National Institute for Health and Care Excellence

Final

Abdominal aortic aneurysm: diagnosis and management

Evidence review G: Tests for predicting outcomes after repair of unruptured abdominal aortic aneurysms

NICE guideline NG156

Methods, evidence and recommendations

March 2020

Final

This evidence review was developed by the NICE Guideline Updates Team

Disclaimer

The recommendations in this guideline represent the view of NICE, arrived at after careful consideration of the evidence available. When exercising their judgement, professionals are expected to take this guideline fully into account, alongside the individual needs, preferences and values of their patients or service users. The recommendations in this guideline are not mandatory and the guideline does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient, in consultation with the patient and/or their carer or guardian.

Local commissioners and/or providers have a responsibility to enable the guideline to be applied when individual health professionals and their patients or service users wish to use it. They should do so in the context of local and national priorities for funding and developing services, and in light of their duties to have due regard to the need to eliminate unlawful discrimination, to advance equality of opportunity and to reduce health inequalities. Nothing in this guideline should be interpreted in a way that would be inconsistent with compliance with those duties.

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Tests for predicting outcomes after repair of unruptured abdominal aortic aneurysms

Review question

What tests are effective in predicting poor and good surgical outcomes in people with unruptured abdominal aortic aneurysms?

Introduction

Prediction of perioperative and postoperative outcomes in patients undergoing elective abdominal aortic aneurysm (AAA) repair is important. A number of preoperative assessment methods have been proposed, which include the assessment of cardiac, pulmonary, renal, and cognitive function and physical activity. This review question aims to determine which tests are effective in predicting poor and good outcomes in people with unruptured AAAs who are being considered for repair.

PICO table

Table 1: Inclusion criteria

Review Question 8	**What tests are effective in predicting poor and good surgical outcomes in people with unruptured AAAs?**
Population	People who are being assessed for surgery for a confirmed unruptured AAA Subgroups: by type of surgery
Index test / factors of interest	Cardiac fitness: • Cardiopulmonary exercise testing (CPET) • Echocardiography • Cardiac perfusion scans • Noninvasive cardiac stress testing Pulmonary fitness: • Cardiopulmonary exercise testing (CPET) • Lung/pulmonary function tests • Spirometry Renal status: • Baseline blood test for renal function (eGFR) Cognitive status: • Montreal cognitive assessment (MoCA) test • Mini Mental State Examination (MMSE) Physical activity/frailty levels: • Duke activity index

Review Question 8	What tests are effective in predicting poor and good surgical outcomes in people with unruptured AAAs?
	• Metabolic equivalents test (METs or MET-TEST) • Edmonton frail scale • Comprehensive frailty assessment instrument (CFAI)
Outcome/endpoint	• Mortality • Peri- and post-operative complications • Successful exclusion of the aneurysm, aneurysm rupture, or further aneurysm growth • Need for reintervention • 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 broad search strategy was used to gather all studies that examine the diagnosis, surveillance or monitoring of AAAs. This was a 'bulk' search that covered multiple review questions. The reviewer sifted the database to identify all studies that met the set of criteria outlined in Table 1. For the full review protocol, see Appendix A.

Initially, randomised controlled trials, quasi randomised controlled trials and systematic reviews of these studies, examining effectiveness of preoperative tests in predicting poor and good surgical outcomes in people with unruptured AAAs, were included. However, studies of such designs were not identified during sifting.

Due to insufficient evidence and the prognostic nature of the review question, the study design for the review was changed retrospectively. Following committee discussions, prospective cohort studies with sample size of more than 500 participants were included. Studies with smaller sample size (>200) were also considered.

Studies were excluded if they were:

- Case-control or cross-sectional studies
- Not in English
- Not full reports of the study (for example, published only as an abstract)
- Not peer-reviewed.

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, 3 prospective cohort studies were included. Two studies included in the evidence review assessed whether preoperative cardiopulmonary exercise testing (CPET) derived variables were useful

in predicting mortality in patients undergoing elective open and endovascular AAA repair. These studies examined the following CPET variables:

- Oxygen consumption at anaerobic threshold (VO_2 at AT)
- Peak oxygen consumption (Peak VO_2)
- Ventilatory equivalents for carbon dioxide (V_E/ V_{CO2})

One study was included in the evidence review which assessed the role of preoperative baseline blood tests for renal function (estimated glomerular filtration rate; eGFR) as a predictor of medium term mortality and cardiovascular complications after EVAR.

An update literature search was performed and provided by Cochrane, in December 2017. The search found a total of 2,180 abstracts; of which, 1 full manuscript was ordered. Upon review of the full manuscript, it did not meet 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 table 2 below.

Table 2: Summary of included studies

Study	Details
Grant S W, Hickey G L, Wisely N A, Carlson E D, Hartley R A, Pichel A C, Atkinson D, and Mccollum C N (2015) Cardiopulmonary Exercise Testing And Survival After Elective Abdominal Aortic Aneurysm Repair. British Journal of Anaesthesia 114(3), 430-436	Location(s): UK Study design: Prospective cohort study Population: All patients who underwent a symptom limited maximal exercise CPET before elective AAA repair at Central Manchester Foundation Trust and University Hospital of South Manchester Sample Size: 506 Outcome: Reduced survival after elective AAA surgery Risk factors: VO_2 at AT<10.2 ml kg^{-1} min^{-1}, VE/VCO_2 at AT>42, peak VO_2<15 ml kg^{-1} min^{-1}, ≥2 sub- threshold CPET values and 3 sub-threshold CPET values.
Hartley R A, Pichel A C, Grant S W,Hickey G L, Lancaster P S, Wisely N A, Mccollum C N, and Atkinson D (2012) Preoperative Cardiopulmonary Exercise Testing And Risk Of Early Mortality Following Abdominal Aortic Aneurysm Repair. The British Journal of Surgery 99(11), 1539-46	Location(s): UK Study design: Prospective cohort study Population: All patients who underwent a symptom-limited, maximal exercise CPET according to the Wasserman protocol before elective AAA repair at Central Manchester

Study	Details
	University Hospital Trust and University Hospital of South Manchester. Sample Size: 415 Outcome: Mortality at 30 and 90 days following surgery Risk factors: VO_2 at AT< 10.2 ml/kg/min, VE/VCO_2 at AT>42, peak VO_2<15 ml/ kg/ min and ≥2 subthreshold CPET values.
Saratzis Athanasios, Sarafidis Pantelis, Melas Nikolaos, Saratzis Nikolaos, and Kitas George (2013) Impaired Renal Function Is Associated With Mortality And Morbidity After Endovascular Abdominal Aortic Aneurysm Repair. Journal of Vascular Surgery 58(4), 879-85	Location(s): UK/ Greece Study design: Prospective cohort study Population: Patients undergoing elective EVAR of an intrarenal AAA in a tertiary referral centre Sample Size: 383 Outcome: Death, nonfatal myocardial infraction, stroke, and peripheral vascular complications defined as any patient presenting with symptomatic (rest-pain, tissue- loss, claudication) arterial disease with an ankle-brachial pressure index <0.9 or relevant imaging that confirms the presence of arterial disease. Risk factor: Estimated glomerular filtration rate (eGFR)

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 in this guideline 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 tests predictive of poor and good surgical outcomes in people with unruptured aneurysms. No full tests 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.

Economic model

This review question does not lend itself to economic evaluation, and was not prioritised by the committee for economic modelling. As such, no economic models was developed for this review question.

Evidence statements

CPET variables

Two studies were identified which examined different CPET variables at specific thresholds. The evidence statements below were written to reflect these thresholds.

Oxygen consumption at anaerobic threshold (VO_2 at AT)

Low-quality evidence from 1 prospective cohort study, including 415 people undergoing elective AAA repair, indicated that people with oxygen consumption at AT below 10.2 ml/kg/min had a higher risk of 30 day mortality compared with people with AT above this threshold.

Oxygen consumption (peak VO_2)

Low- to moderate-quality evidence from 2 prospective cohort studies including 921 people undergoing elective AA repair, indicated that people with oxygen consumption below 15 ml/kg/min had a higher risk of post-surgical and 90 day mortality compared with people with oxygen consumption above this threshold.

Ventilatory equivalents for carbon dioxide (VE/VCO_2)

Moderate-quality evidence from 1 prospective cohort study, including 506 people undergoing elective AAA repair indicated that people with VE/VCO_2 at anaerobic threshold above 42 had a higher risk of post-surgical mortality, compared with people with VE/VCO_2 at anaerobic threshold below this threshold.

Number of CPET sub-threshold values

Low-quality evidence from 1 prospective cohort study, including 415 people undergoing elective AAA repair, indicated that people with at least two CPET sub-threshold values were at a higher risk of 30 and 90 day mortality.

eGFR (baseline blood test for renal function)

Low-quality evidence from 1 prospective cohort study, including 383 people undergoing elective EVAR, indicated that higher eGFR by 1 mL/min/1.73 m^2 at baseline was associated with a lower risk of death, nonfatal myocardial infarction, stroke, and peripheral vascular complications as well as all-cause mortality, during follow-up.

The committee's discussion of the evidence

Interpreting the evidence

The outcomes that matter most

The committee agreed that perioperative mortality, particularly 30-day mortality, was an important outcome. Identification of people at high risk of perioperative mortality allows healthcare professionals to judge whether surgery should be offered to people as well as plan care and support accordingly.

