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ORIGINAL ARTICLE

Artificial neural network score potential in in-hospital mortality after ruptured aortic aneurysm repair in a tertiary hospital

Leandro Nóbrega, Lara Dias, Tiago Pereira, Tiago Moura, Rita Piedade, Pedro Paz Dias, Marina Dias-Neto, Joana Ferreira, Armando Mansilha

Serviço de Angiologia e Cirurgia Vascular, Centro Hospitalar Universitário de São João, Porto
Departamento de Fisiologia e Cirurgia, Faculdade de Medicina, Universidade do Porto

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ABSTRACT

INTRODUCTION: Isolated use of scoring systems is not recommended for selecting patients for repair or palliation of ruptured abdominal aortic aneurysm (rAAA). Artificial intelligence may lead to improved scoring systems in the future, but current evidence is scarce. The aim of this study is to assess the applicability and potential of an artificial neural network (ANN) score in a tertiary hospital.

METHODS: A retrospective review of patients who underwent repair for rAAA at a tertiary institution from January 2012 to December 2024 was conducted. One point was assigned for each ANN item: age > 70 years, loss of consciousness, cardiac arrest, and shock. The primary outcome was in-hospital mortality.

RESULTS: A total of 150 patients were admitted for rAAA repair between 2012 and 2024. Three patients were excluded for lack of relevant information. The mean age was 73.7 (±9.5) years, and the majority were male (91.2%; n=134). The prevalence of smoking history was 47.6% (n=70). Open repair was performed in 58.5% (n=86). According to the ANN score, 17.0% (n=25) scored 0, 25.2% (n=37) scored 1, 32.0% (n=47) scored 2, 19.0% (n=28) scored 3, and 6.8% (n=10) scored 4. In the univariable analysis, patients with scores of 3 and 4 had a higher risk of in-hospital mortality (OR 11.8; 3.2-43.0, CI 95%; p < 0.001 and OR 10.3; 1.7-60.9, CI 95%; p = 0.010, respectively), whereas patients with a score of 2 had higher mortality but did not reach statistical significance (OR 2.7; 0.9-7.7, CI 95%; p = 0.064). The area under the curve for the ANN score was 0.72 (CI 95% 0.63-0.80).

CONCLUSION: The ANN score had moderate predictive power for in-hospital mortality in our population, especially among patients with higher scores. However, the study's unicentric and retrospective nature are limitations. Future models based on a larger number of patients may yield better predictive performance.

Keywords: Aortic Rupture; Mortality; Artificial Intelligence

INTRODUCTION

Ruptured abdominal aortic aneurysm (rAAA) is a surgical emergency associated with high mortality, which can be as high as 40%.[1] In hemodynamically unstable patients undergoing open surgical repair (OSR), mortality can reach 60%.[2] Despite the decrease in mortality with endovascular repair (EVAR) and centralization of care, rAAA remains a complex clinical scenario.[3]

The 2024 ESVS Clinical Practice Guidelines on the Management of Aorto-iliac Artery Aneurysms recommend against using scoring systems alone to select patients for

Corresponding Author:
Leandro Nóbrega | leandronobrega515@gmail.com
Alameda Professor Hernâni Monteiro, 4200 - 319 Porto, Portugal

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repair or palliation in rAAA (Class III; Level B), but they may help in discussions with patients and families.[3] Over the years, several scores have been developed to aid decision-making and predict mortality in rAAA. These include the Vascular Study Group of New England [4], the Dutch Aneurysm Score[5], the Harborview Risk Score[6], and the modified Harborview Risk Score[7], all of which can predict 30-day or in-hospital mortality. Some, such as the Artificial Neural Network Score (ANN)[8], are based on artificial intelligence. According to the authors, they input all variables into an ANN program and randomly selected a "training" set of 80% of patients. The software used a series of equations based on the hyperbolic tangent function to develop a complex model in which factors or combinations thereof lead to survival or in-hospital mortality, and it outputs a value between 0 (survival) and 1 (in-hospital mortality). This model requires no minimum sample size or parameters but used a 20% validation set and k-fold validation as a precaution against overfitting to ensure internal validity. It was compared with the Glasgow Aneurysm Score in a population in which EVAR was performed in 13.6% of cases.[8]

Artificial intelligence may improve scoring systems in the future, but current evidence is scarce. This study aims to assess the applicability and potential of this ANN score in a tertiary hospital.

