National Institute for Health and Care Excellence

Final

Abdominal aortic aneurysm: diagnosis and management

Evidence review B: Imaging techniques to diagnose abdominal aortic aneurysms

NICE guideline NG156

Methods, evidence and recommendations

March 2020

Final

This evidence review was developed by the NICE Guideline Updates Team

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Imaging techniques to diagnose abdominal aortic aneurysms

Review questions

Which imaging techniques are the most useful in confirming the presence and size of an abdominal aortic aneurysm?

What imaging techniques are most accurate in confirming the presence of a ruptured abdominal aortic aneurysm?

Introduction

These review questions aim to determine:

- which imaging technique is most accurate in providing a definitive diagnosis of unruptured or ruptured abdominal aortic aneurysms (AAA)
- which imaging technique is most accurate in determining the size of unruptured AAA
- which imaging techniques are most acceptable to patients and clinicians, taking into account the safety profiles of the approaches

PICO tables

Table 1: Inclusion criteria for review question 2: techniques for confirming the presence and size of an AAA

Population	People with a suspected AAA Subgroups: presence of symptoms, by size of aneurysm, women, ethnicity
Index test	• Ultrasound (different approaches to measurement: from where to where?) • MRI angiography
Reference standard	CT (gold-standard) was preferred though other reference standards were considered.
Outcomes	• Diagnostic accuracy (sensitivity and specificity) for the detection of unruptured AAAs • Adverse events • Inter-technique variation in aneurysm diameter (maximum anteroposterior diameter) • Acceptability of approach to patients and clinicians • Quality of life • Resource use and cost

Table 2: Inclusion criteria for review question 18: techniques for confirming the presence of ruptured AAA

Population	People with a suspected ruptured AAA
Intervention	• Ultrasound, including 'focused ultrasound' (different approaches to measurement: from where to where?)

Population	People with a suspected ruptured AAA
	• CT • MRI
Reference standard	• Surgical confirmation alone (preferred reference standard) • CT and/or surgical confirmation (it is likely that this will be considered lower quality – unless CT has 100% agreement with surgical confirmation, in which case it will be pooled in a single analysis with the data that uses surgical confirmation alone as the reference standard – and therefore given lower weight in the decision-making)
Outcomes	• Diagnostic accuracy (sensitivity and specificity) • Adverse events • Acceptability of approach to patients and clinicians • Resource use and cost

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 pull in 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 assessed the accuracy, safety and acceptability of imaging techniques in the diagnosis of AAAs, including asymptomatic aneurysms, symptomatic unruptured aneurysms, and ruptured aneurysms. Cross-sectional studies comparing index tests with reference standards outlined in table 1 and 2, above, were included. Detailed criteria are outlined in the review protocol which can be found in Appendix A.

Studies were excluded if:

- they were not in English;
- they were not full reports of the study (for example, published only as an abstract);
- they were not peer-reviewed;
- they were published before the year 2000 (imaging techniques were of lower quality before this time and therefore not considered relevant to current practice);
- data reported for diagnostic test accuracy did not allow the calculation of both sensitivity and specificity.

Clinical evidence

Included studies

From a database of 12,786 abstracts, 205 were identified as being potentially relevant. Following full-text review of these articles, 1 systematic review (including 6 studies) and 10 primary studies met the inclusion criteria for the review question related to imaging of unruptured AAA. No relevant evidence was identified for review question related to confirmatory imaging of ruptured AAA.

An update search was conducted in December 2017, to identify any relevant studies published during guideline development. The search found 2,598 abstracts; of which 1 was considered potentially relevant. Upon review of the full manuscript, the study was not considered relevant to either review question. As a result no additional studies were included.

Excluded studies

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

Summary of clinical studies included in the evidence review

Diagnosing unruptured AAAs

Systematic review

Study	Details
Rubano E, Mehta N, Caputo W et al. (2013) Systematic review: emergency department bedside ultrasonography for diagnosing suspected abdominal aortic aneurysm (Provisional abstract). Academic Emergency Medicine, 20, pp.128-138	Study design: systematic review of cross-sectional studies Location: USA Population: people over 18 years with suspected unruptured AAA Sample size: the systematic review included 7 studies (655 patients); however for the purpose of this NICE review only 6 of those studies (including 634 participants) were considered relevant Index test: bedside ultrasound performed by emergency physicians Reference standard: CT, MR imaging, aortography, ED ultrasound reviewed by radiology, or official ultrasound performed by radiology, exploratory laparotomy, or autopsy results Outcomes: diagnostic accuracy (sensitivity and specificity)

Cross-sectional studies not included in the systematic review

Study	Details
Dent B, Kendall R J, Boyle AA et al. (2007). Emergency ultrasound of the abdominal aorta by UK emergency physicians: A prospective cohort study. Emergency Medicine Journal, 24, pp.547-549	Study design: cross-sectional study Location: UK Population: people with suspected unruptured AAA Sample size: 70 people Index test: emergency physician-performed ultrasound

Study	Details
	Reference standard: CT, formal ultrasound, laparotomy, or post-mortem Outcomes: diagnostic accuracy (sensitivity and specificity)
Vidakovic R, Feringa HHH, Kuiper RJ, et al. (2007). Comparison with computed tomography of two ultrasound devices for diagnosis of abdominal aortic aneurysm. The American journal of cardiology, 100, pp.1786-91	Study design: systematic review Location: Netherlands Population: people referred for surgical treatment of peripheral arterial disease who were screened for AAA Sample size: 146 people Index test: ultrasound Reference standard: axial CT Outcomes: diagnostic test accuracy (sensitivity and specificity)

See Appendix D for full evidence tables.

Measuring diameters of unruptured AAAs

Study	Details
Bredhal K, Sandholt B, Lonn L, et al. (2015) Three-dimensional ultrasound evaluation of small asymptomatic abdominal aortic aneurysms. European Journal of Vascular and Endovascular Surgery, 49, pp.289-296	Study design: cross-sectional study Location: Denmark Population: patients with small native asymptomatic AAA Sample size: 122 consecutive ultrasound examinations Index test: ultrasound and 3D-ultrasoundd Reference standard: CT Outcomes: inter-technique variation in aneurysm diameter measurements
Chiu K W. H, Ling L, Tripathi Vet al. (2014). Ultrasound measurement for abdominal aortic aneurysm screening: A direct comparison of the three leading methods. European Journal of Vascular and Endovascular Surgery, 47, pp.367-373	Study type: cross-sectional study Location(s): UK Population: people being screened for unruptured AAA Sample size: 50 people Index test: ultrasound Reference standard: Contrast-enhanced CT Outcomes: inter-observer variation in aneurysm diameter measurements
Gray C, Goodman P, Badger S A et al. (2014). Comparison of colour duplex ultrasound with computed tomography to measure the maximum abdominal aortic aneurysmal diameter. International Journal of Vascular Medicine, 2014	Study type: cross-sectional study Location(s): Ireland Population: people being screened for unruptured AAA Sample size: 126 people, 130 pairs of tests Index test: colour duplex ultrasound Reference standard: CT Outcomes: inter-technique variation in aneurysm diameter measurements

Study	Details
Manning BJ, Kristmundsson T, Sonesson Bj, et al. (2009). Abdominal aortic aneurysm diameter: a comparison of ultrasound measurements with those from standard and three-dimensional computed tomography reconstruction. Journal of vascular surgery, 50, pp.263-8	Study type: cross-sectional study Location(s): Sweden Population: people with unruptured AAA Sample size: 109 people Index test: ultrasound Reference standard: spiral CT Outcomes: inter-technique variation in aneurysm diameter measurements
Sprouse LR, Meier GH, Lesar CJ et al. (2003). Comparison of abdominal aortic aneurysm diameter measurements obtained with ultrasound and computed tomography: Is there a difference? Journal of vascular surgery, 38, pp.466-2	Study type: cross-sectional study (retrospective) Location(s): USA Population: people with unruptured AAA from a national endograft trial Sample size: 334 people Index test: duplex ultrasound Reference standard: CT Outcomes: inter-technique variation in aneurysm diameter measurements
Sprouse LR, Meier GH, Parent FN, DeMasi RJ, Glickman MH, and Barber GA. (2004). Is ultrasound more accurate than axial computed tomography for determination of maximal abdominal aortic aneurysm diameter? European Journal of Vascular and Endovascular Surgery, 28, pp.28-35	Study type: cross-sectional study Location(s): USA Population: people presenting with asymptomatic AAA Sample size: 38 people Index test: duplex ultrasound Reference standard: spiral CT Outcomes: inter-technique variation in aneurysm diameter measurements
Wanhainen A, Bergqvist D, and Bjorck M. (2002). Measuring the abdominal aorta with ultrasonography and computed tomography - Difference and variability. European Journal of Vascular and Endovascular Surgery, 24, pp.428-434	Study type: cross-sectional study (retrospective) Location(s): Sweden Population: people being screened for unruptured AAA Sample size: 61 patients Index test: ultrasound Reference standard: CT Outcomes: inter-technique variation in aneurysm diameter measurements
Wolf F, Plank C, Beitzke D, et al. (2011). Prospective evaluation of high-resolution MRI using gadofosveset for Stent-Graft planning: Comparison with CT angiography in 30 patients. American Journal of Roentgenology, 197, pp.1251-1257	Study design: systematic review Location: Population: Sample size: Index test: Reference standard: Outcomes:

See Appendix D for full evidence tables.

Diagnosis of ruptured AAAs

No relevant studies were identified.

Quality assessment of clinical studies included in the evidence review

See Appendix F 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 titles and abstracts for these review questions, 1 full text was retrieved for detailed consideration; however this was not retained. Therefore no relevant economic evidence was identified for these review questions. Original economic modelling was not prioritised for these review questions.

An update search was conducted in December 2017, to identify any relevant health economic analyses published during guideline development. The search found 814 abstracts; none of which were considered relevant to this review question. As a result no additional studies were included.

Excluded studies

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

Economic model

Health economic modelling was not prioritised for this review question and, therefore no model was developed for it.

Evidence statements

Ultrasound for diagnosing unruptured AAAs

Low-quality evidence from 8 cross-sectional studies, including 850 people with or without symptoms of AAA, highlighted that a positive finding on ultrasound increases the probability that an AAA is present (based on positive likelihood ratio) to a degree that is likely to be very large. Conversely low-quality evidence from the same studies highlighted that a negative finding on ultrasound decreases the probability that an AAA is present (based on negative likelihood ratio) to a degree that is likely to be very large

Low-quality evidence from 7 cross-sectional studies, including 704 people with symptoms of AAA, highlighted that a positive finding on ultrasound increases the probability that an AAA is present (based on positive likelihood ratio) to a degree that is likely to be very large. Low-quality evidence from the same studies highlighted that a negative finding on ultrasound decreases the probability that an AAA is present (based on negative likelihood ratio) to a degree that is likely to be very large.

Ultrasound for measuring the size of unruptured AAAs

Very low-quality evidence from 11 evaluations, containing 1,060 paired images from people with a suspected AAA, showed ultrasound to generally underestimate aneurysm diameter relative to CT, though the data could not be pooled in a meta-analysis. The 95% limits of agreement between ultrasound and CT tended to be wide and varied, with upper and lower limits often falling outside a range of clinically acceptable error specified by the NHS AAA Screening Programme (−0.5 to 0.5 cm).

MRI for measuring the size of unruptured AAAs

Low-quality evidence from 1 evaluation, containing 91 paired images from people with a suspected AAA, was inconclusive about the degree of variation between aneurysm diameters measured by MRI and CT.

Diagnosis of ruptured AAAs

No relevant evidence was identified for the diagnosis of ruptured AAAs.

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The committee's discussion of the evidence

Interpreting the evidence

The outcomes that matter most

The guideline committee discussed the relative importance of a variety of outcomes and agreed that the following would be most useful to their decision-making:

- Diagnostic accuracy for the detection of AAAs. In particular, the negative likelihood ratio was considered the most important of the accuracy measures as the consequences of missing a case were described as potentially severe.
- Inter-technique variation in the maximum anteroposterior diameter of the abdominal aorta.
- Acceptability of approach to patients and clinicians.

The quality of the evidence

Diagnosing and measuring the size of unruptured AAAs

The majority of evidence came from studies which assessed the diagnostic accuracy of ultrasound, and only 1 low-quality study was found evaluating the accuracy of magnetic resonance angiography. Since little evidence was found on magnetic resonance angiography, and it is not routinely used to measure the size and shape of AAA, the committee agreed to focus their discussions on ultrasound. Reporting in many of the ultrasound studies was poor: details of study designs were often unclear, with use of blinding, avoidance of inappropriate exclusions, and intervals between index tests and reference standards not consistently reported. The committee noted that the diagnostic test accuracy data were almost exclusively obtained from bedside FAST (Focused Assessment with Sonography in Trauma) ultrasound scans of people who presented at emergency departments with symptoms indicative of AAA presence. They also recognised that the people who performed the scans in included studies may not have been representative of a typical emergency department, where there is wide variation in the experience of staff using ultrasound machines. With this in mind, the committee considered that the evidence had limited applicability to people without symptoms of AAA who may receive other forms of ultrasound in other settings. They agreed that the type of ultrasound used to detect AAA in people without symptoms should be based on clinical judgment and availability of ultrasound equipment.

The committee noted that there were different reference standards used across included studies. They agreed that CT is currently the best imaging modality for obtaining a definitive diagnosis of unruptured AAA but also recognised that it is not 100% accurate. The committee agreed to downgrade the quality of the overall pooled evidence because CT was not used as a reference standard in some studies. However, they noted that sensitivity analysis of studies that only used CT as a reference standard demonstrated similarly large effect sizes to those of the overall pooled analysis.

It was not possible to pool data on inter-technique variation in aneurysm diameter measurements because of the way data were reported. The committee considered that the lack of a summary estimate and associated confidence interval for this type of outcome made interpretation of the data challenging. There was some variation in the mean differences reported and 95% limits of agreement were often wide and varied. The committee noted that the NHS AAA Screening Programme had specified a clinically acceptable range of error between -0.5 cm and 0.5 cm, and agreed that this was an appropriate threshold for assessing imprecision. Upon using this threshold, the committee noted that the data on inter-technique variation in aneurysm diameter measurements between ultrasound and CT appeared to highlight a moderate degree of imprecision. The committee were not too concerned about this as they were aware that people undergoing elective AAA repair will usually receive some form of CT imaging to confirm the size, position and shape of their aneurysms before AAA repair. With this in mind, the committee reached a consensus to recommend preoperative contrast-enhanced arterial-phase CT angiography of aneurysms that have been identified as reaching the threshold for surgical repair (>5.5 cm) by ultrasound. This is widely accepted as best practice.

The committee noted variations in measurement planes and parameters (‘from where to where’) used across included studies. In their experience there is no preferred approach from a surgical perspective; however, the inner edge has a clearer line from which to measure, suggesting that measurement from the inner to inner edge may be more reproducible. In the absence of any evidence to make a recommendation, the committee agreed that the potential for reproducibility supported a recommendation for setting the anterior-posterior inner-to-inner diameter as the standard measurement parameter. They noted that this reflects the current practice of the NHS AAA Screening Programme.

In the absence of evidence on patient or clinician acceptability, the committee agreed that, in their experience, ultrasound and preoperative CT angiography were widely accepted by clinicians. They considered that the minimally invasive nature of the imaging techniques would also make them appealing patients.

Diagnosing ruptured AAAs

No evidence was identified relating to diagnostic imaging of people with suspected ruptured AAA. As a result, the committee extrapolated data from people with symptomatic unruptured AAA and drafted consensus recommendations based on their skills and experience (refer to the benefits and harms section below).

Benefits and harms

Diagnosing and measuring the size of unruptured AAAs

In the absence of evidence on ultrasound in people without symptoms of AAA, the committee considered it appropriate to extrapolate from data obtained from people with symptomatic aneurysms. The diagnostic accuracy effect sizes in this high-risk group were large enough for the committee to conclude that ultrasound was safe to use in asymptomatic patients, who have a lower risk of aneurysm-related morbidity or mortality. Although ultrasound consistently underestimated aneurysm diameter compared with CT, the committee agreed that it was not enough to preclude a recommendation of ultrasound in this lower-risk group.

Although studies highlighted a trend towards larger measurement errors with increasing aneurysm size, the committee did not believe that the data were consistent enough to lead to different diagnostic strategies based on AAA diameter. The committee recognised that the risk of rupture varies according to AAA size, with increasing diameters associated with increasing risk of rupture. For this reason, they recommended that people who have been identified as having AAAs 5.5 cm in diameter or larger should be seen by a regional vascular service within two weeks. They agreed that a longer referral time would be acceptable for people with smaller aneurysms to reflect the lower risk of rupture in this population. The committee noted that within the NHS AAA screening programme it is expected that people identified as having aneurysms less than 5.5 cm in diameter are seen by a vascular nurse within 12 weeks (3 months) of diagnosis to receive some clinical input. As some people are not routinely monitored within the screening programme (for example, woman), the committee thought that it would be useful to specify this timeframe in the recommendations.