The quality of the evidence

Overall, the evidence ranged from low to moderate quality. With regard to evidence identified for CPET, the committee noted that Hartley et al. (2012) and Grant et al. (2015) had a small number of outcomes. In Hartley et al. (2012), which included 415 patients, 19 deaths had occurred overall. In Grant et al. (2015), which included a cohort that significantly overlapped with the Hartley 2012 study, 90 deaths had occurred during the follow up period. The committee noted that, while CPET may provide healthcare professionals valuable objective information on the fitness of people prior to elective AAA repair, the evidence was not robust enough to make strong recommendations for the use of the test as a decisive arbiter of fitness. Moreover, the committee agreed that individual CPET parameters should not be used in isolation to decide whether a patient should have surgery or not, but instead, may be used to inform shared decision making in context of medical history and examination.

Additionally, 1 study (Saratzi et al., 2013) examined the role of preoperative renal function measured using eGFR as a predictor of medium-term mortality and cardiovascular outcomes after elective EVAR. During the follow-up period, 20 deaths occurred along with 31 cardiovascular complications. No information was provided on loss to follow up, nor about whether attempts were made to collect information about patients who may have dropped out. With the low number of outcomes and the lack of information on loss to follow up, the committee agreed that the study lacked credibility. The committee further noted that any statistically significant effect may not necessarily correlate to any patient benefit.

Based on the quality of evidence, the committee agreed not to make recommendations based on eGFR. However, the committee did recommend that the AAA guideline include signposting to NICE's guideline NG45, which does include recommendations on the assessment of kidney function before major or complex surgery.

Benefits and harms

The committee agreed that CPET can identify individuals at increased risk of perioperative complications. This, in turn, can allow the optimisation of perioperative care. CPET results can also support informed consent as discussions can take place between people and healthcare professionals on the best approach to treatment.

The committee also noted that, while CPET is generally a safe method of assessment, there is a small chance that CPET testing can cause exercise-related cardiovascular events or mortality. They agreed that the risks associated with CPET testing were similar to undertaking mild-to-moderate exercise. Before testing, people would be clinically evaluated to ensure that they are fit for testing. Therefore, the committee deemed CPET a low-risk investigation.

Cost effectiveness and resource use

The committee agreed that, while CPET is used in the management of other conditions such as heart failure, not all hospitals have access to CPET equipment. It was identified that the cost of equipment could range between £40–50,000, with each test costing approximately £200 per patient. Furthermore, the committee agreed that trained respiratory physiologists would be required for the interpretation of CPET results. In hospitals where experienced professionals are not present, specialist training would be required to perform CPET which adds further cost.

In their experience, the committee estimated that around 50% of hospitals currently use CPET. To overcome barriers to the access to CPET equipment, the test could be outsourced; however there are further cost implications associated with the establishment of such a service.

Taking cost effectiveness and resource use into consideration, the committee made recommendations for healthcare professionals to only consider CPET when it may be useful for subsequent shared decision-making.

Other factors the committee took into account

Evidence identified in this review demonstrated that CPET could be used as a means of managing outcomes; however, due to the strength of the evidence, the committee agreed that decision making should not be based on CPET testing alone. Instead, CPET should only be considered as part of the whole preoperative assessment if it is likely to aid in shared decision-making.

While the evidence showed that a higher baseline eGFR at baseline was associated with a reduced risk of medium-term mortality and cardiovascular complications after elective EVAR, the evidence did not identify an adequate threshold which could aid in decision-making. Additionally, there was a lack of evidence for the use of other tools such as echocardiography. Because of this, the committee agreed to refer to the current NICE guideline on routine preoperative tests for elective surgery (NICE clinical guideline NG45). This guideline covers routine preoperative tests for people aged over 16 who are having elective surgery.

The committee discussed any potential differences in the utility of CPET in men and women. They agreed that, although the majority of the evidence presented was in men, there was no reason to believe that outcomes would be different between men and women. Therefore it was agreed that the recommendations should apply to all people for whom surgery is being considered.

Appendices

Appendix A – Review protocol

Review protocol for the effectiveness of tests in predicting poor and good surgical outcomes

Review Question 8	What tests are effective in predicting poor and good surgical outcomes in people with unruptured abdominal aortic aneurysms?
Objectives	To determine which tests should be performed in assessing the risks of surgery in people with an abdominal aortic aneurysm in whom EVAR or open surgical repair is being considered
Type of review	Prognostic
Language	English only
Study design	Initially, the following studies designs were included in the review protocol: • Systematic reviews of study designs listed below • Randomised controlled trials • Quasi-randomised controlled trials If insufficient evidence identified, non-randomised controlled trials were to be considered. Following committee meeting, study design was retrospectively changed to include the following studies designs to match the prognostic nature of the review question: • Prospective observational studies using multivariate analysis; population >500 • Prospective observational studies using smaller populations (>200) will be considered if insufficient evidence is identified
Status	Published papers only (full text) No date restrictions
Population	People who are being assessed for surgery for a confirmed unruptured abdominal aortic aneurysm Subgroups: by type of surgery
Intervention	Cardiac fitness: • Cardiopulmonary exercise testing (CPET) • Echocardiography • Cardiac perfusion scans • Noninvasive cardiac stress testing Pulmonary fitness:

Review Question 8	**What tests are effective in predicting poor and good surgical outcomes in people with unruptured abdominal aortic aneurysms?**
	• Cardiopulmonary exercise testing (CPET) • Lung/pulmonary function tests • Spirometry Renal status: • Baseline blood test for renal function (eGFR) Cognitive status: • Montreal cognitive assessment (MoCA) tests • Mini Mental State Examination (MMSE) Physical activity/frailty levels: • Duke activity index • Metabolic equivalents test (METs or MET-TEST) • Edmonton frail scale • Comprehensive frailty assessment instrument (CFAI)
Comparator	Initially, the following comparators were included in the review protocol: • No test, or other test in their 'class' Following committee meeting and prognostic nature of review question, comparators were removed.
Endpoints	• Mortality • Peri- and post-operative complications • Successful exclusion of the aneurysm, aneurysm rupture, or further aneurysm growth • Need for reintervention • Quality of life • Resource use, including length of hospital or intensive care stay, and costs
Other criteria for inclusion / exclusion of studies	Exclusion: • Abstract/non-published
Baseline characteristics to be extracted in evidence tables	• Age • Sex • Size of aneurysm • Comorbidities
Search strategies	See Appendix B

Review Question 8	**What tests are effective in predicting poor and good surgical outcomes in people with unruptured abdominal aortic aneurysms?**
Review strategies	Appropriate NICE Methodology Checklists, depending on study designs, will be used as a guide to appraise the quality of individual studies. 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	Grant, S.W., Hickey, G.L., Wisely, N.A., Carlson, E.D., Hartley, R.A., Pichel, A.C., Atkinson, D. Cardiopulmonary exercise testing and survival after elective abdominal aortic aneurysm repair. Br J Anaesth 2015;114(3):430-36

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 8

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.
10 exp models, statistical/
11 or/5-10

Medline Strategy, searched 29th September 2016 Database: 1946 to September Week 3 2016 Search Strategy:	
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/
11	Monte Carlo Method/
12	Decision Trees/
13	econom*.tw.
14	cba.tw.

