



**Australian Government**  
**Department of Health and Ageing**



Australia and New Zealand Horizon Scanning Network

**ANZHSN**

AN INITIATIVE OF THE NATIONAL, STATE AND  
TERRITORY GOVERNMENTS OF AUSTRALIA  
AND THE GOVERNMENT OF NEW ZEALAND

# **Horizon Scanning Technology Prioritising Summary**

## **The APACHE-AAA scoring system in patients undergoing abdominal aortic aneurysm repair**

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**Australian  
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Register  
of New  
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Surgical**



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Enquiries about the content of the report should be directed to:

HealthPACT Secretariat  
Department of Health and Ageing  
MDP 106  
GPO Box 9848  
Canberra ACT 2606  
AUSTRALIA

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This Horizon scanning prioritising summary was prepared by Ms. Karen Humphreys from the Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S).

# PRIORITISING SUMMARY

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**REGISTER ID**

**S000067**

**NAME OF TECHNOLOGY**

**APACHE-AAA SCORING SYSTEM**

**PURPOSE AND TARGET GROUP**

**PATIENTS UNDERGOING ABDOMINAL AORTIC ANEURYSM REPAIR**

## STAGE OF DEVELOPMENT (IN AUSTRALIA)

- |   |   |
|---|---|
| <input type="checkbox"/> Yet to emerge              | <input type="checkbox"/> Established  |
| <input type="checkbox"/> Experimental               | <input type="checkbox"/> Established <i>but</i> changed indication or modification of technique |
| <input checked="" type="checkbox"/> Investigational | <input type="checkbox"/> Should be taken out of use   |
| <input type="checkbox"/> Nearly established         |   |

## AUSTRALIAN THERAPEUTIC GOODS ADMINISTRATION APPROVAL

- |  |             |           |
|--|-------------|-----------|
| <input type="checkbox"/> Yes                       | ARTG number | <b>NA</b> |
| <input type="checkbox"/> No                        |             |           |
| <input checked="" type="checkbox"/> Not applicable |             |           |

## INTERNATIONAL UTILISATION

COUNTRY	LEVEL OF USE		
	Trials Underway or Completed	Limited Use	Widely Diffused
Australia	✓		
Canada	✓		
Germany	✓		
Greece	✓		
Switzerland	✓		
United Kingdom	✓		
United States	✓		

## IMPACT SUMMARY

The APACHE II scoring system has been available for several decades and was originally developed for use in acutely ill patients to predict risk of death. An emerging use for a modified version of this scoring system (APACHE-AAA) is to predict mortality risk in patients who have undergone abdominal aortic aneurysm (AAA) repair. The APACHE-AAA was designed for use in an audit capacity to assess quality of care in AAA patients, adjusting for hospital related factors and the patient case mix.

## **BACKGROUND**

An abdominal aortic aneurysm is defined as a dilation of the abdominal aorta greater than > 3 cm (Golledge et al. 2006). AAAs, which occur gradually over a number of years due to progressive weakening of the aortic wall, usually manifest in the section of the aorta located near the kidneys (Vorp 2007). Caused by weakening of the aortic wall, if left untreated, AAAs will progressively dilate and can eventually rupture (Golledge et al. 2006). Treatment of an unruptured AAA involves repair by either open surgery or a minimally invasive endoluminal procedure (Golledge et al. 2006).

Elective open repair of an AAA has a mortality rate of between 2.5% (Lederle et al. 2002) and 9.5% (Hadjianastasiou et al. 2006). Mortality in the minimally invasive procedure (endovenous repair) was one third of that of open repair in the EVAR-1 and DREAM trials (Greenhalgh et al. 2004; Blankensteijn et al. 2005). In contrast, the mortality rate associated with emergency repair of a ruptured AAA is around 50%. Patients who present to the emergency department alive often survive the initial emergency procedure, but die or develop life-threatening complications in the postoperative period (Sandford et al. 2007). Since most patients with AAA are elderly, the likelihood of AAA rupture must be balanced against the risks associated with surgical repair (Vorp 2007). Small AAAs tend to be followed by periodic ultrasound surveillance until the aortic diameter approaches 5.5 cm, when the risk of surgical repair is deemed warranted (Golledge et al. 2006).