METHODS

We performed a retrospective review of consecutive patients who underwent rAAA repair at a tertiary center between January 2012 and December 2023. Patient demographics, comorbid conditions, vital signs, laboratory values, repair type, and postoperative outcomes were collected. Only patients with isolated abdominal aortic aneurysms or aorto-iliac aneurysms were included. We excluded patients without complete data for score calculation, as well as those with thoracic or isolated iliac aneurysms.

The ANN score includes the following items: age > 70 years, loss of consciousness, cardiac arrest, and shock. Loss of consciousness was defined as a Glasgow Coma Scale score below 15 at any time. Shock was defined as the presence of at least one of the following: SBP < 90, HR > 120, diaphoresis and/or pallor. Documentation in the medical record was sufficient to attribute a variable, as in the original study.[8] The primary outcome was in-hospital mortality.

For statistical analyses, we used SPSS (IBM Corp., IBM SPSS Statistics for Mac, version 30.0, Armonk, NY, USA). We performed univariate analyses to calculate odds ratios. Discrimination was quantified using receiver operating characteristic (ROC) curves (fair discrimination: area under the curve [AUC] ≥ 0.70).

RESULTS

A total of 150 patients were admitted for rAAA repair during the analyzed time period. We excluded three patients due to missing clinical information needed to calculate the ANN score. Aneurysm diameter information was available for only 128 patients.

Most patients were male (91.2%; n=134), and the mean age was 73.7 (±9.5) years. Hypertension had the highest prevalence (71.4%; n=105), while 47.6% (n=70) and 13.6% (n=20) had a history of smoking and diabetes mellitus, respectively. Table 1 shows patients' demographics and characteristics.

Table 1. Patient demographics and characteristics

Characteristics	Total (n=147)
Sex (male)	134 (91.2%)
Age (years)	73.7 ± 9.5
Smoking History	70 (47.6%)
Hypertension	105 (71.4%)
Diabetes Mellitus	20 (13.6%)
Dyslipidaemia	69 (46.9%)
Chronic Kidney Disease	18 (12.2%)
Cerebrovascular Disease	12 (8.2%)
Coronary Artery Disease	26 (17.7%)
Open Surgical Repair	86 (58.5%)

Most patients were transferred from another hospital (64.6%; n=95), and a minority had a known aneurysm diagnosis (27.9%; n=41). The mean aneurysm diameter was 83.13 (±21.30) mm. OSR was performed in 58.5% (n=86).

Tables 2 and 3 present the distribution of patients by item and score, respectively. Table 4 shows mortality rates. In the univariable analysis, patients with scores of 3 and 4 had a higher risk of in-hospital mortality (OR 11.8; 95% CI 3.2-43.0; p < 0.001 and OR 10.3; 95% CI 1.7-60.9; p = 0.010, respectively), whereas patients with a score of 2 had higher mortality but did not reach statistical significance (OR 2.7; 0.9-7.7, CI 95%; p = 0.064). Patients with a score of 1 also did not have a statistically significantly higher mortality risk (OR 1.4; 0.5-4.2, CI 95%; p = 0.556). The area under the curve for the ANN score was 0.72 (95% CI, 0.63- 0.80).

Table 2. Artificial Neural Network Score Item Distribution

ANN Item	N (%)
Age>70 years	96 (65.3%)
Loss of Consciousness	62 (42.2%)
Cardiac Arrest	12 (8.2%)
Shock	87 (59.2%)

ANN – Artificial Neural Network

Table 3. Artificial Neural Network Score Distribution

ANN Item	N (%)
0	25 (17.0%)
1	37 (25.2%)
2	47 (32.0%)
3	28 (19.0%)
4	10 (6.8%)