Medline Strategy

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.
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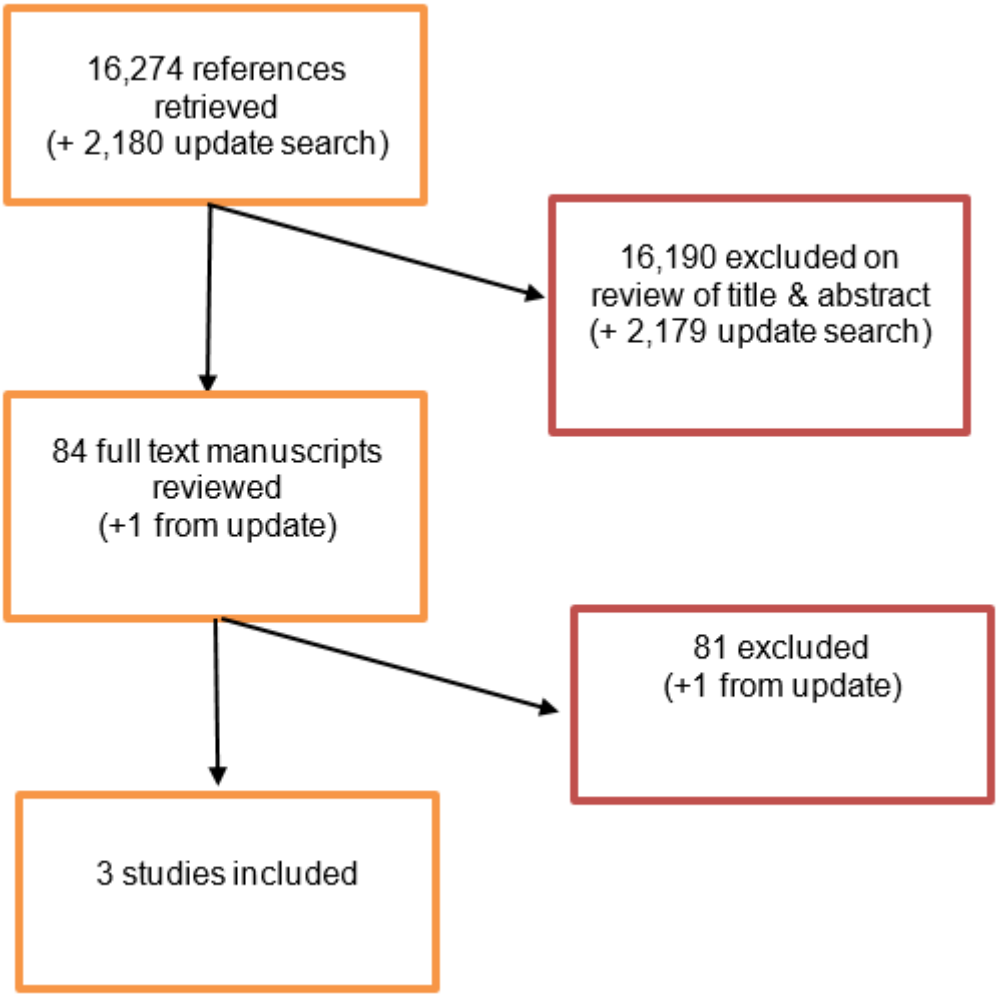
16 (qol or hql or hqol or hrqol).tw.
17 (hye or hyes).tw.
18 health* year* equivalent*.tw.
19 utilit*.tw.
20 (hui or hui1 or hui2 or hui3).tw.
21 disutili*.tw.
22 rosser.tw.
23 quality of wellbeing.tw.
24 quality of well-being.tw.
25 qwb.tw.
26 willingness to pay.tw.
27 standard gamble*.tw.
28 time trade 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	**Grant S W, Hickey G L, Wisely N A, Carlson E D, Hartley R A, Pichel A C, Atkinson D, and Mccollum C N (2015) Cardiopulmonary Exercise Testing And Survival After Elective Abdominal Aortic Aneurysm Repair. British Journal of Anaesthesia 114(3), 430-436**
Study details	Study design: Prospective cohort study Location(s): UK Aim of the study: Investigate whether preoperative CPET- derived variables are predictors of survival after elective open and endovascular AA repair (EVAR) Study dates: January 2007 to October 2012 Follow-up: 26 months with a maximum follow-up time of 67 months Sources of funding: No specific funding received for this study
Participants	Sample size: 506 patients. Cohort significantly overlaps with Hartley 2012 study. Inclusion criteria: All patients who underwent a symptom limited maximal exercise CPET before elective AAA repair at Central Manchester Foundation Trust and University Hospital of South Manchester Exclusion criteria: None specified Baseline characteristics: • Mean age: 73.4 years • Sex: 82.6% male • Mean aneurysm diameter: 63.1 mm • Diabetes: 9.5% • Ischaemic heart disease: 44.9% • Treated hypertension: 46.6%
Methods	Data collection: CPET performed on all patients using a cycle ergometer and a ramped test (Wasserman) protocol. Tests were performed and interpreted by appropriately trained consultant anaesthetists to a set of standardised clinical criteria across the two participating centres. Data on different CPET variables were collected and discriminatory thresholds for these variables were selected a priori based on published studies shown to identify those at increased risk of morbidity and death among non-cardiac

Full citation	**Grant S W, Hickey G L, Wisely N A, Carlson E D, Hartley R A, Pichel A C, Atkinson D, and Mccollum C N (2015) Cardiopulmonary Exercise Testing And Survival After Elective Abdominal Aortic Aneurysm Repair. British Journal of Anaesthesia 114(3), 430-436**
	surgery. Preoperative laboratory investigations were carried out, along with diagnosis of a juxta/supra renal AAA as defined by the operating surgeon. Follow-up data were collected using the NHS Demographic Batch Service. Analysis: All variables missing more than 15% of subjects were excluded from analysis. Cox proportional hazard multivariate analysis conducted, stratified on operation type and adjusted for age, female gender, diabetes, inducible cardiac ischaemia, statin, creatinine, urea, haemoglobin, VE/VO2 > 42 at AT and peak VO2 <15 (ml kg-1 min-1).
Outcomes	Outcome: Reduced survival after elective AAA repair Risk factors: VO2 at AT<10.2 ml kg-1 min-1, VE/VCO2 at AT>42, peak VO2<15 ml kg-1 min-1, ≥2 sub- threshold CPET values and 3 sub- threshold CPET values.
Study Appraisal using CASP (Critical appraisal skills programme)	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? No- Stepwise regression not performed. Only variables with p-values <0.2 in univariate analysis were included in multivariate model. 6. (a) Was the follow up of subjects complete enough? Unclear (b) Was the follow up of subjects long enough? Yes Overall risk of bias: Moderate Directness: directly applicable

Full citation	**Hartley R A, Pichel A C, Grant S W, Hickey G L, Lancaster P S, Wisely N A, Mccollum C N, and Atkinson D (2012) Preoperative Cardiopulmonary Exercise Testing And Risk Of Early Mortality Following Abdominal Aortic Aneurysm Repair. The British Journal of Surgery 99(11), 1539-46**
Study details	Study design: Prospective cohort study Location(s): UK Aim of the study: Evaluate whether preoperative CPET-derived variables are useful in the prediction of early mortality in patients undergoing elective open and endovascular (EVAR) AAA repair. Study dates: February 2007 to November 2011 Follow-up: 30 days and 90 days following surgery Sources of funding: Not specified
Participants	Sample size: 415 (included 17 patients who were part of pilot study between 2005 and January 2007) Inclusion criteria: All patients who underwent a symptom-limited, maximal exercise CPET according to the Wasserman protocol before elective AAA repair at Central Manchester University Hospital Trust and University Hospital of South Manchester. Exclusion criteria: None specified Baseline characteristics: • Mean age: not reported • Sex: 78.8% male • AAA diameter >65 mm: 34.9% • Diabetes: 6.8% • Ischaemic heart disease: 33.6% • Treated hypertension: 33.6%
Methods	Data collection: CPET was done with the intention of achieving maximal patient effort. Data on different CPET variables was collected. Discriminatory threshold values of these CPET variables were chosen based on published studies shown to identify those at increased risk of morbidity and death among patients undergoing major non-cardiac surgery. Patient characteristics including age, sex, diagnosis of insulin treated diabetes mellitus, ischaemic heart disease, treated hypertension and preoperative medications were recorded. AAA level was defined by the responsible surgeon. Preoperative measurements of haemoglobin, urea and creatinine were also recorded. Mortality following hospital discharge was collected using the NHS demographic Batch Service.

Full citation	**Hartley R A, Pichel A C, Grant S W, Hickey G L, Lancaster P S, Wisely N A, Mccollum C N, and Atkinson D (2012) Preoperative Cardiopulmonary Exercise Testing And Risk Of Early Mortality Following Abdominal Aortic Aneurysm Repair. The British Journal of Surgery 99(11), 1539-46**
	Analysis: All variables missing for more than 15% of subjects were excluded from analysis. Univariate and Multivariable logistic regression analyses adjusted for (1) open surgery, AT <10.2 ml per kg per min, Peak VO2 <15 ml per kg per min, Inducible cardiac ischaemia and anaemia (2) ≥2 subthreshold CPET values, Inducible cardiac ischaemia, open surgery, juxta/ suprarenal AAA and anaemia
Outcomes	Outcome: Mortality at 30 and 90 days following surgery Risk factors: VO2 at AT< 10.2 ml per kg per min, VE/VCO2 at AT>42, peak VO2<15 ml per kg per min and ≥2 subthreshold CPET values.
Study Appraisal using CASP (Critical appraisal skills programme)	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? Unclear. If VO2 at AT could not be determined from CPET it was assumed to be less than 10.2 ml per kg per min. 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? No- Stepwise regression not performed. Variables were included in a complete multivariable logistic regression model. This model was used as the initial model for running a backwards model selection algorithm using Akaike's information criterion. Co-linearity between variables was not explored. 6. (a) Was the follow up of subjects complete enough? Unclear (b) Was the follow up of subjects long enough? Yes Overall risk of bias: High Directness: directly applicable

Full citation	**Saratzis Athanasios, Sarafidis Pantelis, Melas Nikolaos, Saratzis Nikolaos, and Kitas George (2013) Impaired Renal Function Is Associated With Mortality And Morbidity After Endovascular Abdominal Aortic Aneurysm Repair. Journal of Vascular Surgery 58(4), 879-85**
Study details	Study design: Prospective cohort study Location(s): UK/ Greece Aim of the study: Examine the role of preoperative renal function, measured with eGFR using the most contemporary formula (Chronic Kidney Disease Epidemiology Collaboration [CKD-EPI] equation as a predictor of medium- term mortality and cardiovascular outcome after EVAR. Study dates: January 2008 to April 2011 Follow-up: 34± 12 months Sources of funding: Not specified
Participants	Sample size: 383 Inclusion criteria: Patients eligible for EVAR is they had an AAA diameter >5 cm; AAA<5 cm with a rapidly increasing sac (>1 cm per year) Exclusion criteria: Patients with leaking, ruptured, infected, or inflammatory aneurysms and patients with end-stage renal disease receiving renal replacement therapy at baseline. Baseline characteristics • Mean age: 69 • Sex: 91.7% male • Mean aneurysm diameter: 62.0 mm • Diabetes: 18.7% • Previous myocardial infarction: 9.7% • Previous stroke: 7.3% • Peripheral arterial disease: 18.5%
Methods	Data collection: Baseline documentation of demographics and comorbidities was performed prior to EVAR. All participants underwent computed tomography angiography. Blood samples were obtained prior to any imaging requiring the administration of contrast. Assessment of renal function was based on eGFR, which was calculated from standardised serum creatinine measurements, using the CKD-EPI equation. A standard follow-up protocol, including a visit to the hospital 30 days, 6 months, and 12 months after the operation and annually thereafter, was used.

