From the Society for Vascular Surgery

Preoperative risk score for the prediction of mortality after repair of ruptured abdominal aortic aneurysms

Brandon T. Garland, MD,[a] Patrick J. Danaher, PhD,[b] Sarasi Desikan, MD,[b] Nam T. Tran, MD,[b] Elina Quiroga, MD,[b] Niten Singh, MD,[b] *and* Benjamin W. Starnes, MD,[b] *Denver, Colo; and Seattle, Wash*

ABSTRACT

Objective: Even in the ruptured endovascular aneurysm repair first era, there are still patients who will not survive their ruptured abdominal aortic aneurysm (rAAA). All previously published mortality risk scores include intraoperative variables and are not helpful with the decision to operate or in providing preoperative patient and family counseling. The purpose of this study was to develop a practical preoperative risk score to predict mortality after repair of rAAA.

Methods: Data of all patients with rAAA presenting between January 1, 2002, and October 31, 2013, were collected. Logistic regression was used to evaluate predictive variables both univariately and jointly, and the results of multivariate models guided the definition of the final simplified scoring algorithm.

Results: There were 303 patients who presented during the study period. Sixteen patients died in the emergency department, en route to surgery, or after choosing comfort care. Preoperative variables most predictive of mortality were age >76 years (odds ratio [OR], 2.11; confidence interval [CI], 1.47-4.97; $P = .011$), creatinine concentration >2.0 mg/dL (OR, 3.66; CI, 1.85-7.24; $P < .001$), pH <7.2 (OR, 2.58; CI, 1.27-5.24; $P = .009$), and systolic blood pressure *ever* <70 mm Hg (OR, 2.70; CI, 1.46-4.97; $P = .002$). Assigning 1 point for each variable, patients were stratified according to the preoperative rAAA mortality risk score (range, 0-4). For all repairs, at 30 days, patients with 1 point suffered 22% mortality; 2 points, 69% mortality; and 3 points, 80% mortality. All patients with 4 points died. There was a mortality benefit for ruptured endovascular aneurysm repair across all categories.

Conclusions: Our rAAA mortality risk score is based on four variables readily assessed in the emergency department and allows accurate prediction of 30-day mortality after repair of rAAAs. It also has a direct impact on clinical decision-making by adding prognostic information to the decision to transfer patients to tertiary care centers and aiding in preoperative discussions with patients and their families. (J Vasc Surg 2018;■:1-7.)

Keywords: Ruptured abdominal aortic aneurysm; REVAR; Mortality risk score; Treatment outcome

Ruptured abdominal aortic aneurysms (rAAAs) remain a leading cause of death in the United States and Europe, with mortality after ruptured open repair (rOR) reported as high as 80%.[1-4] Mortality, however, has improved during the past 40 years,[5] and survival benefit has been shown with the adoption of a ruptured endovascular aneurysm repair (rEVAR) first strategy,[6,7] multidisciplinary patient care protocols,[8-10] and regionalization of advanced aortic care.[11,12] Patients fortunate enough to qualify for rEVAR also have significant survival benefit,[9,12] with mortality reported as low as 16% in some series.[13]

Despite these advancements, many patients will succumb to their rAAA regardless of the care they receive, and it remains difficult to tell who will live and who will die. Several risk scores have been derived to predict mortality after repair of rAAA, such as the Glasgow Aneurysm Score (GAS),[14] Hardman index,[15] Vancouver score,[16] Edinburgh Ruptured Aneurysm Score,[17] and Vascular Study Group of New England (VSGNE) rAAA risk score.[18] However, these scores have differing levels of clinical utility. The GAS has been found to not be predictive of mortality in the endovascular era,[19,20] and both the Hardman index and GAS fail to predict mortality in the highest risk populations.[18] The VSGNE score has been validated in the endovascular era, but it includes intraoperative variables, limiting its clinical utility in preoperative decision-making. We sought to develop a practical, clinically relevant *preoperative* rAAA mortality risk score to aid in clinical decision-making in the endovascular era.

METHODS

Database. Our institution prospectively maintains a ruptured aneurysm data set that includes all patients with a diagnosis of rAAA since January 1, 2002. The maintenance of this data set is approved by our Institutional Review Board, and patients provided written consent or

From the Vascular Institute of the Rockies, Denver[a]; and the Division of Vascular Surgery, Harborview Medical Center, University of Washington, Seattle.[b]

Author conflict of interest: none.

Presented at and a finalist in the poster session of the 2015 Vascular Annual Meeting of the Society for Vascular Surgery, Chicago, Ill, June 17-20, 2015.

