Comparison of a Vascular Study Group of New England risk prediction model with established risk prediction models of in-hospital mortality after elective abdominal aortic aneurysm repair

Mohammad H. Eslami, MD,[a] Denis Rybin, MS,[b] Gheorghe Doros, PhD,[b] Jeffrey A. Kalish, MD,[b] and Alik Farber, MD,[a] for the Vascular Study Group of New England, *Boston, Mass*

Background: A certain number of deaths may result from elective abdominal aortic aneurysm (AAA) repair due to inherent risks of operation; however, no agreement exists about which predictive model for in-hospital mortality is most accurate in predicting these events. This study developed a risk prediction model using Vascular Study Group of New England (VSGNE) data and compared it with established models.

Methods: VSGNE data (2003-2013) were queried for patients undergoing elective AAA repair by open or endovascular techniques. Clinical variables and known predictors of mortality were included in a full prediction model. Backward elimination with $\alpha = .2$ was used to construct a parsimonious model. This VSGNE model was compared with established models—Medicare, Glasgow Aneurysm Score (GAS), and Vascular Governance North West (VGNW)—based on the scope of VSGNE data collection. Model fit was compared with the Vuong test. Model discrimination was compared in equally sized risk-group VSGNE terciles.

Results: The overall mortality rate for 4431 elective AAA patients was 1.4%. The discriminating ability of the VSGNE model was high (C statistic = 0.822) and corrected slightly to 0.779 after internal validation. Vuong tests yielded significant overall fit difference favoring the VSGNE model over the Medicare (C statistic = 0.769), VGNW (C statistic = 0.767), and GAS (C statistic = 0.685) models. The VGNW and Medicare models performed better than GAS in predicting mortality among risk-group terciles.

Conclusions: The VSGNE risk prediction model is best at forecasting mortality among this patient population. The Medicare and VGNW models showed good discrimination. (J Vasc Surg 2015;62:1125-33.)

Abdominal aortic aneurysms (AAAs) are often diagnosed on imaging studies performed for unrelated reasons,[1] and this scenario typically leads to patients being confronted with the prospect of major surgery despite the lack of any symptoms related to the AAA. Current literature supports elective repair for an AAA with a diameter >5.5 cm, and despite numerous advances in the field of vascular surgery, AAA repair carries a 1% to 5% perioperative mortality rate.[2] Certain demographic factors, comorbidities, and intraoperative details have been found to significantly affect mortality rates after elective AAA repair.

In addition, hospital volume,[3] surgeon specialty, and volume[4] have also been shown to influence mortality. These latter factors have prompted calls for regionalization of AAA repair.[5]

Knowing the risk for perioperative mortality is important to most patients, particularly when an asymptomatic AAA is discovered. Risk predictive models can help a patient understand his or her individual mortality risk and guide the patient and surgeon in clinical decision making. Such risk predictive models also allow for risk-adjusted comparison of outcomes among surgeons. A number of established risk predictive models for elective and symptomatic AAA repair have been developed.[6-9]

Grant et al[10] recently evaluated these established models on the United Kingdom National Vascular Database and noted that the Medicare[7] and Vascular Governance Northwest (VGNW) models[6] performed well. In the United States, different quality initiative projects have created cardiac risk index calculation models that a patient or practitioner can use to calculate a patient's cardiac risks after vascular procedures on their Web sites. How commonly these are used during the preoperative conversation with a patient or how commonly patients are referred to these Web sites for calculating their own risks is difficult to ascertain.

The main purpose of this study was to develop a simple risk predictive model of in-hospital mortality after elective

Variables included in the model
Procedure type
Age
Gender
Smoking
Diabetes
Myocardial disease
Cerebrovascular Disease
Congestive Heart Failure
Chronic Obstructive Pulmonary Disease
Myocardial Disease
Peripheral Vascular Disease
Renal Disease
Creatinine
Hematocrit
BMI
Pre-operative Meds