Diagnosing ruptured AAAs

The committee agreed that the data relating to symptomatic aneurysms had some applicability to people with ruptured aneurysms. The majority of studies assessed bedside FAST ultrasound, which is often used in emergency settings, and can be performed simultaneously with resuscitative efforts. The speed at which bedside FAST ultrasound can be performed, combined with its availability and utility in emergency settings, led the committee to recommend the technique for assessing people with suspected symptomatic or ruptured AAA.

Although FAST ultrasound was shown to have a high sensitivity and specificity, the committee agreed that a negative ultrasound result from a person with symptoms suggestive of AAA may not always be sufficient to conclude that that a patient does not need further assessment or treatment. The committee's cautiousness was driven by the data on inter-technique variation which showed that ultrasound tended to underestimate aneurysm diameters. Since the committee were mindful of the potential for harm posed by a false-negative result, they recommended that clinicians should immediately contact a regional vascular service if a clinical suspicion of symptomatic or ruptured AAA remains in the absence of ultrasound confirmation of AAA presence.

The committee discussed whether CT could be recommended for diagnosing symptomatic or ruptured AAA. They acknowledged that, although it is the best imaging technique, recommending a CT scan for all patients who are symptomatic (whether as the sole test or as a subsequent test to the FAST ultrasound) was not considered safe as it may unnecessarily delay the transfer of patients to the regional vascular service for treatment. Furthermore, performing a CT scan in all patients would also incur considerable costs.

Therefore, the decision whether to perform CT scan after an initial ultrasound or to immediately transfer a patient should be made under the guidance of a regional vascular service.

The committee also discussed the role of CT angiography in patients who have been transferred to a regional vascular service, and are being considered for emergency repair. They expressed the view that it would be bad practice to undertake emergency EVAR without performing CT angiography. However, they also acknowledged that, where a patient's condition is critically unstable, a vascular specialist may need to rely on a strong clinical diagnosis coupled with ultrasound imaging to inform their decision to attempt open surgical repair. Therefore, the committee agreed it would be unsafe to recommend that CT should always be undertaken and, instead, agreed that it should be considered in each case.

Cost effectiveness and resource use

Diagnosis and measuring the size of unruptured AAAs

No cost-effectiveness evidence was identified for this review, and it was not prioritised for economic modelling. The committee agreed that recommending ultrasound for unruptured (symptomatic or asymptomatic) or ruptured AAAs would have a little impact on resources since it is already widely used in practice.

The committee considered that it was not feasible to perform CT scans on every person with an AAA because such an approach would have a considerable impact on costs and resources. They agreed that the risks associated with surgical repair and the potential usefulness of preoperative CT scans to aid in decision-making would justify this approach in people with AAAs identified as being 5.5 cm or larger by ultrasound. Since this is already current practice, the recommendation will not have a significant resource impact.

Other factors the committee took into account

In the absence of studies evaluating the diagnostic accuracy of ultrasound according sex, the committee had no reason to believe that different imaging strategies should be adopted for men and women. As a result, no sex-specific recommendations were drafted.

Appendices

Appendix A – Review protocols

Review protocol for review question 2: Which imaging techniques are the most useful in confirming the presence and size of an abdominal aortic aneurysm?

Review question 2	Which imaging techniques are the most useful in confirming the presence and size of an abdominal aortic aneurysm?
Objectives	To determine which imaging technique is most accurate in providing a definitive diagnosis of an unruptured abdominal aortic aneurysm, including measurement of its size To determine which imaging techniques are most acceptable to patients and clinicians, taking into account the safety profiles of the approaches
Type of review	Diagnostic
Language	English
Study design	Systematic reviews of study designs listed below Cross-sectional studies
Status	Published papers only (full text) No date restrictions
Population	People with a suspected abdominal aortic aneurysm Subgroups: presence of symptoms, by size of aneurysm, women, ethnicity
Index tests	Ultrasound (different approaches to measurement: from where to where?) MRI angiography
Reference standard	CT NB: CT was initially noted as the preferred reference standard. However, upon review of the evidence, the committee retrospectively amended the protocol to consider partially applicable evidence that used other reference standards like: ultrasound reviewed by a radiologist, official ultrasound performed by a radiologist, exploratory laparotomy, or autopsy results.
Outcomes	Diagnostic accuracy (sensitivity and specificity) for the detection of unruptured abdominal aortic aneurysms Adverse events Inter-technique variation in aneurysm diameter (maximum anteroposterior diameter) Acceptability of approach to patients and clinicians Quality of life Resource use and cost
Other criteria for inclusion / exclusion of studies	Exclusion: Non-English language Abstract/non-published Diagnostic accuracy measures for which both sensitivity and specificity are not available/ cannot be calculated Publication before the year 2000
Baseline characteristics to be extracted in evidence tables	Age Sex

Review question 2	Which imaging techniques are the most useful in confirming the presence and size of an abdominal aortic aneurysm?
	Comorbidities
Search strategies	To be developed
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	None identified.

Review protocol for review question 18: What imaging techniques are most accurate in confirming the presence of a ruptured abdominal aortic aneurysm?

Review question 18	What imaging techniques are most accurate in confirming the presence of a ruptured abdominal aortic aneurysm?
Objectives	To determine which imaging technique is most accurate in providing a definitive diagnosis of ruptured abdominal aortic aneurysm To determine which imaging techniques are most acceptable to patients and clinicians, taking into account the safety profiles of the approaches
Type of review	Diagnostic
Language	English
Study design	Systematic reviews of study designs listed below Cross-sectional studies
Status	Published papers only (full text) No date restrictions
Population	People with a suspected ruptured abdominal aortic aneurysm
Index tests	Ultrasound, including ‘focused ultrasound’ (different approaches to measurement: from where to where?) CT MRI
Reference standard	1. Surgical confirmation alone (preferred evidence) or 2. CT and/or surgical confirmation (it is likely that this will be considered lower quality – unless CT has 100% agreement with surgical confirmation, in which case it will be pooled in a single analysis with the data that uses surgical confirmation alone as the reference standard – and therefore given lower weight in the decision-making)
Outcomes	Diagnostic accuracy (sensitivity and specificity) Adverse events Acceptability of approach to patients and clinicians Resource use and cost
Other criteria for inclusion / exclusion of studies	Exclusion: Non-English language

<table>
<tr><th>Review question 18</th><th>What imaging techniques are most accurate in confirming the presence of a ruptured abdominal aortic aneurysm?</th></tr>
<tr><td></td><td>Abstract/non-published
Diagnostic accuracy measures for which both sensitivity and specificity are not available/ cannot be calculated
Publication before the year 2000</td></tr>
<tr><td>Baseline characteristics to be extracted in evidence tables</td><td>Age
Sex
Position of aneurysm
Comorbidities
Blood pressure
Presence of shock</td></tr>
<tr><td>Search strategies</td><td>See Appendix B</td></tr>
<tr><td>Review strategies</td><td>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.
<table>
<tr><th>Analysis</th><th>Reference standard</th><th>Index tests</th></tr>
<tr><td>1</td><td>Surgical confirmation alone</td><td>Ultrasound
CT
MRI</td></tr>
<tr><td>2</td><td>CT alone or in combination with surgical confirmation</td><td>Ultrasound
MRI</td></tr>
</table>
All key findings from evidence will be presented in GRADE profiles and further summarised in evidence statements</td></tr>
<tr><td>Key papers</td><td>None identified.</td></tr>
</table>

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 questions 2 and 18

Medline Strategy, searched 13th April 2016 **Database: Ovid MEDLINE(R) 1946 to March Week 5 2016** **Search Strategy:**
1 Aortic Aneurysm, Abdominal/
2 (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.
3 Aortic Rupture/
4 (AAA or RAAA).tw.
5 (endovascular* adj4 aneurysm* adj4 repair*).tw.
6 (endovascular* adj4 aort* adj4 repair*).tw.
7 (EVAR or EVRAR or FEVAR or F-EAVAR or BEVAR or B-EVAR).tw.
8 (Anaconda or Zenith Dynalink or Hemobahn or Luminex* or Memoth-erm or Wallstent).tw.

Medline Strategy, searched 13th April 2016 Database: Ovid MEDLINE(R) 1946 to March Week 5 2016 Search Strategy:
9 (Viabahn or Nitinol or Hemobahn or Intracoil or Tantalum).tw. 10 or/1-9 11 X-Rays/ 12 (x-ray* or x ray* or xray* or x-radiation* or x radiation* or roentgen ray* or grenz ray* or radiograph*).tw. 13 Aortography/ 14 aortograph*.tw. 15 Tomography, X-Ray Computed/ (16 (cat scan* or ct scan* or cine ct or cine-ct or tomodensitomet*).tw. 17 ((computed or computer assisted or computeriz* or computeris* or electron beam* or axial*) adj4 tomograph*).tw. 18 Four-Dimensional Computed Tomography/ 19 (4d ct or 4dct or 4-dimensional CT or four dimensional CT).tw. 20 exp Tomography, Spiral Computed/ 21 ((helical or spiral) adj4 ct*).tw. 22 exp Magnetic Resonance Imaging/ 23 (nmr tomograph* or mr tomograph* or nmr imag* or mri scan* or functional mri* or fmri* or zeugmatograph* or cine-mri* or cinemri*).tw. 24 (proton spin adj4 tomograph*).tw. 25 ((chemical shift or magnetic resonance or magneti* transfer) adj4 imag*).tw. 26 exp Angiography/ 27 (angiograph* or arteriograph*).tw. 28 exp Ultrasonography/ 29 (ultrasound* or ultrason* or sonograph* or echograph* or echotomograph*).tw. 30 exp Echocardiography/ 31 echocardiograph*.tw. 32 Finite element analysis/ 33 (finite adj4 element* adj4 analys*).tw. 34 (finite adj4 element* adj4 comput*).tw. 35 FEA.tw. 36 ((wall adj4 stress adj4 analys*) or (wall adj4 stress adj4 comput*)).tw. 37 exp Computer simulation/ 38 Software/ 39 Image interpretation, computer-assisted/ or Radiographic image interpretation, computer-assisted/ 40 Imaging Three-Dimensional/ 41 exp Image enhancement/ 42 Stress, mechanical/ 43 (stress* adj4 mechanical*).tw. 44 (scan* or imag*).tw. 45 Watchful waiting/ 46 (watchful adj4 waiting*).tw. 47 Mass screening/ 48 screen*.tw.

Medline Strategy, searched 13th April 2016 Database: Ovid MEDLINE(R) 1946 to March Week 5 2016 Search Strategy:
49 Population surveillance/
50 surveillan*.tw.
51 ((period* or test* or frequen* or regular* or routine* or rate or optimal* or optimis* or optimiz* or repeat* or interval*) adj4 (test* or monitor* or observ* or measur* or assess* or screen* or re-screen* or rescreen* or exam* or evaluat*)).tw.
52 ((aneursym* or sign* or diameter or risk*) adj4 (grow* or siz* or measur* or expan* or ruptur* or tear* or progress* or enlarg* or dilat* or bulg* or evaluat*)).tw.
53 Patient Selection/
54 ((patient or subject or criteria or treatment*) adj4 select*).tw.
55 ((follow-up or follow up) adj4 (visit* or repeat* or monitor* or assess* or care*)).tw.
56 Aftercare/
57 (aftercare or after-care).tw.
58 Disease progression/
59 ((disease or illness or condition) adj4 (progress* or worsen* or exacerbat* or deterior* or course or duration or trajector* or improv* or recur* or relaps* or remission)).tw.
60 or/11-59
61 10 and 60
62 animals/ not humans/
63 61 not 62
64 limit 63 to english language
Note: Systematic Review and Observational study filters appended to strategy.

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.

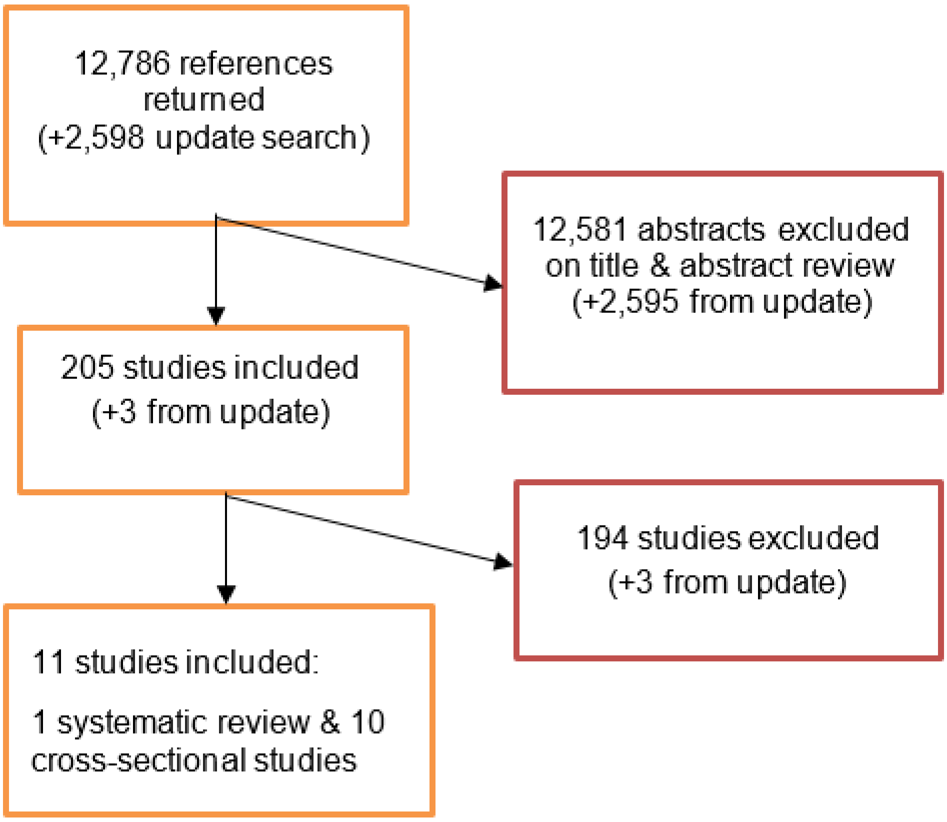
Health economics search strategy

Medline Strategy
Economic evaluations
1 Economics/
2 exp "Costs and Cost Analysis"/
3 Economics, Dental/

Medline Strategy
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. 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.

