National Institute for Health and Care Excellence

Draft for consultation

Abdominal aortic aneurysm: diagnosis and management

Evidence review S: Risk factors for predicting survival after AAA rupture

NICE guideline <number>

Evidence reviews

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ISBN:

Contents

Risk factors for predicting survival after AAA rupture 5
Review question 5
Introduction 5
PICO table 5
Methods and process 5
Clinical evidence 6
Summary of clinical studies included in the evidence review 6
Quality assessment of clinical studies included in the evidence review 9
Economic evidence 9
Evidence statements 9
Recommendations 10
Rationale and impact 11
The committee's discussion of the evidence 11
Appendices 13
Appendix A – Review protocols 13
Review protocol for risk factors predicting survival after AAA rupture 13
Appendix B – Literature search strategies 15
Clinical search literature search strategy 15
Health Economics literature search strategy 16
Appendix C – Clinical evidence study selection 19
Appendix D – Clinical evidence tables 20
Appendix E – GRADE tables 48
Mortality within 48 hours 48
30-day or in-hospital mortality 48
Long term (5-year) mortality 57
Appendix F – Economic evidence study selection 60
Appendix G – Excluded studies 61
Clinical studies 61
Economic studies 70
Appendix H – Glossary 71

Risk factors for predicting survival after AAA rupture

Review question

Which signs, symptoms, risk factors (or combinations of these) and assessment tools predict survival in people with ruptured abdominal aortic aneurysms?

Introduction

This review question aims determine which risk factors or assessment tools are accurate in predicting survival and might therefore inform the decision to undertake surgery for a ruptured abdominal aortic aneurysm (AAA).

PICO table

Table 1: Inclusion criteria

Parameter	Inclusion criteria
Population	• People with a ruptured AAA
Index test / factors of interest	• Respiratory failure • Intubation • Cardiac arrest • Myocardial ischaemia on ECG • Hypoxia • Hypotension • Altered consciousness • Glasgow aneurysm score • Hardman index • Position and anatomy of aneurysm, including morphology scores • Cardiovascular disease • Renal disease • COPD • Obesity • Ethnicity • Blood pressure • Presence of shock
Endpoints	• Mortality • Quality of life • Resource use, including length of hospital or intensive care stay, and costs

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in Appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

A single broad search was used to identify all studies that examine the diagnosis, surveillance or monitoring of AAAs. This was a 'bulk' search that covered multiple review

questions. The database was sifted to identify all studies that met the criteria detailed in Table 1. The relevant review protocol can be found in Appendix A.

Initially the review protocol outlined that prospective or retrospective observational studies that use multivariate logistic regression or Cox regression to explore the association between risk factors and mortality in people with ruptured AAA would be sought. However the protocol was subsequently amended to incorporate a sample size restriction to the inclusion criteria: only studies with more than 200 participants were included.

Studies were excluded if they:

- were not in English
- were not full reports of the study (for example, published only as an abstract)

Clinical evidence

Included studies

From an initial database of 16,274 abstracts, 84 were identified as being potentially relevant. Following full-text review of these articles, 16 studies were included. These included 3 prospective cohort studies and 13 retrospective cohort studies.

An update literature search was performed and provided by Cochrane, in December 2017. The search found a total of 2,180 abstracts; of which, 15 full manuscripts were ordered. Upon review of the full manuscripts, none of the studies met the inclusion criteria for this review question.

Excluded studies

The list of papers excluded at full-text review, with reasons, is given in Appendix G.

Summary of clinical studies included in the evidence review

A summary of the included studies is provided in the below table.

Table 2: Included studies

Study	Details
Brahmbhatt R, Gander J, Duwayri Y et al. (2016) Improved trends in patient survival and decreased major complications after emergency ruptured abdominal aortic aneurysm repair. Journal of vascular surgery 63(1), 39-47	Study design: retrospective cohort study Location(s): USA and Canada Population: people who underwent emergency EVAR or open surgical repair Sample size: 2,761 Outcome: 30-day mortality Risk factors: COPD, functional status, preoperative creatinine, age, intraoperative transfusion, and preoperative haematocrit
Dueck Andrew D, Kucey Daryl S, Johnston K et al. (2004) Survival after ruptured abdominal aortic aneurysm: effect of patient, surgeon, and hospital factors. Journal of vascular surgery 39(6), 1253-60	Study design: retrospective cohort study Location(s): Canada Population: residents of Ontario who underwent emergency repair (unspecified) of ruptured AAA Sample size: 2,601 Outcome: 30-day mortality (NB: authors described this as “decreased survival”) Risk factors: age and sex
Giles K A, Hamdan A D, Pomposelli F B et al. (2009) Population-based	Study design: retrospective cohort study Location(s): USA

Study	Details
outcomes following endovascular and open repair of ruptured abdominal aortic aneurysms. Journal of Endovascular Therapy 16(5), 554-564	Population: people who underwent emergency EVAR or open surgical repair of ruptured AAA Sample size: 28,429 Outcome: in-hospital mortality Risk factors: age and sex
Heller J A, Weinberg A, Arons R, et al. (2000) Two decades of abdominal aortic aneurysm repair: have we made any progress?. Journal of vascular surgery 32(6), 1091-100	Study design: retrospective cohort study Location(s): USA Population: people who underwent emergency repair (unspecified) of ruptured AAA Sample size: 67,751 Outcome: operative mortality Risk factors: age, sex and renal failure
Korhonen S J, Ylonen K, Biancari F et al. (2004) Glasgow Aneurysm Score as a predictor of immediate outcome after surgery for ruptured abdominal aortic aneurysm. The British journal of surgery 91(11), 1449-52	Study design: retrospective cohort study Location(s): Finland Population: people who underwent emergency repair (unspecified) of ruptured AAA Sample size: 836 Outcome: 30-day mortality Risk factors: shock and Glasgow Aneurysm Score
McPhee James, Eslami Mohammad H, Arous Elias J, et al. (2009) Endovascular treatment of ruptured abdominal aortic aneurysms in the United States (2001-2006): a significant survival benefit over open repair is independently associated with increased institutional volume. Journal of vascular surgery 49(4), 817-26	Study design: retrospective cohort study Location(s): USA Population: people who underwent emergency EVAR or open surgical repair of ruptured AAA Sample size: 27,750 Outcome: in-hospital mortality Risk factors: age, sex, congestive heart failure, hypertension, chronic lung disease, liver disease, renal failure, and diabetes
Mureebe L, Egorova N, McKinsey JF et al. (2010) Gender trends in the repair of ruptured abdominal aortic aneurysms and outcomes. Journal of vascular surgery 51(4 Suppl), 9S-13S	Study design: retrospective cohort study Location(s): USA Population: people who underwent emergency EVAR or open surgical repair of ruptured AAA Sample size: 51,000 Outcome: 30-day mortality Risk factors: age and sex
Noel A A, Gloviczki P, Cherry Jr, K J et al. (2001) Ruptured abdominal aortic aneurysms: the excessive mortality rate of conventional repair. Journal of vascular surgery : official publication, the Society for Vascular Surgery [and] International Society for Cardiovascular Surgery, and North American Chapter 34(1), 41-46	Study design: retrospective cohort study Location(s): USA Population: people who underwent EVAR or open surgical repair for ruptured AAA Sample size: 413 Outcome: 30-day mortality Risk factors: age, APACHE II score, cardiac arrest,
Robinson WP, Schanzer A, Li Y et al. (2013) Derivation and validation of a practical risk score for prediction of mortality after open repair of ruptured abdominal aortic aneurysms in a US regional cohort and comparison to existing scoring systems. Journal of vascular surgery 57(2), 354-61	Study design: prospective cohort study Location(s): USA Population: all people who underwent open repair of ruptured AAA Sample size: 242 Outcome: in-hospital mortality Risk factors: age, cardiac arrest, and loss of consciousness,

Study	Details
Robinson WP, Schanzer A, Aiello FA, Flahive J et al. (2016) Endovascular repair of ruptured abdominal aortic aneurysms does not reduce later mortality compared with open repair. Journal of vascular surgery 63(3), 617-24	Study design: retrospective cohort study Location(s): USA Population: people who underwent emergency EVAR or open surgical repair of ruptured AAA Sample size: 1,109 Outcome: 5-year mortality Risk factors: sex, age, systolic blood pressure, loss of consciousness, cardiac arrest, dialysis, and history of cerebrovascular disease
Schlosser FJ. V, Vaartjes I, van der H et al (2010) Mortality after hospital admission for ruptured abdominal aortic aneurysm. Annals of vascular surgery 24(8), 1125-32	Study design: retrospective cohort study Location(s): Netherlands Population: people admitted to hospital with a ruptured AAA were included (type of repair aneurysm repair procedure was not specified) Sample size: 1,463 Outcome: 28-day, and 5-year mortality Risk factors: age, sex, diabetes, ischemic heart disease, congestive heart failure, and cerebrovascular disease
Trenner M, Haller B, Sollner H et al. (2015) Twelve years of the quality assurance registry on ruptured and non-ruptured abdominal aortic aneurysms of the German Vascular Society (DGG): Part 3: Predictors of perioperative outcome with a focus on annual caseload. English version. Gefasschirurgie 20(1), 32-44	Study design: Retrospective cohort study Location(s): Germany Population: people who underwent EVAR or open repair for ruptured or unruptured AAA Sample size: 4,859 Outcome: in-hospital mortality Risk factors: age, AAA diameter, presence of iliac aneurysms
Van Beek , S C, Reimerink J J, Vahl A C et al. (2014) Outcomes after open repair for ruptured abdominal aortic aneurysms in patients with friendly versus hostile aortoiliac anatomy. European Journal of Vascular and Endovascular Surgery 47(4), 380-387	Study design: prospective cohort study Location(s): Netherlands Population: : people with ruptured aortoilliac aneurysms who underwent open surgical repair Sample size: 208 Outcome: 30-day or in-hospital mortality (composite rate) Risk factors: age, sex, cardiac comorbidity, COPD, renal comorbidity, cerebrovascular comorbidity and the need for cardiopulmonary resuscitation
Van Dongen , HPA, Leusink JA, Moll FL et al. (1998) Ruptured abdominal aortic aneurysms: Factors influencing postoperative mortality and long-term survival. European Journal of Vascular and Endovascular Surgery 15(1), 62-66	Study design: retrospective cohort study Location(s): Netherlands Population: people who underwent open surgical repair of ruptured AAA were included Sample size: 309 Outcome: mortality within 48 hours, and 30-day mortality Risk factors: age and hypotension
Visser JJ, Williams M, Kievit Jur, Bosch JL et al. (2009) Prediction of 30-day mortality after endovascular repair or open surgery in patients with ruptured abdominal aortic aneurysms. Journal of vascular surgery 49(5), 1093-9	Study design: prospective cohort study Location(s): Netherlands Population: people who presented with ruptured AAAs and were treated by EVAR or open surgical repair Sample size: : 201 Endpoint: 30-day mortality Risk factors: age, shock, myocardial disease (myocardial infarction and/or angina pectoris), cerebrovascular disease and renal failure
Von Meijenfeldt GCI, Ultee KH.J, Eefting D et al. (2014) Differences in	Study design: retrospective cohort study

Study	Details
mortality, risk factors, and complications after open and endovascular repair of ruptured abdominal aortic aneurysms. European Journal of Vascular and Endovascular Surgery 47(5), 479-486	Location(s): Netherlands Population: 221 Sample size: Outcome: 30-day mortality Risk factors: age, haemoglobin level, eGFR measurments, and presence of shock

See Appendix D for full evidence tables.

Quality assessment of clinical studies included in the evidence review

See Appendix E for full GRADE tables, highlighting the quality of evidence from the included studies.

Economic evidence

Included studies

A literature search was conducted jointly for all review questions by applying standard health economic filters to a clinical search for AAA. This search returned a total of 5,173 citations. Following review of all titles and abstracts, no studies were identified as being potentially relevant to risk factors associated with aneurysm expansion or rupture. No full texts were retrieved, and so no studies were included as economic evidence.

An update search was conducted in December 2017, to identify any relevant health economic analyses published during guideline development. The search found 814 abstracts; all of which were not considered relevant to this review question. As a result no additional studies were included.

Excluded studies

No studies were retrieved for full-text review.

Evidence statements

Mortality within 48 hours

Moderate-quality evidence from 1 retrospective cohort study, including 309 people with ruptured AAA, indicated that increasing age increased the odds of death within 48 hours of open surgical repair.

30-day and in-hospital mortality

Low- to moderate-quality evidence from 1 prospective and 10 retrospective cohort studies, including 178,994 people with ruptured AAA, indicated that the following risk factors increased the odds of death within 30 days (or within hospital) after EVAR or open surgical repair:

- Increasing age
- Female gender
- Increasing aneurysm diameter
- Myocardial disease
- Liver disease
- Renal failure

- Cerebrovascular disease
- Increasing creatinine levels
- Increasing Glasgow Aneurysm Scale scores
- Increasing APACHE II scores
- Increasing American society of anaesthesiology (ASA) score
- Shock
- Cardiac arrest
- Haemoglobin <11mg/dL

Moderate- to high-quality evidence from 1 prospective and 1 retrospective cohort study, including 551 people with ruptured AAA, indicated that loss of consciousness and hypotension longer than 60 minutes increased the odds of death within 30 days (or in-hospital) of open surgical repair.

Low-quality evidence from 1 retrospective cohort study, including 27,750 people with ruptured AAA, indicated that hypertension and increasing haematocrit levels decreased the odds of death within 30 days (or in-hospital mortality) of EVAR or open surgery.

Very low-quality evidence from 3 retrospective cohort studies, including up to 30,551 people with ruptured AAA, reported inconsistent associations between COPD or congestive heart failure and the odds of death within 30 days (or in-hospital mortality) of EVAR or open surgery.

Very low- to low-quality evidence from 4 retrospective cohort studies, including up to 29,213 people with ruptured AAA, could not detect an association between coronary heart disease or diabetes and the odds of death within 30 days (or in-hospital mortality) of EVAR or open surgery.