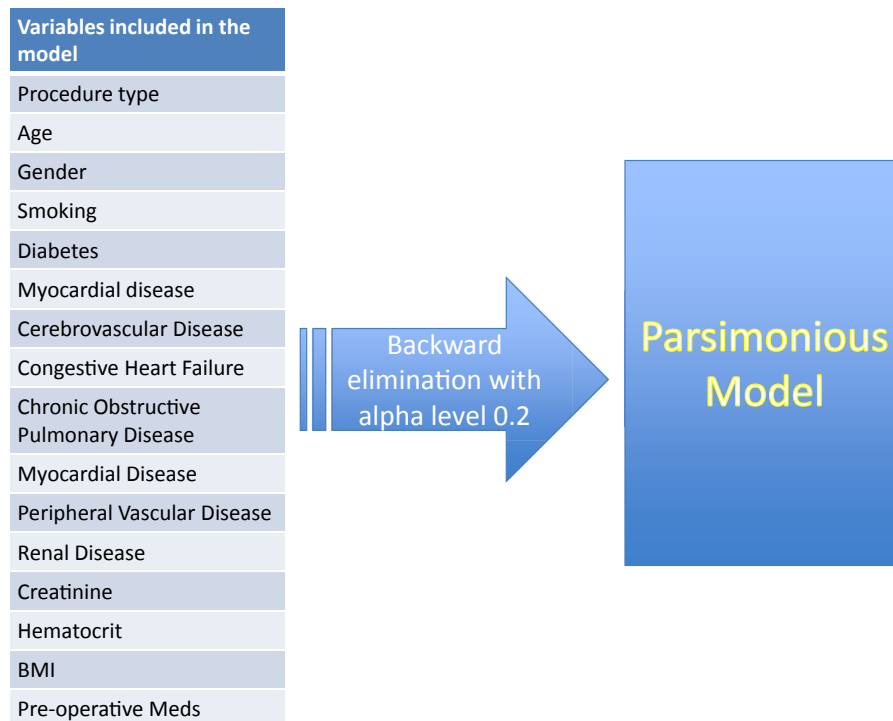Backward elimination with alpha level 0.2 → **Parsimonious Model**

Fig 1. Schematic of the process to arrive at the Vascular Study Group of New England (VSGNE) parsimonious model. Preoperative medications include β-blockers and statins at the day of surgery, without any information about the duration of the medication use. *BMI,* Body mass index.

AAA repair among the Vascular Study Group of New England (VSGNE) patients. The current models are cumbersome and require complicated calculation, and many do not account for the anatomic information of the aneurysm or the planned conduct of aortic repair. The performance of this model was then compared against three established models: the Medicare,[7] Glasgow Aneurysm Score (GAS),[8] and VGNW[6] models. Comparison was performed across the entire cohort and then by dividing the sample into three surgical risk terciles—low risk, medium risk, and high risk—using the American Society of Anesthesiologists Physical Status Classification risk stratification.

METHODS

The VSGNE database and data collection. Details about the VSGNE database are widely available[11] and previously published.[12] This regional cooperative was created in 2002 to prospectively collect data on patients who undergo vascular procedures with the aim of improving regional outcomes in vascular surgery.[12] Since its inception, the database has expanded to include >35 academic and community hospitals.[11] Data are prospectively collected by trained nurses or clinical abstractors on >100 clinical and demographic variables as defined by VSGNE.[11] The Institutional Review Board of Boston University School of Medicine has approved the use of deidentified data for this study. Because we used deidentified database, informed consent was not required.

Cohort. All patients who underwent elective infrarenal AAA repairs in >30 VSGNE centers between 2003 and 2013 were evaluated for all demographic data, perioperative comorbidities, and specific intraoperative details such as open vs endovascular repair and the position of the aortic clamp during open repair. The study excluded patients in the database who had a nonelective admission for AAA repair, had prior aortic surgery, were missing information for age, gender, or procedure type, and those with a supraceliac clamp during aortic repair.

Descriptive analyses were performed on the entire cohort, identifying mortality risk factors. These factors were compared between the two operative groups using the Student *t*-test for continuous variables and the χ^2 test for categoric variables.

Model creation and internal validation. The VSGNE tracks outcomes, including in-hospital mortality, adverse events, and long-term survival, by matching patients with the Social Security Death Index. The primary outcome of interest was in-hospital postprocedural mortality. To create a risk predictive model of mortality, we included clinical variables of interest in a full predictive model using multivariable logistic regression (Fig 1; Table I). Backward elimination procedure with an $\alpha = .2$ was used to create a more parsimonious model of variables that independently predict mortality.[13]

The predictive performance of these models was determined using threshold independent measures. Calibration