Medline Strategy	
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

Diagnosing unruptured AAA

Systematic review

<table>
<tr><th>Full citation</th><th>Rubano E, Mehta N, Caputo W et al. (2013) Systematic review: emergency department bedside ultrasonography for diagnosing suspected abdominal aortic aneurysm (Provisional abstract). Academic Emergency Medicine, 20, pp.128-138</th></tr>
<tr><td>Study details</td><td>Study type: systematic review of cross-sectional studies
Location(s): USA
Aim(s): To explore whether emergency department-performed ultrasound was sufficiently accurate at ruling out an AAA in a patient with a suspected aneurysm
Study dates: studies published from 1965 to 2011 were included
Follow-up: not reported
Sources of funding: not reported</td></tr>
<tr><td>Participants</td><td>Population: people over 18 years with suspected unruptured AAA
Sample size: the systematic review included 7 studies (655 patients); however for the purpose of this NICE review only 6 of those studies (including 634 participants) were considered relevant
Review-level inclusion criteria: prospective studies in which beside ultrasound was used to assess the presence of AAA in patients with symptoms or signs suggestive of AAAs were included
Review-level exclusion criteria: not specified
Study-level selection criteria:
<table>
<tr><th>Study</th><th>Patient characteristics</th></tr>
<tr><td>Kuhn, 2000</td><td>Inclusion criteria: people over 50 years with suspected of AAA; abdominal/back pain of unclear origin or presumed renal colic
Exclusion criteria: presence of an AAA had already been established by prior radiologic investigation</td></tr>
<tr><td>Rowland, 2001</td><td>Inclusion criteria: people over 50 years presenting with abdominal pain/back pain with unclear etiology or renal colic; adults with a pulsatile abdominal masses
Exclusion criteria: pregnant women</td></tr>
<tr><td>Jones, 2003</td><td>Inclusion criteria: not defined but examination was performed only if clinically indicated
Exclusion criteria: not reported</td></tr>
<tr><td>Tayal, 2003</td><td>Inclusion criteria: people with suspected of AAA; people presenting with abdominal, flank and/or back pain, or syncope
Exclusion criteria: people with known diagnosis of AAA</td></tr>
</table></td></tr>
</table>

	Knaut, 2005	Inclusion criteria: people over 50 years presenting with abdominal pain who were scheduled for abdominal/pelvic CT Exclusion criteria: people with ruptured AAA who went to surgery without CT scan being performed
	Constantino, 2005	Inclusion criteria: people over 55 years presenting with one of the following: abdominal, back, flank or chest pain or hypertension as well as clinical suggestion of AAA Exclusion criteria: people with a known diagnosis of AAA

Index test

Review level: Emergency department-performed ultrasound: bedside ultrasound performed by emergency physicians

Study	Index test
Kuhn, 2000	Bedside ultrasound machine was performed by emergency physicians with 3 or more years of postgraduate experience. No prior ultrasound experience was needed but examiners attended course prior to start of the study.
Rowland, 2001	Bedside ultrasound machine was performed by emergency physicians with 3 or more years of postgraduate experience. No prior ultrasound experience was needed but examiners attended course prior to start of the study.
Jones, 2003	One of three emergency physicians or a critical care fellow performed examinations. All attended 4-hour ultrasound workshop prior to study commencement
Tayal, 2003	Senior ED residents and board certified emergency physicians Minimum introductory emergency ultrasound education who performed at least 50 emergency ultrasound Unclear from where to where was measured
Knaut, 2005	ED 2nd-, 3rd- and 4th-year residents and emergency physicians Annual formal didactic 5-hour training Measurements taken from inner wall to inner wall
Constantino, 2005	Third-year emergency medicine residents 23-day ultrasound rotation completing at least 150 emergency ultrasound Unclear from where to where was measured

Reference standard

Review level: CT, MR imaging, aortography, ED ultrasound reviewed by radiology, or official ultrasound performed by radiology, exploratory laparotomy, or autopsy results

Study-level:

Study	Reference standard
Kuhn, 2000	Radiologist ultrasound, abdominal CT, angiography, laparotomy or radiology review of ED images
Rowland, 2001	Radiologist ultrasound, abdominal CT, angiography, laparotomy or radiology review of ED images
Jones, 2003	Radiologist ultrasound, abdominal CT or laparotomy
Tayal, 2003	Radiologist ultrasound, abdominal CT, angiography or laparotomy
Knaut, 2005	Aortic diameter from abdominal CT measured by two separate radiologist at SMA, bifurcation and longitudinal

	Constantino, 2005	Radiologist ultrasound, abdominal CT, angiography or laparotomy

Outcomes measures	Diagnostic accuracy: The following data were extracted from included studies

Study	AAA, (n/N)	Sensitivity (95% CI)	Specificity (95% CI)
Kuhn, 2000	26/68	100%	95.2% (89 to 100%)
Rowland, 2001	12/33	100%	100%
Jones, 2003	40/66	97.5% (92.6 to 100%)	100%
Tayal, 2003	27/125	100%	98% (95 to 100%)
Knaut, 2005	5/104	100%	97% (94 to 100%)
Constantino, 2005	36/238	100%	100%

Risk of bias assessment	1. Does the review address an appropriate and clearly focused question that is relevant to the review question? Yes 2. Does the review collect the type of studies considered relevant to the review question? Yes 3. Is the literature search sufficiently rigorous to identify all the relevant studies? Yes 4. Is study quality assessed and reported? Yes 5. Is an adequate description of methodology included, and the methods used appropriate to the question? Yes 6. Is there concern that the included patients do not match the review question? No 7. Is there concern that the index test, its conduct, or interpretation differ from the review question? No 8. Is there concern that the target condition as defined by the reference standard does not match the review? Yes; CT not used in all patients – where possible, the reviewer will remove studies that do not include CT in the reference standard Overall risk of bias: Low Directness: Directly applicable

Study-level risk of bias

NB: risk of bias assessments were extracted and are reported as stated in the Rubano (2013) systematic review.

Item		Lanoix et al., 2000[39]	Kuhn et al., 2000[40]	Rowland et al., 2001[41]	Jones et al., 2003[42]	Tayal et al., 2003[43]	Knaut et al., 2005[44]	Costantino et al., 2005[45]
1	Was the spectrum of patients described in the paper and was it chosen adequately?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
2	Were selection criteria described clearly?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
3	Is the reference standard likely to classify the target condition?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
4	Was there an abnormally long time period between the performance of the test under evaluation and the confirmation of the diagnosis with the reference standard?	[redacted]	No	No	No	No	No	No
5	Did the whole sample, or a random selection of the sample, receive verification using a reference standard of diagnosis?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
6	Did all patients receive the same reference standard regardless of the index test result?	[redacted]	No	No	No	No	Yes	No
7	Were the results of the index test incorporated in the results of the reference standard?	[redacted]	No	No	No	No	No	No
8	Was the execution of the index test described in sufficient detail to permit replication of the test?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
9	Was the execution of the reference standard described in sufficient detail to permit replication of the test?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
10	Were the index test results interpreted blind to the results of the reference standard?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
11	Were the reference standard results interpreted blind to the results of the index test?	[redacted]	Yes	Yes	Unclear	Unclear	Yes	Unclear
12	Was clinical data available when test results were interpreted?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
13	Were uninterpretable/indeterminate/intermediate results reported and included in the results?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
14	Were reasons for drop-out from the study reported?	[redacted]	Yes	Yes	Yes	Yes	Yes	Yes
	Kappa		1	1	1	1	1	1

QUADAS = Quality Assessment of Diagnostic Accuracy Studies.

NB: Data from Lanoix 2000 were not included as the study was not considered relevant this NICE review

Cross-sectional studies not included in the systematic review

Full citation	**Dent B, Kendall R J, Boyle A A, et al. (2007) Emergency ultrasound of the abdominal aorta by UK emergency physicians: A prospective cohort study. Emergency Medicine Journal, 24, pp.547-549**
Study details	Study type: cross-sectional study Location(s): UK Aim(s): to establish whether UK emergency physicians could reliably perform focused ultrasound of the abdominal aorta in patients with suspected AAAs. Study dates: January to December 2005 Follow-up: not reported Sources of funding: sources of funding were not reported but authors stated that they had established an ultrasound course sponsored by an ultrasound machine manufacturer, and profits from the course were used in an educational fund.
Participants	Population: people with suspected unruptured AAA who presented at emergency departments Sample size: 70 people Inclusion criteria: people presenting with back pain, abdominal pain or any other suspicion for the presence of an AAA. Exclusion criteria: not specified Baseline characteristics: Mean age: 73 years Sex: not reported Comorbidities: not reported
Index test	Emergency physician-performed ultrasound: Emergency physicians received standardised training before performing ultrasound scanning for possible AAA. The training consisted of a 1 day course covering both theory and practical skills, combined with a structured training programme. Individuals were only able to undertake unsupervised scans once they had completed a competency based assessment. It is unclear what parameters were used to measure aneurysms.
Reference standard	CT, formal ultrasound, laparotomy, or post-mortem
Outcomes measures	Diagnostic accuracy
Risk of bias assessment	Patient selection: unclear risk of bias • Was a consecutive or random sample of patients enrolled? Unclear • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Unclear • Is there concern that the included patients do not match the review question? No Index test(s): unclear risk of bias

Full citation	Dent B, Kendall R J, Boyle A A, et al. (2007) Emergency ultrasound of the abdominal aorta by UK emergency physicians: A prospective cohort study. Emergency Medicine Journal, 24, pp.547-549
	• Were the index test results interpreted without knowledge of the results of the reference standard? Unclear • If a threshold was used, was it pre-specified? Yes • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: moderate risk of bias • Is the reference standard likely to correctly classify the target condition? Uses a mixed reference standard which includes tests of varying accuracy • Were the reference standard results interpreted without knowledge of the results of the index test? Unclear • Is there concern that the target condition as defined by the reference standard does not match the review question? Yes; CT not used in all patients Flow and timing: moderate risk of bias • Was there an appropriate interval between index test(s) and reference standard? Unclear • Did all patients receive a reference standard? No • Did patients receive the same reference standard? No Were all patients included in the analysis? Yes Overall risk of bias: moderate Directness: directly applicable

Full citation	Vidakovic R, Feringa HHH, Kuiper RJ et al. (2007) Comparison with computed tomography of two ultrasound devices for diagnosis of abdominal aortic aneurysm. The American journal of cardiology, 100, pp.1786-91
Study details	Study type: cross-sectional study Location(s): Netherlands Aim(s): to compare a 2-dimensional, handheld ultrasound device and a newly developed ultrasound volume scanner (based on bladder scan technology) with CT for diagnosing AAA Study dates: not reported Follow-up: not reported Sources of funding: not reported
Participants	Population: people referred for surgical treatment of peripheral arterial disease who were screened for AAA Sample size: 146 people Inclusion criteria: people presenting with asymptomatic AAA larger than 4.0 cm in the outpatient setting Exclusion criteria: people with suprarenal AAAs, aortic dissection, and those with previous aortic surgery were excluded Baseline characteristics: Mean age: 69 years Sex: 87% male Comorbidities: not reported
Index test	Ultrasound: Examinations were performed and reviewed by 2 physicians, both skilled and experienced in abdominal ultrasound using a 2-dimensional, duplex, handheld ultrasound device (USHH). The USHH examination was focused on the identification of the infrarenal aorta. The measurement of its maximal diameter was obtained using on-screen calipers from edge to edge of the aortic wall, including the intraluminal thrombus if present. The probe was maintained perpendicular to the aortic blood flow determined by colour doppler to yield orthogonal sections of the aorta. Measurements were taken from the lowest renal artery to the aortic bifurcation. The maximal obtained diameter in any direction, expressed in millimetres, was used for analysis.
Reference standard	Axial CT: The examinations were performed with 4-mm slice thickness and 4-mm increments, with 100 ml of non-ionic contrast medium. Results were reported as the maximal diameter of the infrarenal aorta in any direction.
Outcomes measures	Diagnostic test accuracy
Risk of bias assessment	Patient selection: low risk of bias • Was a consecutive or random sample of patients enrolled? Yes • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Yes • Is there concern that the included patients do not match the review question? No

	Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No. Study also examined a handheld ultrasound volume scanner for 3-dimensional measurements, originally intended as an automatic bladder volume indicator (BVI); however, the Committee did not feel that this was relevant to practice and therefore the data for this imaging technique was not included. Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: moderate risk of bias • Was there an appropriate interval between index test(s) and reference standard? Unclear • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: low Directness: directly applicable

Measuring diameters of unruptured AAA

Full citation	Bredahl K, Sandholt B, Lonn L et al. (2015) Three-dimensional ultrasound evaluation of small asymptomatic abdominal aortic aneurysms. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 49, 289-96
Study details	Study type: cross-sectional study Location(s): Denmark Aim(s): to determine any difference in paired size estimation associated with three 3D-US derived methods using 3D-CT as gold standard. Furthermore, the study aimed to assess 3D-US reproducibility in terms of agreement between two physicians. Study dates: March 2013 to February 2014 Follow-up: not reported Sources of funding: the Danish Heart Foundation, the AP Moeller Foundation, and the Frankel Foundation provided financial support for this research project.
Participants	Population: patients with small native asymptomatic AAA Sample size: 122 consecutive ultrasound examinations were performed Inclusion criteria: consecutive patients with small native asymptomatic AAA (>3.0cm) were prospectively and consecutively enrolled into the study if their aneurysm diameter was less than 5.5 cm for men and less than 5.2 cm for women. Patients with incidental AAA findings of CTA were included for 3D-US versus 3D-CT comparisons. Exclusion criteria: patients were excluded if bowel gas or obesity made insonation inadequate; in particular if visualisation of the circumferential aortic wall on several images made at least one of the physicians lose confidence in the 3D AAA reconstruction. Patients with aortic-iliac aneurysms were excluded if the abdominal and the iliac component were not clearly distinguishable on ultrasound. Baseline characteristics: not reported
Index test	US and 3D-US (leading- to leading): First, a ultrasound dual plane diameter was measured on the transverse display from the leading edge of the adventitia anterior wall to the leading edge of the adventitia posterior wall in peak systole. Next, the 3D-US acquisition was performed during breath hold (<2 seconds)
Reference standard	CT: CT was used as gold standard when ultrasound and CT were compared and the entire aneurysm was displayed, provided the slice thickness was less than 5 mm and the CT was performed within 3 months of the ultrasound examination.
Outcomes measures	Inter-technique variation in aneurysm diameter
Risk of bias assessment	Patient selection: unclear risk of bias • Was a consecutive or random sample of patients enrolled? Unclear • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Unclear

Full citation	Bredahl K, Sandholt B, Lonn L et al. (2015) Three-dimensional ultrasound evaluation of small asymptomatic abdominal aortic aneurysms. European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery 49, 289-96
	• Is there concern that the included patients do not match the review question? Yes; Consecutive patients with small native asymptomatic AAA including patients referred because CT had revealed a coincidental AAA were included. However, the reviewer felt that the study could still provide useful information of the measurement of AAAs. Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Unclear – CT performed within 3 months of the ultrasound examination • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? No Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: Low Directness: Directly applicable

Full citation	Chiu K W. H, Ling L, Tripathi V et al. (2014) Ultrasound measurement for abdominal aortic aneurysm screening: A direct comparison of the three leading methods. European Journal of Vascular and Endovascular Surgery, 47, pp.367-373
Study details	Study type: cross-sectional study Location(s): UK Aim(s): this study evaluates the accuracy, reproducibility, and repeatability of three methods of aortic diameter measurement by ultrasound: inner-to-inner, leading-to-leading edge, and outer-to-outer. The secondary objective of this study was to determine whether aneurysm size or grade of operator had any effect on either intra- or inter-observer variability. Study dates: 2010 to 2012 Follow-up: not reported Sources of funding: not reported
Participants	Population: people being screened for unruptured AAA Sample size: 50 people Inclusion criteria: not specified Exclusion criteria: not specified Baseline characteristics: not reported
Index test	Ultrasound (inner-to-inner, leading-to-leading, and outer-to-outer): A total of 1,800 measurements (50 measurements using 3 different methods measured twice by 6 different assessors) were performed. All three measurements were measured from the same images on the anterior-posterior axis. Six assessors were used: two experienced sonographers, two IR fellows, and two consultant vascular IR radiologists. All six assessors had over 4 years' experience in ultrasound imaging and are trained in peripheral vascular imaging.
Reference standard	Contrast-enhanced CT (outer-to-outer) CT was performed, within 3 months of the US, by two experienced radiologists using the outer-to- outer edge anterior-posterior diameter at the level of maximum aneurysm diameter after multiplanar reformatting.
Outcomes measures	Inter-observer variation in aneurysm diameter
Risk of bias assessment	Patient selection: moderate risk of bias • Was a consecutive or random sample of patients enrolled? Unclear; used a convenience sample. Patients were allocated into five groups depending on reported aortic diameters (group I-V): group I <2.5 cm (n = 42), group II 2.5-3.4 cm (n = 45), group III 3.5-4.4 cm (n = 25), group IV 4.5-5.4 cm (n = 32), and group V >5.4 cm (n = 45). Ten patients in each group were selected randomly to be included in the study. • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Unclear • Is there concern that the included patients do not match the review question? No Index test(s): low risk of bias

Full citation	Chiu K W. H, Ling L, Tripathi V et al. (2014) Ultrasound measurement for abdominal aortic aneurysm screening: A direct comparison of the three leading methods. European Journal of Vascular and Endovascular Surgery, 47, pp.367-373
	• Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Yes • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care: low risk of bias • Other than the intervention under study, is the same care associated with the administration of each imaging technique? No; CT assessed solely by experienced radiologists, whereas ultrasound assessed by a range of professionals (experienced sonographers, two IR fellows, and two consultant vascular IR radiologists), though all over 4 years' experience in ultrasound imaging and are trained in peripheral vascular imaging. Overall risk of bias: Low Directness: Directly applicable