Mortality within 5 years

Very low- to moderate-quality evidence from 2 retrospective cohort studies, including up to 2,567 people with ruptured AAA, indicated that increasing age, congestive heart disease, a history of cerebrovascular disease, cardiac arrest, loss of consciousness and a systolic blood pressure below 90 mmHg increased the odds of death within 5 years of EVAR or open surgical repair.

Very low-quality evidence from 2 retrospective cohort studies, including 2,567 people with ruptured AAA, could not detect an association between being female and the odds of death within 5 years of EVAR or open surgical repair.

Very low-quality evidence from 1 retrospective cohort study, including up to 1,463 people with ruptured AAA, could not detect an association between ischaemic heart disease and death within 5 years of EVAR or open surgical repair.

Recommendations

S1. Do not use any single symptom, sign or patient-related risk factor to determine whether aneurysm repair is suitable for a person with a ruptured AAA.

S2. Do not use patient risk assessment tools (scoring systems) to determine whether aneurysm repair is suitable for a person with a ruptured AAA.

Rationale and impact

Why the committee made the recommendations

There is evidence that some risk factors and risk assessment tools are associated with poor postoperative outcomes. However, it is not clear how any particular factor or combination of factors could be used to decide if aneurysm repair is suitable for a person with a ruptured AAA.

Impact of the recommendations on practice

The recommendations will have a beneficial impact, by ensuring decisions about care are not made based on inappropriate factors or tools. This, in turn, should prevent inappropriate decisions being made about patient care.

The committee's discussion of the evidence

Interpreting the evidence

The outcomes that matter most

The committee considered that the most important outcome is equitable access of a patient to appropriate assessment and a balanced decision of care.

The quality of the evidence

The committee noted that some of the evidence came from retrospective cohort studies, and these studies may have been prone to selection bias because study samples (people with ruptured AAA) were determined by retrospective review of disease classification codes from data disease registers, hospital records, and health insurance provider databases. It was agreed that bias may have been introduced in some studies as investigators ascertained the presence or absence of risk factors (covariates) by retrospectively reviewing data from these data sources. Furthermore, the committee noted that studies which included mixed populations of people treated by EVAR or open surgical repair did not use type of treatment as a confounding factor in their analyses. The committee agreed there was reasonable evidence that some symptoms, signs, risk factors and assessment tools were associated with postoperative outcomes but they could not identify specific factors that were strong enough to inform the decision on whether or how to operate on people with ruptured AAA. Additionally, the committee considered that there was no evidence to demonstrate that use of these factors as decision-making tools affects care and subsequent outcomes of people with ruptured AAA. In light of this, the committee agreed that recommendations were needed to highlight that individual factors should not be used to inform treatment decisions.

The committee were mindful that AAA is a clinical area in which there is disproportionately more evidence on men than women. The committee discussed the studies highlighting that women were more likely to die from aneurysm rupture than men, and agreed that female sex could not be used as a sole factor to inform the treatment decisions. Moreover, the committee could not identify additional factors that, when combined with female sex, could be used to inform the decision to operate. As a result, the committee decided that it was not possible to make a recommendation specific to women.

Benefits and harms

The committee agreed that the evidence identified on risk assessment tools failed to show that individual tools could be used determine how a person with a ruptured AAA should be treated. The committee emphasised that there would be some potential for harm if clinicians made their decision to operate solely on the basis of risk assessment tool scores because

some people would be inappropriately denied treatment. Thus, they decided to make a separate recommendation specific to risk assessment tools. The committee were aware that a few clinicians have been using the Hardman index in practice; however, it was noted that none of the identified studies assessing the Hardman index met inclusion criteria for this review (mainly due to small sample sizes). The committee were aware that the excluded evidence on the Hardman index generally highlighted that the risk assessment tool had insufficient prognostic power to inform decisions to operate.

Cost effectiveness and resource use

The committee considered that the recommendations were unlikely to have an impact on cost effectiveness and resource use.

Other factors the committee took into account

The committee discussed whether the recommendations needed to list all the risk factors that were not useful on their own for deciding whether or how to intervene in a person with a ruptured AAA. It was agreed that such a list would be cumbersome. Moreover, the committee did not want to give the impression of having identified signs, symptoms and risk factors that should not be taken into account at all; rather, they wanted to emphasise that any single factor, on its own, should not be used to define decision-making..

1 Appendices

2 Appendix A – Review protocols

3 Review protocol for risk factors predicting survival after AAA rupture

Review question 21	**Which signs, symptoms, risk factors (or combinations of these) and assessment tools predict survival in people with ruptured abdominal aortic aneurysms?**
Objectives	To determine which risk factors or assessment tools are accurate in predicting survival and might therefore inform the decision to undertake surgery for a ruptured abdominal aortic aneurysm
Type of review	Prognostic
Language	English
Study design	Initially, the following study designs were included in the review protocol: • prospective or retrospective observational studies using multivariate analysis The protocol was subsequently amended to restrict study sample sizes to more than 200 participants
Status	Published papers only (full text) No date restrictions
Population	People with a ruptured abdominal aortic aneurysm
Index test / factors of interest	Respiratory failure Intubation Cardiac arrest Myocardial ischaemia on ECG Hypoxia Hypotension Altered consciousness Glasgow aneurysm score Hardman index Position and anatomy of aneurysm, including morphology scores Cardiovascular disease Renal disease COPD Obesity Ethnicity Blood pressure Presence of shock
Endpoint	Mortality Quality of life Resource use, including length of hospital or intensive care stay, and costs
Other criteria for inclusion / exclusion of studies	Exclusion: Non-English language Abstract/non-published
Baseline characteristics to be extracted in evidence tables	Age Sex Size of aneurysm Position of aneurysm Comorbidities
Search strategies	To be developed

Review question 21	Which signs, symptoms, risk factors (or combinations of these) and assessment tools predict survival in people with ruptured abdominal aortic aneurysms?
Review strategies	Double-sifting of randomly selected 20%. Appropriate NICE Methodology Checklists, depending on study designs, will be used as a guide to appraise the quality of individual studies. 20% will be appraised by a second reviewer. Data on all included studies will be extracted into evidence tables. Where statistically possible, a meta-analytic approach will be used to give an overall summary effect. All key findings from evidence will be presented in GRADE profiles and further summarised in evidence statements.
Key papers	Cadili A, Turnbull R, Hervas-Malo M, Ghosh S, Chyczij H. Identifying patients with AAA with the highest risk following endovascular repair. Vasc Endovascular Surg. 2012 Aug;46(6):455-9 von Meijenfeldt,G.C.I., Ultee,K.H.J., Eefting,D., Hoeks,S.E., ten Raa,S., Rouwet,E.V., et al. Differences in mortality, risk factors, and complications after open and endovascular repair of ruptured abdominal aortic aneurysms. Eur J Vasc Endovasc Surg 2014;47(5):479-86

1
2

Appendix B – Literature search strategies

Clinical search literature search strategy

Main searches

Bibliographic databases searched for the guideline

- Cumulative Index to Nursing and Allied Health Literature - CINAHL (EBSCO)
- Cochrane Database of Systematic Reviews – CDSR (Wiley)
- Cochrane Central Register of Controlled Trials – CENTRAL (Wiley)
- Database of Abstracts of Reviews of Effects – DARE (Wiley)
- Health Technology Assessment Database – HTA (Wiley)
- EMBASE (Ovid)
- MEDLINE (Ovid)
- MEDLINE Epub Ahead of Print (Ovid)
- MEDLINE In-Process (Ovid)

Identification of evidence for review questions

The searches were conducted between November 2015 and October 2017 for 31 review questions (RQ). In collaboration with Cochrane, the evidence for several review questions was identified by an update of an existing Cochrane review. Review questions in this category are indicated below. Where review questions had a broader scope, supplement searches were undertaken by NICE.

Searches were re-run in December 2017.

Where appropriate, study design filters (either designed in-house or by McMaster) were used to limit the retrieval to, for example, randomised controlled trials. Details of the study design filters used can be found in section 4.

Search strategy review question 21

Medline Strategy, searched 29th September 2016 **Database: 1946 to September Week 3 2016** **Search Strategy:**
1 Aortic Aneurysm, Abdominal/
2 Aortic Rupture/
3 (aneurysm* adj4 (abdom* or thoracoabdom* or thoraco-abdom* or aort* or spontan* or juxtarenal* or juxta-renal* or juxta renal* or paraerenal* or para-renal* or para renal* or suprarenal* or supra renal* or supra-renal* or short neck* or short-neck* or shortneck* or visceral aortic segment*)).tw.
4 or/1-3
5 prognosis.sh.
6 diagnosed.tw.
7 cohort.mp.
8 predictor:.tw.
9 death.tw.

Medline Strategy, searched 29th September 2016 **Database: 1946 to September Week 3 2016** **Search Strategy:**	
10	exp models, statistical/
11	or/5-10
12	(sensitiv: or predictive value:).mp. or accurac:.tw.
13	11 or 12
14	"signs and symptoms"/
15	((sign or signs) adj5 symptom*).tw.
16	Risk Factors/
17	factor*.tw.
18	predict*.tw.
19	or/14-18
20	13 or 19
21	4 and 20
22	animals/ not humans/
23	21 not 22 (12444)
24	limit 23 to english language

Health Economics literature search strategy

Sources searched to identify economic evaluations

- NHS Economic Evaluation Database – NHS EED (Wiley) last updated Dec 2014
- Health Technology Assessment Database – HTA (Wiley) last updated Oct 2016
- Embase (Ovid)
- MEDLINE (Ovid)
- MEDLINE In-Process (Ovid)

Search filters to retrieve economic evaluations and quality of life papers were appended to the population and intervention terms to identify relevant evidence. Searches were not undertaken for qualitative RQs. For social care topic questions additional terms were added. Searches were re-run in September 2017 where the filters were added to the population terms.

Health economics search strategy

Medline Strategy	
Economic evaluations	
1	Economics/
2	exp "Costs and Cost Analysis"/
3	Economics, Dental/
4	exp Economics, Hospital/
5	exp Economics, Medical/
6	Economics, Nursing/
7	Economics, Pharmaceutical/
8	Budgets/
9	exp Models, Economic/
10	Markov Chains/

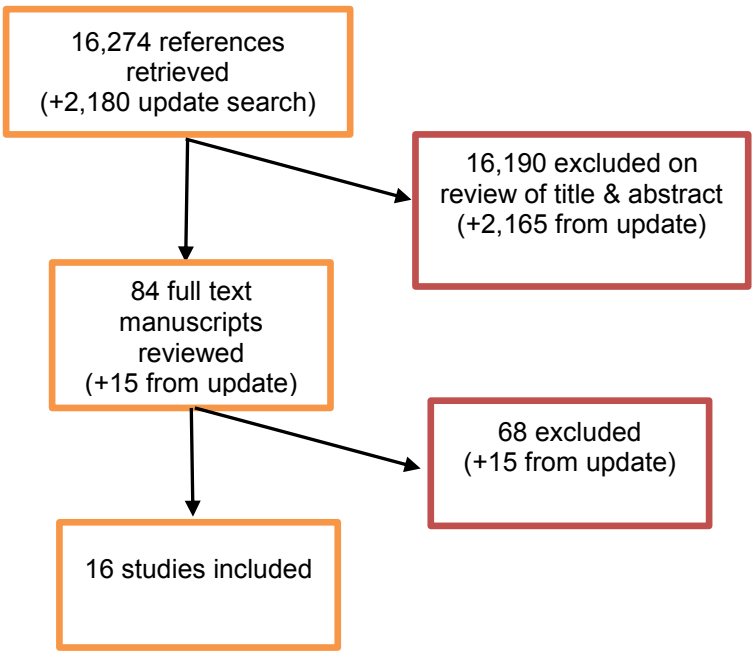
Medline Strategy

11 Monte Carlo Method/
12 Decision Trees/
13 econom*.tw.
14 cba.tw.
15 cea.tw.
16 cua.tw.
17 markov*.tw.
18 (monte adj carlo).tw.
19 (decision adj3 (tree* or analys*)).tw.
20 (cost or costs or costing* or costly or costed).tw.
21 (price* or pricing*).tw.
22 budget*.tw.
23 expenditure*.tw.
24 (value adj3 (money or monetary)).tw.
25 (pharmacoeconomic* or (pharmaco adj economic*)).tw.
26 or/1-25

Quality of life
1 "Quality of Life"/
2 quality of life.tw.
3 "Value of Life"/
4 Quality-Adjusted Life Years/
5 quality adjusted life.tw.
6 (qaly* or qald* or qale* or qtime*).tw.
7 disability adjusted life.tw.
8 daly*.tw.
9 Health Status Indicators/
10 (sf36 or sf 36 or short form 36 or shortform 36 or sf thirtysix or sf thirty six or shortform thirtysix or shortform thirty six or short form thirtysix or short form thirty six).tw.
11 (sf6 or sf 6 or short form 6 or shortform 6 or sf six or sfsix or shortform six or short form six).tw.
12 (sf12 or sf 12 or short form 12 or shortform 12 or sf twelve or sftwelve or shortform twelve or short form twelve).tw.
13 (sf16 or sf 16 or short form 16 or shortform 16 or sf sixteen or sfsixteen or shortform sixteen or short form sixteen).tw.
14 (sf20 or sf 20 or short form 20 or shortform 20 or sf twenty or sftwenty or shortform twenty or short form twenty).tw.
15 (euroqol or euro qol or eq5d or eq 5d).tw.
16 (qol or hql or hqol or hrqol).tw.
17 (hye or hyes).tw.
18 health* year* equivalent*.tw.
19 utilit*.tw.
20 (hui or hui1 or hui2 or hui3).tw.
21 disutili*.tw.
22 rosser.tw.
23 quality of wellbeing.tw.
24 quality of well-being.tw.
25 qwb.tw.