Full citation	**Saratzis Athanasios, Sarafidis Pantelis, Melas Nikolaos, Saratzis Nikolaos, and Kitas George (2013) Impaired Renal Function Is Associated With Mortality And Morbidity After Endovascular Abdominal Aortic Aneurysm Repair. Journal of Vascular Surgery 58(4), 879-85**
	Analysis: Cox regression analyses adjusted for age, gender, AAA diameter, hypertension, diabetes, myocardial infarction, stoke, peripheral arterial disease and statin use. A P-value level of <0.05 was considered statistically significant.
Outcomes	Outcome: Death, nonfatal myocardial infraction, stroke, and peripheral vascular complications defined as any patient presenting with symptomatic (rest-pain, tissue- loss, claudication) arterial disease with an ankle- brachial pressure index <0.9 or relevant imaging that confirms the presence of arterial disease. Risk factor: Estimated glomerular filtration rate (eGFR)
Study Appraisal using CASP (Critical appraisal skills programme)	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? Unclear 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? No. Stepwise logistic regression not performed. Model adjust for factors that were significantly different between groups at baseline. A P value level <0.05 was considered statistically significant. 6. (a) Was the follow up of subjects complete enough? No – no information on loss to follow-up or attempts to collect information on patients who may have dropped out. (b) Was the follow up of subjects long enough? Unclear Overall risk of bias: High Directness: directly applicable

Appendix E– GRADE tables

CPET thresholds and postoperative outcomes

30 day mortality after elective EVAR or open surgical repair

Predictor	No. of studies	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size	Quality
Oxygen consumption at anaerobic threshold (AT) VO_2 at AT<10.2 ml/kg/min	1 Hartley (2012)	Prospective Cohort	Very Serious[1]	N/A[2]	Not Serious	Not Serious	415	OR 6.35 (1.84, 29.80)	Low
Sub-threshold Values ≥ 2 threshold values	1 Hartley (2012)	Prospective cohort	Very Serious[1]	N/A[2]	Not serious	Not Serious	415	OR 11.39 (2.89, 76.46)	Low

1. Stepwise regression was not performed and collinearity between oxygen consumption at AT and oxygen consumption was not explored, downgrade 2 levels.
2. Inconsistency not applicable as evidence from a single study.

90 day mortality after elective EVAR or open surgical repair

Predictor	No. of studies	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size	Quality
Oxygen consumption (Peak VO_2) Peak VO_2 <15 (ml/kg/min)	1 Hartley (2012)	Prospective Cohort	Very Serious[1]	N/A[2]	Not Serious	Not Serious	415	OR 8.59 (2.33, 55.75)	Low
CPET Sub-threshold Values ≥ 2 threshold values	1 Hartley (2012)	Prospective cohort	Very Serious[1]	N/A[2]	Not serious	Not Serious	415	OR 5.40 (1.86, 19.67)	Low

1. Stepwise regression was not performed and collinearity between oxygen consumption at AT and oxygen consumption was not explored, downgrade 2 levels.
2. Inconsistency not applicable as evidence from a single study.

Mortality at median follow-up of 26 months after elective EVAR or open surgical repair

Predictor	No. of studies	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size	Quality
Oxygen consumption (Peak VO_2) Peak VO_2<15 (ml/kg/min)	1 Grant (2015)	Prospective Cohort	Serious[1]	N/A[2]	Not Serious	Not serious	506	HR 1.68 (1.002-2.803)	Moderate
Ventilatory Equivalents for Carbon Dioxide (VE/VCO_2) VE/VCO_2 > 42 at AT	1 Grant (2015)	Prospective cohort	Serious[1]	N/A[2]	Not serious	Not serious	506	HR 1.63 (1.009-2.627)	Moderate

1. Stepwise regression was not performed. Instead the model was adjusted for variables with p-values <0.2 in univariate, downgrade 1 level
2. Inconsistency not applicable as evidence from a single study.

Estimated Glomerular Filtration Rate (eFGR) and postoperative outcomes

Composite rate of death, nonfatal myocardial infarction, stroke, or peripheral vascular complications after EVAR

Predictor	No. of studies	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size	Quality
eGFR, per mL/min/1.73 m^2 (at baseline)	1 Saratzis (2013)	Prospective Cohort	Very Serious[1,2]	N/A[3]	Not Serious	Not Serious	383	HR 0.95 (0.94, 0.97)	Low

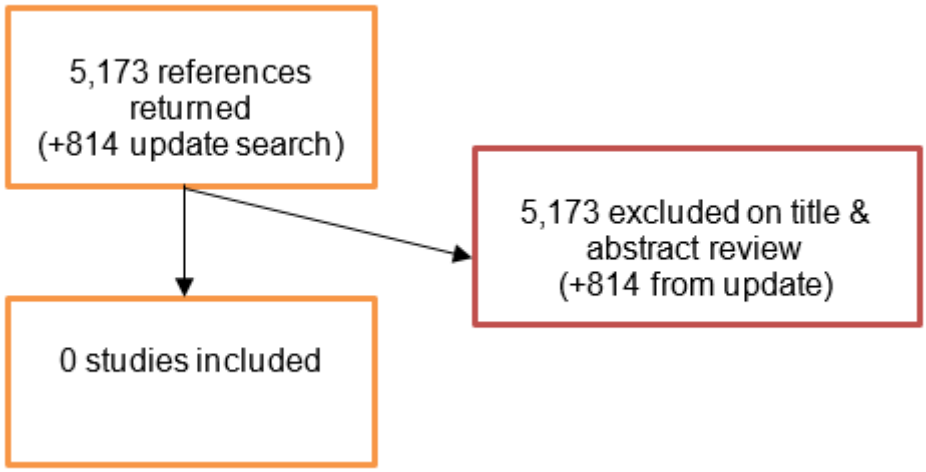
1. Stepwise regression was not performed. Instead model was adjusted for factors that were significantly different between groups at baseline, downgrade 1 level.
2. Loss to follow up not reported, downgrade 1 level
3. Inconsistency not applicable as evidence from a single study.

All-cause mortality after EVAR

Predictor	No. of studies	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	No. of Participants	Effect Size	Quality
eGFR, per mL/ min/ 1.73 m^2 (at baseline)	1 Saratzis (2013)	Prospective Cohort	Very Serious[1,2]	N/A[3]	Not Serious	Not Serious	383	HR 0.94 (0.92, 0.97)	Low

1. Stepwise regression was not performed. Instead model was adjusted for factors that were significantly different between groups at baseline, downgrade 1 level.
2. Loss to follow up not reported, downgrade 1 level
3. Inconsistency not applicable as evidence from a single study.

Appendix F – Economic evidence study selection



Appendix G – Excluded studies

Clinical studies

No.	Study	Reason for Exclusion
1	Appleton N D, Bailey D M, Morris-Stiff G, and Lewis M H (2014) Neutrophil To Lymphocyte Ratio Predicts Perioperative Mortality Following Open Elective Repair Of Abdominal Aortic Aneurysms. Vascular and Endovascular Surgery 48(4), 311-6	Cohort study examined the predictive value of neutrophil to lymphocyte ratio (NLR), which is not an intervention of interest for this review question.
2	Arya S, Kim S I, Duwayri Y, Brewster L P, Veerswamy R, Salam A and Dodson T F (2015) Frailty increases the risk of 30-day mortality, morbidity and failure to rescue after elective abdominal aortic aneurysm repair independent of ae and comorbidities. Journal of Vascular Surgery 61(2), 324-331	Retrospective cohort study assessed frailty using the modified frailty index (mFI). Study design and index not included in review protocol.
3	Bang J Y, Lee J B, Yoon Y, Seo H S, Song J G, and Hwang G S (2014) Acute Kidney Injury After Infrarenal Abdominal Aortic Aneurysm Surgery: A Comparison Of AKIN And RIFLE Criteria For Risk Prediction. British Journal of Anaesthesia 113(6), 994-1000	Retrospective study compared the ability of Acute Kidney Injury Network (AKIN) criteria and Risk, Injury, Failure, Loss, and end-stage (RIFLE) criteria in predicting mortality in patients undergoing infrarenal AA surgery. Study did not look at intervention of interest.
4	Barakat H M, Shahin Y, Mccollum P T, and Chetter I C (2015) Prediction Of Organ-Specific Complications Following Abdominal Aortic Aneurysm Repair Using Cardiopulmonary Exercise Testing. Anaesthesia 70(6), 679-85	Prospective observational study looked specifically at the predictive value of CPET. The study had a sample size of less than 200 participants (n=130).
5	Brown Louise C, Brown Edwina A, Greenhalgh Roger M, Powell Janet T, Thompson Simon G, and Participants UK EVAR Trial (2010) Renal function and abdominal aortic aneurysm (AAA): the impact of different management strategies on long-term renal function in the UK EndoVascular Aneurysm Repair (EVAR) Trials. Annals of Surgery 251(5), 966-75	This prospective study investigated the impact of difference management policies on renal function in patients with AAA. Study compared renal function among people enrolled on to EVAR 1 and EVAR2 trials. This did not match review protocol.
6	Cambria R P, Brewster D C, Abbott W M, L'Italien G J, Megerman J J, Lamuraglia G M, Moncure A C, Zelt D T, and Eagle K (1992) The Impact Of Selective Use Of Dipyridamole-Thallium Scans And Surgical Factors On The Current Morbidity Of Aortic Surgery. Journal of Vascular Surgery 15(1), 43-51	Observational study included individuals with aortoiliac occlusive disease. This did not match review protocol.
7	Davila-Roman V G, Waggoner A D, Sicard G, Geltman E M, Schechtman K B, and Perez J E (1993) Dobutamine Stress Echocardiography Predicts Surgical Outcome In Patients With An Aortic	Retrospective study assessed whether dobutamine stress echocardiography could be used as a predictor for perioperative cardiac events and long term cardiac