Surgeons use clinical judgement to determine if surgery and postoperative intervention for a patient with AAA is appropriate and is associated with a realistic chance of survival (Tambyraja et al. 2007). Risk assessment scoring systems have been developed as a more objective way of identifying those patients who are at high risk of postoperative mortality or morbidity, whether that be from elective or emergency surgery (Sandford et al. 2007). Several scoring systems, such as the Physiological and Outcome Severity Score for enumeration of Mortality and Morbidity (POSSUM), the Acute Physiology and Chronic Health Evaluation II (APACHE II), and the Simplified Acute Physiology Score II (SAPS II) were originally developed for the general acute hospital setting and have since been applied to patients with AAA. These models require peri- and/or postoperative data, and can only be used postoperatively to predict mortality. Others developed specifically for AAA include the Hardman index and the Glasgow Aneurysm Score (GAS), both of which can be calculated preoperatively.

Mortality prediction scoring systems can have various functions depending on whether they can be calculated pre- or postoperatively. They may be used as an audit of clinical performance by comparing actual with predicted mortality or used in research to compare group characteristics. At the patient level, an accurate mortality prediction system can potentially be used by clinicians to guide patients and their relatives through the informed consent process for surgery or postoperative treatment options, and more controversially to influence pre- or postoperative clinical management (Hadjianastasiou et al. 2006).

A recent systematic review concluded that the POSSUM, GAS, Hardman index, and Vancouver Scoring System were not effective tools for predicting postoperative mortality

in patients with a ruptured AAA (Tambyraja et al. 2007). The generic APACHE II scoring system, which was first described in 1985 for use in patients admitted to the intensive care unit (ICU), has also been applied to patients who have undergone elective or emergency AAA repair. It uses a point score based on the values of 12 routine physiologic measures, age, and previous health status, to stratify acutely ill patients by risk of death (Knaus et al. 1985). The 12 variables are: temperature; mean arterial pressure; heart rate; respiratory rate; partial oxygen pressure; arterial pH; serum levels of sodium, potassium and creatinine; haematocrit; white blood count; and Glasgow coma score. APACHE II scores are completed in the first 24 hours after surgery, and can range from 0 to 71; high scores have been shown to correlate with an increased risk of hospital death (Knaus et al. 1985).

A recent study by Sandford et al. (2007) compared APACHE II to POSSUM and SAPS II, in 152 patients undergoing open aneurysm repair (101 elective and 35 emergency patients). APACHE II predictions were close to actual mortality rates in elective surgery patients (prediction 5.1%, actual mortality 5.0%). However, discrimination tests found that APACHE II, and also the other models examined, had poor efficiency and were neither sensitive nor specific in identifying patients at risk from elective repair. In emergency patients APACHE II predictions were poor (prediction 19.4%, actual mortality 46.0%), with a form of the POSSUM (RAA-POSSUM) producing the closest prediction in emergency patients, at 47.7%. Discrimination tests also found APACHE II performed poorly in the emergency group, and there was no significant correlation between predicted and observed mortalities for any of the systems.

Based on the available evidence, the generic APACHE II appears to have poor discrimination in AAA patients. Recently however, the APACHE II has been modified specifically for use in AAA repair patients and adjusted for individual ICU-related effects on outcome, such as structure and process of care (Hadjianastassiou et al. 2005). The new APACHE-AAA retains the major determinants of outcome from APACHE II, such as age, previous health status and physiologic measures score, and also includes operative urgency as a predictor variable. The values of these variables are collected immediately after surgery before the patients are admitted to the ICU care, in contrast to the APACHE II, which uses the most extreme values in the first 24 hours after ICU admission (Hadjianastassiou et al. 2005). An APACHE-AAA score quantifies the risk of death after AAA surgery, and was designed for use in evaluative research and in an audit capacity to assess quality of care (Hadjianastassiou et al. 2007a). If found to be accurate at an individual level, such a score could inform clinicians and patients of mortality risk during the postoperative period (Hadjianastassiou et al. 2006).

#### **CLINICAL NEED AND BURDEN OF DISEASE**

AAA is estimated to be the tenth most common cause of mortality and is responsible for nearly 2% of all deaths (Golledge et al. 2006). The incidence of AAA is increasing in Western countries, and mortality rates are likely to be underestimated because some sudden deaths due to AAA are incorrectly certified as cardiac deaths (Golledge et al. 2006).

In 2003, the incidence of AAA in Australia was 8,847 or 0.4 cases per 1000 individuals (AIHW 2007). Males are more likely than females to develop an AAA (6456 versus 2391), and incidence increases with age (AIHW 2007). Consequently, male gender and increasing age are considered non-modifiable risk factors for AAA (Golledge et al. 2006). In 2003, 1340 deaths (0.1 per 1000 individuals) in Australia were reported to be due to AAA rupture, with the greatest number of deaths occurring in people aged 75 years or older (AIHW 2007).