Medline Strategy	
26	willingness to pay.tw.
27	standard gamble*.tw.
28	time trade off.tw.
29	time tradeoff.tw.
30	tto.tw.
31	or/1-30

Appendix C – Clinical evidence study selection



Appendix D – Clinical evidence tables

Full citation	**Brahmbhatt Reshma, Gander Jennifer, Duwayri Yazan, Rajani Ravi R, Veeraswamy Ravi, Salam Atef, Dodson Thomas F, and Arya Shipra (2016) Improved trends in patient survival and decreased major complications after emergency ruptured abdominal aortic aneurysm repair. Journal of vascular surgery 63(1), 39-47**
Study details	Study design: retrospective cohort study Location(s): USA and Canada Aim of the study: to identify risk adjusted predictors of 30-day morbidity and mortality after EVAR or open surgical repair of ruptured AAA Study dates: 2005 to 2011 Follow-up: 30-days Sources of funding: the source of funding was not reported; however, authors stated that there were no conflicts of interest
Participants	Sample size: 2,761 Inclusion criteria: people who underwent emergency EVAR or open surgical repair of ruptured AAA were included Exclusion criteria: patients under 16 years were excluded Baseline characteristics: • Mean age: 73.1 years • Sex: 75.9% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Comorbidities: not reported
Methods	Data collection: data were obtained from the American College of Surgeons National Surgical Quality Improvement Programme (ACS NSQIP) database. The NSQIP database was made up of clinical information for major inpatient and outpatient surgical procedures performed at more than 200 participating hospitals throughout the United states and Canada. Participation in data collection was optional. Investigators identified the records of patients who underwent emergency aneurysm repair using ICD9 and Current Procedural Terminology and codes and noted in the NSQIP database. Analysis: multivariate logistic regression
Outcomes	Endpoint: 30-day mortality Risk factors: COPD, functional status, preoperative creatinine, age, intraoperative transfusion, and preoperative haematocrit
Risk of bias assessment	1. Did the study address a clearly focused issue? Yes

Full citation	**Brahmbhatt Reshma, Gander Jennifer, Duwayri Yazan, Rajani Ravi R, Veeraswamy Ravi, Salam Atef, Dodson Thomas F, and Arya Shipra (2016) Improved trends in patient survival and decreased major complications after emergency ruptured abdominal aortic aneurysm repair. Journal of vascular surgery 63(1), 39-47**
(using CASP tool)	2. Was the cohort recruited in an acceptable way? No – Hospital participation in entering data into the NSQIP database was optional. Furthermore, investigators identified patients who underwent emergency repair of ruptured AAA using ICD 9 and American Current Procedural Terminology codes. 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed patient data (including demographics and comorbidities) from a surgical registry to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: stepwise regression was not performed. Instead, all variables with p-values <0.2 in univariate analyses were included in a logistic regression model. Overall risk of bias: high Directness: directly applicable

Full citation	**Dueck Andrew D, Kucey Daryl S, Johnston K Wayne, Alter David, and Laupacis Andreas (2004) Survival after ruptured abdominal aortic aneurysm: effect of patient, surgeon, and hospital factors. Journal of vascular surgery 39(6), 1253-60**
Study details	Study design: retrospective cohort study Location(s): Canada Aim of the study: to determine the effects of patient, surgeon and hospital factors on survival after repair of ruptured AAA Study dates: April 1992 to March 2001 Follow-up: 30 days Sources of funding: the source of funding was not reported; however, authors stated that there were no conflicts of interest
Participants	Sample size: 2,601 Inclusion criteria: residents of Ontario who underwent emergency repair (unspecified) of ruptured AAA were included Exclusion criteria: non-residents of Ontario who underwent surgery in the province were excluded Baseline characteristics: • Mean age: 71.9 years • Sex: 81.2% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Comorbidities: not reported
Methods	Data collection: who underwent emergency repair of ruptured AAA were identified using billing codes obtained from the Ontario Health Insurance Plan (OHIP) database, which captures 95% of physician billings in Ontario. Data relating to patient, surgeon and hospital factors were obtained from five data sources: OHIP, the Canadian Institute for Health Information database, the Ontario Physician human resources data centre, and census data. Analysis: multivariate Cox proportional hazards analysis
Outcomes	Endpoint: 30-day mortality (NB: authors described this as “decreased survival”) Risk factors: age and sex
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? No – Patients were identified using billing codes from a health insurance provider database. 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed four data sources (including health insurance provider and census data) to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear

Full citation	**Dueck Andrew D, Kucey Daryl S, Johnston K Wayne, Alter David, and Laupacis Andreas (2004) Survival after ruptured abdominal aortic aneurysm: effect of patient, surgeon, and hospital factors. Journal of vascular surgery 39(6), 1253-60**
	6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: factors associated with survival were identified with a proportional hazards multivariate backward selection process Overall risk of bias: high Directness: directly applicable

Full citation	**Giles K A, Hamdan A D, Pomposelli F B, Wyers M C, Dahlberg S E, and Schermerhorn M L (2009) Population-based outcomes following endovascular and open repair of ruptured abdominal aortic aneurysms. Journal of Endovascular Therapy 16(5), 554-564**
Study details	Study design: retrospective cohort study Location(s): USA Aim of the study: to evaluate national outcomes after EVAR and open surgical repair of ruptured AAA Study dates: 2000 to 2005 Follow-up: not reported Sources of funding: this study was supported by a grant from the American National Institutes of Health (NIH)
Participants	Sample size: 28,429 Inclusion criteria: people who underwent emergency EVAR or open surgical repair of ruptured AAA were included Exclusion criteria: people younger than 18 years, people with a concomitant diagnosis of intact AAA, and people with thoracic or thoracoabdominal aneurysms were excluded Baseline characteristics: • Mean age: EVAR group, 75 years; open repair group, 73 years • Sex: EVAR group, 78% male; open repair group, 78% male • Mean aneurysm diameter: not reported • Position of aneurysm: Not specified • Hypertension: EVAR group, 51.6%; open repair group, 43.5% • Coronary artery disease: EVAR group, 28.1%; open repair group, 21.6% • Congestive heart failure: EVAR group, 17.8%; open repair group, 16.4% • Diabetes: EVAR group, 9.6%; open repair group, 8.8% • Chronic renal failure: EVAR group, 1.6%; open repair group, 1.2% • Cerebrovascular disease: EVAR group, 4.1%; open repair group, 3.8%

Full citation	**Giles K A, Hamdan A D, Pomposelli F B, Wyers M C, Dahlberg S E, and Schermerhorn M L (2009) Population-based outcomes following endovascular and open repair of ruptured abdominal aortic aneurysms. Journal of Endovascular Therapy 16(5), 554-564**
	• COPD: EVAR group, 29.9%; open repair group, 32.4%
Methods	Data collection: data were obtained from the American Nationwide Inpatient Sample database; which covers approximately 20% of non-federal hospitalisations from 38 American states. Investigators identified patients with ruptured AAA using ICD9 procedure codes as well as Clinical Modification System codes. After identification of the sample, ICD9 diagnosis codes were used to identify comorbid conditions and complications. Analysis: multivariate logistic regression
Outcomes	Endpoint: in-hospital mortality Risk factors: age and sex
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? No – investigators identified patients who underwent emergency repair of ruptured AAA using ICD 9 diagnosis/procedure codes and Clinical Modification System codes. 3. Was the exposure accurately measured to minimise bias? Yes – although investigators retrospectively reviewed patient diagnosis codes, the risk factors (age and sex) assessed in the multivariate regression are considered to be accurately measured. 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: Multivariate analysis was performed by backwards selection of variables obtaining significance on univariate analysis Overall risk of bias: moderate Directness: directly applicable

Full citation	**Heller J A, Weinberg A, Arons R, Krishnasastry K V, Lyon R T, Deitch J S, Schulick A H, Bush H L, Jr , and Kent K C (2000) Two decades of abdominal aortic aneurysm repair: have we made any progress?. Journal of vascular surgery 32(6), 1091-100**
Study details	Study design: retrospective cohort study Location(s): USA Aim of the study: to investigate the incidence and outcome of AAA repair in America, over a 19-year period using a well-established national database Study dates: 1979 to 1997 Follow-up: not reported Sources of funding: the source of funding was not reported; however, authors stated that there were no conflicts of interest
Participants	Sample size: 67,751 Inclusion criteria: people who underwent emergency repair (unspecified) of ruptured AAA were included Exclusion criteria: not reported Baseline characteristics: • Median age: men, 72 years; women, 78 years • Sex: 77.6% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Comorbidities: not reported
Methods	Data collection: investigators obtained data from the American National Hospital Discharge Survey (NHDS) database. The data entered into the database were collected by evaluation of inpatient records from 500 acute care, non-federally funded hospitals. Two data collection processes were used: either hospital staff evaluated patient records and transcribed them into an NHDS medical abstract form, or an automated system was used to collect the data. Analysis: multivariate logistic regression
Outcomes	Endpoint: operative mortality; assumed to be 30-day or in-hospital mortality Risk factors: age, sex and renal failure
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? No – investigators identified patients who underwent emergency repair of ruptured AAA using ICD 9 diagnosis/procedure codes and Clinical Modification System codes. 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed data from a national hospital discharge database to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear

Full citation	**Heller J A, Weinberg A, Arons R, Krishnasastry K V, Lyon R T, Deitch J S, Schulick A H, Bush H L, Jr , and Kent K C (2000) Two decades of abdominal aortic aneurysm repair: have we made any progress?. Journal of vascular surgery 32(6), 1091-100**
	(b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: stepwise regression was not performed. Instead, all variables with p-values <0.25 in univariate analyses were included in a logistic regression model. Overall risk of bias: high Directness: directly applicable

Full citation	**Korhonen S J, Ylonen K, Biancari F, Heikkinen M, Salenius J P, Lepantalo M, Finnvasc Study, and Group (2004) Glasgow Aneurysm Score as a predictor of immediate outcome after surgery for ruptured abdominal aortic aneurysm. The British journal of surgery 91(11), 1449-52**
Study details	Study design: retrospective cohort study Location(s): Finland Aim of the study: to assess the value of the Glasgow Aneurysm Score in predicting postoperative death after repair of ruptured AAA Study dates: January 1996 to December 1999 Follow-up: 30-days Sources of funding: not reported
Participants	Sample size: 836 Inclusion criteria: people who underwent emergency repair (unspecified) of ruptured AAA were included Exclusion criteria: not reported Baseline characteristics: • Mean age: 70.5 years • Sex: 87.1% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • COPD: 13.4% • Coronary artery disease: 43.2% • Cerebrovascular disease: 13.4% • Renal failure: 3.3% • Hypertension: 37.2%

Full citation	**Korhonen S J, Ylonen K, Biancari F, Heikkinen M, Salenius J P, Lepantalo M, Finnvasc Study, and Group (2004) Glasgow Aneurysm Score as a predictor of immediate outcome after surgery for ruptured abdominal aortic aneurysm. The British journal of surgery 91(11), 1449-52**
	• Diabetes: 6.7% • Hyperlipidaemia: 4.5%
Methods	Data collection: investigators obtained preoperative, intraoperative and postoperative data from the Finnish national Vascular registry (Finnvasc) that collected data from 21 surgical centres across the country. Preoperative Glasgow Aneurysm Scale scores were not readily available from the Finnvasc registry. As a result, investigators had to calculate scores using information from the clinical profiles/records of patients' clinical reported in the registry Analysis: multivariate logistic regression
Outcomes	Endpoints: 30-day mortality Risk factors: shock and Glasgow Aneurysm Score
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed data from a vascular surgery registry to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Yes (b) Have they taken account of the confounding factors in the design and/or analysis? Yes 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: logistic regression with backwards stepwise selection was employed for multivariate analyses Overall risk of bias: moderate Directness: directly applicable

Full citation	**McPhee James, Eslami Mohammad H, Arous Elias J, Messina Louis M, and Schanzer Andres (2009) Endovascular treatment of ruptured abdominal aortic aneurysms in the United States (2001-2006): a significant survival benefit over open repair is independently associated with increased institutional volume. Journal of vascular surgery 49(4), 817-26**
Study details	Study design: retrospective cohort study Location(s): USA Aim of the study: to evaluate national outcomes of patients who underwent EVAR for ruptured AAA Study dates: 2001 to 2006 Follow-up: not reported Sources of funding: authors received funding but it was not clear who funded them
Participants	Sample size: 27,750 Inclusion criteria: people who underwent emergency EVAR or open surgical repair of ruptured AAA were included Exclusion criteria: people with ICD 9 codes indicating intact AAA were excluded Baseline characteristics: • Mean age: 73.1 years • Sex: 77.1% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Renal failure: 8.0% • Congestive heart failure: 2.8% • Diabetes: 8.8% • Chronic lung disease: 34.3% • Hypertension: 37.6% • Obesity: 3.6% • Liver disease: 0.96%
Methods	Data collection: data were obtained from the American Nationwide Inpatient Sample database; which covers approximately 20% of non-federal hospitalisations from 38 American states. Investigators identified patients with ruptured AAA using ICD9 procedure codes as well as Clinical Modification System codes. After identification of the sample, ICD9 diagnosis codes were used to identify comorbid conditions and complications. Analysis: multivariate logistic regression
Outcomes	Endpoints: in-hospital mortality Risk factors: age, sex, congestive heart failure, hypertension, chronic lung disease, liver disease, renal failure, and diabetes

Full citation	**McPhee James, Eslami Mohammad H, Arous Elias J, Messina Louis M, and Schanzer Andres (2009) Endovascular treatment of ruptured abdominal aortic aneurysms in the United States (2001-2006): a significant survival benefit over open repair is independently associated with increased institutional volume. Journal of vascular surgery 49(4), 817-26**
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? No – investigators identified patients who underwent emergency repair of ruptured AAA using ICD 9 diagnosis/procedure codes. 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed patient diagnosis codes to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other consideration: it is unclear whether a stepwise approach was used in the logistic regression analysis Overall risk of bias: high Directness: directly applicable