No.	Study	Reason for Exclusion
	Aneurysm And Peripheral Vascular Disease. Journal of the American College of Cardiology 21(4), 957-6	morbidity and mortality. Study design did not match protocol.
8	De Haro, Joaquin, Bleda Silvia, and Acin Francisco (2016) C - reactive Protein Predicts Aortic Aneurysmal Disease Progression after Endovascular Repair. International Journal of Cardiology 202(), 701-6	Prospective cohort study examined the prognostic significance of the rate of variation of C - reactive protein (CRP) levels in relation to aneurysmal disease progression after EVAR. This did not match review protocol.
9	De Mol Van Otterloo, J C A, Van Bockel, J H , Steyerberg E W, Feuth J D. M, Weeda H W. H, and Brand R (1995) The Potential Of Simple Clinical Information And Electrocardiogram To Predict Mortality Of Primary Elective Abdominal Aortic Reconstruction. European Journal of Vascular and Endovascular Surgery 10(4), 470-477	Retrospective observational study assessed the importance of simple clinical information to predict mortality after primary elective aortic reconstruction. This did not match review protocol.
10	Errington M L, Ferguson J M, Gillespie I N, Connell H M, Ruckley C V, and Wright A R (1997) Complete Pre-Operative Imaging Assessment Of Abdominal Aortic Aneurysm With Spiral CT Angiography. Clinical Radiology 52(5), 369-77	Prospective study evaluated whether spiral CT angiography (SCTA) alone provides sufficient information to plan aneurysm repair. This did not match review protocol.
11	Fontaine R, Kolh P, Creemers E, Gerard P, Kerstenne M A, Van Damme H, and Limet R (2008) Open Surgery For Abdominal Aortic Aneurysm Or Aorto-Iliac Occlusive Disease - Clinical And Ultrasonographic Long-Term Results. Acta Chirurgica Belgica 108(4), 393-399	This retrospective study utilised patient population which included patients with aorto-iliac occlusive disease. This did not match review protocol.
12	Gargiulo M, Gallitto E, Serra C, Freyrie A, Mascoli C, Bianchini Massoni, De Matteis M, De Molo C, and Stella A (2014) Could Four-Dimensional Contrast-Enhanced Ultrasound Replace Computed Tomography Angiography During Follow Up Of Fenestrated Endografts? Results of a Preliminary Experience. European Journal of Vascular and Endovascular Surgery 48(5), 536-42	The population utilised in this prospective observational study were patients who had underwent FEVAR follow up. The study had a sample size of less than 200 participants (n=22).
13	Guirguis-Blake Janelle M, Beil Tracy L, Senger Caitlyn A, and Whitlock Evelyn P (2014) Ultrasonography Screening for Abdominal Aortic Aneurysms: A Systematic Evidence Review for the U.S. Preventive Services Task Force. Annals of Internal Medicine 160(5), 321-9	Systematic review examined the benefits and harms of ultrasonography screening for AAA. This did not match review protocol.
14	Hiramoto Jade S, Howell Benjamin, Reilly Linda M, and Chuter Timothy A. M (2008) Effect Of Systemic Blood Pressure On Aneurysm Size In The Presence Of A Type II Endoleak. Vascular 16(6).321-5	Prospective observational study examined whether systemic hypertension is a risk factor for aneurysm enlargement. This did not match review protocol.

No.	Study	Reason for Exclusion
15	Ho Pei, Ting Albert C. W, and Cheng Stephen W. K (2004) Blood Loss and Transfusion in Elective Abdominal Aortic Aneurysm Surgery. ANZ Journal of Surgery 74(8), 631-4	This observational study analysed the pattern of blood loss and transfusion as well as the risk factors of blood loss during open repair. This did not match the objectives of this review protocol.
16	Huddle Matthew G, Schlosser Felix J. V, Dewan Michael C, Indes Jeffrey, and Muhs Bart E (2009) Can Laboratory Tests Predict The Prognosis Of Patients After Endovascular Aneurysm Repair? Current Status and Future Directions. Vascular 17(3), 129-37	Meta- analysis assessed serum creatinine as an indicator for mortality and morbidity after EVAR. This test is not included in review protocol.
17	Inoue Y, Yoshikawa D, Ishii H, Isobe S, Kumagai S, Suzuki S, Okumura S, Hayashi M, Matsubara T, Ohshima S, and Banno H (2013) Post-Stress Perfusion Abnormalities Detected On Myocardial Perfusion Single-Photon Emission Computed Tomography Predict Long-Term Mortality After Elective Abdominal Aortic Aneurysm Repair. Circulation Journal 77(5), 1229-1234	Case-control study examined summed stress score evaluated on preoperative pharmacologic stress myocardial perfusion SPECT for cardiovascular death in patients undergoing AAA repair. Study design does not match protocol.
18	Kaladji Adrien, Cardon Alain, Abouliatim Issam, Campillo-Gimenez Boris; Heautot Jean Francois, and Verhoye Jean-Philippe (2012) Preoperative Predictive Factors Of Aneurysmal Regression Using The Reporting Standards For Endovascular Aortic Aneurysm Repair. Journal of Vascular Surgery 55(5), 1287-95	Retrospective study assessed preoperative clinical and anatomical factors that are predictive of aneurysmal regression after EVAR. This this not match review protocol.
19	Kaufman J A, Yucel E K, Waltman A C, Geller S C, Prince M R, Cambria R P, Brewster D C, and Abbott W M (1994) MR Angiography In The Preoperative Evaluation Of Abdominal Aortic Aneurysms: A Preliminary Study. Journal of Vascular and Interventional Radiology 5(3), 489-96	Prospective study compared magnetic resonance angiography and conventional angiography in the preoperative evaluation of renal, superior mesenteric and celiac arteries in patients with AAA. This did not match review protocol.
20	Kok Annette M, Nguyen V Lai, Speelman Lambert, Brands Peter J, Schurink Geert-Willem H, Van De Vosse, Frans N, and Lopata Richard G. P (2015) Feasibility Of Wall Stress Analysis Of Abdominal Aortic Aneurysms Using Three-Dimensional Ultrasound. Journal of Vascular Surgery 61(5), 1175-84	Prospective observational study investigated the feasibility of 3D ultrasound based wall stress analysis of AAA. This is not an intervention included in the protocol.
21	Kopolovic Ilana, Simmonds Kim, Duggan Shelley, Ewanchuk Mark, Stollery Daniel E, and Bagshaw Sean M (2013) Risk Factors And Outcomes Associated With Acute Kidney Injury Following Ruptured Abdominal Aortic Aneurysm. BMC Nephrology 14(), 99	Retrospective cohort study examined risk factors and outcomes associated with acute kidney injury in patients with ruptured aneurysms. Study design did not match review protocol.
22	Kwon Hyunwook, Ko Gi-Young, Kim Min-Ju, Han Youngjin, Noh Minsu, Kwon Tae-Won, and Cho Yong-Pil (2016) Effects Of	Retrospective observational study examined the risk factors associated with the risk of developing post-implantation systemic