Full citation	Gray C, Goodman P, Badger S A et al. (2014) Comparison of colour duplex ultrasound with computed tomography to measure the maximum abdominal aortic aneurysmal diameter. International Journal of Vascular Medicine, 2014
Study details	Study type: cross-sectional study Location(s): Ireland Aim(s): to compare the two imaging modalities of colour duplex ultrasound and CT in assessment of the maximum aneurysm diameter in patients under surveillance for AAA Study dates: January 2007 to December 2009 Follow-up: not reported Sources of funding: sources of funding were not reported but authors declared that there were no conflicts of interests regarding the publication of this paper
Participants	Population: people being screened for unruptured AAA Sample size: 126 people, 130 pairs of tests Inclusion criteria: people under surveillance for AAA who had colour duplex ultrasound and CT scans performed within 90 days of each other Exclusion criteria: some were excluded as they did not have comparable scans within the 90-day period; in all cases, this was because these aneurysms fell below the standard threshold for intervention of 5.5 cm and thus a CT was not warranted Baseline characteristics: Mean age: mean male age was 76.1 years and the mean female age was 76.2 years Sex: 78.6% male Comorbidities: not reported
Index test	Colour duplex ultrasound (outer-to-outer): All ultrasound scans were performed in the supine position by a qualified vascular technologist proficient in abdominal imaging. The maximum anterior to posterior wall diameter and the maximum transverse wall diameter were recorded with the greater of the two measurements being taken as the maximum aneurysm diameter and used for comparison in this study. The outer-to-outer diameter was used for the definition of AAA diameter.
Reference standard	CT (outer-to-outer): All CT scans were carried out in the radiology department following their standard protocol for abdominal imaging. The maximum aneurysm diameter documented on the report by a consultant radiologist was used for comparison in this study. The outer-to-outer diameter was also used as the diameter definition for CT scans, to ensure equality of definition in comparison.
Outcomes measures	Inter-technique variation in aneurysm diameter measurements
Risk of bias assessment	Patient selection: low risk of bias • Was a consecutive or random sample of patients enrolled? Yes • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Yes

Full citation	Gray C, Goodman P, Badger S A et al. (2014) Comparison of colour duplex ultrasound with computed tomography to measure the maximum abdominal aortic aneurysmal diameter. International Journal of Vascular Medicine, 2014
	• Is there concern that the included patients do not match the review question? No Index test(s): unclear risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Unclear • If a threshold was used, was it pre-specified? Unclear • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: unclear risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Unclear • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: unclear risk of bias • Was there an appropriate interval between index test(s) and reference standard? Yes • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care: low risk of bias • Other than the intervention under study, is the same care associated with the administration of each imaging technique? No; ultrasound carried out by vascular technologist proficient in abdominal imaging, CT by the Radiology department. Overall risk of bias: low Directness: directly applicable

Full citation	**Manning BJ, Kristmundsson T, Sonesson Bj et al. (2009) Abdominal aortic aneurysm diameter: a comparison of ultrasound measurements with those from standard and three-dimensional computed tomography reconstruction. Journal of vascular surgery, 50, pp.263-8**
Study details	Study type: cross-sectional study Location(s):Sweden Aim(s): to define the relationship between commonly used CT measurement techniques and those based on current reporting standards and to compare the values obtained with diameter measured using ultrasound Study dates: not reported Follow-up: not reported Sources of funding: not reported
Participants	Population: people with unruptured AAA Sample size: 109 people Inclusion criteria: people referred for assessment for a suspected AAA were included Exclusion criteria: people in whom more than 90 days had elapsed between the time of the CT scan and the ultrasound measurement were excluded. Patients were also excluded because either they did not have thin-slice CT scans ≤5 mm in thickness, they did not have contrast-enhanced scans, a centreline calculation was not possible due to the presence of orally administered contrast material, or because they had previously undergone aortic intervention. Patients with saccular or inflammatory aneurysms were also excluded. Baseline characteristics: Mean age: 72 ± 8 years Sex: 84.4% male Comorbidities: not reported
Index test	US (outer-to-outer): Maximal anteroposterior diameter was registered with echo-tracking ultrasound equipment. All measurements were performed on patients in the supine position by one of two experienced technicians. The diameter is registered from intimal layer to intimal layer.
Reference standard	Spiral CT (outer-to-outer): Data sets acquired by a multi-detector row spiral CT scanner were analysed using 3D software tools at a post-processing workstation. Measurements taken from axial cuts included the AP maximal aortic diameter, the diameter of the maximal ellipse in any direction, and the diameter perpendicular to the maximal ellipse at the widest point. The semi-automated centreline calculation was then performed on the 3D aortic reconstruction, and its accuracy was confirmed by examining the images perpendicular to the projected centreline. Maximal diameter in any direction was measured from the 2D image representing the plane orthogonal to the centreline of flow. All measurements were taken from outer wall to outer wall, and images were stored electronically.
Outcomes measures	Inter-technique variation in aneurysm diameter measurements
Risk of bias assessment	Patient selection: low risk of bias • Was a consecutive or random sample of patients enrolled? Yes

Full citation	**Manning BJ, Kristmundsson T, Sonesson Bj et al. (2009) Abdominal aortic aneurysm diameter: a comparison of ultrasound measurements with those from standard and three-dimensional computed tomography reconstruction. Journal of vascular surgery, 50, pp.263-8**
	• Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Yes • Is there concern that the included patients do not match the review question? Yes; participants were not those with a 'suspicion of AAA', they were those in whom AAA had already been found. However, the reviewer felt that the study could still provide useful information of the measurement of AAAs. Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Yes, within 90 days • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: low Directness: directly applicable

Full citation	Sprouse LR, Meier GH, Lesar CJ et al. (2003) Comparison of abdominal aortic aneurysm diameter measurements obtained with ultrasound and computed tomography: Is there a difference? Journal of vascular surgery, 38, pp.466-2
Study details	Study type: cross-sectional study (retrospective) Location(s): USA Aim(s): to assess the paired differences in AAA diameter measurements obtained with CT and ultrasound in a large national endograft trial, including only baseline examinations in which both ultrasound and CT measurements of aneurysm diameter were available. Study dates: not reported Follow-up: not reported Sources of funding: not reported
Participants	Population: people with unruptured AAA from a national endograft trial Sample size: 334 people Inclusion criteria: baseline examinations in which both ultrasound and CT measurements of aneurysm diameter were available. Exclusion criteria: images of poor quality, as determined by the core laboratory, were not assessed for maximal diameter and were excluded. Baseline characteristics: Mean age: not reported Sex: not reported Comorbidities: not reported
Index test	Duplex ultrasound: Maximal aortic diameter were recorded performed at 29 separate centres (local sites), with numerous types of equipment, according to a protocol provided by the core laboratory. No standardized assessment was used to correlate or compare measurements between centres. Calipers were used in all cases, and magnification was used at the discretion of the observer. Multiple measurements were often performed to arrive at the maximal diameter; however, the protocol did not require a pre-set number of measurements. It is unclear from what parameters were used to measure aneurysms.
Reference standard	CT Maximal aortic diameter were recorded performed at 29 separate centres (local sites), with numerous types of equipment, according to a protocol provided by the core laboratory. No standardized assessment was used to correlate or compare measurements between centres. Calipers were used in all cases, and magnification was used at the discretion of the observer. Multiple measurements were often performed to arrive at the maximal diameter; however, the protocol did not require a pre-set number of measurements.
Outcomes measures	Inter-technique variation in aneurysm diameter measurements
Risk of bias assessment	Patient selection: unclear risk of bias • Was a consecutive or random sample of patients enrolled? Unclear • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Unclear

Full citation	Sprouse LR, Meier GH, Lesar CJ et al. (2003) Comparison of abdominal aortic aneurysm diameter measurements obtained with ultrasound and computed tomography: Is there a difference? Journal of vascular surgery, 38, pp.466-2
	• Is there concern that the included patients do not match the review question? Unclear Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Yes, within 1 month • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? No; initially, spiral CT was used; however, helical CT was used when it became available during the course of the study • Were all patients included in the analysis? Yes Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: low Directness: directly applicable

Full citation	**Sprouse LR, Meier GH, Parent FN (2004) Is ultrasound more accurate than axial computed tomography for determination of maximal abdominal aortic aneurysm diameter? European Journal of Vascular and Endovascular Surgery, 28, pp.28-35**
Study details	Study type: cross-sectional study Location(s): USA Aim(s): to compare maximal AAA diameter by US, axial CT, and orthogonal CT, and to assess the effect that AAA angulation has on each measurement. Study dates: not reported Follow-up: not reported Sources of funding: not reported
Participants	Population: people presenting with asymptomatic AAA Sample size: 38 people Inclusion criteria: people presenting with asymptomatic AAA larger than 4.0 cm in the outpatient setting Exclusion criteria: people with suprarenal AAAs, aortic dissection, and those with previous aortic surgery were excluded Baseline characteristics: Mean age: not reported Sex: not reported Comorbidities: not reported
Index test	Duplex ultrasound (outer-to-outer): Standard aortoiliac duplex ultrasound was performed by four registered vascular technologists. With the ultrasound probe positioned transversely on the abdomen, the AAA from the lowest renal artery to the aortic bifurcation was assessed for maximal diameter. Multiple measurements were performed to arrive at the maximal diameter along the major axis. The maximal diameter was defined as the largest external diameter (adventitia to adventitia) of the AAA measured in any direction from the representative images. On screen calipers were used for all measurements.
Reference standard	Spiral CT (outer-to-outer): Abdominal and pelvic CT scans were performed with a multi-detector spiral CT four detectors, and the data were processed to produce a reconstructed 3D model of the AAA. The 3D model was scanned from the lowest renal artery to the aortic bifurcation by two observers to locate the site of maximal diameter. Using a combination of the model and the CT slices measurement of maximal AAA diameter was performed in both the axial and orthogonal planes. Multiple measurements were performed by each observer. The final recorded maximal diameter represented an average of the maximal diameter (adventitia to adventitia) measured by each observer.
Outcomes measures	Inter-technique variation in aneurysm diameter measurements
Risk of bias assessment	Patient selection: unclear risk of bias • Was a consecutive or random sample of patients enrolled? Unclear • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Unclear

Full citation	Sprouse LR, Meier GH, Parent FN (2004) Is ultrasound more accurate than axial computed tomography for determination of maximal abdominal aortic aneurysm diameter? European Journal of Vascular and Endovascular Surgery, 28, pp.28-35
	• Is there concern that the included patients do not match the review question? Yes; participants were not those with a 'suspicion of AAA', they were those in whom AAA had already been found. However, the reviewer felt that the study could still provide useful information of the measurement of AAAs. Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Yes, within 60 days • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: low Directness: directly applicable

Full citation	Wanhainen A, Bergqvist D, and Bjorck M. (2002) Measuring the abdominal aorta with ultrasonography and computed tomography - Difference and variability. European Journal of Vascular and Endovascular Surgery, 24, pp.428-434
Study details	Study type: cross-sectional study (retrospective) Location(s): Sweden Aim(s): to estimate the agreement between the two techniques in measuring the dimensions of the abdominal aorta in subjects with and without AAA. The importance of aortic size, plane of measurement and BMI was also evaluated. Study dates: not reported Follow-up: not reported Sources of funding: the study was supported by grants from The Co-ordinate Centre of the Northern Counties of Sweden (VISARE-NORR), the County of VaÈsternorrlands Research and Development (FoU) Centre, the Gore Sweden Research Foundation, the Ture Stenholm's Foundation for Surgical Research and the Swedish Medical Research Council
Participants	Population: people being screened for unruptured AAA Sample size: 61 patients Inclusion criteria: people over 65 years who were seen by a population-based AAA screening programme Exclusion criteria: people were excluded due to suboptimal visibility of ultrasound or CT Baseline characteristics: Mean age: 70.4 years Sex: 82% male Comorbidities: not reported
Index test	Ultrasound: All ultrasound examinations were performed by the same experienced radiologist. The subjects were fasted four hours before examination. It is unclear from what parameters were used to measure aneurysms.
Reference standard	CT: Helical CT-scans were done with 10 mm slices at 7.5 mm increment (space) from the xiphoid process to the aortic bifurcation. No intravenous contrast was administered. The images were stored on an optical disc from which the readings were done afterwards on a workstation (Advantage Windows) by one radiologist.
Outcomes measures	Diagnostic test accuracy (sensitivity and specificity)
Risk of bias assessment	Patient selection: unclear risk of bias • Was a consecutive or random sample of patients enrolled? Unclear • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Unclear • Is there concern that the included patients do not match the review question? Yes; participants were not those with a 'suspicion of AAA', they were those in whom AAA had already been found and in whom CT was needed for a purpose not related to the study purpose. However, the reviewer felt that the study could still provide useful information of the measurement of AAAs.

	Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Unclear • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: low Directness: directly applicable

Full citation	Wolf F, Plank C, Beitzke D et al. (2011). Prospective evaluation of high-resolution MRI using gadofosveset for Stent-Graft planning: Comparison with CT angiography in 30 patients. American Journal of Roentgenology, 197, pp.1251-1257
Study details	Study type: cross-sectional study (retrospective) Location(s): Austria Aim(s): to compare high-resolution gadofosveset-enhanced MR angiography with the reference standard CT angiography in planning EVAR of AAAs. Study dates: May 2009 to June 2010 Follow-up: not reported Sources of funding: not reported
Participants	Population: people scheduled for EVAR of an unruptured infrarenal AAA Sample size: 30 patients Inclusion criteria: people scheduled for EVAR of an unruptured infrarenal AAA Exclusion criteria: people with contraindications for MRI (pacemaker, implantable defibrillator, metallic implants, claustrophobia) or highly impaired renal function (glomerular filtration rate < 30 mL/min) were excluded. Pregnant or breast-feeding women as well as patients younger than 18 years were also excluded Baseline characteristics: Mean age: 71 years Sex: 100% male Comorbidities: not reported
Index test	High-resolution gadofosveset-enhanced MR angiography. High-resolution MR angiography steady-state datasets were used to create axial, coronal, and sagittal multiplanar reconstructions with a slice thickness of 0.6 mm and an increment of 2 mm. Examinations were interpreted by 2 vascular radiologists. All measurements were performed on a PACS workstation using the electronic measurement tool.
Reference standard	Contrast-enhanced CT angiography All scans ranged from the diaphragm to the femoral head. From the CT data sets, a secondary raw dataset with a slice thickness of 1 mm and an increment of 0.5 mm was reconstructed as the basis for further 3D reconstructions. In addition, an axial dataset with a slice thickness of 3 mm and an increment of 2 mm was reconstructed for the CT report. Examinations were interpreted by 2 vascular radiologists in consensus. All measurements were performed on a PACS workstation using the electronic measurement tool.
Outcomes measures	Inter-technique variation in aneurysm diameter measurements
Risk of bias assessment	Patient selection: low risk of bias • Was a consecutive or random sample of patients enrolled? Yes • Was a case-control design avoided? Yes • Did the study avoid inappropriate exclusions? Yes

	• Is there concern that the included patients do not match the review question? Yes; participants were not those with a 'suspicion of AAA', they were those in whom AAA had already been found. However, the reviewer felt that the study could still provide useful information of the measurement of AAAs. Index test(s): low risk of bias • Were the index test results interpreted without knowledge of the results of the reference standard? Yes • If a threshold was used, was it pre-specified? n/a • Is there concern that the index test, its conduct, or interpretation differ from the review question? No Reference standard: low risk of bias • Is the reference standard likely to correctly classify the target condition? Yes • Were the reference standard results interpreted without knowledge of the results of the index test? Yes • Is there concern that the target condition as defined by the reference standard does not match the review question? No Flow and timing: low risk of bias • Was there an appropriate interval between index test(s) and reference standard? Yes • Did all patients receive a reference standard? Yes • Did patients receive the same reference standard? Yes • Were all patients included in the analysis? Yes Other care • Other than the intervention under study, is the same care associated with the administration of each imaging technique? Yes Overall risk of bias: low Directness: directly applicable

Diagnosis of unruptured AAAs

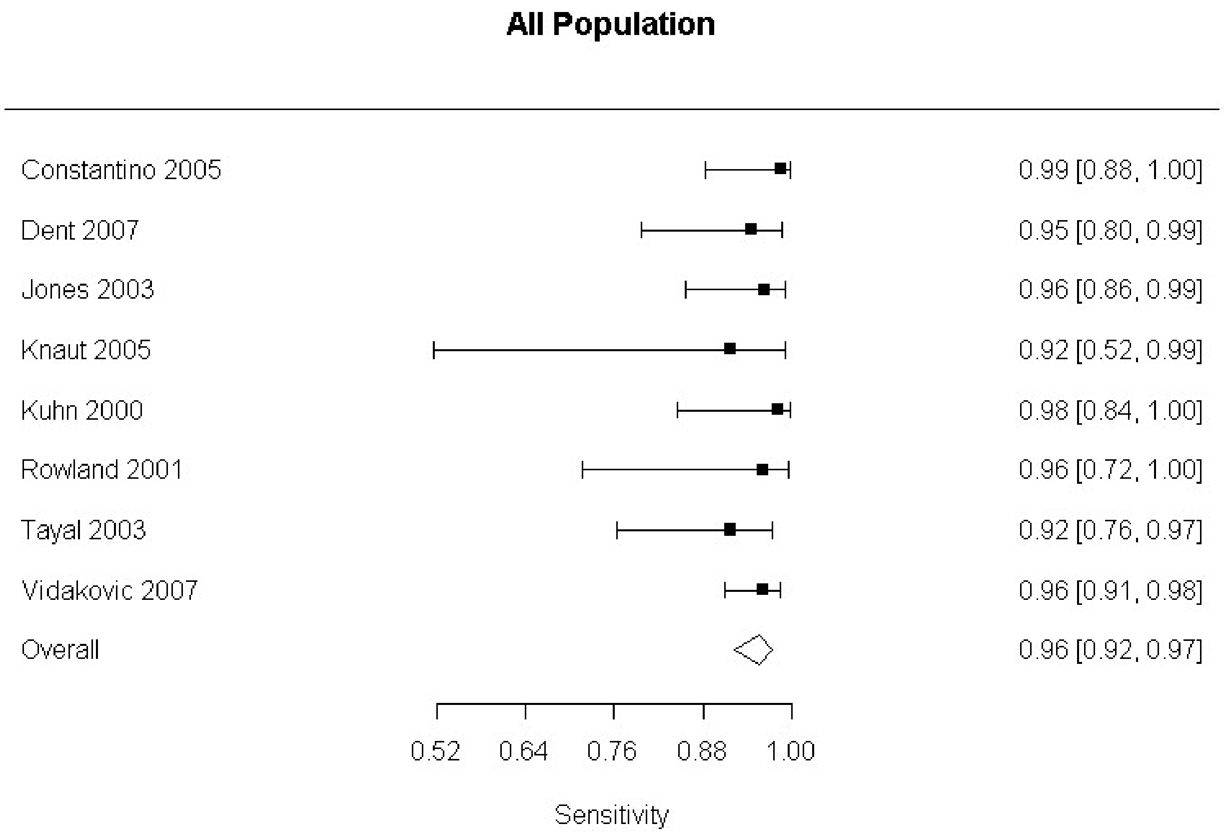
No relevant studies were identified.