Full citation	**Mureebe Leila, Egorova Natalia, McKinsey James F, and Kent K Craig (2010) Gender trends in the repair of ruptured abdominal aortic aneurysms and outcomes. Journal of vascular surgery 51(4 Suppl), 9S-13S**
Study details	Study design: retrospective cohort study Location(s): USA Aim of the study: to evaluate gender-specific trends in the diagnosis and treatment of ruptured AAA in the United States Medicare population Study dates: 1995 to 2006 Follow-up: 30-days Sources of funding: no external funding was received
Participants	Sample size: 51,000 Inclusion criteria: people who underwent emergency EVAR or open surgical repair of ruptured AAA were included Exclusion criteria: not reported Baseline characteristics: not reported
Methods	Data collection: most data were obtained from the Medicare Inpatient Standard Analytical file: a national database which collects data on all Medicare reimbursed hospitalisations. The Medicare Inpatient Standard Analytical file data were supplemented by data from other Medicare databases. Investigators identified patients with ruptured AAA using ICD9 procedure codes. Analysis: multivariate logistic regression
Outcomes	Endpoint: 30-day mortality Risk factors: age and sex
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? No – investigators identified patients who underwent emergency repair of ruptured AAA using ICD 9 diagnosis/procedure codes 3. Was the exposure accurately measured to minimise bias? Yes – although investigators retrospectively reviewed patient diagnosis codes, the risk factors (age and sex) assessed in the multivariate regression are considered to be accurately measured 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: it is unclear whether a stepwise approach was used in the logistic regression analysis Overall risk of bias: moderate

Full citation	**Noel A A, Gloviczki P, Cherry Jr, K J, Bower T C, Panneton J M, Mozes G I, Harmsen W S, Jenkins G D, Hallett Jr, and J W (2001) Ruptured abdominal aortic aneurysms: the excessive mortality rate of conventional repair. Journal of vascular surgery : official publication, the Society for Vascular Surgery [and] International Society for Cardiovascular Surgery, and North American Chapter 34(1), 41-46**
Study details	Study design: retrospective cohort study Location(s): USA Aim of the study: to review clinical variables affecting outcomes of all patients who underwent surgical repair for ruptured AAA at a single vascular centre Study dates: January 1980 to November 1998 Follow-up: 30-days Sources of funding: not reported
Participants	Sample size: 413 Inclusion criteria: patients who underwent EVAR or open surgical repair for ruptured AAA at a single centre were included Exclusion criteria: people with ruptured thoracoabdominal, isolated iliac artery aneurysms; pseudoaneurysms; or chronic, contained aneurysms were excluded Baseline characteristics: • Mean age: 74.3 years • Sex: 82% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Coronary artery disease: 48% • Peripheral vascular disease: 20% • Hypertension:53% • Diabetes: 14% • COPD: 33% • Renal insufficiency: 13%
Methods	Data collection: investigators identified the study sample and ascertained the presence of risk factors by retrospectively reviewing hospital records. Preoperative data included clinical presentation, haematocrit, blood pressure, APACHE Analysis: multivariate logistic regression
Outcomes	Endpoint: 30-day mortality Risk factors: age, APACHE II score, cardiac arrest,

Full citation	**Noel A A, Gloviczki P, Cherry Jr, K J, Bower T C, Panneton J M, Mozes G I, Harmsen W S, Jenkins G D, Hallett Jr, and J W (2001) Ruptured abdominal aortic aneurysms: the excessive mortality rate of conventional repair. Journal of vascular surgery : official publication, the Society for Vascular Surgery [and] International Society for Cardiovascular Surgery, and North American Chapter 34(1), 41-46**
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed hospital records to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Yes (b) Have they taken account of the confounding factors in the design and/or analysis? Yes 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? yes Other considerations: stepwise selection was used to identify significant predictors Overall risk of bias: moderate Directness: directly applicable

Full citation	**Robinson William P, Schanzer Andres, Li Youfu, Goodney Philip P, Nolan Brian W, Eslami Mohammad H, Cronenwett Jack L, and Messina Louis M (2013) Derivation and validation of a practical risk score for prediction of mortality after open repair of ruptured abdominal aortic aneurysms in a US regional cohort and comparison to existing scoring systems. Journal of vascular surgery 57(2), 354-61**
Study details	Study design: prospective cohort study Location(s): USA Aim of the study: to develop a practical risk score for in-hospital mortality after open repair of ruptured AAA Study dates: 2003 to 2009 Follow-up: not reported Sources of funding: no external funding was received
Participants	Sample size: 242 Inclusion criteria: all patients who underwent open repair of ruptured AAA at 10 centres were included Exclusion criteria: not reported Baseline characteristics: • Mean age: not reported • Sex: 85.1% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Hypertension: 81.1% • Diabetes: 15.6% • Coronary artery disease: 11.6% • Congestive heart failure: 33.8% • COPD: 42.1% • Creatinine >2.1 mg/dL: 1.4%
Methods	Data collection: trained nurses or clinical abstractors collected and entered data on over 100 clinical and demographic variables prospectively. Patients were evaluated for medical comorbidities as well as parameters reflective of preoperative severity of illness, including systolic blood pressure, history of preoperative cardiac arrest, haemoglobin, and creatinine. Research analysts were blinded to patient, surgeon and hospital identity. Analysis: multivariate logistic regression
Outcomes	Endpoint: in-hospital mortality Risk factors: age, cardiac arrest, and loss of consciousness,

Full citation	**Robinson William P, Schanzer Andres, Li Youfu, Goodney Philip P, Nolan Brian W, Eslami Mohammad H, Cronenwett Jack L, and Messina Louis M (2013) Derivation and validation of a practical risk score for prediction of mortality after open repair of ruptured abdominal aortic aneurysms in a US regional cohort and comparison to existing scoring systems. Journal of vascular surgery 57(2), 354-61**
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? Yes 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: stepwise elimination was used to identify variables independently predictive of mortality. Overall risk of bias: low Directness: directly applicable

Full citation	**Robinson William P, Schanzer Andres, Aiello Francesco A, Flahive Julie, Simons Jessica P, Doucet Danielle R, Arous Elias, and Messina Louis M (2016) Endovascular repair of ruptured abdominal aortic aneurysms does not reduce later mortality compared with open repair. Journal of vascular surgery 63(3), 617-24**
Study details	Study design: retrospective cohort study Location(s): USA Aim of the study: to assess long-term mortality of patients who underwent EVAR or open surgical repair of ruptured AAA Study dates: 2003 to 2013 Follow-up: 5 years Sources of funding: no external funding was received
Participants	Sample size: 1,109 Inclusion criteria: people who underwent emergency EVAR or open surgical repair of ruptured AAA were included Exclusion criteria: Patients with missing data and prior aneurysm repair or other aortic surgery were excluded from the analysis Baseline characteristics: • Mean age: not reported • Sex: EVAR group, 78% male; open repair group, 78% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Hypertension: EVAR group, 79%; open repair group, 78% • Diabetes: EVAR group, 17%; open repair group, 15% • Coronary artery disease: EVAR group, 23%; open repair group, 25% • Congestive heart failure: EVAR group, 14%; open repair group, 8.9% • Coronary artery bypass grafting: EVAR group, 23%; open repair group, 20% • COPD: EVAR group, 33%; open repair group, 35% • Cerebrovascular disease: EVAR group, 2.8%; open repair group, 3.6% • Creatinine >2.1 mg/dL: EVAR group, 8.9%; open repair group, 10%
Methods	Data collection: data on patients who underwent EVAR or open surgical repair of ruptured AAA were retrospectively obtained from the VQ1 database: a vascular surgery registry that incorporates data from over 300 academic and community hospitals. Analysis: Multivariate cox regression
Outcomes	Endpoint: 5-year mortality Risk factors: sex, age, systolic blood pressure, loss of consciousness, cardiac arrest, dialysis, and history of cerebrovascular disease
Risk of bias assessment	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes

Full citation	**Robinson William P, Schanzer Andres, Aiello Francesco A, Flahive Julie, Simons Jessica P, Doucet Danielle R, Arous Elias, and Messina Louis M (2016) Endovascular repair of ruptured abdominal aortic aneurysms does not reduce later mortality compared with open repair. Journal of vascular surgery 63(3), 617-24**
(using CASP tool)	3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed data from a vascular surgery registry to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: stepwise regression was performed Overall risk of bias: moderate Directness: directly applicable

Full citation	**Schlosser Felix J. V, Vaartjes Ilonca, van der Heijden , Geert J M. G, Moll Frans L, Verhagen Hence J. M, Muhs Bart E, de Borst , Gert J, Tiel Groenestege, Andreas T, Kardaun Jan W. P. F, Reitsma Johannes B, van der Graaf , Yolanda , and Bots Michiel L (2010) Mortality after hospital admission for ruptured abdominal aortic aneurysm. Annals of vascular surgery 24(8), 1125-32**
Study details	Study design: retrospective cohort study Location(s): Netherlands Aim of the study: to quantify age- and gender-specific mortality risks for patients hospitalised for ruptured AAA Study dates: January to December 1997 (1 year), and January to December 2000 (1 year) Follow-up: 5-years Sources of funding: the study was supported by a grant of Netherlands Heart Foundation
Participants	Sample size: 1,463 Inclusion criteria: people admitted to hospital with a ruptured AAA were included (type of repair aneurysm repair procedure was not specified) Exclusion criteria: people with a previous hospital admission for the same condition or other peripheral arterial disease were excluded Baseline characteristics: • Mean age: 73.3 years • Sex: 85.6% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Cardiovascular disease: 18.5% • Acute myocardial infarction: 2.8% • Ischaemic heart disease: 8.0% • Congestive heart failure: 2.1% • Diabetes: 2.7%
Methods	Data collection: data were obtained by linking 3 national databases: the Dutch Hospital Discharge Register, the population register, and Statistics Netherlands. Investigators identified the records of patients who underwent emergency aneurysm repair using ICD9 codes. The presence of risk factors was also ascertained using ICD9 codes; however, no information was available about the performed surgical procedure, the size of the AAA, or several potential important established risk factors (lipids, blood pressure, smoking, family history). Analysis: multivariate Cox proportional hazards survival analysis
Outcomes	Endpoint: 28-day, and 5-year mortality Risk factors: age, sex, diabetes, ischemic heart disease, congestive heart failure, and cerebrovascular disease
Risk of bias assessment	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? No – investigators identified patients who underwent emergency repair of ruptured AAA using ICD 9 diagnosis/procedure codes

Full citation	**Schlosser Felix J. V, Vaartjes Ilonca, van der Heijden , Geert J M. G, Moll Frans L, Verhagen Hence J. M, Muhs Bart E, de Borst , Gert J, Tiel Groenestege, Andreas T, Kardaun Jan W. P. F, Reitsma Johannes B, van der Graaf , Yolanda , and Bots Michiel L (2010) Mortality after hospital admission for ruptured abdominal aortic aneurysm. Annals of vascular surgery 24(8), 1125-32**
(using CASP tool)	3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed patient diagnosis codes to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: it is unclear whether a stepwise approach was used in the logistic regression analysis Overall risk of bias: High Directness: directly applicable

Full citation	**Trenner M, Haller B, Sollner H, Storck M, Umscheid T, Niedermeier H, and Eckstein H H (2015) Twelve years of the quality assurance registry on ruptured and non-ruptured abdominal aortic aneurysms of the German Vascular Society (DGG): Part 3: Predictors of perioperative outcome with a focus on annual caseload. English version. Gefasschirurgie 20(1), 32-44**
Study details	Study design: Germany Location(s): Retrospective cohort study Aim of the study: to assess clinical, morphological and structural predictors of increased mortality of patients undergoing EVAR or open surgical repair of ruptured and non-ruptured AAA Study dates: January 1999 to December 2010 Follow-up: not reported Sources of funding: not reported
Participants	Sample size: 4,859 Inclusion criteria: patients who underwent EVAR or open repair for ruptured or unruptured AAA. Analyses were stratified according to whether aneurysms had ruptured or not Exclusion criteria: Not reported Baseline characteristics: • Mean Age: 73.8 years • Sex: not reported • Mean aneurysm diameter: 7.6 cm • Position of aneurysm: 27.1% of patients had an iliac artery aneurysm • Comorbidities: Coronary Heart Disease, 71.6%; COPD, 56.3%; Creatinine > 2mg/dl, 24.5%
Methods	Data collection: investigators obtained data from a German AAA quality assurance registry: 201 hospitals across Germany participated in data collection. Assessment of whether complications were present was performed at the discretion of the treating physician, according to general clinical standards. Analysis: multivariate logistic regression
Outcomes	Endpoint: in-hospital mortality Risk factors: age, AAA diameter, presence of iliac aneurysms
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed data from a quality assurance registry to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear

Full citation	**Trenner M, Haller B, Sollner H, Storck M, Umscheid T, Niedermeier H, and Eckstein H H (2015) Twelve years of the quality assurance registry on ruptured and non-ruptured abdominal aortic aneurysms of the German Vascular Society (DGG): Part 3: Predictors of perioperative outcome with a focus on annual caseload. English version. Gefasschirurgie 20(1), 32-44**
	(b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: it is unclear whether a stepwise approach was used in the logistic regression analysis Overall risk of bias: moderate Directness: directly applicable