No.	Study	Reason for Exclusion
	Postimplantation Systemic Inflammatory Response On Long-Term Clinical Outcomes After Endovascular Aneurysm Repair Of An Abdominal Aortic Aneurysm. Medicine 95(32), E4532	inflammatory (PIS) response. This does not match review protocol.
23	Lacquaniti Antonio, Giardina Massimiliano, Lucisano Silvia, Messina Roberto, Buemi Antoine, Risitano Claudia D, Chirico Valeria, Buemi Michele, and David Antonio (2013) Neutrophil Gelatinase-Associated Lipocalin (NGAL) And Endothelial Progenitor Cells (EPCS) Evaluation In Aortic Aneurysm Repair. Current Vascular Pharmacology 11(6), 1001-10	This case control study evaluated the diagnostic power of serum NGAL and urine NGAL, which is not an intervention of interest for this review question.
24	Lawrence-Brown M M, Norman P E, Jamrozik K, Semmens J B, Donnelly N J, Spencer C, and Tuohy R (2001) Initial Results Of Ultrasound Screening For Aneurysm Of The Abdominal Aorta In Western Australia: Relevance For Endoluminal Treatment Of Aneurysm Disease. Cardiovascular Surgery 9(3), 234-40	Randomised control trial assessed the value of screening programmes in males. This did not match the objectives of the review question.
25	Leo E, Biancari F, Hanhela R, Karlqvist K, Romsi P, Ylonen K, Rainio P, Satta J, and Juvonen T (2005) Baseline Oxygen Delivery Is Associated With An Increased Risk Of Severe Postoperative Complications After Elective Open Repair Of Abdominal Aortic Aneurysm. The Journal of Cardiovascular Surgery 46(3), 279-84	Retrospective study evaluated whether baseline hemodynamic parameters are predictive of postoperative outcomes. This does not match review protocol.
26	Liapis Christos D, Kakisis John D, Dimitroulis Dimitrios A, Daskalopoulos Marios, Nikolaou Alexios, and Kostakis Alkiviadis G (2003) Carotid Ultrasound Findings As A Predictor Of Long-Term Survival After Abdominal Aortic Aneurysm Repair: A 14-Year Prospective Study. Journal of Vascular Surgery 38(6), 1220-5	Prospective cohort study evaluated the effect of carotid stenosis on long term survival after open AAA repair. This did not match review protocol.
27	Ligush John Jr, Pearce Jeffrey D, Edwards Matthew S, Eskridge Matthew R; Cherr Gregory S, Plonk George W, and Hansen Kimberley J (2002) Analysis Of Medical Risk Factors And Outcomes In Patients Undergoing Open Versus Endovascular Abdominal Aortic Aneurysm Repair. Journal of Vascular Surgery 36(3), 492-9	Prospective cohort study compared preoperative medical risk factors and perioperative outcomes of patients undergoing endovascular repair and open repair. Study did not focus on interventions of interest.
28	Luebke Thomas and Brunkwall (2014) Type B Aortic Dissection: A Review of Prognostic Factors and Meta-Analysis of Treatment Options. Aorta 2(6), 265-78	Systematic review did not focus on the objectives of this review.
29	Marrocco-Trischitta Massimiliano M,Melissano Germano, Kahlberg Andrea, Setacci Francesco, Segreti Sara, Spelta	Cohort study compared the impact of reanastomosis and graft interposition during

No.	Study	Reason for Exclusion
	Sara, and Chiesa Roberto (2007) Glomerular Filtration Rate After Left Renal Vein Division And Reconstruction During Infrarenal Aortic Aneurysm Repair. Journal of Vascular Surgery 45(3), 481-6	AAA repair on renal function. This did not match the objectives of this review.
30	Matsumura Yoshihisa, Wada Michiko, Hirakawa Daigo, Yasuoka Yuka, Morimoto Norihito, Takeuchi Hiroaki, Kitaoka Hiroaki, Orihashi Kazumasa, And Sugiura Tetsuro (2016) Clinical Utility Of Transthoracic Echocardiography For Screening Abdominal Aortic Aneurysm: A Prospective Study In A Japanese Population. Cardiovascular Ultrasound 14(), 8	Prospective observational study evaluated the clinical utility of transthoracic echocardiography for AAA screening. This does not match the objectives of this study.
31	Mcphail N V, Ruddy T D, Calvin J E, Davies R A, and Barber G G (1989) A Comparison Of Dipyradimole-Thallium Imaging And Exercise Testing In The Prediction of Postoperative Cardiac Complications In Patients Requiring Arterial Reconstruction. Journal of Vascular Surgery 10(1), 51-56	Prospective observational study examined the individual and combined predictive values of dipyridamole- thallium imaging and exercising testing. Patient population included individuals with aortoiliac occlusive disease. Sample size was less than 200 participants (n=70).
32	Mehta Manish, Paty Philip S. K, Byrne John, Roddy Sean P, Taggert John B, Sternbach Yaron, Ozsvath Kathleen J, and Darling R Clement, 3rd (2013) The Impact Of Hemodynamic Status On Outcomes Of Endovascular Abdominal Aortic Aneurysm Repair For Rupture. Journal of Vascular Surgery 57(5), 1255-60	Retrospective review evaluated the outcomes of EVAR for ruptured AAA based on patient's hemodynamic status. This does not match protocol for this review.
33	Moran J, Wilson F, Guinan E, Mccormick P, Hussey J, and Moriarty J (2016) Role Of Cardiopulmonary Exercise Testing As A Risk-Assessment Method In Patients Undergoing Intra-Abdominal Surgery: A Systematic Review. British Journal of Anaesthesia 116(2), 177-91	Systematic review of observational studies. This review did not specifically focus of AAA and also reviewed hepatic transplant and resection, colorectal, pancreatic, renal transplant, upper gastrointestinal, bariactric, and general intra-abdominal surgery. Individual studies were assessed to determine if they met inclusion criteria for this review question.
34	Mukherjee Jayanta T, Nautiyal Amit, and Labib Sherif B (2012) Mycotic Aneurysms of the Ascending Aorta in the Absence of Endocarditis. Texas Heart Institute Journal 39(5), 692-5	This is a case report, which does not match review protocol.
35	Myers Jonathan, Powell Alyssa, Smith Kimberly, Fonda Holly, Dalman Ronald L, and Stanford A A A. Sccor Investigators (2011) Cardiopulmonary Exercise Testing In Small Abdominal Aortic Aneurysm: Profile, Safety, And Mortality Estimates. European Journal of Cardiovascular Prevention and Rehabilitation 18(3), 459-66	Sub study of the Stanford AAA SCCOR programme in which the safety of cardiopulmonary exercise was evaluated. This does not match objective of review.
36	Nathan Derek P, Brinster Clayton J, Jackson Benjamin M, Wang Grace J, Carpenter Jeffrey P, Fairman Ronald M, and Woo	Retrospective observational study examined the predictors of decreased survival after

No.	Study	Reason for Exclusion
	Edward Y (2011) Predictors Of Decreased Short- And Long-Term Survival Following Open Abdominal Aortic Aneurysm Repair. Journal of Vascular Surgery 54(5), 1237-43	open AAA repair. Study does not match review protocol.
37	Nguyen Bao-Ngoc, Neville Richard F, Rahbar Rodeen, Amdur Richard, and Sidawy Anton N (2013) Comparison Of Outcomes For Open Abdominal Aortic Aneurysm Repair And Endovascular Repair In Patients With Chronic Renal Insufficiency. Annals of Surgery 258(3), 394-9	Prospective study compared the outcomes of EVAR and open surgery in patients with chronic renal insufficiency. This did not match review protocol.
38	Oh S H, Chang S A, Jang S Y, Park S J, Choi J O, Lee S C, Park S W, Oh J K, and Kim D K (2010) Routine Screening For Abdominal Aortic Aneurysm During Clinical Transthoracic Echocardiography In A Korean Population. Echocardiography 27(10), 1182-1187	Retrospective observational study examined the presence of AAA in patients undergoing a routine transthoracic echocardiography, which does not match the review protocol.
39	P, Verzini F, Parlani G, Rango P D, Parente B, Giordano G, Mosca S, and Maselli A (2003) Predictive Factors And Clinical Consequences Of Proximal Aortic Neck Dilatation In 230 Patients Undergoing Abdominal Aorta Aneurysm Repair With Self-Expandable Stent-Grafts. Journal of Vascular Surgery 37(6), 1200-1205	Prospective observational study examined CT scans of patients after AAA surgery. This does not match the objectives of this review.
40	Patel Virendra I, Lancaster Robert T, Conrad Mark F, Lamuraglia Glenn M, Kwolek Christopher J, Brewster David C, and Cambria Richard P (2011) Comparable Mortality With Open Repair Of Complex And Infrarenal Aortic Aneurysm. Journal of Vascular Surgery 54(4), 952-9	Retrospective cohort study compared outcomes of patients undergoing complex aneurysm repair to that of patients undergoing infrarenal abdominal aortic aneurysms repair. This does not match review protocol.
41	Pellikka P A, Roger V L,Oh J K, Seward J B, and Tajik A J (1996) Safety of performing dobutamine stress echocardiography in patients with abdominal aortic aneurysm > or = 4 cm in diameter. The American journal of cardiology 77(5), 413-6	Retrospective observational study reviewed the safety of performing dobutamine stress echocardiography in patients with AAA. The study had sample size of less than 200 (n=98).
42	Peppelenbosch Noud, Buth Jacob, Harris Peter L, van Marrewijk Corine, Fransen Gerdine, and Collaborators Eurostar (2004) Diameter of abdominal aortic aneurysm and outcome of endovascular aneurysm repair: does size matter? A report from EUROSTAR. Journal of vascular surgery 39(2), 288-97	Retrospective observational study examined the effect of preoperative diameter of AAA on the midterm outcome after EVAR. This did not match review protocol.
43	Pirgakis Konstantinos M, Makris Konstantinos, Dalainas Ilias, Lazaris Andreas M, Maltezos Chrisostomos K, and Liapis Christos D (2014) Urinary Cystatin C As An Early Biomarker Of Acute Kidney Injury After Open And Endovascular Abdominal Aortic	Prospective cohort study evaluated whether urinary cystatin C (uCysC) can detect renal dysfunction earlier than serum creatinine (sCr) in patients undergoing EVAR and open repair. This did not match study protocol.