## **DIFFUSION**

The generic APACHE II system has been available since 1985 and is widely diffused across Australia, Europe, and North America (Knaus et al. 1985). The APACHE II is used in intensive care units in Australia to compare their morbidity and mortality rates against the national average (ANZICS 2007). However, it is not routinely used for predicting individual mortality risk in patients undergoing AAA repair, with surgeons tending to use clinical judgement in the assessment of risk (Tambyraja et al. 2007). The APACHE-AAA has only been investigated in the UK (Hadjianastassiou et al. 2005).

## **COMPARATORS**

Other scoring systems that have been investigated for use in AAA patients to predict postoperative mortality include (Tambyraja et al. 2007, Tang et al. 2007, Sandford et al. 2007):

- Physiological and Operative Severity Score for enUmeration of Mortality and Morbidity (POSSUM);
- Simplified Acute Physiology Score II (SAPS II);
- Vascular Biochemistry and Haematology Outcome Models (VBHOM);
- Estimation of Physiologic Ability and Surgical Stress (E-PASS).
- Hardman Index;
- Glasgow Aneurysm Score (GAS);

The Hardman Index and Glasgow Aneurysm scale were designed specifically for use in AAA patients, whereas POSSUM, SAPS II, VBHOM, and E-PASS are generic scoring systems. The POSSUM, SAPS II, and E-PASS require peri- and/or postoperative data, and thus, like the APACHE-AAA, can only be used postoperatively to predict mortality. The VBHOM, Hardman Index, and Glasgow Aneurysm Score can potentially be performed preoperatively to predict likelihood of mortality after surgery.

Actual mortality is usually used as the reference standard in studies evaluating the effectiveness of scoring systems. For individual patients, clinical judgement could also be considered a comparator.

## **SAFETY AND EFFECTIVENESS ISSUES**

The effectiveness of the APACHE-AAA, the modified version of the APACHE II, has been explored in four studies to date, all from the same research team in the UK.

### **a) Safety**

No safety issues were reported by the studies for the calculation of APACHE-AAA scores.

### **b) Effectiveness**

Studies evaluating the APACHE-AAA model use measures of discrimination and calibration. Discrimination refers to the ability of the model to assign higher probabilities of death to the non-surviving patients than the survivors. This is measured through a receiver operating characteristic (ROC) curve. A receiver operator characteristic (ROC) curve is a plot of the true-positive rate (sensitivity) against the false-positive rate (1 - specificity). Since a perfect diagnostic test would have a sensitivity and specificity of one, the closer the area under the ROC curve is to one, the higher the diagnostic accuracy of the test. Values for the area under the curve between 0.7 and 0.8 represent reasonable discrimination and values  $>0.8$  display good discrimination (Hadjianastassiou et al. 2007). Calibration or goodness-of-fit refers to the ability of the model to assign the correct probabilities of outcome (death) to individual patients. Studies often assess this ability using the Hosmer-Lemeshow C statistic (H-L C statistic), where a high, non-significant P-value indicates a good model fit (Hadjianastassiou et al. 2007a).

Hadjianastassiou et al. (2005) developed the APACHE-AAA and used it in 24 ICUs in the United Kingdom. The study included all patients who underwent elective or emergency open surgical repair of an AAA over a nine-year period and were managed in an ICU after the operation, resulting in 1289 elective and 605 emergency patients. The actual mortality rate was 21.5% (408/1896) (9.6% for the elective patient group and 46.9% for the emergency patient group). APACHE-AAA had better discrimination than the original APACHE II model (ROC curve area 0.85 (95% confidence interval (CI), 0.82 to 0.87) and 0.81 (95% CI, 0.79 to 0.84) respectively). The statistical significance of this difference was not reported. The APACHE-AAA also had better calibration than the original APACHE II model (H-L C statistic 6.14 (P = 0.632) and 256 (P < 0.001), respectively) (Hadjianastassiou et al. 2005).