Full citation	**Van Beek , S C, Reimerink J J, Vahl A C, Wisselink W, Reekers J A, Legemate D A, and Balm R (2014) Outcomes after open repair for ruptured abdominal aortic aneurysms in patients with friendly versus hostile aortoiliac anatomy. European Journal of Vascular and Endovascular Surgery 47(4), 380-387**
Study details	Study design: prospective cohort study Location(s): Netherlands Aim of the study: to assess the risk of mortality in patients with ruptured aortoilliac aneurysms that were unsuitable for EVAR Study dates: May 2004 to February 2011 Follow-up: not reported Sources of funding: This study was partially funded by the AMC Foundation and the Netherlands Heart Foundation
Participants	Sample size: 208 Inclusion criteria: people with ruptured aortoilliac aneurysms who underwent open surgical repair were included. All patients had aneurysms that were considered unsuitable for treatment with EVAR. Exclusion criteria: people who had previously undergone aortic reconstruction, had a ruptured AAA with an aortoenteric fistula, or whose anatomy was not classified, were excluded. Baseline characteristics: • Mean age: 74.3 years • Sex: 77% male • Mean aneurysm diameter: • Position of aneurysm: aortoilliac aneurysm • Cardiac comorbidity: 44% • Pulmonary comorbidity: 22% • Renal comorbidity: 13% • Cerebrovascular comorbidity: 17%
Methods	Data collection: investigators recruited people who could not participate in the Amsterdam Acute Aneurysm (AJAX) due to 'hostile' aneurysm anatomies that precluded EVAR (as they automatically received open surgery). Mortality data were collected prospectively and verified by checking for errors in the communal registry of all death certificates in the Netherlands. Analysis: multivariate logistic regression
Outcomes	Endpoint: 30-day or in-hospital mortality (composite rate) Risk factors: age, sex, cardiac comorbidity (arrhythmia, cardiac surgery or myocardial infarction), COPD, renal comorbidity (history of chronic kidney failure or dialysis), cerebrovascular comorbidity previous history of transient ischemic attack or stroke) and the need for cardiopulmonary resuscitation

Full citation	**Van Beek , S C, Reimerink J J, Vahl A C, Wisselink W, Reekers J A, Legemate D A, and Balm R (2014) Outcomes after open repair for ruptured abdominal aortic aneurysms in patients with friendly versus hostile aortoiliac anatomy. European Journal of Vascular and Endovascular Surgery 47(4), 380-387**
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? Yes 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Yes (b) Have they taken account of the confounding factors in the design and/or analysis? Yes 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: it is unclear whether a stepwise approach was used in the logistic regression analysis Overall risk of bias: low Directness: directly applicable

Full citation	**Van Dongen , H P A, Leusink J A, Moll F L, Brons F M, De Boer , and A (1998) Ruptured abdominal aortic aneurysms: Factors influencing postoperative mortality and long-term survival. European Journal of Vascular and Endovascular Surgery 15(1), 62-66**
Study details	Study design: retrospective cohort study Location(s): Netherlands Aim of the study: To update mortality rates and long-term survival of patients admitted to the hospital with ruptured AAA and to study prognostic factors associated with mortality Study dates: January 1980 and January 1994 Follow-up: 30 days Sources of funding: not reported
Participants	Sample size: 309 Inclusion criteria: people who underwent open surgical repair (termed, laparotomy) of ruptured AAA were included. Rupture was defined as either evidence of retroperitoneal haematoma or free blood in the peritoneal cavity at the time of laparotomy. Exclusion criteria: not specified Baseline characteristics: • Mean age: 71 years • Sex: 89% male • Mean aneurysm diameter: not reported • Position of aneurysm: not reported • Comorbidities: not reported
Methods	Data collection: data relating to patient demographics, comorbidities and in-hospital mortality were collected by retrospective review of patient records. Mortality after hospital discharge was determined by obtaining information from the administration of the municipality in which the patient had lived. If the patient had moved to another municipality the new address was requested and the procedure was repeated until the present place of residence or date of death was known. Analysis: multivariate logistic regression and Cox proportional hazards survival analysis
Outcomes	Endpoint: mortality within 48 hours, and 30-day mortality Risk factors: age and hypotension
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed hospital records to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes

Full citation	**Van Dongen , H P A, Leusink J A, Moll F L, Brons F M, De Boer , and A (1998) Ruptured abdominal aortic aneurysms: Factors influencing postoperative mortality and long-term survival. European Journal of Vascular and Endovascular Surgery 15(1), 62-66**
	5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: it is unclear whether a stepwise approach was used in the logistic regression analysis Overall risk of bias: moderate Directness: directly applicable

Full citation	**Visser Jacob J, Williams Martine, Kievit Jur, Bosch Johanna L, and Group A Study (2009) Prediction of 30-day mortality after endovascular repair or open surgery in patients with ruptured abdominal aortic aneurysms. Journal of vascular surgery 49(5), 1093-9**
Study details	Study design: prospective cohort study Location(s): Netherlands Aim of the study: to identify risk factors that predict 30-day mortality for patients with ruptured AAA treated with endovascular repair or open surgery Study dates: December 2004 to October 2006 Follow-up: 30-days Sources of funding: The study was funded by Erasmus MC Health Care Efficiency grant and an unrestricted educational grant from the “Lijf en Leven” Foundation.
Participants	Sample size: 201 Inclusion criteria: people who presented with ruptured AAAs and were treated by EVAR or open surgical repair were included. Exclusion criteria: people were excluded if they died before AAA repair could be initiated Baseline characteristics: • Mean age: 73.3 years • Sex: 85.6% male • Mean aneurysm diameter: not reported • Position of aneurysm: infarenal, 58%; juxtarenal, 34%; suprarenal,3%; not reported, 5% • Renal insufficiency: 11.9% • Diabetes: 10.4% • Hypertension: 44.3%

Full citation	**Visser Jacob J, Williams Martine, Kievit Jur, Bosch Johanna L, and Group A Study (2009) Prediction of 30-day mortality after endovascular repair or open surgery in patients with ruptured abdominal aortic aneurysms. Journal of vascular surgery 49(5), 1093-9**
	• Angina pectoris: 11.9% • Previous myocardial infarction: 23.4% • Heart failure: 10% • COPD: 23.4%
Methods	Data collection: The study was performed across 5 hospitals in the Netherlands. Prospectively collected data included patient characteristics, renal insufficiency, diabetes, hypertension, angina pectoris, myocardial infarction, congestive heart failure, myocardial infarction, congestive heart failure or cerebrovascular disease, haemodynamic condition, presence of shock. In order to obtain information about 30-day mortality and the causes of death, medical records of the participating hospitals were prospectively reviewed. Analysis: multivariate logistic regression
Outcomes	Endpoint: 30-day mortality Risk factors: age, shock, myocardial disease (myocardial infarction and/or angina pectoris), cerebrovascular disease and renal failure
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? Yes 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear (b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: all variables considered in the Glasgow Aneurysm Scale were included in the multivariate logistic regression analysis Overall risk of bias: low Directness: directly applicable

Full citation	**Von Meijenfeldt, G C I, Ultee K H. J, Eefting D, Hoeks S E, Ten Raa, S , Rouwet E V, Hendriks J M, Verhagen H J. M, Bastos Goncalves, and F M (2014) Differences in mortality, risk factors, and complications after open and endovascular repair of ruptured abdominal aortic aneurysms. European Journal of Vascular and Endovascular Surgery 47(5), 479-486**
Study details	Study design: retrospective cohort study Location(s): Netherlands Aim of the study: to assess differences in postoperative complications and survival in people who underwent EVAR and open repair for ruptured AAA Study dates: January 2000 to June 2013 Follow-up: 30-days Sources of funding: no external funding was received
Participants	Sample size: 221 Inclusion criteria: people with ruptured AAA who underwent EVAR or open surgical repair were included Exclusion criteria: Patients with infected aneurysms and those having had prior aneurysm repair were excluded Baseline characteristics: • Mean age: EVAR group, 72.1 years; open surgery group, 71.9 years • Sex: EVAR group, 93% male; open surgery group, 89% male • Mean aneurysm diameter: not reported • Position of aneurysm: all were infrarenal aneurysm • Comorbidities: not reported
Methods	Data collection: investigators identified patients who underwent AAA repair procedures by retrospectively reviewing hospital records and operation codes. If confirmed, patient demographics, clinical baseline characteristics, intraoperative details, and clinical and laboratory outcome were obtained. Postoperative complications and events were retrieved from hospital registries. Survival status and the exact date of death of treated patients were obtained via the national civil registry. Analysis: multivariate logistic regression
Outcomes	Endpoint: 30-day or in-hospital mortality Risk factors: age, haemoglobin level, eGFR measurments, and presence of shock
Risk of bias assessment (using CASP tool)	1. Did the study address a clearly focused issue? Yes 2. Was the cohort recruited in an acceptable way? Yes 3. Was the exposure accurately measured to minimise bias? No – investigators retrospectively reviewed hospital records to ascertain the presence/absence of risk factors 4. Was the outcome accurately measured to minimise bias? Yes 5 (a) Have the authors identified all important confounding factors? Unclear

Full citation	**Von Meijenfeldt, G C I, Ultee K H. J, Eefting D, Hoeks S E, Ten Raa, S , Rouwet E V, Hendriks J M, Verhagen H J. M, Bastos Goncalves, and F M (2014) Differences in mortality, risk factors, and complications after open and endovascular repair of ruptured abdominal aortic aneurysms. European Journal of Vascular and Endovascular Surgery 47(5), 479-486**
	(b) Have they taken account of the confounding factors in the design and/or analysis? Unclear 6 (a) Was the follow up of subjects complete enough? Yes (b) Was the follow up of subjects long enough? Yes Other considerations: stepwise regression was not performed. Instead, all significant variables in univariate analyses were included in a logistic regression model Overall risk of bias: high Directness: directly applicable

Appendix E – GRADE tables

Mortality within 48 hours

Age

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
Open surgery only									
Age: ≥70 vs. <70 years	Van Dongen (1998)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	309	OR[a] 7.2 (2.1, 25.1)	Moderate

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level

30-day or in-hospital mortality

Age

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR only									
Age: ≥75 vs. <75	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Very serious[3,4]	221	OR[a] 1.5 (Not significant; CI not reported)	Very low
Open surgery only									
Age: 69-75 >75 years, All vs. <69 years	Van Beek (2014)	Prosp. cohort	Not serious	N/A	Not serious	Serious[3]	208	OR[a] 1.52 (0.63, 3.66) OR[a] 2.05 (0.95, 4.47)	Moderate
Age: >76 vs. ≤76	Robinson (2013)	Prosp. cohort	Not serious	N/A	Not serious	Not serious	242	OR[a] 5.3 (2.8, 10.1)	High

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
Age: ≥75 vs. <75	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[4]	221	OR[a] 2.8 (Significant; CI not reported)	Very low
Age: >80 years vs. <70 years	Van Dongen (1998)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	309	HR[a] 5.1 (2.1, 11.6)	Moderate
EVAR or open surgery (or surgical approach not specified)									
Age: per year increase	3 (Mureebe 2010, Noel 2001, Schlosser 2010)	Retro. cohort	Very serious[1,5]	Not serious	Not serious	Not serious	52,876	OR[a] 1.08 (1.07, 1.08) OR[a] 1.05 (1.02, 1.09) HR[a] 1.04 (1.03, 1.05)	Moderate
Age: per 5 year increase	Dueck (2004)	Retro. cohort	Very serious[1,5]	N/A	Not serious	Not serious	2,601	HR[a] 1.2 (1.16, 1.25)	Low
Age: per 10 year increase	Visser (2009)	Prosp. cohort	Not serious	N/A	Not serious	Not serious	201	OR[a] 2.21 (1.18, 4.13)	Low
Age: 65-79, ≥80 years All vs. <65 years	Trenner 2015	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	4,859	OR[a] 1.82 (1.46, 2.28) OR[a] 3.75 (2.94, 4.78)	Moderate
Age: 60-70, 70-80, ≥80 years All vs. <60	Giles (2009)	Retro. cohort	Serious[5]	N/A	Not serious	Not serious	28,429	OR[a] 1.6 (1.3, 2.1) OR[a] 2.4 (1.9, 3.1) OR[a] 4.2 (3.2, 5.4)	Moderate
Age > 70 Vs. <70	Heller (2000)	Retro. cohort	Very serious[1,2,5]	N/A	Not serious	Not serious	67,751	OR[a] 4.8 (3.0, 78.0)	Low
Age: >80 vs. <80	McPhee (2009)	Retro. cohort	Very serious[1,5]	N/A	Not serious	Not serious	27,750	OR[a] 1.95 (1.72, 2.22)	Low

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.
1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.
2. Stepwise regression was not performed. Instead, variables found to be significant in univariate analyses were input into logistic regression models; downgrade 1 level.
3. 95% CI crosses the line of no effect (1); downgrade 1 level.
4. 95% CI not reported; downgrade 1 level
5. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.

Sex

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
Open surgery only									
Female	Van Beek (2014)	Prosp. cohort	Not serious	N/A	Not serious	Serious[1]	208	OR[a] 1.53 (0.79, 2.99)	Moderate
EVAR or open surgery (or surgical approach not specified)									
Female	6 (Dueck 2004, Giles 2009, McPhee 2009, Mureebe 2010, Schlosser 2010, Heller 2000)	Retro. cohort	Very serious[2,3]	Not serious	Not serious	Not serious	178,994	HR[a] 1.2 (1.05, 1.38) OR[a] 1.3 (1.1, 1.4) OR[a] 1.41 (1.23, 1.61) OR[a] 1.53 (1.47, 1.58) HR[a] 1.11 (0.92, 1.34) OR[a] 3.0 (1.7, 5.2)	Low

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.
1. 95% CI crosses the line of no effect (1); downgrade 1 level.
2. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.
3. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.

Aneurysm diameter & anatomy

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Diameter: 50-59 60-69 ≥70 mm All vs. <50mm	Trenner 2015	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	4,859	OR[a] 1.33 (0.94, 1.87) OR[a] 1.56 (1.16, 2.09) OR[a] 2.31 (1.37, 2.36)	Moderate

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.