No.	Study	Reason for Exclusion
	Aneurysm Repair. Annals of Vascular Surgery 28(7), 1649-58	
44	Prentis James M, Trenell Michael I, Jones Dave J, Lees Tim, Clarke Mike, and Snowden Chris P (2012) Submaximal Exercise Testing Predicts Perioperative Hospitalization After Aortic Aneurysm Repair. Journal of Vascular Surgery 56(6), 1564-70	Prospective study assessed the use of CPET to predict morbidity in patients scheduled for elective EVAR or open AAA repair. The study had a sample size of less than 200 participants (n=185).
45	Rai Divyajeet, Wisniowski Brendan, Bradshaw Barbara, Velu Ramesh, Tosenovsky Patrik, Quigley Francis, Walker Philip J, and Golledge Jonathan (2014) Abdominal Aortic Aneurysm Calcification And Thrombus Volume Are Not Associated With Outcome Following Endovascular Abdominal Aortic Aneurysm Repair. European Radiology 24(8), 1768-76	Observational study assessed the association of AAA calcification and thrombus volume with outcome following EVAR using quantifiable computed tomography assessment protocol. This study did not examine the effectiveness of an intervention of interest.
46	Raman Kathleen G, Missig-Carroll Nita, Richardson Tracey, Muluk Satish C, and Makaroun Michel S (2003) Color-Flow Duplex Ultrasound Scan Versus Computed Tomographic Scan In The Surveillance Of Endovascular Aneurysm Repair. Journal of Vascular Surgery 38(4), 645-51	Retrospective observational study compared computed tomography (CT) and colour flow duplex ultrasound scanning (CDU). Study design does not match protocol.
47	Sadek Mikel, Dexter David J, Rockman Caron B, Hoang Han, Mussa Firas F, Cayne Neal S, Jacobowitz Glen R, Veith Frank J, Adelman Mark A, and Maldonado Thomas S (2013) Preoperative Relative Abdominal Aortic Aneurysm Thrombus Burden Predicts Endoleak And Sac Enlargement After Endovascular Aneurysm Repair. Annals of Vascular Surgery 27(8), 1036-41	Retrospective cohort study assessed preoperative CT variables that predict AAA remodelling and sac behaviour post-EVAR. Study design did not match review protocol.
48	Sailer Anna M, Nelemans Patricia J, Van Berlo Camille, Yazar Ozan De Haan, Michiel W, Fleischmann Dominik, and Schurink Geert Willem H (2016) Endovascular Treatment Of Complex Aortic Aneurysms: Prevalence Of Acute Kidney Injury And Effect On Long-Term Renal Function. European Radiology 26(6), 1613-9	Retrospective study evaluated the predictors for short and long term renal function changes after complex fenestrated and branched endovascular aortic repair. This did not match review protocol.
49	Salaman R A, Shandall A, Morgan R H, Fligelstone L, Davies W T, and Lane I F (1994) Intravenous digital subtraction angiography versus computed tomography in the assessment of abdominal aortic aneurysm. The British journal of surgery 81(5), 661-3	Retrospective study compared the accuracy of preoperative computed tomography and intravenous digital subtraction angiography in assessing proximal and distal aneurysm. Study design did not match review protocol.
50	Sampaio Sergio M, Panneton Jean M; Mozes Geza I, Andrews James C, Bower Thomas C, Karla Manju, Noel Audra A, Cherry Kenneth J, Sullivan Timothy, and Gloviczki Peter (2004) Proximal Type I Endoleak After Endovascular Abdominal	This retrospective observational study did not examine effectiveness of intervention of interest.

No.	Study	Reason for Exclusion
	Aortic Aneurysm Repair: Predictive Factors. Annals of Vascular Surgery 18(6), 621-8	
51	Sarac Timur P, Clair Daniel G, Hertzer Norman R, Greenberg Roy K, Krajewski Leonard P, O'Hara Patrick J, and Ouriel Kenneth (2002) Contemporary Results of Juxtarenal Aneurysm Repair. Journal of Vascular Surgery 36(6), 1104-11	Observational study was not relevant for this review as it focused on comparing different clamp locations.
52	Saratzis A N, Bath M F, Harrison S C, Sayers R D, and Bown M J (2015) Impact of Fenestrated Endovascular Abdominal Aortic Aneurysm Repair on Renal Function. Journal of Endovascular Therapy 22(6), 889-896	Case control study combined with systematic review, assessed the impact of fenestrated EVAR on renal function perioperatively and at midterm. This did not match the objectives of this review question.
53	Saratzis A, Melas N, Mahmood A, and Sarafidis P (2015) Incidence Of Acute Kidney Injury (AKI) After Endovascular Abdominal Aortic Aneurysm Repair (EVAR) And Impact On Outcome. European Journal of Vascular and Endovascular Surgery 49(5), 534-540	Prospective cohort study assessed the incidence of acute kidney injury after EVAR and the impact on AKI on mortality and cardiovascular morbidity. This did not match review protocol.
54	Saratzis Athanasios, Nduwayo Sarah, Sarafidis Pantelis, Sayers Robert D, and Bown Matthew J (2016) Renal Function Is The Main Predictor Of Acute Kidney Injury After Endovascular Abdominal Aortic Aneurysm Repair. Annals of Vascular Surgery 31(), 52-9	Case control study assessed the predictive factors of acute kidney injury after EVAR. This did not match review protocol.
55	Saratzis Athanasios, Sarafidis Pantelis, Melas Nikolaos, Hunter James P, Saratzis Nikolaos, Kiskinis Dimitrios, and Kitas George D (2012) Suprarenal Graft Fixation In Endovascular Abdominal Aortic Aneurysm Repair Is Associated With A Decrease In Renal Function. Journal of Vascular Surgery 56(3), 594-600	Nested case control study compared the 6- and 12- month effects on renal function of suprarenal and infrarenal proximal stent graft fixation in EVAR. Study design does not match protocol.
56	Sato D T, Goff C D, Gregory R T, Robinson K D, Carter K A, Hefts B R, Vilsack H B, Gayle R G, Parent Iii F. N, Demasi R J, and Meier G H (1998) Endoleak After Aortic Stent Graft Repair: Diagnosis By Color Duplex Ultrasound Scan Versus Computed Tomography Scan. Journal of Vascular Surgery 28(4), 657-663	This retrospective observational study compared the accuracy of colour duplex ultrasound scan to a computerised axial tomography scan in the diagnosis of endoleaks after stent graft repair. This does not match the objectives of this review.
57	Scali Salvatore, Patel Virendra, Neal Daniel, Bertges Daniel, Ho Karen, Jorgensen Jens-Eldrup, Cronenwett Jack, And Beck Adam (2015) Preoperative Beta-Blockers Do Not Improve Cardiac Outcomes After Major Elective Vascular Surgery And May Be Harmful. Journal of Vascular Surgery 62(1), 166-176.E2	Retrospective cohort study assessed whether the initiation of beta-blockers before major elective vascular surgery decreased postoperative cardiac events or mortality. This did not match review protocol.
58	Schouten Olaf, Kok Niels F. M, Hoedt Marco T. C, Van Laanen, Jorinde H H, and Poldermans Don (2006) The Influence Of	Retrospective cohort study examined the influence of aneurysm size on perioperative

No.	Study	Reason for Exclusion
	Aneurysm Size On Perioperative Cardiac Outcome In Elective Open Infrarenal Aortic Aneurysm Repair. Journal of Vascular Surgery44 (3), 435-41	cardiac outcome. This did not match review protocol.
59	Shin Sung, Kwon Tae-Won, Cho Yong-Pil, Lee Jong-Young, Park Hojong, and Han Youngjin (2013) Preoperative Cardiac Evaluation By Dipyridamole Thallium-201 Myocardial Perfusion Scan Provides No Benefit In Patients With Abdominal Aortic Aneurysm. World Journal of Surgery 37(12), 2965-71	Not a controlled trial. This retrospective observational evaluated the benefits of preoperative dipyridamole thallium-201 myocardial perfusion scans in patients undergoing AAA repair. There was no comparator.
60	Steyerberg E W, Kievit J, De Mol Van Otterloo J C, Van Bockel J H, Eijkemans M J, and Habbema J D (1995) Perioperative Mortality Of Elective Abdominal Aortic Aneurysm Surgery. A Clinical Prediction Rule Based On Literature and Individual Patient Data. Archives of Internal Medicine 155(18), 1998-2004	This study combined results from literature data with individual patient data to produce a clinical prediction rule that estimates mortality of elective aneurysm surgery. This did not match review protocol.
61	Svensjo S, Mani K, Bjorck M, Lundkvist J, and Wanhainen A (2014) Screening for abdominal aortic aneurysm in 65-year-old men remains cost-effective with contemporary epidemiology and management. European Journal of Vascular and Endovascular Surgery 47(4), 357-365	Observational study examines the cost effectiveness of one time AAA screening of 65 year old men. This does not match the objectives of this review.
62	Takahashi Junichiro, Wakamatsu Yutaka, Ishii Kouji, Kanaoka Tsuyoshi, Gohda Toshihiro, Sasaki Shigeyuki, and Matsui Yoshiro (2011) Preoperative HDL-C Predicts Later Cardiovascular Events After Abdominal Aortic Aneurysm Surgery. Annals of Vascular Diseases 4(2), 115-20	Retrospective study examined the predictive value of serum lipid levels on the development of later cardiovascular events after AAA surgery. This did not match review protocol.
63	Tew Garry A, Weston Matthew, Kothmann Elke, Batterham Alan M, Gray Joanne, Kerr Karen, Martin Denis, Nawaz Shah, Yates David, and Danjoux Gerard (2014) High-Intensity Interval Exercise Training before Abdominal Aortic Aneurysm Repair (HIT-AAA): Protocol for a Randomised Controlled Feasibility Trial. BMJ Open 4(1), E004094	Not correct study type. Protocol outlines randomised controlled feasibility trial for high intensity interval exercise training.
64	Truijers M, Resch T, Van Den Berg J C, Blankensteijn J D, and Lonn L (2009) Endovascular Aneurysm Repair: State-Of-Art Imaging Techniques For Preoperative Planning And Surveillance. The Journal of Cardiovascular Surgery 50(4), 423-38	Literature review of imaging modalities (duplex ultrasound, transoesophageal echocardiography, computed tomography and magnetic resonance) available to the vascular specialist involved in complex EVAR. Study design does not match protocol.
65	Van Eps, R G Statius, Leurs L J, Hobo R, Harris P L, Buth J, and Collaborators Eurostar (2007) Impact Of Renal Dysfunction On Operative Mortality Following Endovascular Abdominal Aortic Aneurysm	Case-control study which examined the impact of renal dysfunction on postoperative mortality, using EUROSTAR registry. Study design did not match protocol.