Hadjianastassiou et al. (2006) used the same study population as Hadjianastassiou et al. (2005) to compare the APACHE-AAA model with clinicians' estimates. In a subset of patients (25%) used for validation of the models, the area under the ROC curve was 0.87 (95% CI 0.82 to 0.91) for the APACHE-AAA. Clinicians' estimates were significantly lower than APACHE-AAA, and with regards to calibration, only the APACHE-AAA had a non-significant P-value indicating a good model fit (H-L C statistic 14.97, P = 0.06) (Hadjianastassiou et al. 2006).

Hadjianastassiou et al. (2007a) and Hadjianastassiou et al. (2007b) further examined the APACHE-AAA model by comparing it with the POSSUM and VBHOM scoring systems for predicting postoperative mortality, and determining its external validity by testing it in a separate population from the one used in its development. Both studies used a population consisting of 541 patients who underwent elective or emergency open surgical repair of AAA (325 elective and 216 emergencies) from two United Kingdom ICUs that were not included in Hadjianastassiou et al. (2005). The actual mortality rate was 6.2% (20/541) for elective and 28.7% (62/541) for emergency surgery. Hadjianastassiou et al. (2007a) found that the APACHE-AAA produced a ROC curve area of 0.84 (95% CI, 0.80 to 0.89), which was not significantly different from POSSUM model values ( $p = 0.23$ ). The APACHE-AAA gave a ROC curve area of 0.88 (95% CI, 0.81 to 0.94) for elective patients and 0.74 (95% CI, 0.66 to 0.82) in emergency patients. These values were not significantly different from the POSSUM model values ( $P = 0.83$  for elective;  $P = 0.27$  for emergency), but were significantly better than those of the VBHOM model values ( $P = 0.04$  for elective;  $P < 0.001$  for emergency). The APACHE-AAA displayed a good model fit during calibration tests for the entire patient group (H-L C statistic 7.78,  $P = 0.46$ ), elective group (H-L C statistic 7.3,  $P = 0.50$ ) and emergency group (H-L C statistic 6.20,  $P = 0.62$ ). The POSSUM and APACHE-AAA models all had H-L C statistics with  $P$ -values  $< 0.05$ , showing poor calibration (Hadjianastassiou et al. 2007a). The discrimination values reported in the external validation by Hadjianastassiou et al. (2007b) (0.84, 95% CI 0.80 to 0.89) were not significantly different ( $P = 0.88$ ) from those of the Hadjianastassiou et al. (2005) APACHE-AAA development study (0.85, 95% CI 0.82 to 0.87).

### **COST IMPACT**

Current AAA repair procedures are expensive and carry significant morbidity and mortality risks (Vorp 2007). The Medicare Benefits Schedule reimbursement fees for AAA repair are listed in Table 1. There are no data on the cost of performing the APACHE-AAA scoring system on a patient; however, the scoring variables used tend to be routinely collected in an acute hospital setting (Knaus et al. 1985). Australian ICUs are currently collecting these variables in general ICU patients to calculate APACHE II scores for the purpose of audit (ANZICS 2007).

### **ETHICAL, CULTURAL OR RELIGIOUS CONSIDERATIONS**

If a scoring system such as the APACHE system is calculated postoperatively and indicates significant mortality risk, there is controversy as to whether such information should be used in individual clinical care (Hadjianastassiou et al. 2006). Any scoring system would require extensive validation before it could be used at an individual patient level, particularly if it will influence patient care (Tambyraja et al. 2007). This issue is more pertinent in preoperative scoring systems that can potentially be used in individual preoperative decision making.

## **OTHER ISSUES**

No other issues were identified from the retrieved material.

## **SUMMARY OF FINDINGS**

The recently developed APACHE-AAA, which adjusts for individual ICU related effects on outcome, has been internally and externally validated in both elective and emergency AAA patients by a research group in the UK. The APACHE-AAA system had high discrimination and calibration, and performed better than APACHE II in patients who had undergone AAA repair. An external validation study reported similar high discrimination and calibration results. APACHE-AAA was found to have higher discrimination than clinicians' estimates and VBHOM modelling, similar discrimination to POSSUM models, and better calibration than POSSUM models, VBHOM and clinicians' estimates. It should be noted that the comparison between APACHE-AAA and VBHOM may not be valid, as VBHOM is designed to be calculated preoperatively, whereas APACHE-AAA is calculated postoperatively. Further research is required to establish if the specific APACHE-AAA model is applicable in settings other than UK ICUs, and before such a tool can be considered for use in mortality prediction for either research and audit or individual patient purposes. No issues were reported regarding the safety of performing the APACHE-AAA scoring system on patients undergoing AAA repair.