Comorbid conditions

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
Open surgery only									
COPD	Van Beek (2014)	Prosp. cohort	Not serious	N/A	Not serious	Not serious	208	OR[a] 2.33 (1.17, 4.64)	High
Cardiac comorbidity (arrhythmia, cardiac surgery or myocardial infarction)	Van Beek (2014)	Prosp. cohort	Not serious	N/A	Not serious	Serious[1]	208	OR[a] 1.23 (0.70, 2.24)	Moderate
Renal comorbidity (history of chronic kidney failure or dialysis)	Van Beek (2014)	Prosp. cohort	Not serious	N/A	Not serious	Serious[1]	208	OR[a] 1.39 (0.60, 3.25)	Moderate
Cerebrovascular comorbidity	Van Beek (2014)	Prosp. cohort	Not serious	N/A	Not serious	Serious[1]	208	OR[a] 1.29 (0.60, 2.77)	Moderate

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
previous history of transient ischemic attack or stroke)									
EVAR or open surgery (or surgical approach not specified)									
COPD	2 (Brahmbhatt 2016, McPhee 2009)	Retro. cohort	Very serious[2,3]	Not Serious[4]	Not serious	Not serious	30,551	OR[a] 2.4 (1.7, 3.4) OR[a] 0.74 (0.62, 0.89)	Very low
Congestive heart failure	2 (McPhee 2009, Schlosser 2010)	Retro. cohort	Very serious[2,3]	Not Serious[4]	Not serious	Not serious	29,213	OR[a] 0.83 (0.57, 1.23) HR[a] 1.52 (1.03, 2.25)	Very low
Ischaemic/coronary heart disease	Schlosser (2010)	Retro. cohort	Very serious[2,3]	N/A	Not serious	Serious[1]	1,463	HR[a] 1.01 (0.78, 1.30)	Very low
Myocardial disease (myocardial infarction and/or angina pectoris)	Visser (2009)	Prosp. cohort	Not serious	N/A	Not serious	Not serious	201	OR[a] 1.18 (1.13, 2.89)	High
Hypertension	McPhee (2009)	Retro. cohort	Very serious[2,3]	N/A	Not serious	Not serious	27,750	OR[a] 0.72 (0.60, 0.87)	Low
Liver disease	McPhee (2009)	Retro. cohort	Very serious[2,3]	N/A	Not serious	Not serious	27,750	OR[a] 3.35 (1.94, 5.78)	Low
Renal failure	3 (McPhee 2009, Heller 2000,	2 Retro. and 1	Very serious[2,3]	N/A	Not serious	Not serious	95,702	OR[a] 1.07 (0.84, 1.37) OR[a] 2.5 (1.3, 4.9) OR[a] 3.03 (1.55, 5.89)	Low

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
	Visser 2009)	prosp. cohort							
Diabetes	2 (McPhee 2009, Schloesser 2010)	Retro. cohort	Very serious[2,3]	N/A	Not serious	Serious[1]	29,213	OR[a] 1.17 (0.92, 1.48) HR[a] 1.09 (0.73, 1.62)	Very low
Cerebrovascular disease	2 (Schlosser 2010, Visser 2009)	1 Retro. and 1 prosp. cohort	Very serious[2,3]	Not serious	Not serious	Not serious	1,664	HR[a] 1.44 (1.01, 2.06) HR[a] 2.20 (1.19, 4.07)	Low

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.
1. 95% CI crosses the line of no effect (1); downgrade 1 level.
2. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.
3. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.
4. 95% CIs of one of two similar sized studies crosses line of no effect (non-significant result), making it difficult to ascertain the overall significance of the evidence as a whole, downgrade 1 level.

Preoperative clinical tests

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR only									
Haemoglobin <11mg/dL	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[3]	221	OR[a] 3.24 (significant; CI not reported)	Very low
eGFR <60	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Very serious[3,4]	221	OR[a] 1.5 (Not significant; CI not reported)	Very low

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
Open surgery only									
Haemoglobin <11mg/dL	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[3]	221	OR[a] 3.4 (significant; CI not reported)	Very low
eGFR <60	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Very serious[3,4]	221	OR[a] 1.5 (Not significant; CI not reported)	Very low
Duration of hypotension: >60 mins vs. <30 mins	Van Dongen (1998)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	309	HR[a] 2.2 (1.0, 5.0) *significant	Moderate
EVAR or open surgery (or surgical approach not specified)									
Creatinine: per g/dL increase	Brahmbhatt (2016)	Retro. cohort	Very serious[1,2,5]	N/A	Not serious	Not serious	2,761	OR[a] 1.2 (1.0, 1.2) *significant	Low
Haematocrit: per percentage increase	2 (Brahmbhatt 2016, Noel 2001)	Retro. cohort	Very serious[1,2,5]	Not serious	Not serious	Not serious	3,192	OR[a] 0.94 (0.91, 0.97) OR[a] 0.98 (0.95, 1.0) *significant	Low

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.
2. Stepwise regression was not performed. Instead, variables found to be significant in univariate analyses were input into logistic regression models; downgrade 1 level.
3. 95% CI not reported; downgrade 1 level
4. 95% CI crosses the line of no effect (1); downgrade 1 level.
5. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.

Shock, cardiac arrest, and loss of consciousness

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR only									
Shock	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[3,4]	221	OR[a] 0.73 (Not significant; CI not reported)	Very low
Open surgery only									
Shock	Von Meijenfeldt (2014)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[3]	221	OR[a] 2.4 (significant; CI not reported)	Very low
Cardiac arrest	Robinson (2013)	Prosp. cohort	Not serious	N/A	Not serious	Not serious	242	OR[a] 4.3 (1.6, 12.0)	High
Loss of consciousness	Robinson (2013)	Prosp. cohort	Not serious	N/A	Not serious	Not serious	242	OR[a] 2.7 (1.2, 6.0)	High
EVAR or open surgery (or surgical approach not specified)									
Shock	2 (Korhonen 2004, Visser 2009)	1 retro. and 1 prop. cohort	Serious[1]	Not serious	Not serious	Not serious	1,037	OR[a] 2.13 (1.45, 3.11) OR[a] 3.82 (2.29, 6.38)	Moderate
Cardiac arrest	Noel (2001)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	413	OR[a] 3.14 (1.39, 7.11)	Moderate

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.
2. Stepwise regression was not performed. Instead, variables found to be significant in univariate analyses were input into logistic regression models; downgrade 1 level.
3. 95% CI not reported; downgrade 1 level
4. 95% CI crosses the line of no effect (1); downgrade 1 level.

Risk assessment tool score

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Per 10 unit increase in GAS score	Korhonen (2004)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	836	OR[a] 1.81 (1.54, 2.12)	Low
Per unit increase in APACHE II score	Noel (2001)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	413	OR[a] 1.05 (1.01, 1.09)	Moderate
ASA score: 3 4-5 All vs 1-2 ASA: American Society of Anaesthesiologists	Trenner (2015)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	4,859	OR[a] 1.86 (1.41, 2.45) OR[a] 4.95 (3.73, 6.56)	Moderate

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.

Long term (5-year) mortality

Age

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Age: per year increase	Schlosser 2010	Retro. cohort	Very serious[1,2]	N/A	Not serious	Not serious	1,463	HR[a] 1.05 (1.04, 1.06)	Low
Age: per 5 year increase	Robinson (2016)	Retro. cohort	Serious[2]	N/A	Not serious	Not serious	1,104	OR[a] 1.4 (1.3, 1.4)	Moderate

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.

2. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.

Sex

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Female	2 (Robinson 2016, Schlosser 2010)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[3]	2,567	OR[a] 1.3 (1.03, 1.6) HR[a] 1.14 (0.96, 1.35)	Very low

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.

2. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.

3. Visual inspection of point estimates and 95% CIs across studies indicates inconsistent findings, downgrade 1 level.

Comorbid conditions

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Congestive heart disease	Schlosser (2010)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Not serious	1,463	HR[a] 1.55 (1.06, 2.26)	Low
Ischaemic heart disease	Schlosser (2010)	Retro. cohort	Very serious[1,2]	N/A	Not serious	Serious[3]	1,463	HR[a] 1.05 (0.84, 1.32)	Very low
History of cerebrovascular disease	2 (Robinson 2016, Schlosser 2010)	Retro. cohort	Very serious[1,2]	Not serious	Not serious	Not serious	2,567	OR[a] 1.7 (1.1, 2.7) HR[a] 1.60 (1.16, 2.21)	Low

a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

1. Patients with ruptured AAA (study sample) was determined by retrospectively reviewing classification codes (such as ICD 9 codes) in disease registers and health insurance provider databases; downgrade 1 level.

2. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.

3. 95% CI crosses the line of no effect (1); downgrade 1 level.

Preoperative clinical tests

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Systolic blood pressure: <90mmHG vs. >90mmHG	Robinson (2016)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	1,104	OR[a] 1.4 (1.1, 1.7)	Moderate

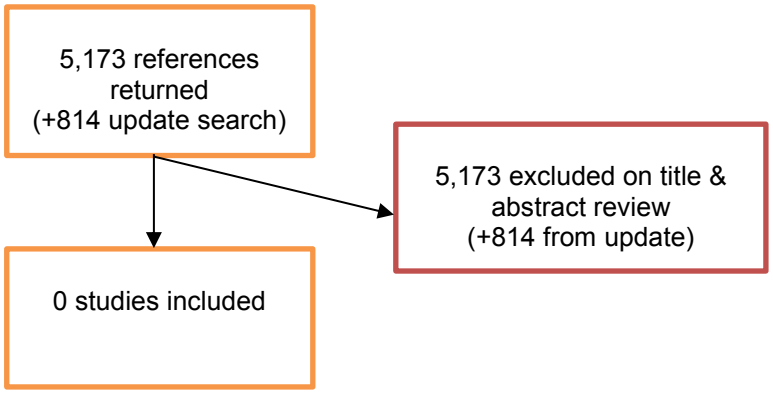
a. As multivariate analyses were performed, hazard and odds ratios were reported adjusting for confounders or other factors.

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level.									

Cardiac arrest, loss of consciousness, shock

Predictor	No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	No. of participants	Effect size (95% CI)	Quality
EVAR or open surgery (or surgical approach not specified)									
Cardiac arrest	Robinson (2016)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	1,104	OR[a] 2.9 (2.2, 3.9)	Moderate
Loss of consciousness	Robinson (2016)	Retro. cohort	Serious[1]	N/A	Not serious	Not serious	1,104	OR[a] 1.7 (1.3, 2.2)	Moderate
a. As multivariate analyses were performed hazard, and odds ratios were reported adjusting for confounders or other factors.									
1. Investigators ascertained the presence/absence of risk factors (covariates) by retrospectively reviewing data from disease registers, health insurance provider databases, or hospital records; downgrade 1 level									

Appendix F – Economic evidence study selection



Appendix G – Excluded studies

Clinical studies

No.	Study	Reason for exclusion
1	Aburahma A F, Woodruff B A, Stuart S P et al. (1991) Early diagnosis and survival of ruptured abdominal aortic aneurysms. The American journal of emergency medicine 9(2), 118-21	Sample size less than 200 participants.
2	AbuRahma A F, Woodruff B A, Lucente F et al. (1991) Factors affecting survival of patients with ruptured abdominal aortic aneurysm in a West Virginia community. Surgery Gynecology and Obstetrics 172(5), 377-382	Sample size less than 200 participants.
3	Acosta S, Lindblad B, and Zdanowski Z (2007) Predictors for Outcome after Open and Endovascular Repair of Ruptured Abdominal Aortic Aneurysms. European Journal of Vascular and Endovascular Surgery 33(3), 277-284	Sample size less than 200 participants.
4	Ahn Hyo Yeong, Chung Sung Woon, Lee Chung Won et al. (2012) Factors affecting the postoperative mortality in the ruptured abdominal aortic aneurysm. The Korean journal of thoracic and cardiovascular surgery 45(4), 230-5	Abstract states multivariate was performed but there is no mention of such analysis in the full manuscript: only univariate analysis is mentioned. As a result, it was not possible to ascertain which results were obtained from multivariate analysis.
5	Alexander S, Bosch J L, Hendriks J M et al. (2008) The 30-day mortality of ruptured abdominal aortic aneurysms: influence of gender, age, diameter and comorbidities. The Journal of cardiovascular surgery 49(5), 633-7	Sample size less than 200 participants.
6	Alonso-Perez M, Segura R J, Sanchez J et al. (2001) Factors increasing the mortality rate for patients with ruptured abdominal aortic aneurysms. Annals of vascular surgery 15(6), 601-7	Sample size less than 200 participants.
7	Anain Paul M, Anain Joseph M, Sr ,Tiso Michael et al. (2007) Early and mid-term results of ruptured abdominal aortic aneurysms in the endovascular era in a community hospital. Journal of vascular surgery 46(5), 898-905	Sample size less than 200 participants.
8	Antonello M, Frigatti P, Maturi C et al. (2009) Open repair for ruptured abdominal aortic aneurysm: is it possible to predict survival?. Annals of vascular surgery 23(2), 159-66	Sample size less than 200 participants.
9	Antonopoulos Constantine N, Kakisis John D, Andrikopoulos Vasilios, et al. (2014) Predictors affecting in-hospital mortality of ruptured abdominal aortic aneurysms: a	Sample size less than 200 participants.

