Mortality variability after endovascular versus open abdominal aortic aneurysm repair in a large tertiary vascular center using a Medicare-derived risk prediction model

Caitlin W. Hicks, MD, MS, James H. Black III, MD, Isibor Arhuidese, MD, MPH, Luda Asanova, MD, Umair Qazi, MD, MPH, Bruce A. Perler, MD, Julie A. Freischlag, MD, and **Mahmoud B. Malas, MD, MHS,** *Baltimore, Md*

Objective: **Previous reports have documented better outcomes after open abdominal aortic aneurysm (AAA) repair in tertiary centers compared with lower-volume hospitals, but outcome variability for endovascular AAA repair (EVAR) vs open AAA repairs in a large tertiary center using a Medicare-derived mortality risk prediction model has not been previously reported. In the current study, we compared the observed vs predicted mortality after EVAR and open AAA repair in a single large tertiary vascular center.**

Methods: **We retrospectively analyzed all patients who underwent repair of a nonruptured infrarenal AAA in our center from 2003 to 2012. Univariable and multivariable logistic regression were used to evaluate 30-day mortality. Patients were stratified into low-risk, medium-risk, and high-risk groups, and mortality was predicted for each patient based on demographics and comorbidities according to the Medicare risk prediction model.**

Results: **We analyzed 297 patients (EVAR, 72%; open AAA repair, 28%; symptomatic, 25%). Most of our patients were of high and moderate risk (48% and 28%, respectively). The observed 30-day mortality was 1.9% after EVAR vs 2.4% after open repair (odds ratio [OR], 0.77; 95% confidence interval [CI], 0.14-4.29; $P = .67$). There was no difference in mortality with EVAR vs open repair after adjusting for predefined patient characteristics (OR, 0.92; 95% CI, 0.16-7.43; $P = .93$); only preoperative renal disease was predictive of 30-day mortality after AAA repair in our cohort (OR, 8.39; 95% CI, 1.41-67.0). The observed mortality within our study was significantly lower than the Medicare-derived expected mortality for each treatment group within patients stratified as high risk or medium risk ($P \leq .0002$ for all).**

Conclusions: **Despite treating patients with high preoperative risk status, we report a 10-fold decrease in operative mortality for EVAR and open AAA repair in a tertiary vascular center compared with national Medicare-derived predictions. High-risk patients should be considered for aneurysm management in dedicated aortic centers, regardless of approach. (J Vasc Surg 2015;61:291-7.)**

Abdominal aortic aneurysms (AAAs) affect between 4% and 8% of people in the United States and account for >7500 deaths annually.[1,2] Historically, the surgical standard of care for symptomatic or large (>5.0 cm) AAAs was open surgical repair. However, the advent of endovascular aneurysm repair (EVAR) in recent years has drastically changed current practice patterns, especially in the presence of data suggesting that perioperative mortality is reduced with EVAR.[3-6] EVAR has also been demonstrated to reduce perioperative complications and hospital length of stay compared with open AAA repair, often making this the favored approach among older and higher-risk patients.[7-12]

From the Division of Vascular and Endovascular Therapy, Johns Hopkins Bayview Medical Center and Johns Hopkins Hospital.

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Reprint requests: Mahmoud B. Malas, MD, MHS, Department of Vascular and Endovascular Surgery, Johns Hopkins Bayview Medical Center, 4940 Eastern Ave, Bldg A/5, Ste 547, Baltimore, MD 21224 (e-mail: bmalas1@jhmi.edu).

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Despite this, long-term mortality after EVAR and open AAA repair appears to be similar, and EVAR is associated with higher costs, more intensive follow-up regimens, and an increased need for reintervention postoperatively.[6,9,11,13] As a result, the indications for performing one approach over another are not currently clear. Several algorithms to predict mortality have been developed in an attempt to risk-stratify patients considering surgical repair for AAA, including the Glasgow Aneurysm Score, Leiden Score, Society for Vascular Surgery/American Association for Vascular Surgery Comorbidity Scoring System, Hardman Index, Eagle Score, and Vascular Governance North-West model.[14-20] However, these models were developed based on data only from patients undergoing open AAA repair and have been shown to overpredict mortality in the EVAR population.[18,20] A more recent model proposed by Giles et al[15] used data from 45,660 Medicare beneficiaries to develop a scoring algorithm to predict perioperative (30-day) mortality after EVAR or open AAA repair. Patients are stratified as high risk, medium risk, and low risk for surgical repair based on their age, sex, comorbidities, and proposed surgical approach, generating an individualized risk assessment that can help guide clinical decision making.

To date, the Giles model has not been applied to assess outcomes after EVAR vs open AAA repair in tertiary centers specifically. Previous studies have demonstrated that early mortality after AAA repair is highly dependent on hospital volume and surgeon experience.[21-23] This effect is thought to be the result of better management of complications such as renal failure at high-volume institutions[24]; the higher mortality that is observed at lower-volume hospitals is thought to be the result of a "failure to rescue" phenomenon.[25] The experience-based outcome variability for EVAR has not yet been evaluated but would presumably follow a similar pattern, with better outcomes observed in more experienced, tertiary centers. In the current study, we compare the perioperative morbidity and mortality observed with EVAR vs open AAA repair at a single large tertiary vascular center with the predicted mortality as generated by application of the Giles risk stratification model.