Appendix E – Forest plots

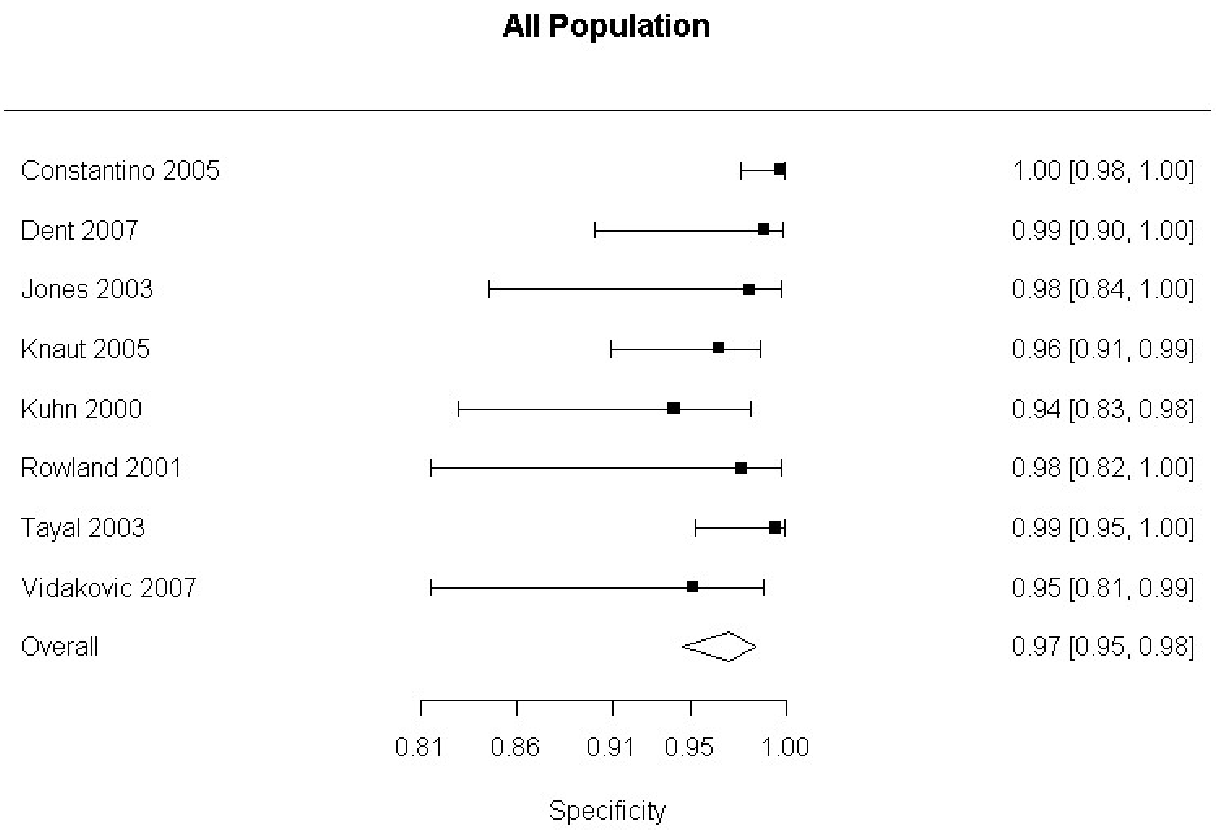
Diagnostic accuracy of ultrasound for identifying unruptured AAA in people with or without symptoms

Note: Multiple reference standards were used; including CT, MR imaging, aortography, emergency department ultrasound reviewed by a radiologist, an official ultrasound performed by a radiologist, exploratory laparotomy, and autopsy results.