No.	Study	Reason for exclusion
	Greek multicenter study. Annals of vascular surgery 28(6), 1384-90	
10	Aranson Nathan J, Lancaster Robert T, Ergul Emel, et al. (2016) Chronic Kidney Disease Class Predicts Mortality After Abdominal Aortic Aneurysm Repair in Propensity-matched Cohorts From the Medicare Population. Annals of surgery 264(2), 386-91	Not specific to ruptured AAA: all patients underwent elective AAA repair.
11	Baderkhan H, Goncalves F M. B, Oliveira N G, et al. (2016) Challenging Anatomy Predicts Mortality and Complications after Endovascular Treatment of Ruptured Abdominal Aortic Aneurysm. Journal of Endovascular Therapy 23(6), 1-9	Sample size less than 200 participants
12	Biancari F, Venermo M, Finnish Arterial Disease, and Investigators (2011) Open repair of ruptured abdominal aortic aneurysm in patients aged 80 years and older. The British journal of surgery 98(12), 1713-8	Sample size less than 200 participants.
13	Bonardelli Stefano, Cervi Edoardo, Maffeis Roberto et al. (2011) Open surgery in endovascular aneurysm repair era: simplified classification in two risk groups owing to factors affecting mortality in 137 ruptured abdominal aortic aneurysms (RAAAs). Updates in surgery 63(1), 39-44	Sample size less than 200 participants.
14	Botha J A, Tiruvoipati R, Last G C et al. (2008) Predictors of outcome of ruptured aortic aneurysms in a metropolitan hospital. Anaesthesia and intensive care 36(4), 560-4	Sample size less than 200 participants.
15	Bown M J, Cooper N J, Sutton A J, et al. (2004) The post-operative mortality of ruptured abdominal aortic aneurysm repair. European Journal of Vascular and Endovascular Surgery 27(1), 65-74	Sample size less than 200 participants.
16	Cadili Ali, Turnbull Robert, Hervas-Malo Marilou et al. (2012) Identifying patients with AAA with the highest risk following endovascular repair. Vascular and endovascular surgery 46(6), 455-9	Not specific to ruptured AAA: investigators assessed all patients undergoing EVAR at a single centre, regardless of whether their aneurysms had ruptured or not. Additionally, the study included less than 200 participants.
17	Chagpar Ryaz B, Harris Jeremy R, Lawlor D Kirk et al. (2010) Early mortality following endovascular versus open repair of ruptured abdominal aortic aneurysms. Vascular and endovascular surgery 44(8), 645-9	Sample size less than 200 participants.
18	Chen J C, Hildebrand H D, Salvian A J et al. (1996) Predictors of death in nonruptured and ruptured abdominal aortic	Sample size less than 200 participants.

No.	Study	Reason for exclusion
	aneurysms. Journal of Vascular Surgery 24(4), 614-623	
19	Cho Jae-Sung, Kim Jang Yong, Rhee Robert Y et al. (2008) Contemporary results of open repair of ruptured abdominal aortoiliac aneurysms: effect of surgeon volume on mortality. Journal of vascular surgery 48(1), 10-8	Sample size less than 200 participants.
20	De Rango , P , Simonte G, Manzone A, et al. (2016) Arbitrary Palliation of Ruptured Abdominal Aortic Aneurysms in the Elderly is no Longer Warranted. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 51(6), 802-9	Sample size less than 200 participants.
21	De Rango , P , Simonte G, Manzone A, et al. (2017) Mortality Risk for Ruptured Abdominal Aortic Aneurysm in Women. Annals of vascular surgery 39, 143-151	Sample size less than 200 participants
22	Dingemans Siem A, Jonker Frederik H. W, Moll Frans L, et al. (2016) Aneurysm Sac Enlargement after Endovascular Abdominal Aortic Aneurysm Repair. Annals of vascular surgery 31, 229-38	Systematic review which included studies that employed multiple study designs. Individual studies were assessed to establish if they met criteria for inclusion in this NICE review.
23	Goncalves F B, Ultee K H. J, Hoeks S E, et al. (2016) Life expectancy and causes of death after repair of intact and ruptured abdominal aortic aneurysms Presented in the Plenary Rapid Pace Session at the 2015 Vascular Annual Meeting of the Society for Vascular Surgery, Chicago, Ill, June 17-20, 2015. Journal of vascular surgery 63(3), 610-6	Not specific to ruptured AAA: authors pooled data from patients with unruptured and ruptured aneurysms.
24	Guo Q, Du X, Zhao J, et al. (2017) Prevalence and risk factors of type II endoleaks after endovascular aneurysm repair: A meta-analysis. PLoS ONE 12(2), 0170600	Systematic review which included studies that employed multiple study designs. Individual studies were assessed to establish if they met criteria for inclusion in this NICE review.
25	Gutierrez-Morlote J, Llorca J, Ibanez de Elejalde, et al. (2002) Predictors of mortality in patients undergoing surgery for ruptured aortic aneurysm. Vasa - Journal of Vascular Diseases 31(4), 265-268	Sample size less than 200 participants.
26	Gwon JG, Kwon TW, Cho YP, et al. (2016) Analysis of in hospital mortality and long-term survival excluding in hospital mortality after open surgical repair of ruptured abdominal aortic aneurysm. Annals of surgical treatment and research 91(6), 303-308	Not specific to ruptured AAA: the study sample included patients with intact AAA (81.6%) and ruptured AAA (18.4%).
27	Halpern V J, Kline R G, D'Angelo A J, et al. (1997) Factors that affect the survival rate of patients with ruptured abdominal aortic	Sample size less than 200 participants.

No.	Study	Reason for exclusion
	aneurysms. Journal of Vascular Surgery 26(6), 939-948	
28	Hardman D T, Fisher C M, Patel M I et al. (1996) Ruptured abdominal aortic aneurysms: who should be offered surgery?. Journal of vascular surgery 23(1), 123-9	Sample size less than 200 participants.
29	Hashimoto Makoto, Ito Toshiro, Kurimoto Yoshihiko et al. (2013) Preoperative arterial blood lactate levels as a predictor of hospital mortality in patients with a ruptured abdominal aortic aneurysm. Surgery today 43(2), 136-40	Sample size less than 200 participants.
30	Healey CT, Neilson M, Clark D, et al. (2017) Predicting Mortality of Ruptured Abdominal Aortic Aneurysms in the Era of Endovascular Repair. Annals of vascular surgery 38, 59-63	Conference abstract
31	Ho Man-Fung, Chan Yiu-Che, Cheung Grace C et al. (2014) Multicenter audit of emergency endovascular repair of infrarenal aortic aneurysms. Annals of vascular surgery 28(3), 560-7	Sample size less than 200 participants.
32	Hultgren R, Granath F, and Swedenborg J et al. (2007) Different Disease Profiles for Women and Men with Abdominal Aortic Aneurysms. European Journal of Vascular and Endovascular Surgery 33(5), 556-560	Not specific to ruptured AAA: authors pooled data from patients with unruptured and ruptured aneurysms.
33	Janczyk Randy J, Howells Greg A, Bair Holly A et al. (2004) Hypothermia is an independent predictor of mortality in ruptured abdominal aortic aneurysms. Vascular and endovascular surgery 38(1), 37-42	Sample size less than 200 participants.
34	Jang HN, Park HO, Yang JH, Yang TW, et al. (2017) Evaluation of Preoperative Predictors of 30-Day Mortality in Patients with Ruptured Abdominal Aortic Aneurysm. Vascular specialist international 33(3), 93-98	Sample size less than 200 participants.
35	Johnston K W, Ameli F M, Au H H, Baird R J, Balachandra V K et al. (1994) Ruptured abdominal aortic aneurysm: Six-year follow-up results of a multicenter prospective study. Journal of Vascular Surgery 19(5), 888-900	Sample size less than 200 participants.
36	Karthikesalingam A, Holt P J, Vidal-Diez A, Ozdemir B A et al. (2014) Mortality from ruptured abdominal aortic aneurysms: Clinical lessons from a comparison of outcomes in England and the USA. The Lancet 383(9921), 963-969	Multivariate regression was not performed to assess risk factors associated with survival/mortality.

No.	Study	Reason for exclusion
37	Kauvar David S, Sarfati Mark R, and Kraiss Larry W (2012) Intraoperative blood product resuscitation and mortality in ruptured abdominal aortic aneurysm. Journal of vascular surgery 55(3), 688-92	Sample size less than 200 participants.
38	Kim Sang Dong, Hwang Jeong Kye, Park Sun Cheol et al. (2012) Predictors of postoperative mortality of ruptured abdominal aortic aneurysm: a retrospective clinical study. Yonsei medical journal 53(4), 772-80	Sample size less than 200 participants.
39	Kordzadeh A, Malietzis G, Browne T et al. (2015) Neutrophil to lymphocyte ratio (NLR) of five predicts 30-day morbidity in ruptured abdominal aortic aneurysms (rAAA): A retrospective cohort study. International Journal of Surgery 15, 45-48	Sample size less than 200 participants.
40	Krenzien Felix, Matia Ivan, Wiltberger Georg et al. (2014) Early prediction of survival after open surgical repair of ruptured abdominal aortic aneurysms. BMC surgery 14, 92	Sample size less than 200 participants.
41	Kurc Erol, Sanioglu Soner, Ozgen Ayca et al. (2012) Preoperative risk factors for in-hospital mortality and validity of the Glasgow aneurysm score and Hardman index in patients with ruptured abdominal aortic aneurysm. Vascular 20(3), 150-5	Sample size less than 200 participants.
42	Lambert M E, Baguley P, and Charlesworth D (1986) Ruptured abdominal aortic aneurysms. The Journal of cardiovascular surgery 27(3), 256-61	Sample size less than 200 participants.
43	Li Hao-Jui, Kao Tsung-Chi, Liu Dah-Wel, et al. (2011) Predictors of outcome after open repair of ruptured abdominal aortic aneurysms. Chang Gung medical journal 34(5), 520-7	Sample size less than 200 participants.
44	Lo Albert, and Adams Dave (2004) Ruptured abdominal aortic aneurysms: risk factors for mortality after emergency repair. The New Zealand medical journal 117(1203), U1100	Sample size less than 200 participants.
45	Mathisen SR, and Abdelnoor M (2017) Beneficial effect of statins on total mortality in abdominal aortic aneurysm (AAA) repair. Vascular medicine (London, and England) 22(5), 406-410	Out of scope: this retrospective cohort study explores the efficacy of a postoperative pharmacological intervention on mortality rates after AAA repair.
46	Maynard N D, Taylor P R, Mason R C et al. (1996) Gastric intramucosal pH predicts outcome after surgery for ruptured abdominal aortic aneurysm. European Journal of Vascular and Endovascular Surgery 11(2), 201-206	Multivariate analysis was not performed to assess risk factors associated with survival/mortality.

No.	Study	Reason for exclusion
47	McCready R A, Siderys H, Pittman J N et al. (1993) Ruptured abdominal aortic aneurysms in a private hospital: a decade's experience (1980-1989). Annals of vascular surgery 7(3), 225-8	Sample size less than 200 participants.
48	Mell Matthew W, O'Neil Amy S, Callcut Rachael A et al. (2010) Effect of early plasma transfusion on mortality in patients with ruptured abdominal aortic aneurysm. Surgery 148(5), 955-62	Sample size less than 200 participants.
49	Mell Matthew W, Callcut Rachael A, Bech Fritz et al. (2012) Predictors of emergency department death for patients presenting with ruptured abdominal aortic aneurysms. Journal of vascular surgery 56(3), 651-5	Study assessed hospital-related risk factors such as, rural versus urban, teaching versus non-teaching, emergency department volume, and region.
50	Montan Carl, Johansson Fredrik, Hedin Ulf et al. (2015) Preoperative hypofibrinogenemia is associated with increased intraoperative bleeding in ruptured abdominal aortic aneurysms. Thrombosis research 135(3), 443-8	Sample size less than 200 participants.
51	Morisaki K, Yamaoka T, Iwasa K et al. (2017) Preoperative risk factors for aneurysm sac expansion caused by type 2 endoleak after endovascular aneurysm repair. Vascular 25(5), 533-541	Out of scope: study explores outcomes of patients with unruptured aneurysms who underwent AAA repair procedures
52	Nakayama Atsuko, Morita Hiroyuki, Miyata Tetsuro, Hoshina Katsuyuki, Nagayama Masatoshi, Takanashi Shuichiro, Sumiyoshi Tetsuya, Komuro Issei, and Nagai Ryozo (2014) Predictors of mortality after emergency or elective repair of abdominal aortic aneurysm in a Japanese population. Heart and vessels 29(1), 65-70	Sample size less than 200 participants.
53	Nie W, Wang Y, Yao K et al. (2016) Serum angiotensin-converting enzyme 2 is an independent risk factor for in-hospital mortality following open surgical repair of ruptured abdominal aortic aneurysm. Experimental and Therapeutic Medicine 12(3), 1412-1418	Sample size less than 200 participants.
54	Opfermann P, von Allmen , R , Diehm N et al. (2011) Repair of ruptured abdominal aortic aneurysm in octogenarians. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 42(4), 475-83	Sample size less than 200 participants.
55	Ouriel K, Geary K, Green R M, Fiore W et al. (1990) Factors determining survival after ruptured aortic aneurysm: the hospital, the surgeon, and the patient. Journal of vascular surgery 11(4), 493-6	Sample size less than 200 participants.

No.	Study	Reason for exclusion
56	Overbey DM, Glebova NO, Chapman BC, et al. (2017) Morbidity of endovascular abdominal aortic aneurysm repair is directly related to diameter. Journal of vascular surgery 66(4), 1037-1047.e7	Not specific to ruptured AAA: all patients underwent elective AAA repair.
57	Ozen A, Hanedan M O, Songur C M et al. (2015) Risk factors for survival following open surgical repair of ruptured abdominal aortic aneurysms: A 13-year experience. Journal of Tehran University Heart Center 10(3), 117-121	Sample size less than 200 participants.
58	Piper Greta, Patel Nilesh A, Chandela Sweeta et al. (2003) Short-term predictors and long-term outcome after ruptured abdominal aortic aneurysm repair. The American surgeon 69(8), 703-10	Inadequate data presented: authors reported that multivariate analysis was performed; however, they did not report numerical outcomes of their analysis. They stated that core temperature was associated with mortality but did not report the direction of effects. Furthermore, the study included less than 200 participants.
59	Reimerink J J, van der Laan, M J, Koelemay M J et al. (2013) Systematic review and meta-analysis of population-based mortality from ruptured abdominal aortic aneurysm. The British journal of surgery 100(11), 1405-13	Systematic review of studies assessing mortality rates over different time periods. Risk factors associated with mortality were not assessed.
60	Ribeiro M, Oderich GS, Macedo T, et al. (2017) Assessment of aortic wall thrombus predicts outcomes of endovascular repair of complex aortic aneurysms using fenestrated and branched endografts. Journal of vascular surgery 66(5), 1321-1333	Study included people with different types of aneurysms. Less than 200 people in the sample had AAA. Results were not stratified according to type of aneurysm.
61	Richards T, Goode S D, Hinchliffe R et al. (2009) The importance of anatomical suitability and fitness for the outcome of endovascular repair of ruptured abdominal aortic aneurysm. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 38(3), 285-90	Sample size less than 200 participants.
62	San Norberto, Enrique M, Fuente Ruth, Garcia-Saiz Irene et al. (2016) New scale for predicting mortality in ruptured abdominal aortic aneurysms. Nueva escala de prediccion de mortalidad en los aneurismas de aorta abdominal rotos. 94(6), 339-45	Sample size less than 200 participants.
63	Sarac Timur P, Bannazadeh Mohsen, Rowan A F et al. (2011) Comparative predictors of mortality for endovascular and open repair of ruptured infrarenal abdominal aortic aneurysms. Annals of vascular surgery 25(4), 461-8	Sample size less than 200 participants.

