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Risk Stratification of Ruptured Abdominal Aortic Aneurysms in Patients Treated by Open Surgical Repair

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WHAT THIS PAPER ADDS

The present study evaluated scoring systems for ruptured abdominal aortic aneurysms treated by open surgery. The Edinburgh Rupture Aneurysm Score was superior in predicting outcome and handling. A stepwise increase in the score was correlated with a consecutive increase in mortality. Moreover, the analyses showed a diverse prevalence of survival between different subgroups (10—70%). This high variance underscores the need for risk stratification in clinical trials because only risk based subgroups allow precise analysis in different clinical settings and for different treatment options.

Objective: The present study tested scoring models for ruptured abdominal aortic aneurysms (rAAAs) in patients treated by open surgical repair (OSR). Scores were tested in a European population to validate their applicability for predicting outcome.

Methods: Between 2002 and 2013, 92 patients with rAAAs underwent OSR and medical records were reviewed retrospectively. The Edinburgh Rupture Aneurysm Score (ERAS), Vascular Study Group of New England (VSGNE) rAAA risk score, Hardman Index, and Glasgow Aneurysm Score (GAS) were calculated and analyzed according to in hospital mortality. The discriminatory power and calibration of all models were assessed by applying the receiver operating characteristic and the Hosmer—Lemeshow test χ^2.

Results: An ERAS $\leq$1 ($n = 55$), 2 ($n = 15$) and 3 ($n = 16$) was associated with a mortality of 27%, 47%, and 69%, respectively. The calibration was the best of all tested scores ($\chi^2 = 0.44$; $p = .81$) and the area under the curve (AUC) was 0.71 (95% CI 0.6—0.82; $p = .001$). A VSGNE rAAA risk score = 0 ($n = 19$), 1 ($n = 15$), 2 ($n = 19$), 3 ($n = 25$), and $\geq$4 ($n = 9$) was associated with a mortality of 11%, 20%, 32%, 72%, and 56%, and an AUC of 0.76 (95% CI 0.66—0.87; $p = .001$). The calibration was reduced ($\chi^2 = 6.9$; $p = .08$). The GAS and Hardman Index increased stepwise with increasing in hospital mortality, but were inferior to ERAS and the VSGNE rAAA risk score. The Hardman Index showed the smallest AUC (0.68; 95% CI 0.56—0.80; $p = .011$) and demonstrated a lack of fit ($\chi^2 = 8.2$; $p = .04$). The GAS showed good discrimination (AUC = 0.75; 95% CI 0.64—0.85; $p < .001$) and calibration ($\chi^2 = 0.85$; $p = .66$); however, the parametric scale of GAS limits its use to classifying patients according to their risk.

Conclusion: The present study revealed remarkable differences in survival between subgroups (10—70%) and underscores the need for risk stratification. The ERAS was favorable with striking ease of use and high accuracy in predicting outcome.

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INTRODUCTION

Endovascular aneurysm repair (EVAR) and open surgical repair (OSR) are competitively employed for the treatment of ruptured aortic abdominal aneurysms (rAAA), with continued debate about the best treatment option with the lowest mortality rate. Systematic reviews based on observational studies have revealed survival benefits for EVAR,[1—3] although randomized trials did not show significant differences in mortality.[4—6] The reason for those disparate results is unclear.

High mortality variance between different clinical trials illustrates one dilemma:[7] RAAA are not classified. Patients with retroperitoneal bleeding are compared with patients with "free ruptures," and patients under resuscitation are compared with hemodynamically stable patients. Clearly,

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intra-abdominal bleeding is the overall life limiting factor causing instability and hemodynamic shock. One way to assess the severity of the patient's condition and hemodynamic shock is the use of risk scores, which were initially introduced to vascular surgery to predict outcome. The Vascular Study Group of New England (VSGNE) rAAA risk score is derived from intra-operative and pre-operative parameters.[8] The Edinburgh Rupture Aneurysm Score (ERAS),[9] the Glasgow Aneurysm Score (GAS),[10] and the Hardman Index[11] are derived exclusively from pre-operative parameters (Table 1).