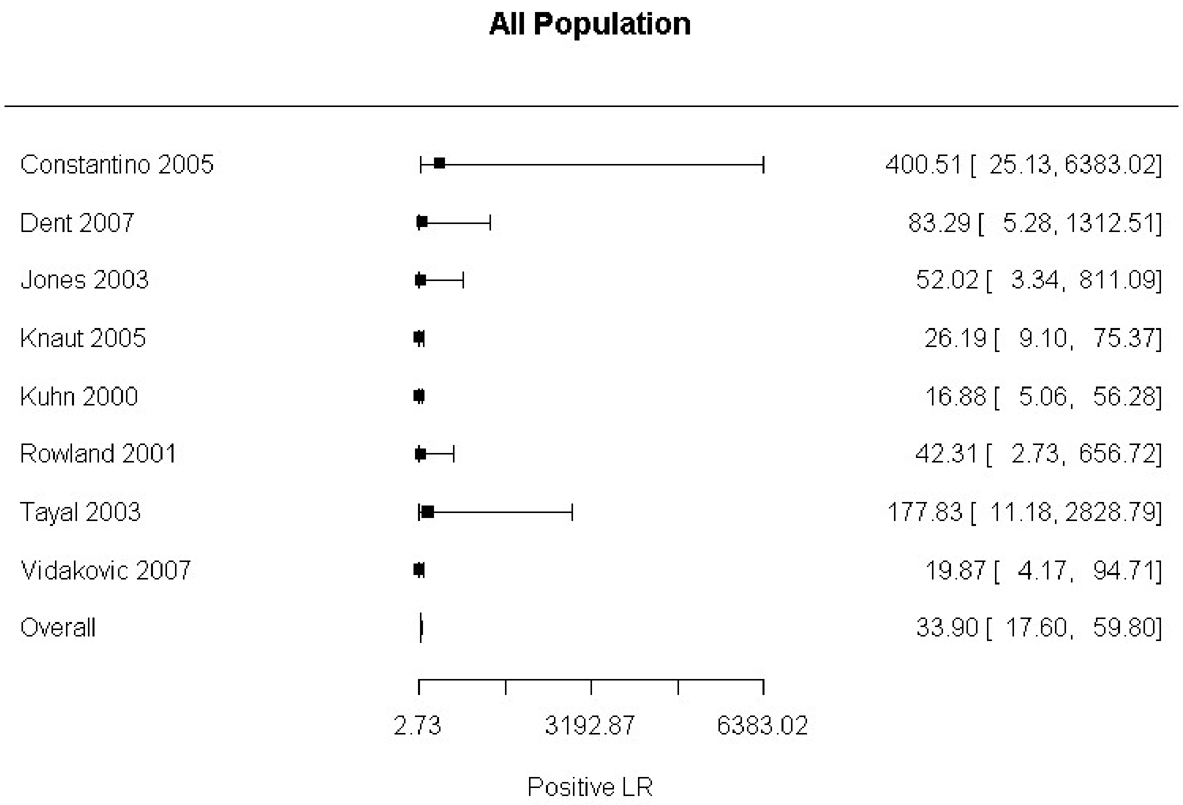
Sensitivity



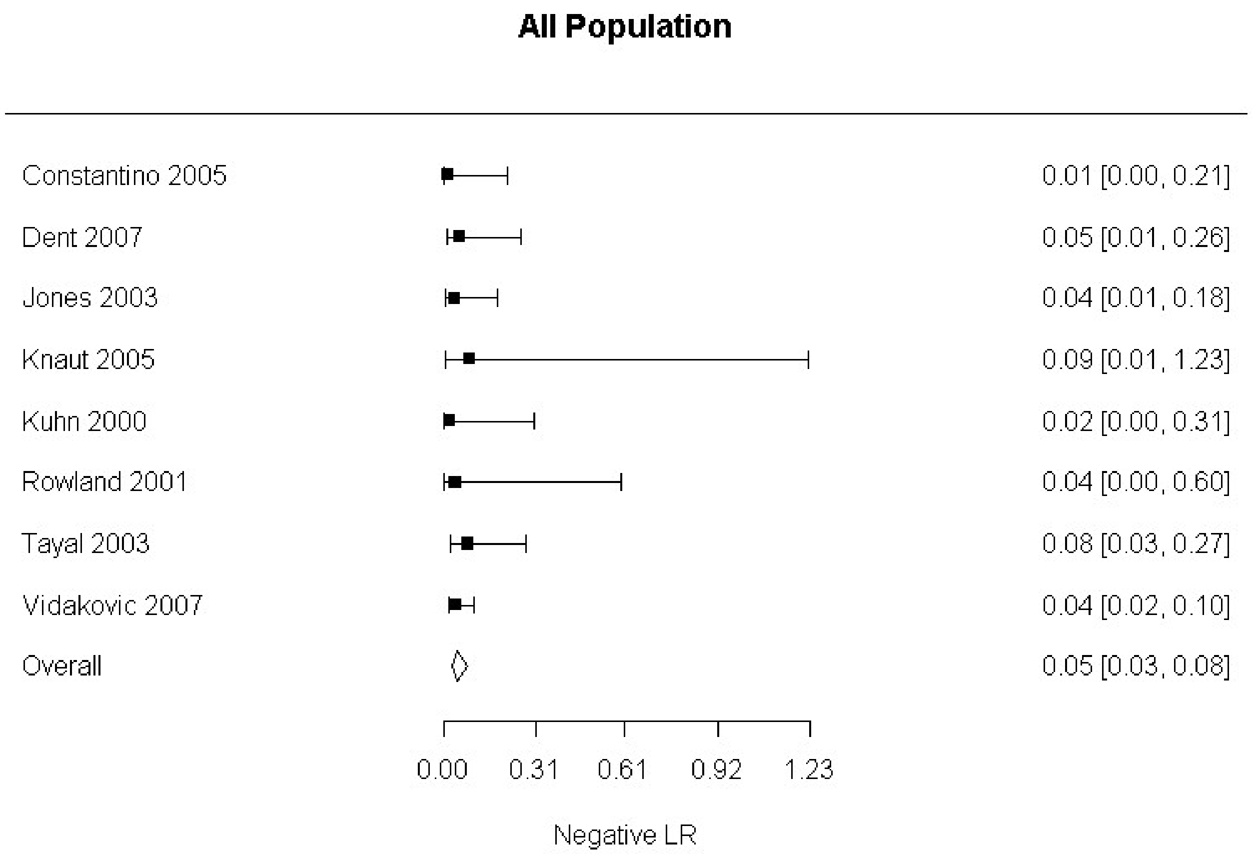
Specificity



Positive likelihood ratio



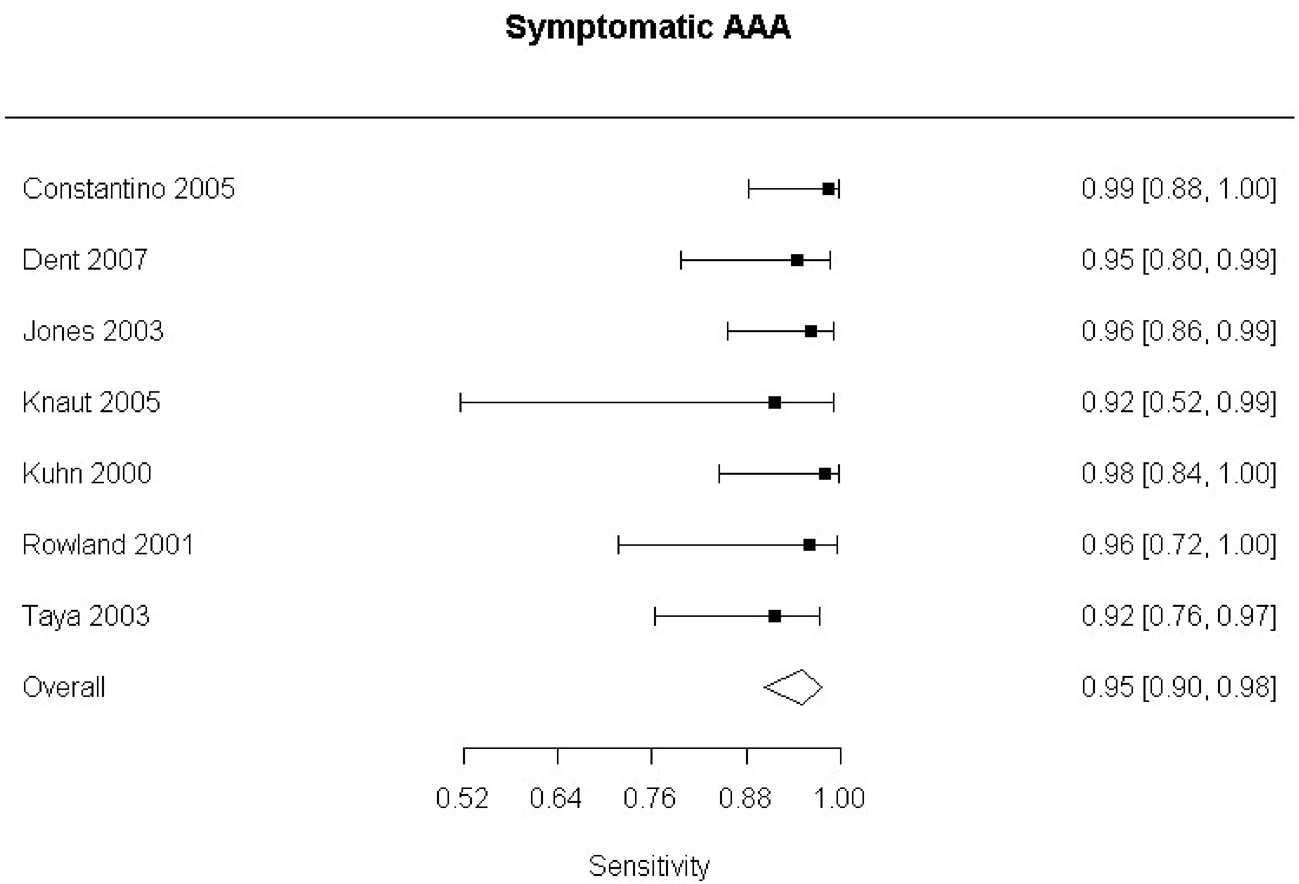
Negative likelihood ratio



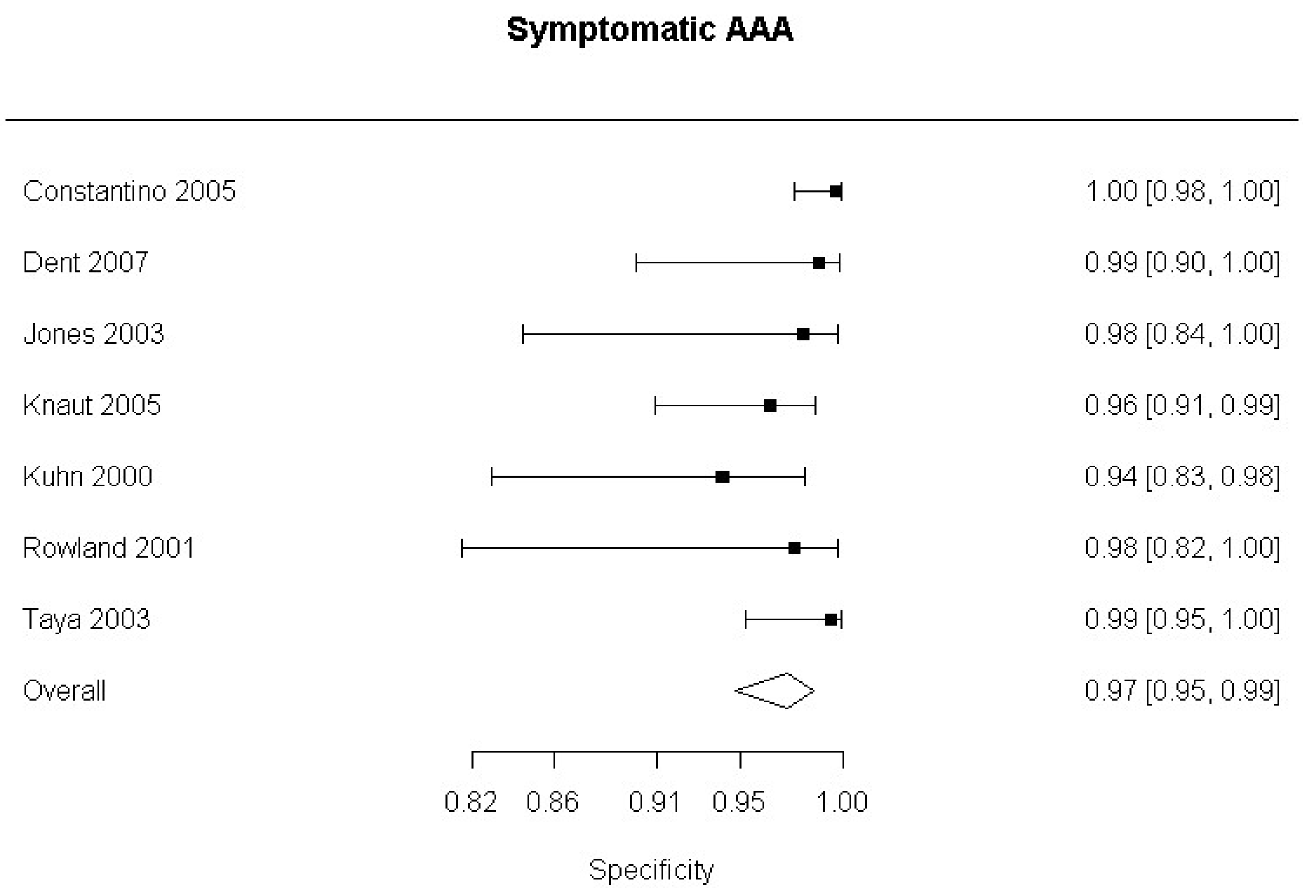
Diagnostic accuracy of ultrasound for identifying unruptured AAA in people with symptoms

Note: Multiple reference standards were used; including CT, MR imaging, aortography, emergency department ultrasound reviewed by a radiologist, an official ultrasound performed by a radiologist, exploratory laparotomy, and autopsy results.

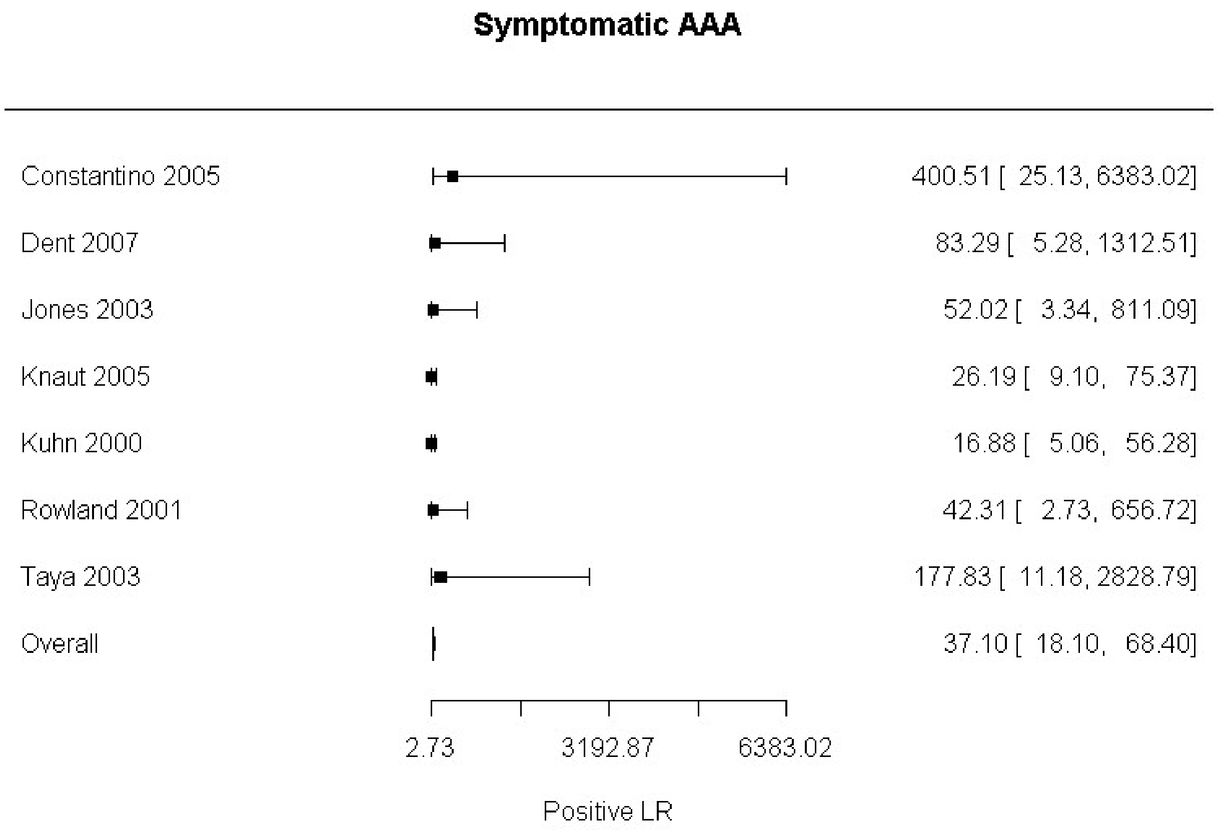
Sensitivity



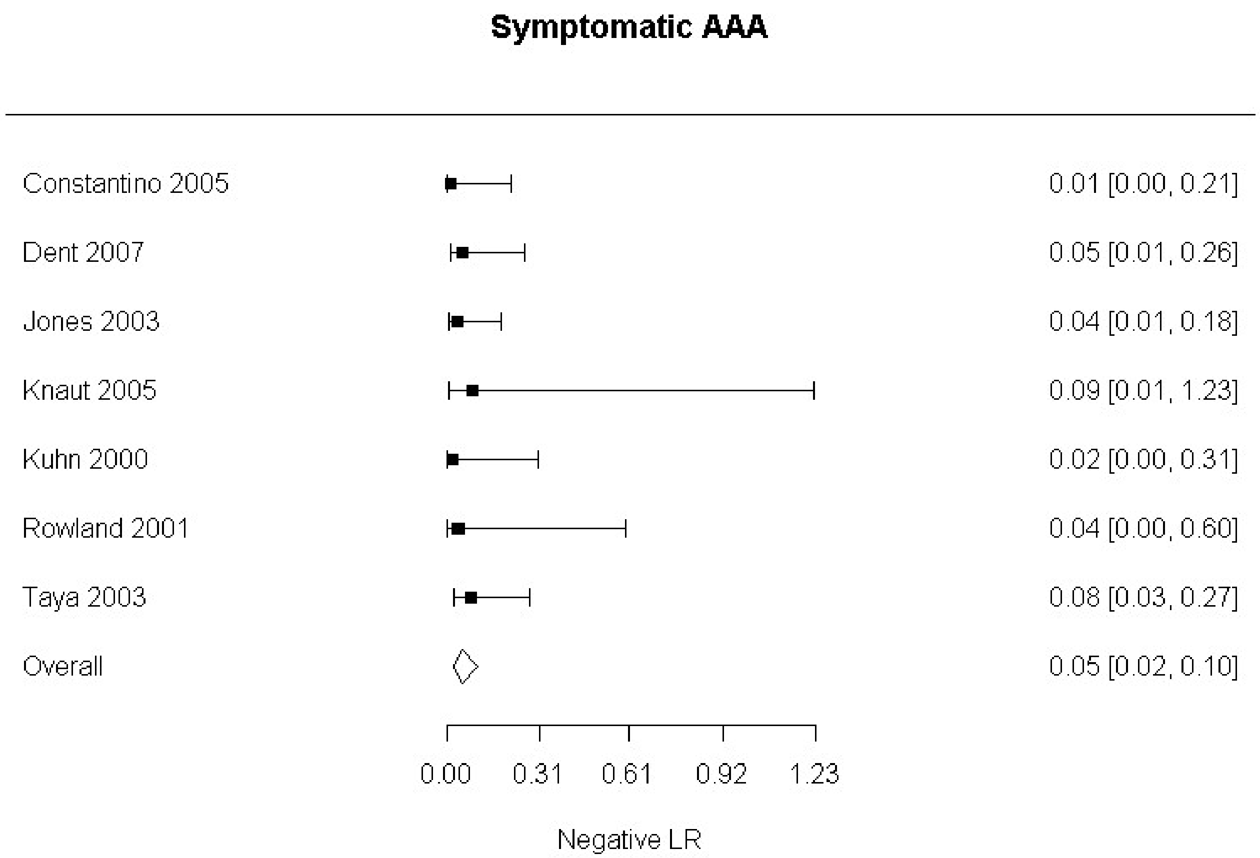
Specificity



Positive likelihood ratio



Negative likelihood ratio



Appendix F – GRADE tables

Ultrasound for diagnosing and measuring diameters of unruptured AAAs

Diagnostic accuracy

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Inconsistency	Indirectness	Imprecision	Quality
Diagnostic test accuracy in full population (symptomatic or asymptomatic)										
8[1]	Cross Sectional	850	96% (92%, 97%)	97% (95%, 98%)	LR+ 33.9 (17.6, 59.8)	Serious[2]	Not serious	Serious[3]	Not serious	Low
					LR- 0.05 (0.03, 0.08)	Serious[2]	Not serious	Serious[3]	Not serious	Low
Diagnostic test accuracy in full population (symptomatic or asymptomatic) sensitivity analysis: CT reference standard only										
2[4]	Cross sectional	250	96% (91%, 98%)	97% (92%, 99%)	LR+ 26.81 (10.61, 67.73)	Serious[5]	Not serious	Not serious	Not serious	Moderate
					LR- 0.04 (0.02, 0.10)	Serious[5]	Not serious	Not serious	Not serious	Moderate
Diagnostic test accuracy in people who present with symptoms										
7[6]	Cross Sectional	704	95% (90%, 98%)	97% (95%, 99%)	LR+ 37.1 (18.1, 68.4)	Serious[2]	Not serious	Serious[3]	Not serious	Low
					LR- 0.05 (0.02, 0.10)	Serious[2]	Not serious	Serious[3]	Not serious	Low
Diagnostic test accuracy in people who present with symptoms sensitivity analysis: CT reference standard only										
1[7]	Cross Sectional	104	92% (38%, 100%)	97% (91%, 99%)	LR+ 26.19 (9.1, 75.37)	Not serious	N/A	Not serious	Not serious	High
					LR- 0.09 (0.01, 1.23)	Not serious	N/A	Not serious	Serious[8]	Moderate

1. Constantino (2005), Dent (2007), Jones (2003), Knaut (2005), Kuhn (2000), Rowland (2001), Tayal (2003), Vidakovic (2007)
2. Unclear if reference standard results were interpreted blind to the results of the index test, downgrade 1 level.
3. CT was not used as the reference standard in all patients (i.e. other reference standards were used across included studies), downgrade 1 level.
4. Knaut (2005) & Vidakovic (2007)

No. of studies	Study design	Sample size	Sensitivity (95%CI)	Specificity (95%CI)	Effect size (95%CI)	Risk of bias	Inconsistency	Indirectness	Imprecision	Quality

5. Unclear if there is an appropriate interval between ultrasound and CT scans, downgrade 1 level.
6. Constantino (2005), Dent (2007), Jones (2003), Knaut (2005), Kuhn (2000), Rowland (2001), Tayal (2003)
7. Knaut (2005)
8. Downgrade 1 level as 95% confidence interval of likelihood ratio crosses one end of a defined MID interval (0.5, 2)

Inter-technique variation in aneurysm diameter

Evaluations	Quality assessment					Pairs of images examined	Effect estimate: Limit of agreement (LOA)	Quality
	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			
Inter-technique variation in aneurysm diameter								
10[1]	Cross-sectional	Very serious[2,3]	Serious[4]	Not serious	Very serious[5]	1060	Range of MDs -0.95 to 0.09 cm[5] 95% LOA: Range of lower limits -1.32 to -0.26 cm Range of upper limits 0.32 to 1.0 cm	Very low

1. 3 evaluations from Chiu (2014); 1 from Gray (2014); 1 from Manning (2009); 2 from Sprouse (2004); 1 from Sprouse (2003); 1 from Vidakovic (2007); 1 from Wanhainen (2002)
2. Unclear whether consecutive or random samples of patients were assessed, downgrade 1 level.
3. Unclear whether studies avoided inappropriate exclusions, downgrade 1 level.
4. Studies used different ultrasound and CT measurement plans and/or parameters (where to where), downgrade 1 level
5. Data not reported in a manner to allow meta-analysis, therefore precluding formal assessment of imprecision; very wide and varied 95% LOA, with upper and lower limits falling outside the range specified as acceptable by the NHS AAA Screening Programme (-0.5 to 0.5 cm), downgrade 2 levels.

Inter-technique variation in aneurysm diameter accounting for 'from where to where' the measurements were taken

Evaluations	Quality assessment					Pairs of images examined	Effect estimate: Limit of agreement (LOA)	Quality
	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			
Inter-technique variation in aneurysm diameter – subgroup: measurement from inner to inner edge								
1[1]	Cross-sectional	Very serious[2, 3]	N/A	Not serious	Serious[4]	50	MD -0.5 cm 95% LOA -1.32 to 0.32 cm	Very low
Inter-technique variation in aneurysm diameter – subgroup: measurement from leading to leading edge								
1[1]	Cross-sectional	Very serious[2,3]	N/A	Not serious	Serious[4]	50	MD -0.32 cm 95% LOA -1.11 to 0.47 cm	Very low
Inter-technique variation in aneurysm diameter – subgroup: measurement from outer to outer edge								
5[5]	Cross-sectional	Serious[6]	Serious[7]	Not serious	Very serious[8]	365	Range of MDs -0.42 to -0.04 cm[8] 95% LOA: Range of lower limits -0.93 to -0.26 cm Range of upper limits 0.45 to 1.0 cm	Very low

1. Chiu (2014)
2. Unclear whether consecutive or random samples of patients were assessed, downgrade 1 level.
3. Unclear whether studies avoided inappropriate exclusions, downgrade 1 level.
4. Very wide 95% LOA with lower limit falling well below that specified as acceptable by the NHS AAA Screening Programme (-0.5 cm), downgrade 1 level.
5. 1 evaluation from Chiu (2014); 1 evaluation from Gray (2014); 1 evaluation from Manning (2009); 2 evaluations from Sprouse (2004)
6. Unclear if reference standard results were interpreted blind to the results of the index test, downgrade 1 level.
7. Studies used different ultrasound and CT measurement plans and/or parameters ('where to where'), downgrade 1 level
8. Data not reported in a manner to allow meta-analysis, therefore precluding formal assessment of imprecision; very wide and varied 95% LOA, with upper and lower limits falling outside the range specified as acceptable by the NHS AAA Screening Programme (-0.5 to 0.5 cm), downgrade 2 levels.

