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Development and External Validation of a Model Predicting Death After Surgery in Patients With a Ruptured Abdominal Aortic Aneurysm: The Dutch Aneurysm Score

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WHAT THIS PAPER ADDS

This paper presents a new model, the Dutch Aneurysm Score (DAS), predicting risk of death after intervention for a ruptured abdominal aorta aneurysm (rAAA). It uses easy to obtain pre-operative variables; age, lowest systolic blood pressure, cardiopulmonary resuscitation, and haemoglobin level. This study shows the DAS is a more accurate risk model than the Glasgow Aneurysm Score for rAAAs. The DAS can reliably be used by clinicians to make a more informed decision in dialogue with the patient and their family whether or not to proceed with surgical intervention.

Objective: The decision whether or not to proceed with surgical intervention of a patient with a ruptured abdominal aortic aneurysm (rAAA) is very difficult in daily practice. The primary objective of the present study was to develop and to externally validate a new prediction model: the Dutch Aneurysm Score (DAS).

Methods: With a prospective cohort of 10 hospitals ($n = 508$) the DAS was developed using a multivariate logistic regression model. Two retrospective cohorts with rAAA patients from two hospitals ($n = 373$) were used for external validation. The primary outcome was the combined 30 day and in-hospital death rate. Discrimination (AUC), calibration plots, and the ability to identify high risk patients were compared with the more commonly used Glasgow Aneurysm Score (GAS).

Results: After multivariate logistic regression, four pre-operative variables were identified: age, lowest in hospital systolic blood pressure, cardiopulmonary resuscitation, and haemoglobin level. The area under the receiver operating curve (AUC) for the DAS was 0.77 (95% CI 0.72–0.82) compared with the GAS with an AUC of 0.72 (95% CI 0.67–0.77). The DAS showed a death rate in patients with a predicted death rate $\geq$80% of 83%.

Conclusions: The present study shows that the DAS has a higher discriminative performance (AUC) compared with the GAS. All clinical variables used for the DAS are easy to obtain. Identification of low risk patients with the DAS can potentially reduce turndown rates. The DAS can reliably be used by clinicians to make a more informed decision in dialogue with the patient and their family whether or not to proceed with surgical intervention.

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INTRODUCTION

The population based 30 day death rate of patients with a ruptured abdominal aortic aneurysm (rAAA) is approximately 74% (95% CI 72–77%).[1] Two thirds of patients with a rAAA reach the hospital alive, but an average of 40% (range 9–80% from 21 studies) of these are not surgically treated in many hospitals because of presumed very poor prognosis, advanced age, and/or patient preference. Criteria whether to surgically treat or not, vary significantly according to local experience and cultural settings.[2] The decision to start or withhold surgical intervention is based on an evaluation of the patient's clinical condition, the surgeon's experience, and the patient's preferences. It is a subjective interpretation by the doctor, the patient, and the relatives. As a consequence, considerable differences exist

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in turndown rates. In the recently published IMPROVE and AJAX trials, the turndown rates were 23% (299/1275 patients) and 9% (46/520 patients), respectively.[3–5] Clinicians and patients could benefit from a tool to predict survival after surgical intervention, especially, if one considers the high burden for relatives, hospitals, and society in case of unsuccessful repair. A prediction model is an objective way to evaluate the chances of successful intervention.

Several models have been developed to predict death after surgical intervention in patients with a rAAA. In a recent external validation study in the Amsterdam region,[6] the Glasgow Aneurysm Score (GAS)[7,8] most accurately predicted death after intervention for a rAAA compared with the Vancouver scoring system,[9] the Edinburgh Ruptured Aneurysm Score,[10] and the Hardman index.[11] However, the GAS which was originally developed for elective as well as rAAA, could not reliably support the decision to withhold surgery. Because the alternative to repair generally results in death of the patient, the model should be very reliable. Furthermore, a uniformly used prediction model could enhance the transparency of ruptured aneurysm care.