Besides predicting mortality, scoring models can be useful in the design of clinical trials. Scores can be applied to stratify cohorts according to their severity of rupture, and, hence, low risk patients and high risk patients can be pooled and analyzed separately.[12] This is of special interest as clinical trials are conducted in a manner to avoid heterogeneous patient characteristics. In addition, opposing results from recent clinical trials could be clarified by risk stratification as this has often been neglected.[7]

In the present study, several scoring systems were tested in patients with rAAA treated by OSR. The VSGNE risk score and ERAS were validated for the first time in a European population by a research group who did not develop the score. In addition, the GAS and Hardman Index were tested. The present report underscores the diverse prevalence of survival rates between subgroups and emphasizes the use of scoring models when comparing EVAR and OSR.

METHODS

Setting

This retrospective study was conducted at the Division for Vascular Surgery, Department of Surgery, University Hospital Leipzig (Leipzig, Germany) and comprised only patients who underwent OSR. Ninety-eight patients with rAAA were admitted between January 2002 and August 2013, and 92 of them underwent OSR. Six patients were excluded from analysis because they were treated by EVAR; this was first used in the department in 2011 and performed when suitable (proximal neck length $>$ 10 mm, proximal neck diameter $<$ 32 mm and proximal neck angulation $< 90°$).

Pre-operative diagnostic steps were supervised by the consultant vascular surgeon including medical history, physical examination, abdominal ultrasound, and computed tomography. Surgery was performed by the consultant vascular surgeon. The diagnosis of rAAA was defined as a considerable amount of retroperitoneal or intraperitoneal blood when no other cause of bleeding was identified. The intensive care unit provided beds exclusively for surgical patients and was supervised by the Department of Anesthesiology and Intensive Care Medicine.[13] Medical records were reviewed based on outcome and clinical characteristics including lowest systolic blood pressure before surgery (SBP), time between admission and surgery, aortic clamp position, blood transfusion, type of rupture, and type of surgery.

Scoring models

To predict the outcome in patients who underwent OSR, different scoring models were assessed and validated (Table 1). The following models were tested: the VSGNE rAAA risk score,[8] ERAS,[9] GAS,[10] and the Hardman Index.[11] These models are based on pre-operative patient characteristics, except for the VSGNE risk score (which includes suprarenal clamping as an intra-operative variable). The GAS represents a parametric variable. Therefore, the score was split into quartiles (1—4), allowing comparison of GAS with other scores that have categorical characteristics. Scores for ERAS, VSGNE, GAS, and the Hardman Index were not calculated in 6, 5, 2, and 18 cases, respectively (Fig. S1, Supplementary material). Missing parametric variables were imputed by linear regression; missing categorical values were imputed by logistic regression.

Statistical analyses

The area under the receiver operating characteristic curve (AUC) was calculated to assess the discriminative power of each scoring model to predict whether a patient would survive or die. Calibration was assessed by Hosmer—Lemeshow test χ^2 to determine the goodness of fit. Briefly, a $\chi^2 > 0.05$ indicated a good fit as the observed mortality does not differ from the predicted mortality according to the grade of the score. Univariate analysis of all variables was carried out to

Table 1. Calculation of scoring systems.

RAAA scoring system	
Edinburgh Ruptured Aneurysm Score	=1 (for hemoglobin <9 g/dL) + 1 (for GCS < 15) + 1 (for pre-operative systolic BP < 90 mmHg)
VSGNE rAAA risk score	=2 (for age > 76) + 2 (for cardiac arrest) + 1 (for loss of consciousness) + 1 (for suprarenal clamping)
Glasgow Aneurysm Score	=Age + 17 (for shock) + 7 (for myocardial disease) + 10 (for cerebrovascular disease) + 14 (for renal disease)
Hardman Index	=1 (for age > 76) + 1 (for creatinine > 190 μmol/L) + 1 (for loss of consciousness after admission) + 1 (for hemoglobin <9 g/dL) + 1 (for electrocardiographic ischemia)

BP = blood pressure; GCS = Glasgow Coma Scale; VSGNE = Vascular Study Group of New England.
Each patient was calculated and staged selectively. Myocardial disease is defined as previous myocardial infarction and/or ongoing angina. Cerebrovascular disease is classified as all grades of stroke, including transient ischemic attack. Renal disease is classified as acute or chronic renal failure. Shock is defined as hypotension, sweating, tachycardia, and pallor.