24.96)	<.001
RAI score 15	795 (25.74)	63 (54.78)	732 (24.62)	<.001
mFI score 0.2	1735 (56.19)	97 (84.35)	1638 (55.1)	<.001
Index distribution, n (%)				
Ganapathi index				<.001
0	988 (32.0)	16 (13.9)	972 (32.7)	
1	1300 (42.1)	41 (35.7)	1259 (42.3)	
2	559 (18.1)	33 (28.7)	526 (17.7)	
3	559 (18.1)	33 (28.7)	526 (17.7)	
4	59 (1.9)	10 (8.7)	49 (1.6)	
Modified frailty index				<.001
<0.1	1353 (43.8)	18 (15.7)	1335 (44.9)	
<0.2	884 (28.6)	33 (28.7)	851 (28.6)	
<0.3	514 (16.6)	23 (20.0)	491 (16.5)	
<0.4	205 (6.6)	24 (20.9)	11 (0.37)	
0.4	132 (4.3)	17 (14.8)	11 (0.37)	
Risk-adjusted index				<.001
6	801 (25.9)	22 (19.1)	1335 (26.2)	
10	1492 (48.3)	30 (26.1)	851 (49.2)	
15	474 (15.3)	31 (15.3)	443 (14.9)	
20	169 (5.5)	13 (11.3)	156 (5.2)	

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Variable	Total (n = 3088)	30-d Mortality (n = 115)	No 30-d Mortality (n = 2973)	P
25	78 (2.5)	5 (4.3)	73 (2.5)	
30	47 (1.5)	10 (8.7)	37 (1.2)	
35	15 (0.5)	2 (1.7)	13 (0.4)	
40	12 (0.4)	2 (1.7)	10 (0.3)	

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; IQR, interquartile range; mFI, modified frailty index; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; RAI, risk analysis index; SD, standard deviation.

Table 2.**Thirty-Day Mortality, Multivariate Logistic Regression**

Index Type	Variable	Odds Ratio (95% CI)	P
Ganapathi	Female (versus male)	0.94 (0.64–1.38)	.75
	Race (versus Caucasian)		
	Asian/Hawaiian Islander	1.32 (0.16–10.56)	.80
	African American	1.09 (0.32–3.68)	.90
	Other	0.83 (0.57–1.23)	.37
	Ganapathi frailty score		
	1 vs 0	1.99 (1.11–3.56)	.02
	2 vs 0	5.43 (2.52–11.70)	<.001
	3 vs 0	7.22 (1.81–3.89)	<.001
	4 vs 0	11.72 (5.0–27.50)	<.001
RAI	Race (versus Caucasian)		
	Asian/Hawaiian Islander	1.67 (0.21–13.28)	.63
	African American	1.108 (0.31–3.72)	.91
	Other	0.86 (0.58–1.26)	.43
	RAI frailty score		
	10 vs 6	0.73 (0.42–1.28)	.28
	15 vs 6	2.48 (1.42–4.34)	.001
	20 vs 6	2.93 (1.44–5.94)	.003
	25 vs 6	2.40 (0.88–6.55)	.086
	30 vs 6	8.82 (3.76–20.69)	<.001
mFI	35 vs 6	7.23 (1.92–27.18)	.003
	40 vs 6	6.66 (1.36–32.28)	.020
	Female (versus male)	1.12 (0.76–1.66)	.16
	Age	1.01 (0.76–1.66)	.56
	Race (versus Caucasian)		
	Asian/Hawaiian Islander	1.52 (0.18–12.77)	.70
	African American	1.27 (0.37–4.33)	.70
	Other	0.89 (0.60–1.31)	.56
	mFI frailty score		
	2 vs 1	2.79 (1.56–5.00)	.001
	3 vs 1	3.34 (1.78–6.26)	.0002
	4 vs 1	9.33 (4.94–17.62)	<.001
	5 vs 1	10.12 (5.02–20.36)	<.001

Abbreviations: CI, confidence interval; mFI, modified frailty index; RAI, risk analysis index.

Table 3.**Major Morbidity, Multivariate Logistic Regression**

Index Type	Variable	Odds Ratio (95% CI)	P
Ganapathi	Female (versus male)	1.00 (0.84–1.20)	.97
	Race (versus Caucasian)		
	Asian/Hawaiian Islander	3.90 (1.38–11.013)	.010
	African American	0.96 (0.49–1.89)	.91
	Other	1.054 (0.88–1.26)	.56
	Ganapathi frailty score		
	1 vs 0	1.49 (1.20–1.89)	.0004
	2 vs 0	2.15 (1.67–2.78)	<.0001
	3 vs 0	3.32 (2.34–4.70)	<.0001
	4 vs 0	11.72 (5.0–27.50)	<.0001
RAI	Race (versus Caucasian)		
	Asian/Hawaiian Islander	4.13 (1.47–11.63)	.0073
	African American	1.071 (0.55–2.087)	.84
	Other	1.071 (0.90–1.28)	.45
	RAI frailty score		
	10 vs 6	0.87 (.70–1.084)	.22
	15 vs 6	1.30 (1.00–1.70)	.054
	20 vs 6	1.73 (1.19–2.49)	.0037
	25 vs 6	2.6 (1.60–4.24)	.0001
	30 vs 6	2.48 (1.32–4.66)	.0050
mFI	Female (versus male)	1.09 (0.91–1.30)	.35
	Age	1.011 (1.003–1.018)	.0041
	Race (versus Caucasian)		
	Asian/Hawaiian Islander	4.44 (1.56–12.60)	.0051
	African American	1.046 (0.54–2.044)	.90
	Other	1.092 (0.91–1.30)	.33
	mFI frailty score		
	2 vs 1	1.37 (1.10–1.71)	.0043
	3 vs 1	1.89 (1.48–2.41)	<.0001
	4 vs 1	2.32 (1.67–3.23)	<.0001
	5 vs 1	3.45 (2.36–5.048)	<.0001

Abbreviations: CI, confidence interval; mFI, modified frailty index; RAI, risk analysis index.