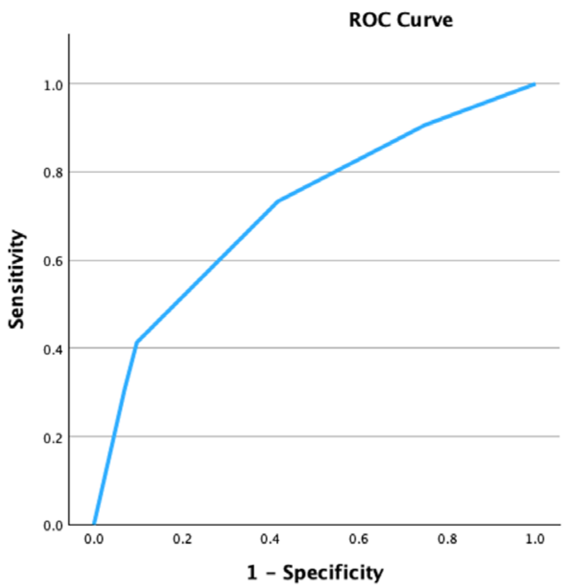
ANN – Artificial Neural Network

Table 3. Mortality according to the Artificial Neural Network Score

ANN Score	Mortality (N (%))
0	7 (28.0%)
1	13 (35.1%)
2	24 (51.1%)
3	23 (82.1%)
4	8 (80.0%)

ANN – Artificial Neural Network

Figure 1. Mortality according to the Artificial Neural Network Score



DISCUSSION

Results in this cohort revealed that the ANN score had moderate discriminative power for predicting in-hospital mortality after rAAA repair. Patients with higher scores (3 and 4) had a significantly higher risk of in-hospital mortality. For patients with scores of 1 and 2, this was not statistically significant. The score's main advantage is its reliance on easily obtainable clinical variables at admission, making it practical for emergency settings.

Wise et al. first published the ANN score.[9] They included 125 patients, of whom 108 (86.4%) underwent OSR. They identified five independent predictors of in-hospital mortality. They excluded kidney disease from the model. In their cohort, the ANN AUC was 0.88 ± 0.04 and demonstrated better discrimination than a multiple logistic regression model and the Glasgow Aneurysm Score (GAS). Compared with our cohort, they had lower mortality rates for scores of 0 (11%) and 1 (16%), fewer patients older than 70 years (54%), and a lower mean age at rupture (70.3 years). Our older population might explain our higher mortality at lower scores and, therefore, the lack of discriminative power. Their results at higher scores align with ours.

More recently, Luebke et al. studied the ANN score at a European center for external validation.[10] They included 130 patients and had a mean age similar to that of our cohort. They did not provide mortality values for each score, but the AUC was 0.82 ± 0.05. They also studied two modified versions of the ANN with 12 (gender, age at rupture, loss of consciousness after presentation, signs of shock, preoperative cardiac arrest, history of myocardial infarction or angina, stroke or transient ischemic attack, any of chronic renal failure, acute kidney injury, urea level >20 mmol/L, creatinine level >1.7 mg/dL and body mass index) and 14 variables (including the GAS and the Hardman Index). The most discriminative model was the ANN with 14 preoperative variables (including the Hardman Index and the GAS), with an AUC of 1.00 ± 0.06. This suggests that there is room to optimize this score to improve discriminative power.

In another study, Li et al. compared eight scores in rAAA.[11] They included 300 patients from a multicenter integrated regional healthcare system with a large central quaternary referral facility. The cohort had a mean age of 73.6 years; 72.1% were MALE and OSR was performed in 49.8%. Their overall 30-day mortality rate was 32.1%. The updated GAS had the best discrimination. Contrary to previously published literature, ANN did not perform as well, and its discrimination was worse with OSR (AUC 0.66) than with EVAR (AUC 0.70). They noted that all models showed only fair discrimination and poor to adequate calibration, reflecting their limited utility in clinical decision-making.

Our study had several limitations. It was a retrospective, single-center design with a small sample. Many patients were transferred from other hospitals, and some were admitted directly to the operating room, which could result in incomplete data capture and potential selection bias. These limitations hinder its generalizability.

The clinical integration of artificial intelligence (AI) may benefit modern healthcare delivery by improving diagnostic accuracy, streamlining clinical workflows, and facilitating personalized patient care. However, these benefits must be carefully weighed against potential drawbacks. Implementing such systems often requires substantial financial investment and specialized staff training, and may introduce technological dependencies that risk disrupting traditional workflows if system failures occur. Ethical considerations are also important, including data privacy, informed patient consent, and the potential erosion of the traditional physician-patient relationship. Establishing sound regulatory frameworks and ethical guidelines will be paramount to maximizing AI's clinical utility while safeguarding patient welfare.

CONCLUSION

In our cohort, the ANN score showed moderate predictive power for in-hospital mortality, particularly among patients with higher scores. However, this was not verified for the first two score levels.

This score has the advantage of using clinical factors that are easy to obtain on admission. However, the study's unicentric, retrospective design and small sample size limit its generalizability. Future models based on a larger number of patients may yield better predictive performance.

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