Inter-technique variation in aneurysm diameter accounting for size of the aneurysm

Evaluations	Quality assessment					Pairs of images examined	Effect estimate: Limit of agreement (LOA)	Quality
	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			
Inter-technique variation in aneurysm diameter – subgroup: by size								
1[1]	Cross-sectional	Serious[2]	N/A	Not serious	Not serious	<5.0 cm n=29	MD 0.0 cm; p value = 0.4 95% LOA -0.46 to 0.47 cm	Moderate
					Serious[3]	>5.0 and <6.5 cm n=88	MD 0.5 cm; p value = 0.2 95% LOA -0.59 to 0.68 cm	Low
					Serious[4]	>6.5 cm n=13	MD -0.1 cm; p value = 0.1 95% LOA -0.55 to 0.35 cm	Low
1[5]	Cross-sectional	Very serious[6,7]	N/A	Not serious	Very serious[8]	<5.0cm n=75	MD 0.71 cm	Very low
					Very serious[8]	>5.0 and <6.5 cm n=207	MD 0.91 cm	Very low
					Very serious[8]	>6.5 cm n=52	MD 1.46 cm	Very low
1[9]	Cross-sectional	Serious[10]	N/A	Not serious	Serious[11]	<3.0 cm n=116	MD 0.05 cm; p value >0.05 95% LOA -0.49 to 0.59 cm	Low
					Serious[11]	3.0 to 5.0 cm n=32	MD 0.05 cm; p value >0.05 95% LOA -0.69 to 0.79 cm	Low
					Serious[11]	>5.0 cm n=84	MD 0.20 cm; p value <0.0001 95% LOA −0.68 to 1.08 cm	Low
1[12]	Cross-sectional	Serious[7]	N/A	Not serious	Serious[11]	<3.0 cm n=28	MD 0.28; 95% CI 0.17 to 0.40 cm 95% LOA -0.29 to 0.85 cm	Low
					Very serious[3]	>3.0 cm n=33	MD -0.07; 95% CI -0.21 to 0.07 cm 95% LOA -0.87 to 0.73 cm	Very low
1[13]	Cross-sectional	Serious[7]	N/A	Not serious	Serious[4]	>3.0 and <5.5 cm in men; <5.2 cm in women n=54	MD -0.26 cm 95% LOA -0.59 to 0.08 cm	Low

Evaluations	Quality assessment					Pairs of images examined	Effect estimate: Limit of agreement (LOA)	Quality
	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			

1 Gray (2014)
2 Unclear if reference standard results were interpreted blind to the results of the index test, downgrade 1 level.
3 Wide 95% LOA with upper and lower limits falling outside the range specified as acceptable by the NHS AAA Screening Programme (-0.5 to 0.5 cm), downgrade 2 levels.
4 Wide 95% LOA with a lower limit falling below that specified as acceptable by the NHS AAA Screening Programme (-0.5 cm), downgrade 1 level.
5 Sprouse (2003)
6 Unclear if a consecutive or random sample of patients was enrolled, downgrade 1 level.
7 Unclear whether inappropriate exclusions were avoided, downgrade 1 level.
8 Authors do not provide sufficient information on which to judge the precision of the effect estimate, downgrade 2 levels
9 Vidakovic (2007)
10 Unclear if there is an appropriate interval between US and CT measurements, downgrade 1 level.
11 Wide 95% LOA with an upper limit falling above that specified as acceptable by the NAAASP (0.5 cm)
12 Wanhainen (2002)
13 Bredahl (2015)

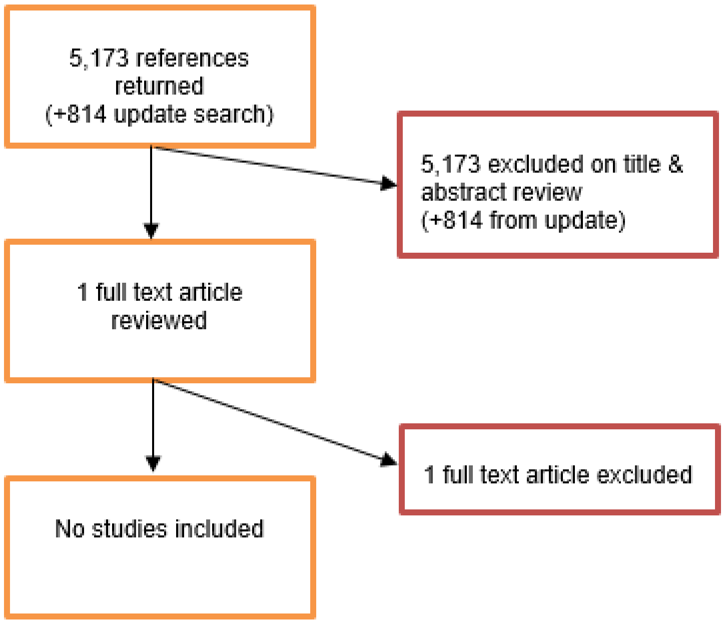
Magnetic resonance angiography for measuring diameters of unruptured AAAs

Inter-technique variation in aneurysm diameter

Evaluations	Quality assessment					Pairs of images examined	Effect estimate	Quality
	Design	Risk of bias	Inconsistency	Indirectness	Imprecision			
Inter-technique variation in aneurysm diameter								
1[1]	cross-sectional	Not serious	Not serious	Not serious	Very serious[2]	30	MD 0.18 cm; 95%CI 0.13 to 0.23 cm	Low

1 Wolf (2011)
2 Limits of agreement not reported, downgrade 2 levels.

Appendix G – Economic evidence study selection



Appendix H – Excluded studies

Clinical studies

Short Title	Title	Reason for exclusion
Abbas (2012)	Assessment of the accuracy of AortaScan for detection of abdominal aortic aneurysm (AAA)	Not a relevant study design
Adam (1998)	The value of computed tomography in the assessment of suspected ruptured abdominal aortic aneurysm	Published before 2000 or systematic review containing only papers published before 2000
Aggarwal (2015)	Clinical impact of USPSTF screening recommendations for abdominal aortic aneurysm: Analysis of Nationwide Inpatient Sample data	Not a relevant intervention and/or comparator
Alamoudi (2015)	Diagnostic efficacy value in terms of sensitivity and specificity of imaging modalities in detecting the abdominal aortic aneurysm: A systematic review	Not a relevant intervention and/or comparator (reference standard not CT; uses digital subtraction angiography)
Al-Zahrani (1995)	Screening for abdominal aortic aneurysm (AAA): Is it worth it?	Not a relevant intervention and/or comparator
Andersen (1983)	Comparison of computed tomography and aortography in abdominal aortic aneurysms	No relevant outcomes reported (does not allow the calculation of both sensitivity and specificity)
Andreozzi (2007)	Appropriateness of diagnostic and therapeutic pathways in patients with vascular disease	Not a relevant study design
Anonymous (1991)	Periodic health examination, 1991 update: 5. Screening for abdominal aortic aneurysm. Canadian Task Force on the Periodic Health Examination	Not a relevant intervention and/or comparator
Anonymous (1992)	Screening for abdominal aortic aneurysms: A review	Not a relevant intervention and/or comparator
Anonymous (2001)	Use of ultrasound imaging by emergency physicians	Not a peer-reviewed publication
Anonymous (2002)	Cost-effective screening test for abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Arlart (1992)	Magnetic resonance angiography of the abdominal aorta	Not a relevant intervention and/or comparator. Not a relevant study design
Armon (1998)	Spiral CT angiography versus aortography in the assessment of aortoiliac length in patients undergoing endovascular abdominal aortic aneurysm repair	Not a relevant intervention and/or comparator. Published before 2000 or systematic review containing only papers published before 2000
Arnell (1996)	Abdominal aortic aneurysm screening in elderly males with atherosclerosis: the value of physical exam	Not a relevant intervention and/or comparator
Atar (2006)	MR angiography for abdominal and thoracic aortic aneurysms: assessment before endovascular repair in patients with impaired renal function	Not the correct population/condition of interest
Axelrod (2002)	Cost of routine screening for carotid and lower extremity occlusive disease	Not a relevant intervention and/or comparator

	in patients with abdominal aortic aneurysms	
Aziz (2003)	Accuracy of three-dimensional simulation in the sizing of aortic endoluminal devices	Not a relevant intervention and/or comparator
Bailey (2001)	Ultrasonography performed by primary care residents for abdominal aortic aneurysm screening: An innovative teaching model	Not a relevant intervention and/or comparator
Bando (2015)	Ultrasound of silence abdominal aortic aneurysm: A milestone evidence in Japanese hypertensive elderly has come out	Not a relevant intervention and/or comparator
Barkin (2004)	Ultrasound detection of abdominal aortic aneurysm	Not a relevant study design
Bashir (2012)	Improved aortic enhancement in CT angiography using slope-based triggering with table speed optimization: a pilot study	Not a relevant intervention and/or comparator
Batagni (2016)	Volumetry and biomechanical parameters detected by 3D and 2D ultrasound in patients with and without an abdominal aortic aneurysm.	No relevant outcomes reported (does not allow the calculation of both sensitivity and specificity)
Baud (1997)	[Criteria for quantification and characterization of aneurysms of the abdominal aorta using ultrasonography. The AFFCA study. French Association of Continuous Education in Angiology]	Not in English
Bayle (1997)	Morphologic assessment of abdominal aortic aneurysms by spiral computed tomographic scanning	Not a relevant intervention and/or comparator
Beachley (1976)	Radiographic findings in aneurysms of the aorta	Not a relevant study design
Beales (2011)	Reproducibility of ultrasound measurement of the abdominal aorta	Not a relevant intervention and/or comparator
Beard (2003)	Screening for abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Beebe (1999)	Screening and preoperative imaging of candidates for conventional repair of abdominal aortic aneurysm	Not a relevant study design
Beeres (2016)	Evaluation of different keV-settings in dual-energy CT angiography of the aorta using advanced image-based virtual monoenergetic imaging	Not a relevant intervention and/or comparator
Bentz (2006)	Towards evidence-based emergency medicine: best BETs from the Manchester Royal Infirmary. Accuracy of emergency department ultrasound scanning in detecting abdominal aortic aneurysm	Not a peer-reviewed publication
Benzaquen (2001)	Screening for abdominal aortic aneurysms during cardiac catheterization	Not a relevant intervention and/or comparator
Bergqvist (1990)	Should screening for abdominal aortic aneurysms be advocated?	Not a relevant intervention and/or comparator

Bergqvist (1992)	Is screening for abdominal aortic aneurysms worthwhile?	Not a relevant intervention and/or comparator
Bergqvist (2013)	Abdominal aortic aneurysm and new WHO criteria for screening	Not a relevant intervention and/or comparator
Bertero (2010)	Screening for abdominal aortic aneurysm, a one-year follow up: an interview study	Not a relevant intervention and/or comparator
Bhalla (2003)	CT of acute abdominal aortic disorders	Not a relevant study design
Bhatt (2007)	Sonographic Evaluation of the Abdominal Aorta	Not a relevant study design
Bhatt (2008)	Catastrophes of Abdominal Aorta: Sonographic Evaluation	Not a relevant study design
Bierig (2009)	Accuracy and cost comparison of ultrasound versus alternative imaging modalities, including CT, MR, PET, and angiography	Not a relevant study design
Billittier (1996)	Radiographic imaging modalities for the patient in the emergency department with abdominal complaints	Not a relevant study design
Bird (2015)	Screening for abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Birjawi (2009)	Emergency abdominal radiology: The acute abdomen	Not a relevant study design
Bjorck (2015)	International update on screening for abdominal aortic aneurysms: Issues and opportunities	Not a relevant intervention and/or comparator
Blaivas (2004)	Frequency of Incomplete Abdominal Aorta Visualization by Emergency Department Bedside Ultrasound	Not a relevant intervention and/or comparator. Not a relevant study design
Bleiweis (1992)	Ultrafast CT and the cardiovascular system	Not a relevant study design
Blois (2012)	Office-based ultrasound screening for abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Bobadilla (2012)	Screening for abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Boll (2003)	Mass screening on abdominal aortic aneurysm in men aged 60 to 65 years in the Netherlands. Impact on life expectancy and cost-effectiveness using a Markov model	Not a relevant intervention and/or comparator
Bolognesi (1996)	Clinical, electrocardiographic, and echocardiographic features in patients with asymptomatic aortic abdominal aneurysm	Not a relevant intervention and/or comparator
Bonnier (2008)	Detection of pathological aortic tissues by infrared multispectral imaging and chemometrics	Not a relevant intervention and/or comparator
Boxt (1985)	Comparison of intravenous digital subtraction angiography to conventional aortography in patients with abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Brambilla (2013)	Cumulative radiation dose from medical imaging in chronic adult patients	Not a relevant study design

Braun (1985)	Measuring abdominal aortic aneurysms on digital subtraction arteriograms	Not a relevant intervention and/or comparator
Bregenzer (2001)	Different sensitivity exhibited by CT and sonography	Not in English
Brewster (1977)	Assessment of abdominal aortic aneurysm size	Not a relevant study design
Bruschi (2015)	A comparison study of radiation exposure to patients during EVAR and Dyna CT in an angiosuite vs. an operating theatre	Not a relevant intervention and/or comparator
Burden (2014)	ACP Journal Club. Review: ultrasonography screening reduces long-term abdominal aortic aneurysm-related mortality	Not a relevant intervention and/or comparator
Bush (2002)	Endovascular aortic aneurysm repair in patients with renal dysfunction or severe contrast allergy: utility of imaging modalities without iodinated contrast	Not a relevant intervention and/or comparator
Buxton (2012)	Molecular imaging of aortic aneurysms	Not a relevant study design
Carriero (1997)	Magnetic resonance angiography and colour-Doppler sonography in the evaluation of abdominal aortic aneurysms	Not a relevant intervention and/or comparator. Published before 2000 or systematic review containing only papers published before 2000
Carstea (2008)	The accuracy of combined physical examination and ultrasonography for the detection of abdominal aorta aneurysm	Not a relevant study design
Catalano (2005)	Ruptured abdominal aortic aneurysm: Categorization of sonographic findings and report of 3 new signs	Not a relevant intervention and/or comparator. Not a relevant study design
Catalano (2005)	Contrast-enhanced sonography for diagnosis of ruptured abdominal aortic aneurysm	Not a relevant intervention and/or comparator. Not a relevant study design
Cho (2014)	Aortic aneurysm screening in a high-risk population: A non-contrast computed tomography study in Korean males with hypertension	Not the correct population/condition of interest
Chun (2013)	Outcomes of an abdominal aortic aneurysm screening program	Not a relevant intervention and/or comparator
Cina (2005)	Review: population-based screening for abdominal aortic aneurysm reduces cause-specific mortality in older men	Not a relevant intervention and/or comparator
Clevert (2007)	Imaging of aortic abnormalities with contrast-enhanced ultrasound. A pictorial comparison with CT	Not a relevant study design
Clevert (2009)	Role of contrast enhanced ultrasound in detection of abdominal aortic abnormalities in comparison with multislice computed tomography	Not a relevant study design
Cloutier (1996)	Predicting survival from ruptured abdominal aortic aneurysm. Computer modeling with AIM versus clinical judgment	Not a relevant intervention and/or comparator