No.	Study	Reason for Exclusion
	Surgery. The British Journal of Surgery 94(2), 174-8	
66	Van Herwaarden, Joost A, Bartels Lambertus W, Muhs Bart E, Vincken Koen L, Lindeboom Maud Y. A, Teutelink Arno, Moll Frans L, and Verhagen Hence J. M (2006) Dynamic Magnetic Resonance Angiography of the Aneurysm Neck: Conformational Changes during the Cardiac Cycle with Possible Consequences for Endograft Sizing and Future Design. Journal of Vascular Surgery 44(1), 22-8	Prospective observational study used high resolution electrocardiograph- gated cine MRA to characterise aortic pulsatility during the cardiac cycle in preoperative and postoperative AAA patients undergoing EVAR. This does not match objectives of the protocol.
67	Vardulaki K A, Walker N M, Couto E, Day N E, Thompson S G, Ashton H A, and Scott R A (2002) Late Results Concerning Feasibility And Compliance From A Randomized Trial Of Ultrasonographic Screening For Abdominal Aortic Aneurysm. The British Journal of Surgery 89(7), 861-4	Randomised control trial examined the feasibility, compliance and benefit of AAA screening. This does not match the objectives of this review.
68	Varetto Gianfranco, Castagno Claudio, Trucco Andrea, Frola Edoardo, Bert Fabrizio, Scozzari Gitana, and Rispoli Pietro (2016) Serum Procalcitonin As a Valuable Diagnostic Tool in the Early Detection of Infectious Complications after Open Abdominal Aortic Repair. Annals of Vascular Surgery 34(), 111-8	Observational study examined whether procalcitonin (PCT) could be a predictive marker in early diagnosis of infectious complications after open abdominal aortic surgery. PCT was not an intervention of interest for this review.
69	Verzini F, Barzi F, Maselli A, Caporali S, Lenti M, Zannetti S, And Cao P (2000) Predictive Factors For Early Success Of Endovascular Abdominal Aortic Aneurysm Repair. Annals of Vascular Surgery 14(4), 318-23	Prospective study examined predictive factors for early success after AAA repair. This did not match review protocol.
70	Vidakovic Radosav, Feringa Harm H. H, Kuiper Ruud J, Karagiannis Stefanos E, Schouten Olaf, Dunkelgrun Martin, Hoeks Sanne E, Bom Nicolaas, Bax Jeroen J, Neskovic Aleksandar N, and Poldermans Don (2007) Comparison With Computed Tomography Of Two Ultrasound Devices For Diagnosis Of Abdominal Aortic Aneurysm. The American Journal of Cardiology 100(12), 1786-91	This prospective observational study evaluated the diagnostic potential and accuracy of AAA detection of two different ultrasound devices. Study population consisted of individuals referred for surgical treatment of peripheral arterial disease. This did not match review protocol.
71	Vowden P, Wilkinson D, Ausobsky J R, and Kester R C (1989) A Comparison of Three Imaging Techniques in the Assessment of an Abdominal Aortic Aneurysm. The Journal of Cardiovascular Surgery 30(6), 891-6	Observational study examined the accuracy of three imaging techniques. The study had a sample size of less than 200 participants (n=25).
72	Walsh Stewart R, Tang Tjun, Sadat Umar, Varty Kevin, Boyle Jonathan R, and Gaunt Michael E (2007) Preoperative Glomerular Filtration Rate and Outcome Following Open	Retrospective observational study assessed the role of preoperative eGFR as a prognostic indicator in open AAA surgery, compared with serum creatinine (sCR). This did not match study protocol.

No.	Study	Reason for Exclusion
	Abdominal Aortic Aneurysm Repair. Vascular and Endovascular Surgery 41(3), 225-9	
73	Welten G M. J. M, Schouten O, Chonchol M, Hoeks S E, Feringa H H. H, Bax J J, Dunkelgrun M, Van Gestel ,Y R B. M, Van Domburg R T, and Poldermans D (2007) Temporary Worsening Of Renal Function After Aortic Surgery Is Associated With Higher Long-Term Mortality. American Journal of Kidney Diseases 50(2), 219-228	Retrospective cohort study assessed the predictive value of renal function changes by examining preoperative and postoperative creatinine clearance, which did not match our review protocol.
74	West Charles A, Noel Audra A, Bower Thomas C, Cherry Kenneth J, Jr Gloviczki Peter, Sullivan Timothy M, Kalra Manju, Hoskin Tanya L, and Harrington Jeffrey R (2006) Factors Affecting Outcomes Of Open Surgical Repair Of Pararenal Aortic Aneurysms: A 10-Year Experience. Journal of Vascular Surgery 43(5), 921-8	This retrospective study focused on outcomes of open surgical repair pararenal aortic aneurysms. This did not match the objectives of this review question.
75	White G H, Advani S M, Williams R A, and Wilson S E (1988) Cardiac Risk Index As A Predictor Of Long-Term Survival After Repair Of Abdominal Aortic Aneurysm. American Journal of Surgery 156(2), 103-7	Retrospective study examined Goldman cardiac risk index as a predictor of long term survival. This did not match study protocol.
76	Winkel Tamara A, Schouten Olaf, Van Kuijk, Jan-Peter, Verhagen Hence J. M, Bax Jeroen J, and Poldermans Don (2009) Perioperative Asymptomatic Cardiac Damage After Endovascular Abdominal Aneurysm Repair Is Associated With Poor Long-Term Outcome. Journal of Vascular Surgery 50(4), 749-754	Observational study assessed the effect of perioperative asymptomatic cardiac damage after EVAR on long term prognosis by assessing the prognostic value of asymptomatic cardiac troponin T release. This did not match review protocol.
77	Wolf Y G, Johnson B L, Hill B B, Rubin G D, Fogarty T J, and Zarins C K (2000) Duplex ultrasound scanning versus computed tomographic angiography for postoperative evaluation of endovascular abdominal aortic aneurysm repair. Journal of vascular surgery 32(6), 1142-8	Prospective observational study assessed the usefulness of duplex ultrasound scanning compared to computed tomography angiography in postoperative evaluation, which does not match objective of this review.
78	Won A, Acosta J A, Browner D, and Hye R J (1998) Validation Of Selective Cardiac Evaluation Prior To Aortic Aneurysm Repair. Archives of Surgery 133(8), 833-838	Case series did not focus match review protocol.
79	Wu H D, Chou Y H, Hsu C C, Chiou H J, Tiu C M, Chang C Y, and Yu C (1997) Sonography Of Abdominal Aortic Aneurysm. Journal of Medical Ultrasound 5(3), 89-94	Observational study evaluated the efficacy of ultrasound in the diagnosis of AAA. This did not match review protocol.
80	Yeung J J, Hernandez-Boussard T M, Song T K, Dalman R L, and Lee J T. A (2009) Preoperative Thrombus Volume Predicts Sac Regression After Endovascular Aneurysm Repair. Journal of Endovascular Therapy 16(3), 380-388	Retrospective study examined whether preoperative aneurysm thrombus correlated with AAA sac regression following EVAR. This did not review protocol.

No.	Study	Reason for Exclusion
81	Zarins Christopher K, Crabtree Tami, Bloch Daniel A, Arko Frank R, Ouriel Kenneth, and White Rodney A (2006) Endovascular Aneurysm Repair At 5 Years: Does Aneurysm Diameter Predict Outcome? Journal of Vascular Surgery 44(5), 920-31	Retrospective study examined the relationship between preoperative aneurysm diameter and long term outcome after EVAR. This study did not focus on an intervention of interest.
82	Zarkowsky Devin S, Hicks Caitlin W, Bostock Ian C, Stone David H, Eslami Mohammad, and Goodney Philip P (2016) Renal dysfunction and the associated decrease in survival after elective endovascular aneurysm repair. Journal of vascular surgery 64(5), 1278-1285.e1	Cohort study that used logistic regression to assess factors associated with postoperative renal dysfunction. Subsequently, investigators used Cox regression to assess whether postoperative renal dysfunction was associated with mortality. This did not match review protocol.

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.