Correspondence: Brandon T. Garland, MD, Harborview Medical Center, 325 9th Ave, Box 359908, Seattle, WA 98104 (e-mail: btgarland@gmail.com).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

https://doi.org/10.1016/j.jvs.2017.12.075

consent was waived as indicated by our Institutional Review Board. Six independent data abstractors collect prehospital, emergency department, anesthetic, operative, radiographic, and follow-up data of all patients presenting with rAAAs.

Cohort. We completed a retrospective analysis of our institutional rAAA database including all patients presenting to our institution with ruptured aneurysms between January 1, 2002, and October 31, 2013. Whereas the database includes 145 patient-specific preoperative variables, we focused our analysis on a subset of those easily measured in the preoperative setting. In the setting of an rAAA, many variables will not be obtained, but we decided that certain core variables were always available, which included the following: age, hematocrit, systolic blood pressure (SBP) values from various time points, use of cardiopulmonary resuscitation, pH, international normalized ratio, creatinine concentration, temperature, partial thromboplastin time, weight, history of coronary artery disease, and loss of consciousness at any time.

Each of the patients who had a preoperative computed tomography scan was reviewed by a single surgeon (B.W.S.), who determined whether the patient was eligible for EVAR on the basis of the following criteria: infrarenal neck length and diameter and access vessel size. The patient was classified as eligible for EVAR or not eligible.

Statistical analysis. We screened preoperative variables with univariate analysis against 30-day survival, using *t*-tests for continuous variables and χ^2 tests for categorical variables. We discarded variables that failed to achieve statistical significance and variables with extensive missing data. Of the SBP measurements, we found "lowest prehospital SBP" to be the most predictive of survival, and we discarded the others.

The remaining variables were analyzed simultaneously using logistic regression, including a term for repair type (rOR vs rEVAR) to control for its dramatic effect on the patients' outcomes. One rEVAR and one rOR patient were missing outcome data, a violation of the assumptions of logistic regression too minor to substantially influence the results of the analysis. Whereas type of repair had a noticeable effect on outcome, separate models predicting 30-day mortality based on type of repair did not yield statistical benefit. Only the variable age >76 years returned different estimated log odds ratios (ORs), and this was not statistically significant (Fig 1). As such, we cannot conclude that the more complex approach of fitting different models would improve on the simpler approach of a single model for both repair types.

The final model unambiguously indicated a smaller set of variables to include in a final algorithm; age, creatinine concentration, pH, and lowest prehospital SBP were highly statistically significant predictors of mortality. Of the remaining variables, only cardiopulmonary resuscitation had a *P* value approaching significance (.1). To achieve a practical risk score, these variables were dichotomized at standard levels, and logistic regression was used for the analysis. To ensure that dichotomized variables were not overly simplistic, the C statistic was evaluated for both dichotomized and continuous models, and the performance of the two models was comparable (Fig 2).

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective single-center cohort study
- **Take Home Message:** In an analysis of 303 patients who presented with a ruptured abdominal aortic aneurysm, four preoperative variables were identified that were most predictive of mortality (age >76 years, creatinine concentration >2 mg/dL, pH <7.2, systolic blood pressure <70 mm Hg), and when applied as a risk score of 1 to 4, they predicted increasing mortality from 22% to 69%, 80%, and 100%, respectively.
- **Recommendation:** This study suggests that a risk score using four preoperative variables can predict risk of 30-day mortality in patients with ruptured abdominal aortic aneurysms.

RESULTS

There were 303 patients who presented with rAAAs at our institution between 2002 and 2013. After 2007, patients were repaired according to an "EVAR first" protocol, with each attending surgeon determining the candidacy for endovascular repair. Our cohort was significantly male (80%), and 50% were older than 76 years. They presented with the typical vascular risk factors, including 65% with hypertension, 39% with coronary artery disease, and 22% with chronic obstructive pulmonary disease. A significant number of patients presented with signs of severe shock, including a preoperative heart rate >100 beats/min (23%), preoperative SBP <70 mm Hg (39%), loss of consciousness (30%), and cardiac arrest (14.5%; Table I). There were significant differences between the rEVAR and rOR cohorts with respect to pH <7.2, incidence of preoperative myocardial infarction, and previous aortic surgery.

Throughout the study period, the majority of patients were repaired with open repair (70%). However, after the implementation of an "EVAR first" protocol, the majority of patients were repaired with rEVAR (53%). Of the 303 patients who presented with rAAA, 236 had preoperative computed tomography scans available.