Frailty and risk in proximal aortic surgery

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Objectives: Although frailty has recently been examined in various populations as a predictor of morbidity and mortality, its effect on thoracic aortic surgery outcomes has not been studied. The objective of the present study was to evaluate the role of frailty in predicting postoperative morbidity and mortality in patients undergoing proximal aortic replacement surgery.

Methods: A retrospective analysis of a prospectively maintained database was performed for all patients undergoing elective and nonelective proximal aortic operations (root, ascending aorta, and/or arch) at a single-referral institution from June 2005 to December 2012. A total of 581 patients underwent proximal aortic surgery, of whom 574 (98.8%) were included in the present analysis; 7 were excluded because of incomplete data. Frailty was evaluated using an index consisting of age >70 years, body mass index <18.5 kg/m^2, anemia, history of stroke, hypoalbuminemia, and total psoas volume in the bottom quartile of the population. One point was given for each criterion met to determine a frailty score of 0 to 6. Frailty was defined as a score of $\geq$2. Risk models for length of stay >14 days, discharge to other than home, 30-day composite major morbidity, 30-day composite major morbidity/mortality, and 30-day and 1-year mortality were calculated using multivariate regression modeling.

Results: Of the 574 patients, 148 (25.7%) were defined as frail (frailty score $\geq$2). The unadjusted 30-day/in-hospital and long-term outcomes were significantly worse for the frail versus nonfrail patients in all but 1 of the outcomes analyzed; no difference was found in the 30-day readmission rates between the 2 groups. In the multivariate model, a frailty score of $\geq$2 was associated with discharge to other than home and 30-day and 1-year mortality.

Conclusions: Frailty, as defined using a 6-component frailty index, can serve as an independent predictor of discharge disposition and early and late mortality risk in patients undergoing proximal aortic surgery. These frailty markers, all of which are easily assessed preoperatively, could provide valuable information for patient counseling and risk stratification before proximal aortic replacement. (J Thorac Cardiovasc Surg 2014;147:186-91)

⚲ Supplemental material is available online.

Repairs of the ascending thoracic aorta and arch have been demonstrated to carry significant potential morbidity and mortality risk.[1,2] A recent study from The Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database examining outcomes in 45,894 patients undergoing ascending aorta replacement (with or without root), with or without arch replacement, from 2004 to 2009 found nonelective case status to be the strongest predictor of major morbidity or mortality, although other comorbid conditions such as severe chronic lung disease, chronic kidney disease, and cerebrovascular disease also predicted an increased risk.[2] Frailty, defined as a state of increased vulnerability to stressors caused by deterioration across multiple physiologic systems, is an independent risk factor for in-hospital mortality, reduced midterm survival, and prolonged residential care requirements in cardiac surgery.[3] Frailty was not examined in the aforementioned large STS Adult Cardiac Surgery Database study, and no other work to date has attempted to examine the effect of frailty on thoracic aortic surgery outcomes. Therefore, the present study sought to establish an objective frailty score for patients undergoing proximal aortic surgery and to evaluate its independent predictive value relative to known risk factors to further improve on existing risk stratification models.

METHODS
Patients and Data Source

A retrospective analysis of a prospectively maintained database was performed for all patients undergoing elective and nonelective proximal aortic operations at a single tertiary referral institution from June 2005

Abbreviations and Acronyms
FP = frail patient
NFP = nonfrail patient
STS = The Society of Thoracic Surgeons
TPV = total psoas volume

to December 2012. Proximal aortic surgery was defined as any procedure involving the aortic root, ascending aorta, and/or aortic arch, performed through a median sternotomy, and using cardiopulmonary bypass with or without hypothermic circulatory arrest. Operations classified as hybrid arch procedures or involving the descending thoracic aorta were excluded. The pre-, intra-, and postoperative variables were obtained from the Duke Thoracic Aortic Surgery Database, a prospectively maintained clinical registry of all patients undergoing thoracic aortic surgery at Duke University Medical Center (Durham, NC). The need for individual patient consent was waived after review and approval by the institutional review board of Duke University. A query of the database identified 581 proximal aortic procedures performed from June 2005 to December 2012. Of these, 574 (98.8%) were included in the present analysis; 7 patients were excluded because of incomplete data. The comorbidities and patient characteristics were defined using STS definitions.[4] All patients underwent annual follow-up examinations at the Duke University Center for Aortic Disease with clinical assessment and computed tomographic angiography, magnetic resonance angiography, and/or echocardiography. Data were collected through the last follow-up visit by the study termination date of December 2012. In addition, the Social Security Death Index (available at: http://ssdi.rootsweb.com/) was queried to confirm all deaths and survey for patients lost to follow-up.