## **HEALTHPACT ACTION**

Based on the similarity of the APACHE-AAA to the APACHE II and the low level of evidence currently available the APACHE-AAA will be archived.

## **NUMBER OF STUDIES INCLUDED**

Total number of studies 4

## **REFERENCES**

Australian and New Zealand Intensive Care Society (ANZICS). ANZICS Adult Patient Database Last updated 2007. [http://www.anzics.com.au/uploads/APDdataform\\_16.pdf](http://www.anzics.com.au/uploads/APDdataform_16.pdf) [Accessed January 2008]

Australian Institute of Health and Welfare (AIHW). The burden of disease and injury in Australia 2003 Last updated 2007.

[http://www.aihw.gov.au/bod/bod\\_2003/annex\\_tables/index.cfm](http://www.aihw.gov.au/bod/bod_2003/annex_tables/index.cfm) [Accessed November 2007]

Blankensteijn JD, de Jong SECA, Prinssen M, van der Ham AC, Buth J, van Sterkenburg SMM, Verhagen HJM, Buskens E and Grobbee DE. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. *The New England Journal of Medicine* 2005; 352(23):2398-405

Greenhalgh RM, Brown LC, Kwong GP, Powell JT and Thompson SG. Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomised controlled trial. *Lancet* 2004; 364(9437):843-8

Golledge J, Muller J, Daugherty A and Norman P. Abdominal Aortic Aneurysm. Pathogenesis and implications for management. *Arteriosclerosis, Thrombosis, and Vascular Biology* 2006; 26(12):2605-2613

Hadjianastassiou VG, Tekkis PP, Goldhill DR and Hands LJ. Quantification of mortality risk after abdominal aortic aneurysm repair. *British Journal of Surgery* 2005; 92(9):1092-8.

Hadjianastassiou VG, Franco L, Jerez JM, Evangelou IE, Goldhill DR, Tekkis PP and Hands LJ. Optimal prediction of mortality after abdominal aortic aneurysm repair with statistical models. *Journal of vascular surgery* 2006; 43(3):467-473

Hadjianastassiou VG, Tekkis PP, Athanasiou T, Mukhtadir A, Young JD and Hands LJ. Comparison of mortality prediction models after open abdominal aortic aneurysm repair. *European Journal of Vascular and Endovascular Surgery* 2007a; 33(5):536-43

Hadjianastassiou VG, Tekkis PP, Athanasiou T, Mukhtadir A, Young JD and Hands LJ. External validity of a mortality prediction model in patients after open abdominal aortic aneurysm repair using multi-level methodology. *European Journal of Vascular and Endovascular Surgery* 2007b; 34(5):514-21.

Knaus WA, Draper EA, Wagner DP and Zimmerman JE. APACHE II: a severity of disease classification system. *Critical Care Medicine* 1985; 13(10):818-29.

Lederle FA, Wilson SE, Johnson GR et al. Immediate repair compared with surveillance of small abdominal aortic aneurysms. *The New England Journal of Medicine* 2002; 346(19):1437-1444.

Medicare Australia: Medicare Benefits Schedule. Last Updated 2007.  
<http://www9.health.gov.au/mbs/> [Accessed November 2007]

Sandford RM, Bown MJ and Sayers RD. Scoring systems do not accurately predict outcome following abdominal aortic aneurysm repair. Scoring systems do not accurately predict outcome following abdominal aortic aneurysm repair. *ANZ Journal of Surgery* 2007; 77(4):275-82.

Tambyraja AL, Murie JA and Chalmers RT. Prediction of outcome after abdominal aortic aneurysm rupture. *Journal of Vascular Surgery* 2007 Oct 8; [Epub ahead of print]

Vorp D. Biomechanics of abdominal aortic aneurysm rupture. *Journal of Biomechanics* 2007; 40(9):1887-1902

**SOURCES OF FURTHER INFORMATION**

Original paper describing APACHE II:

Knaus WA, Draper EA, Wagner DP and Zimmerman JE. APACHE II: a severity of disease classification system. *Critical Care Medicine* 1985; 13(10): 818-29.

Systematic review on other mortality scoring systems in AAA:

Tambyraja AL, Murie JA and Chalmers RT. Prediction of outcome after abdominal aortic aneurysm rupture. *Journal of Vascular Surgery* 2007 Oct 8; [Epub ahead of print]

**SEARCH CRITERIA TO BE USED**

Abdominal aortic aneurysm

APACHE

Scoring system