No.	Study	Reason for exclusion
64	Sasaki S, Yasuda K, Yamauchi H et al. (1998) Determinants of the postoperative and long-term survival of patients with ruptured abdominal aortic aneurysms. Surgery Today 28(1), 30-35	Sample size less than 200 participants.
65	Sasaki S, Sakuma M, Samejima M et al. (1999) Ruptured abdominal aortic aneurysms: Analysis of factors influencing surgical results in 184 patients. Journal of Cardiovascular Surgery 40(3), 401-405	Insufficient data reported in the study manuscript. Furthermore the study included less than 200 participants.
66	Scarcello Edoardo, Ferrari Mauro, Rossi Giuseppe et al. (2010) A new preoperative predictor of outcome in ruptured abdominal aortic aneurysms: the time before shock (TBS). Annals of vascular surgery 24(3), 315-20	Insufficient data reported in the study manuscript. Furthermore the study included less than 200 participants.
67	Shackleton C R, Schechter M T, Bianco R, and Hildebrand H D (1987) Preoperative predictors of mortality risk in ruptured abdominal aortic aneurysm. Journal of vascular surgery 6(6), 583-9	Sample size less than 200 participants.
68	Shahidi S, Schroeder T Veith, Carstensen M et al. (2009) Outcome and survival of patients aged 75 years and older compared to younger patients after ruptured abdominal aortic aneurysm repair: do the results justify the effort?. Annals of vascular surgery 23(4), 469-77	Sample size less than 200 participants.
69	Sharif M A, Lee B, Makar et al. (2007) Role of the Hardman index in predicting mortality for open and endovascular repair of ruptured abdominal aortic aneurysm. Journal of Endovascular Therapy 14(4), 528-535	Sample size less than 200 participants.
70	Sharif M A, Arya N, Soong C V et al. (2007) Validity of the Hardman index to predict outcome in ruptured abdominal aortic aneurysm. Annals of vascular surgery 21(1), 34-8	Sample size less than 200 participants.
71	Stenbaek J, Granath F, and Swedenborg J (2004) Outcome after abdominal aortic aneurysm repair. Difference between men and women. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 28(1), 47-51	Authors stated that multivariate regression was performed; however, they did not provide the results of the multivariate analysis.
72	Stone Patrick A, Hayes J David, AbuRahma Ali F et al. (2005) Ruptured abdominal aortic aneurysms: 15 years of continued experience in a southern West Virginia community. Annals of vascular surgery 19(6), 851-7	Sample size less than 200 participants.

No.	Study	Reason for exclusion
73	Tambyraja Andrew L, Murie John A, and Chalmers Roderick T. A (2008) Prediction of outcome after abdominal aortic aneurysm rupture. Journal of vascular surgery 47(1), 222-30	Systematic review which included studies that employed multiple study designs. Individual studies were assessed to establish if they met criteria for inclusion in this NICE review.
74	Treska V, and Novak M (2006) Rupture of abdominal aortic aneurysm--factors of mortality. Bratislavske lekarske listy 107(1-2), 22-5	Authors state that multivariate analysis was performed; however, the results (ORs) of the analysis were not reported. Furthermore, the study's sample size was less than 200 participants.
75	Turton E P. L, Scott D J. A, Delbridge M et al. (2000) Ruptured abdominal aortic aneurysm: A novel method of outcome prediction using neural network technology. European Journal of Vascular and Endovascular Surgery 19(2), 184-189	Sample size less than 200 participants.
76	Ultee KH. J, Zettervall SL, Soden PA, et al. (2016) Incidence of and risk factors for bowel ischemia after abdominal aortic aneurysm repair. Journal of vascular surgery 64(5), 1384-1391	Not specific to ruptured AAA: the study sample included patients with intact AAA (91.2%) and ruptured AAA (8.8%).
77	Urwin S C, and Ridley S A (1999) Prognostic indicators following emergency aortic aneurysm repair. Anaesthesia 54(8), 739-744	Sample size less than 200 participants.
78	Van Beek , Sytse C, Legemate Dink A et al. (2014) Acute kidney injury defined according to the 'Risk,' 'Injury,' 'Failure,' 'Loss,' and 'End-stage' (RIFLE) criteria after repair for a ruptured abdominal aortic aneurysm. Journal of vascular surgery 60(5), 1159-1167.e1	Sample size less than 200 participants.
79	Visser Jacob J, Williams Martine, Kievit Jur et al. (2009) Prediction of 30-day mortality after endovascular repair or open surgery in patients with ruptured abdominal aortic aneurysms. Journal of vascular surgery 49(5), 1093-9	Sample size less than 200 participants.
80	von Meijenfeldt , G C I, van Beek , S C, Bastos Goncalves, F, et al. (2017) Development and External Validation of a Model Predicting Death After Surgery in Patients With a Ruptured Abdominal Aortic Aneurysm: The Dutch Aneurysm Score. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 53(2), 168-174	Study assesses a bespoke risk assessment tool that is not outlined in the review protocol
81	Vos CG, de Vries JP, Werson DA) Evaluation of five different aneurysm scoring systems to predict mortality in ruptured abdominal aortic aneurysm patients. (2016) Evaluation of five different	Unclear whether multivariate analysis was performed.

No.	Study	Reason for exclusion
	aneurysm scoring systems to predict mortality in ruptured abdominal aortic aneurysm patients. Journal of vascular surgery 64(6), 1609-1616	
82	Wallace Gabriel A, Starnes Benjamin W, Hatsukami Thomas S et al. (2013) Favorable discharge disposition and survival after successful endovascular repair of ruptured abdominal aortic aneurysm. Journal of vascular surgery 57(6), 1495-502	Sample size less than 200 participants.
83	Wise Eric S, Hocking Kyle M, and Brophy Colleen M (2015) Prediction of in-hospital mortality after ruptured abdominal aortic aneurysm repair using an artificial neural network. Journal of vascular surgery 62(1), 8-15	Sample size less than 200 participants.

Economic studies

No full text papers were retrieved. All studies were excluded at review of titles and abstracts.

Appendix H – Glossary

Abdominal Aortic Aneurysm (AAA)

A localised bulge in the abdominal aorta (the major blood vessel that supplies blood to the lower half of the body including the abdomen, pelvis and lower limbs) caused by weakening of the aortic wall. It is defined as an aortic diameter greater than 3 cm or a diameter more than 50% larger than the normal width of a healthy aorta. The clinical relevance of AAA is that the condition may lead to a life threatening rupture of the affected artery. Abdominal aortic aneurysms are generally characterised by their shape, size and cause:

- Infrarenal AAA: an aneurysm located in the lower segment of the abdominal aorta below the kidneys.
- Juxtarenal AAA: a type of infrarenal aneurysm that extends to, and sometimes, includes the lower margin of renal artery origins.
- Suprarenal AAA: an aneurysm involving the aorta below the diaphragm and above the renal arteries involving some or all of the visceral aortic segment and hence the origins of the renal, superior mesenteric, and celiac arteries, it may extend down to the aortic bifurcation.

Abdominal compartment syndrome

Abdominal compartment syndrome occurs when the pressure within the abdominal cavity increases above 20 mm Hg (intra-abdominal hypertension). In the context of a ruptured AAA this is due to the mass effect of a volume of blood within or behind the abdominal cavity. The increased abdominal pressure reduces blood flow to abdominal organs and impairs pulmonary, cardiovascular, renal, and gastro-intestinal function. This can cause multiple organ dysfunction and eventually lead to death.

Cardiopulmonary exercise testing

Cardiopulmonary Exercise Testing (CPET, sometimes also called CPX testing) is a non-invasive approach used to assess how the body performs before and during exercise. During CPET, the patient performs exercise on a stationary bicycle while breathing through a mouthpiece. Each breath is measured to assess the performance of the lungs and cardiovascular system. A heart tracing device (Electrocardiogram) will also record the hearts electrical activity before, during and after exercise.

Device migration

Migration can occur after device implantation when there is any movement or displacement of a stent-graft from its original position relative to the aorta or renal arteries. The risk of migration increases with time and can result in the loss of device fixation. Device migration may not need further treatment but should be monitored as it can lead to complications such as aneurysm rupture or endoleak.

Endoleak

An endoleak is the persistence of blood flow outside an endovascular stent - graft but within the aneurysm sac in which the graft is placed.

- Type I – Perigraft (at the proximal or distal seal zones): This form of endoleak is caused by blood flowing into the aneurysm because of an incomplete or ineffective seal at either end of an endograft. The blood flow creates pressure within the sac and significantly increases the risk of sac enlargement and rupture. As a result, Type I endoleaks typically require urgent attention.
- Type II – Retrograde or collateral (mesenteric, lumbar, renal accessory): These endoleaks are the most common type of endoleak. They occur when blood bleeds into the sac from small side branches of the aorta. They are generally considered benign because they are usually at low pressure and tend to resolve spontaneously over time without any need for intervention. Treatment of the endoleak is indicated if the aneurysm sac continues to expand.
- Type III – Midgraft (fabric tear, graft dislocation, graft disintegration): These endoleaks occur when blood flows into the aneurysm sac through defects in the endograft (such as graft fractures, misaligned graft joints and holes in the graft fabric). Similarly to Type I endoleak, a Type III endoleak results in systemic blood pressure within the aneurysm sac that increases the risk of rupture. Therefore, Type III endoleaks typically require urgent attention.
- Type IV– Graft porosity: These endoleaks often occur soon after AAA repair and are associated with the porosity of certain graft materials. They are caused by blood flowing through the graft fabric into the aneurysm sac. They do not usually require treatment and tend to resolve within a few days of graft placement.
- Type V – Endotension: A Type V endoleak is a phenomenon in which there is continued sac expansion without radiographic evidence of a leak site. It is a poorly understood abnormality. One theory that it is caused by pulsation of the graft wall, with transmission of the pulse wave through the aneurysm sac to the native aneurysm wall. Alternatively it may be due to intermittent leaks which are not apparent at imaging. It can be difficult to identify and treat any cause.

Endovascular aneurysm repair

Endovascular aneurysm repair (EVAR) is a technique that involves placing a stent –graft prosthesis within an aneurysm. The stent-graft is inserted through a small incision in the femoral artery in the groin, then delivered to the site of the aneurysm using catheters and guidewires and placed in position under X-ray guidance.

- Conventional EVAR refers to placement of an endovascular stent graft in an AAA where the anatomy of the aneurysm is such that the ‘instructions for use’ of that particular device are adhered to. Instructions for use define tolerances for AAA anatomy that the device manufacturer considers appropriate for that device. Common limitations on AAA anatomy are infrarenal neck length (usually >10mm), diameter (usually ≤30mm) and neck angle relative to the main body of the AAA
- Complex EVAR refers to a number of endovascular strategies that have been developed to address the challenges of aortic proximal neck fixation associated with complicated aneurysm anatomies like those seen in juxtarenal and suprarenal AAAs.

These strategies include using conventional infrarenal aortic stent grafts outside their 'instructions for use', using physician-modified endografts, utilisation of customised fenestrated endografts, and employing snorkel or chimney approaches with parallel covered stents.

Goal directed therapy

Goal directed therapy refers to a method of fluid administration that relies on minimally invasive cardiac output monitoring to tailor fluid administration to a maximal cardiac output or other reliable markers of cardiac function such as stroke volume variation or pulse pressure variation.

Post processing technique

For the purpose of this review, a post-processing technique refers to a software package that is used to augment imaging obtained from CT scans, (which are conventionally presented as axial images), to provide additional 2- or 3-dimensional imaging and data relating to an aneurysm's, size, position and anatomy.

Permissive hypotension

Permissive hypotension (also known as hypotensive resuscitation and restrictive volume resuscitation) is a method of fluid administration commonly used in people with haemorrhage after trauma. The basic principle of the technique is to maintain haemostasis (the stopping of blood flow) by keeping a person's blood pressure within a lower than normal range. In theory, a lower blood pressure means that blood loss will be slower, and more easily controlled by the pressure of internal self-tamponade and clot formation.

Remote ischemic preconditioning

Remote ischemic preconditioning is a procedure that aims to reduce damage (ischaemic injury) that may occur from a restriction in the blood supply to tissues during surgery. The technique aims to trigger the body's natural protective functions. It is sometimes performed before surgery and involves repeated, temporary cessation of blood flow to a limb to create ischemia (lack of oxygen and glucose) in the tissue. In theory, this "conditioning" activates physiological pathways that render the heart muscle resistant to subsequent prolonged periods of ischaemia.

Tranexamic acid

Tranexamic acid is an antifibrinolytic agent (medication that promotes blood clotting) that can be used to prevent, stop or reduce unwanted bleeding. It is often used to reduce the need for blood transfusion in adults having surgery, in trauma and in massive obstetric haemorrhage.