The primary objective of the present study was to develop and to externally validate a more reliable prediction model for patients with a rAAA: the Dutch Aneurysm Score (DAS). Additionally, this study aimed at identifying high risk patients with a predicted 30 day/in-hospital death rate of $\geq$50%. Such a model can support the decision to start surgical intervention or not. With the identification of a low predicted risk of mortality the DAS might also aid in the decision to offer treatment in patients otherwise turned down for surgery. The predictive performance of the DAS was compared with the performance of the GAS.

METHODS

The present study comprised three Dutch cohorts including patients with a rAAA; one cohort from Amsterdam, one from Rotterdam, and one from Groningen. The Amsterdam cohort was used for the development of the DAS and the cohorts from Rotterdam and Groningen for external validation. The diagnosis of rAAA in these cohorts was based on emergency computed tomographic angiography,[12] on findings at operation, or on findings at autopsy. Patients with a previous aortic reconstruction, an inflammatory or mycotic rAAA, or a rAAA with associated trauma, with aorto-caval or aorto-enteric fistula were not included in the present study. The primary endpoint was the combined 30 day and in-hospital death rate. This means patients were included who died in hospital at any time during and after the initial treatment, and all patients who died within 30 days of initial treatment disregarding whether they were in hospital or not. The combination of death rates was chosen because use of only one or the other would render the results more subject to bias, as one will always score a lower death rate than with a combined death rate. This study was approved by the institutional review boards of all three centres (Amsterdam [METC 03/161], Rotterdam [METC 2015/017], and Groningen [M15.169119]).

Details regarding the cohort from Amsterdam have been published previously.[4,6,13] In short, all consecutive patients with a rAAA from 10 hospitals (8 secondary care and 2 tertiary care facilities) in the Amsterdam ambulance region between May 2004 and February 2011 were registered prospectively. Details regarding the cohort from Rotterdam have also been published previously.[14,15] In short, this was a single tertiary centre cohort including all surgically treated patients with a rAAA between January 2004 and December 2012. Patients were identified retrospectively from a hospital registry. The cohort from Groningen was also from a single tertiary centre, including all surgically treated patients with a rAAA between January 2004 and December 2012. Patients were identified from a prospective registry. The Rotterdam and Groningen cohorts were considered acceptable for external validation as treatment protocols and hospital sizes were all similar and hospitals were all located in the same country. The Transparent Reporting of a multivariate Predictions model for individual prognosis or Diagnosis (TRIPOD) statement for reporting a multivariate prediction model were used as guidelines for this article to facilitate assessment of usefulness of this prediction model by the reader.[16,17]

Data management

Data were collected from the medical records for the prospective hospital cohort by the second author and for the two retrospective hospital cohorts by the first author following a standard case protocol. All the data were examined retrospectively. Based on previous prediction models for patients with a rAAA [5–9] and on the availability of the variable in the emergency room, data on the following potential predictors were collected: age (years), sex (male/female), cardiac comorbidity (defined according to the Society for Vascular Surgery (SVS) guidelines as previous history of myocardial infarction, heart failure, cardiac surgery, angina pectoris or arrhythmia), cerebrovascular comorbidity (defined according to the SVS guidelines as previous history of stroke or transient ischaemic attack), lowest pre-operative in-hospital systolic blood pressure (mmHg), cardiopulmonary resuscitation (yes/no), loss of consciousness (yes/no), serum creatinine (μmol/L), serum haemoglobin (mmol/L), and type of intervention (endovascular or open repair). The data were collected in no particular order because the primary endpoint of this study, combined 30 day or in-hospital death rate, was an objective measurement.

Statistical analysis

The statistical analysis was conducted by the second author according to a recently published seven step model for development and an ABCD for validation of a clinical prediction model.[18] The analysis comprised two steps: first, the development of the DAS in the prospective database from Amsterdam also including patients who were rejected for surgery or intervention, and, second, the external validation in the retrospective cohorts from Rotterdam and Groningen.

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