METHODS

Approval from the Johns Hopkins Hospital Institutional Review Board was obtained before the study was initiated. All patients who underwent elective infrarenal AAA repair at our institution between November 28, 2003, and August 30, 2012, were identified for analysis. The study excluded patients with connective tissue disorders, inflammatory aneurysms, and ruptured aneurysms. The electronic medical records were retrospectively reviewed by two independent study team members to collect data on patient demographics, symptoms, comorbidities, surgical technique, postoperative outcomes, and mortality. Patient comorbidities were abstracted based on physician documentation within the electronic medical record. Disagreements on patient coding were settled by input from a third independent team member.

All patients with postoperative clinical visits <1 month old were contacted by telephone to confirm their mortality status. Our primary outcome was perioperative mortality (≤30 days of surgery) after open AAA repair vs EVAR. Our secondary outcome was the incidence of postoperative acute renal failure (ARF), defined according to Acute Kidney Injury Network guidelines.[26]

Descriptive statistics are described as mean ± standard error of the mean or count with percentage, as appropriate. Univariable statistics were performed using Student *t*-tests for continuous variables or the Fisher or Pearson χ^2 tests, or both, for categoric variables to compare morbidity and mortality between patients undergoing open repair vs EVAR. Multivariable logistic regression was used to evaluate adjusted observed perioperative mortality with open repair vs EVAR after accounting for age, sex, and pertinent patient comorbidities (congestive heart failure [CHF], chronic obstructive pulmonary disease, coronary artery disease, and chronic renal insufficiency [CRI]) chosen based on commonly included covariates from prior AAA risk mortality prediction studies.[15-19,27,28]

Patients were then stratified into low-risk, medium-risk, and high-risk groups using the risk prediction model for perioperative mortality of EVAR vs open AAA repair developed by Giles et al.[15] In this model, each patient's risk of mortality after AAA repair is calculated using a logistic regression equation that considers patient characteristics (age, gender), comorbidities (end-stage renal disease [ESRD], CRI, CHF, peripheral vascular disease, and cerebrovascular disease), and treatment (open vs endovascular approach) to derive an overall risk score: Risk score = 4I (female) + 1I (age 70-75) + 6I (age 76-80) + 11I (age >80) + 9I (ESRD)+ 7I (CRI) + 6I (CHF) + 3I (vascular disease) + 12I (open surgery).

Note that in this equation, "*I*" is event, with I = 1 if the event is true, 0 otherwise. Patient data were obtained from manual record review and input into the Medicare-derived equation to determine an individual overall mortality risk score. Scores >11 were designated as high risk for mortality, scores between 3 and 11 were designated as medium risk, and scores <3 were designated as low risk. For risk stratification calculations performed within treatment groups, the treatment effect coefficient of 12 (open surgery) was excluded, with respective mortality probabilities of <1%, 1% to 2%, and >2% for EVAR and <3%, 3% to 6%, and >6% for open AAA repair, as reported by Giles et al.[15]

In addition, a specific Medicare-derived predicted mortality probability (P) was calculated for each patient based on the same model: $\text{logit}(P) = -5.02 + 0.42 \times \text{female} + 0.15 \times \text{age}(70 \text{ to } 75) + 0.63 \times \text{age}(76 \text{ to } 80) + 1.14 \times \text{age}(>80) + 0.71 \times \text{CRI} + 0.95 \times \text{ESRD} + 0.55 \times \text{CHF} + 0.30 \times \text{vascular disease} + 1.17 \times \text{open repair}$.

Observed vs expected mortality (calculated as observed incidence of mortality/the expected incidence of mortality as calculated based on the mean mortality probability within a given group) was compared within risk groups to assess the applicability of the model to predict mortality within our institution's patient population. Note that within the mortality prediction equation, risk with open AAA repair is weighted 1.17 times more than EVAR. Because we noted a particularly high predicted mortality within our patient cohort, we also performed sensitivity analyses with and without the weighted treatment coefficient for open AAA repair (1.17) to determine whether including it significantly affected the calculated predicted mortality risk.

RESULTS

Observed experience. Overall, 297 patients (79.4% male), with a mean age of 72.8 ± 0.47 years, were identified for inclusion in the study. Of these, 214 (72.1%) underwent EVAR and 83 (27.9%) underwent open AAA repair. Patients undergoing open repair were younger (69.2 ± 0.86 vs 74.3 ± 0.54 years; $P < .0001$) and had a higher prevalence of smoking (71.1% vs 54.7%; $P = .01$) compared with patients undergoing EVAR. There were no significant differences in patient gender, race, comorbidities, or symptomatology between groups (Table I).

Death ≤30 days of surgery occurred in 2.02% (n = 6) of patients overall. The observed perioperative mortality was 1.9% (n = 4) after EVAR vs 2.4% (n = 2) after open repair (odds ratio [OR], 0.77; 95% confidence interval [CI], 0.14-4.29; $P = .67$). There was no difference in