Frailty Definition

To classify frailty, a score consisting of 6 components previously identified in the published data as objective indicators of frailty was created. The components were (1) age >70 years,[5] (2) body mass index < 18.5 kg/m²,[6] (3) anemia (<12.0 g/dL for women, <13.0 g/dL for men),[7] (4) hypoalbuminemia (<3.5 g/dL),[8] (5) a history of stroke,[9] and (6) a total psoas volume (TPV) in the bottom quartile of the patient population.[10] For each characteristic a patient fulfilled, they received 1 point to establish a score from 0 to 6. Any patient with a score of ≥2 was defined as frail, analogous to previously published definitions.[5,9] Any missing value among the components of the frailty score was considered normal.

TPV measurements were made using a TeraRecon Aquarius 3-dimensional workstation (TeraRecon Inc, San Mateo, Calif) for all patients with computed tomography scans of the abdomen and pelvis extending to the acetabulum (n = 265; 46.1%). To perform the TPV measurements, the region of interest tool was used to outline the psoas muscle bilaterally on axial images (Figure E1). The selection of the psoas muscle began at the L1 level and continued through the acetabulum, with measurements made at each vertebral level and at approximately 3 equidistant measurements between the top of the sacrum and the acetabulum (total of 8 measurements). Once the psoas muscle had been outlined at the 8 predetermined locations, the volume tool was used to determine the TPV. To account for the potential inclusion of fat or other tissue within the psoas volume, density thresholds of 0 to 161 Hounsfield units, consistent with previous data,[10] were used to select muscle and exclude fat, vasculature, and bone. The resultant TPV was then calculated. Three independent observers, who were unaware of the patient's clinical information, performed the TPV measurements, with multiple measurements made for randomly assigned scans (one third of all measurements) to validate interobserver reliability.

Outcomes

The primary outcome measure was mortality, both 30 day and 1 year. The secondary outcomes included length of stay >14 days, discharge to a destination other than home, readmission within 30 days, composite 30-day major morbidity, and composite 30-day major morbidity and mortality. The composite 30-day major morbidity was defined using the standard STS definition and included reoperation, prolonged mechanical ventilation, acute renal failure, new onset dialysis, and stroke.

Statistical Analysis

Categorical variables were compared using the chi-square test and continuous variables using Student's t test. Backward, stepwise, multivariate logistic regression modeling was used to determine the independent effect of frailty on these outcomes, while controlling for known risk factors. A Kaplan-Meier survival analysis with the log-rank test was used for the long-term survival estimates. The significance levels were set at an α of 0.05 in all cases. We made an affirmative decision to control for a type I error at the level of the comparison; therefore, no corrections for multiple hypothesis testing were made. Statistical analysis was performed using R, version 2.15.1 (Vienna, Austria).

RESULTS

The study cohort consisted of 574 total procedures in 569 patients. Of these patients, 148 (25.7%) were defined as frail (frailty score ≥2). The frail patients (FPs) were older and more likely to be women. They also had a greater comorbid disease burden, including a more frequent history of previous stroke and/or transient ischemic attack, chronic obstructive pulmonary disease, and chronic renal insufficiency, and were more likely to be American Society of Anesthesiologists class 4 (Table 1). The patients in the frail and nonfrail groups did not differ in the type of proximal aortic procedure performed or the incidence of redo sternotomy (Table 2). However, the FPs were more likely to undergo nonelective (urgent and emergent) surgery, including more frequent surgery for aortic dissection, and were also significantly more likely to require concomitant cardiac surgical procedures, most of which were coronary artery bypass grafting (76%).

Examination of the individual frailty characteristics revealed that 280 of the 426 (65.7%) nonfrail patients (NFPs) did not meet any of the frailty criteria. Of the NFPs fulfilling only 1 frailty criterion, the most common finding was the presence of anemia (n = 60; 14.1%). In contrast, anemia (n = 112; 75.7%) and hypoalbuminemia (n = 104; 70.3%) were the most common characteristics present in the FPs (Table E1). Nearly all FPs had a frailty score of 2 or 3 (n = 140; 94.6%), with no patient having a score of 6 (Table E2). Fewer than one half of the FPs (n = 66; 44.6%) were elderly, defined as age >70 years. The unadjusted perioperative (30-day and in-hospital) and long-term outcomes revealed significant differences between the FPs and NFPs in all but 1 of the outcomes analyzed (Table 3). The single exception was the absence of a difference in the 30-day readmission rates between the 2 groups. Mortality at 30 days and 1 year for the entire

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