Cole (1997)	Prospects for screening for abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Collin (1996)	The Oxford Screening Program for aortic aneurysm and screening first-order male siblings of probands with abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Collin (1996)	Influence of screening on the incidence of ruptured abdominal aortic aneurysm: 5-year results of a randomized controlled study	Not a relevant intervention and/or comparator. Not a relevant study design
Collins (2006)	Screening of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Connelly (2002)	The detection and management of abdominal aortic aneurysm: A cost-effectiveness analysis	Not a relevant study design
Connelly (2002)	The detection and management of abdominal aortic aneurysm: a cost-effectiveness analysis	Not a relevant study design
Cosford (2007)	Screening for abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Costantino (2005)	Accuracy of emergency medicine ultrasound in the evaluation of abdominal aortic aneurysm	Duplicate and/or already included within an included systematic review
Cote (2010)	Population ultrasound screening for abdominal aortic aneurysms (Structured abstract)	Not a relevant intervention and/or comparator
Cullenward (1986)	Inflammatory aortic aneurysm (periaortic fibrosis): radiologic imaging	Not a relevant study design
Dabare (2012)	What is the role of screening in the management of abdominal aortic aneurysms?	Not a relevant intervention and/or comparator
Daly (2004)	Screening, diagnosis and advances in aortic aneurysm surgery	Not a relevant study design
das (2005)	Comparison of ultrasonography, computed tomography, and magnetic resonance imaging with intraoperative measurements in the evaluation of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Davies (1991)	Ultrasonography in the acute abdomen	Not the correct population/condition of interest. Not a relevant intervention and/or comparator. Not a relevant study design
Davis (2011)	Computed tomography for the diagnosis and management of abdominal aortic aneurysms	Not a relevant study design
de Gracia (2006)	Correlation between the measurement of transverse diameter in the proximal neck on computed tomography and on aortography before endovascular treatment of infrarenal aortic aneurysm	Not a relevant intervention and/or comparator. Not a relevant study design
de la Motte (2013)	Categorization of aortic aneurysm thrombus morphology by magnetic resonance imaging	Not a relevant intervention and/or comparator
De Rango (2014)	Commentary: Current gaps in diagnosis and management of ruptured abdominal aortic aneurysms: Best	Not a relevant study design

	fusion imaging technology may not replace confusion in physician decision-making	
Diehm (2004)	Multidetector CT angiography versus digital subtraction angiography for aortoiliac length measurements prior to endovascular AAA repair	Not a relevant intervention and/or comparator
Dillavou (2003)	Two-dimensional versus three-dimensional CT scan for aortic measurement	Not a relevant intervention and/or comparator
Dindyal (2015)	Review of the Use of Ionizing Radiation in Endovascular Aneurysm Repair	Not a relevant study design
Dixon (1981)	Computed tomography (CT) of abdominal aortic aneurysms: determination of longitudinal extent	Not a relevant intervention and/or comparator
Doyle (2007)	A comparison of modelling techniques for computing wall stress in abdominal aortic aneurysms	Not a relevant intervention and/or comparator. Not a relevant study design
Dugas (2012)	Reproducibility of abdominal aortic aneurysm diameter measurement and growth evaluation on axial and multiplanar computed tomography reformations	Not a relevant intervention and/or comparator
Engelberger (2017)	Ultrasound screening for abdominal aortic aneurysms.	Descriptive study: no relevant outcomes were reported (does not allow the calculation of both sensitivity and specificity).
Eriksson (1980)	Diagnosis of abdominal aortic aneurysms by aortography, computer tomography and ultrasound	Not a relevant intervention and/or comparator
Federle (2007)	CT criteria for differentiating abdominal hemorrhage: anticoagulation or aortic aneurysm rupture?	Not a relevant intervention and/or comparator
Fitzsimons (1985)	The use of ultrasound in the confirmation and evaluation of abdominal aortic aneurysms	Not a relevant intervention and/or comparator. Published before 2000 or systematic review containing only papers published before 2000
Fleming (2006)	Screening and management of abdominal aortic aneurysm: the best evidence	Not a relevant study design
Fox (1996)	Comparison of magnetic resonance imaging measurements of abdominal aortic aneurysms with measurements obtained by other imaging techniques and intraoperative measurements: possible implications for endovascular grafting	Not a relevant intervention and/or comparator
Gale (1986)	Problems in CT diagnosis of ruptured abdominal aortic aneurysms	Not a relevant study design
Geijer (2005)	Radiation exposure in stent-grafting of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Genovese (2013)	Abdominal vascular emergencies: US and CT assessment	Not a relevant study design
Ghatwary (2013)	A systematic review of protocols for the three-dimensional morphologic assessment of abdominal aortic	Not a relevant intervention and/or comparator

	aneurysms using computed tomographic angiography	
Gomes (1977)	ACTA scanning in the diagnosis of abdominal aortic aneurysms	Not a relevant study design
Gomes (1978)	Ultrasonography and CT scanning: a comparative study of abdominal aortic aneurysms	Not a relevant intervention and/or comparator (surgical diagnosis used a reference; not reported in a way that allowed comparison of US with CT directly)
Gomes (1979)	Abdominal aortic aneurysms: diagnostic review and new technique	Not a relevant intervention and/or comparator
Gore (2000)	Helical CT in the evaluation of the acute abdomen	Not a relevant intervention and/or comparator
Gouliamos (2004)	Screening for abdominal aortic aneurysms during routine lumbar CT scan: modification of the standard technique	Not a relevant study design
Gurtelschmid (2014)	Comparison of three ultrasound methods of measuring the diameter of the abdominal aorta	Not a relevant intervention and/or comparator
Hans (1995)	Routine use of limited abdominal aortography with digital subtraction carotid and cerebral angiography	Not the correct population/condition of interest
Hansen (2016)	Computed Tomographic Angiography of the Abdominal Aorta	Not a relevant study design
Hany (1997)	Evaluation of the aortoiliac and renal arteries: comparison of breath-hold, contrast-enhanced, three-dimensional MR angiography with conventional catheter angiography	Not a relevant intervention and/or comparator
Hardy (1981)	Measurement of the abdominal aortic aneurysm. Plain radiographic and ultrasonographic correlation	Not a relevant intervention and/or comparator
Hasani (2015)	Accuracy of bedside emergency physician performed ultrasound in diagnosing different causes of acute abdominal pain: a prospective study	Not a relevant intervention and/or comparator
Heegaard (2010)	Prehospital ultrasound by paramedics: results of field trial	Not a relevant intervention and/or comparator
Hoornweg (2008)	Interobserver and intraobserver variability of interpretation of CT-angiography in patients with a suspected abdominal aortic aneurysm rupture	Not a relevant intervention and/or comparator. Not a relevant study design
Iezzi (2011)	Proximal aneurysmal neck: Dynamic ECG-gated CT angiography - Conformational pulsatile changes with possible consequences for endograft sizing	Not a relevant intervention and/or comparator
Iezzi (2011)	CT angiography in stent-graft sizing: Impact of using inner vs. outer wall measurements of aortic neck diameters	Not a relevant intervention and/or comparator
IqwiG (2015)	Ultrasound screening for abdominal aortic aneurysms (Structured abstract)	Not a relevant intervention and/or comparator
Jaakkola (1996)	Interobserver variability in measuring the dimensions of the abdominal aorta:	Not a relevant study design (case-control)

	Comparison of ultrasound and computed tomography	
Johansson (2016)	Harms of screening for abdominal aortic aneurysm: Is there more to life than a 0.46% disease-specific mortality reduction?	Not a relevant intervention and/or comparator
Kandarpa (1992)	Prospective double-blinded comparison of MR imaging and aortography in the preoperative evaluation of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Kato (2015)	A propensity score-matching analysis of transthoracic echocardiography and abdominal ultrasonography for the detection of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Kaufman (1994)	MR imaging (including MR angiography) of abdominal aortic aneurysms: comparison with conventional angiography	Not a relevant intervention and/or comparator
Kaufman (1994)	MR angiography in the preoperative evaluation of abdominal aortic aneurysms: a preliminary study	Not a relevant intervention and/or comparator
Knaut (2005)	Ultrasonographic measurement of aortic diameter by emergency physicians approximates results obtained by computed tomography	Duplicate and/or already included within an included systematic review
Koslin (1988)	Preoperative evaluation of abdominal aortic aneurysm by MR imaging with aortography correlation	Not a relevant intervention and/or comparator
Kotze (2009)	Increased Metabolic Activity in Abdominal Aortic Aneurysm Detected by 18F-Fluorodeoxyglucose (18F-FDG) Positron Emission Tomography/Computed Tomography (PET/CT)	Not a relevant intervention and/or comparator
Kotze (2011)	What is the relationship between 18F-FDG aortic aneurysm uptake on PET/CT and future growth rate?	Not a relevant intervention and/or comparator
Kotze (2014)	CT signal heterogeneity of abdominal aortic aneurysm as a possible predictive biomarker for expansion	Not a relevant intervention and/or comparator
Kritpracha (2002)	CT artefacts of the proximal aortic neck: an important problem in endograft planning	Not a relevant intervention and/or comparator
Kuhn (2000)	Emergency department ultrasound scanning for abdominal aortic aneurysm: accessible, accurate, and advantageous	Duplicate and/or already included within an included systematic review
Kvilekval (1990)	The value of computed tomography in the management of symptomatic abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Lamah (1999)	Value of routine computed tomography in the preoperative assessment of abdominal aneurysm replacement	Published before 2000 or systematic review containing only papers published before 2000
Landtman (1984)	Diagnostic value of ultrasound, computed tomography, and	Not the correct population/condition of interest

	angiography in ruptured aortic aneurysms	
Larsson (1984)	Computed tomography versus aortography for preoperative evaluation of abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Lederle (1995)	Variability in measurement of abdominal aortic aneurysms	Published before 2000 or systematic review containing only papers published before 2000
Lee (1975)	A practical approach to the diagnosis of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Leseche (1992)	Diagnosis and management of 17 consecutive patients with inflammatory abdominal aortic aneurysm	Not a relevant study design
Li (2010)	Computed wall stress may predict the growth of abdominal aortic aneurysm	Not a peer-reviewed publication
Limet (1991)	Determination of the expansion rate and incidence of rupture of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Lindholt (1999)	The validity of ultrasonographic scanning as screening method for abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Lisberg (2017)	Abdominal ultrasound-scanning versus non-contrast computed tomography as screening method for abdominal aortic aneurysm - a validation study from the randomized DANCAVAS study.	Not the correct population
Loughran (1986)	A review of the plain abdominal radiograph in acute rupture of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Ludman (2000)	Feasibility of using dynamic contrast-enhanced magnetic resonance angiography as the sole imaging modality prior to endovascular repair of abdominal aortic aneurysms	No relevant outcomes reported (provides data suitable to determine diagnostic test accuracy for suitability for EVAR - not relevant to any of the planned reviews)
Lutz (2003)	Evaluation of aortoiliac aneurysm before endovascular repair: comparison of contrast-enhanced magnetic resonance angiography with multidetector row computed tomographic angiography with an automated analysis software tool	No relevant outcomes reported
Maloney (1977)	Ultrasound evaluation of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Mastracci (2007)	Screening for abdominal aortic aneurysm in Canada: review and position statement of the Canadian Society for Vascular Surgery	Not a relevant intervention and/or comparator
Moll (2011)	Management of abdominal aortic aneurysms clinical practice guidelines of the European society for vascular surgery	Not a relevant study design
Musella (2001)	Magnetic resonance imaging and abdominal wall hernias in aortic surgery	Not a relevant intervention and/or comparator
Nasim (1998)	Role of magnetic resonance angiography for assessment of	Not a relevant intervention and/or comparator

	abdominal aortic aneurysm before endoluminal repair	
Nonent (2007)	Lodixanol in multidetector-row computed tomography angiography (MDCTA): diagnostic accuracy for abdominal aorta and abdominal aortic major-branch diseases using four-, eight- and 16-detector-row CT scanners	Not a relevant intervention and/or comparator
Nordon (2010)	Validation of DynaCT in the morphological assessment of abdominal aortic aneurysm for endovascular repair	Not a relevant intervention and/or comparator
Oates (1993)	Spiral computed tomography angiography vs. conventional angiography. Efficiency & cost factors	Not a relevant intervention and/or comparator. Published before 2000 or systematic review containing only papers published before 2000
Papanicolaou (1986)	Preoperative evaluation of abdominal aortic aneurysms by computed tomography	Not a relevant intervention and/or comparator
Parker (2005)	What imaging studies are necessary for abdominal aortic endograft sizing? A prospective blinded study using conventional computed tomography, aortography, and three-dimensional computed tomography	Not a relevant intervention and/or comparator
Paslawski (2004)	Abdominal aortic aneurysm in ultrasound and CT examination	Not a relevant study design
Passariello (1983)	Angiographic characterization of aortic aneurysms by digital intravenous angiography	Not a relevant intervention and/or comparator
Pavone (1990)	Abdominal aortic aneurysm evaluation: comparison of US, CT, MRI, and angiography	Not a relevant intervention and/or comparator
Pennell (1985)	Inflammatory abdominal aortic aneurysms: a thirty-year review	Not a relevant intervention and/or comparator
Persson (2004)	Volume rendering compared with maximum intensity projection for magnetic resonance angiography measurements of the abdominal aorta	Not a relevant intervention and/or comparator
Petersen (1995)	Magnetic resonance angiography in the preoperative evaluation of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Posacioglu (2002)	Predictive value of conventional computed tomography in determining proximal extent of abdominal aortic aneurysms and possibility of infrarenal clamping	Not a relevant intervention and/or comparator
Rakita (2007)	Spectrum of CT findings in rupture and impending rupture of abdominal aortic aneurysms	Not a relevant study design
Raptopoulos (1996)	Sequential helical CT angiography of aortoiliac disease	Not a relevant intervention and/or comparator
Raskin (1978)	Comparison of computed tomography and ultrasound for abdominal aortic aneurysms: a preliminary study	Not a relevant intervention and/or comparator

Resch (1999)	Abdominal aortic aneurysm morphology in candidates for endovascular repair evaluated with spiral computed tomography and digital subtraction angiography	Not a relevant intervention and/or comparator
Rigatelli (2003)	Thoracic and abdominal aortic aneurysms: Invasive and non-invasive imaging from an endovascular perspective	Not a relevant study design
Roberts (1974)	The diagnosis of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Rudd (2015)	Predicting aortic aneurysm expansion by PET	Not a relevant intervention and/or comparator
Ruff (1988)	Magnetic resonance imaging versus angiography in the preoperative assessment of abdominal aortic aneurysms	Not a relevant study design
Saida (2012)	Prospective intra-individual comparison of unenhanced magnetic resonance imaging vs contrast-enhanced computed tomography for the planning of endovascular abdominal aortic aneurysm repair	No relevant outcomes reported
Salaman (1994)	Intravenous digital subtraction angiography versus computed tomography in the assessment of abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Schuster (2009)	Ultrasound imaging of abdominal aortic aneurysms: Diagnosis of aneurysms and complications and follow-up after endovascular repair	Not a relevant study design
Seeger (1986)	Preoperative CT in symptomatic abdominal aortic aneurysms: accuracy and efficacy	Not a relevant intervention and/or comparator
Sharma (2005)	Aortic aneurysm and dissection: evaluation with spiral CT angiography	Not the correct population/condition of interest
Shin (2000)	Can preoperative spiral CT scans alone determine the feasibility of endovascular AAA repair? A comparison to angiographic measurements	No relevant outcomes reported
Simoni (1996)	Helical CT for the study of abdominal aortic aneurysms in patients undergoing conventional surgical repair	Not a relevant intervention and/or comparator
Singh (2004)	The difference between ultrasound and computed tomography (CT) measurements of aortic diameter increases with aortic diameter: analysis of axial images of abdominal aortic and common iliac artery diameter in normal and aneurysmal aortas. The Tromso Study, 1994-1995	Not a relevant study design
Sivananthan (1993)	Fast magnetic resonance angiography using turbo-FLASH sequences in advanced aortoiliac disease	Not a relevant intervention and/or comparator
Solakovic (2008)	Comparative analysis of diagnostic evaluation of abdominal aortic	Not a relevant intervention and/or comparator

	aneurysm: CT angiography versus Seldinger angiography	
Studer (2014)	Addition of a lateral view improves adequate visualization of the abdominal aorta during clinician performed ultrasound	Not a relevant intervention and/or comparator
Sun (2009)	Computed tomography virtual intravascular endoscopy in the evaluation of fenestrated stent graft repair of abdominal aortic aneurysms	Not a relevant intervention and/or comparator
Tayal (2003)	Prospective study of accuracy and outcome of emergency ultrasound for abdominal aortic aneurysm over two years	Duplicate and/or already included within an included systematic review
Tennant (1993)	Radiologic investigation of abdominal aortic aneurysm disease: comparison of three modalities in staging and the detection of inflammatory change	No relevant outcomes reported
Thomas (1981)	The diagnosis and management of abdominal aortic aneurysms: a comparison of computed tomography, ultrasound and aortography	Published before 2000 or systematic review containing only papers published before 2000
Thurnher (1997)	Evaluation of abdominal aortic aneurysm for stent-graft placement: comparison of gadolinium-enhanced MR angiography versus helical CT angiography and digital subtraction angiography	Published before 2000 or systematic review containing only papers published before 2000
Todd (1991)	The accuracy of CT scanning in the diagnosis of abdominal and thoracoabdominal aortic aneurysms	Not the correct population/condition of interest
van Essen (1999)	Accurate assessment of abdominal aortic aneurysm with intravascular ultrasound scanning: validation with computed tomographic angiography	No relevant outcomes reported
van Prehn (2008)	Intra- and interobserver variability of aortic aneurysm volume measurement with fast CTA postprocessing software	Not a relevant intervention and/or comparator
Vicaretti (1997)	Helical computed tomography in the assessment of abdominal aortic pathology	Not a relevant intervention and/or comparator
Vowden (1989)	A comparison of three imaging techniques in the assessment of an abdominal aortic aneurysm	Not a relevant intervention and/or comparator
Walker (2010)	Clinical practice guidelines for endovascular abdominal aortic aneurysm repair: written by the Standards of Practice Committee for the Society of Interventional Radiology and endorsed by the Cardiovascular and Interventional Radiological Society of Europe and the Canadian Interventional Radiology Association	Not a relevant study design
Williamson (1987)	The role of intravenous digital subtraction angiography as an adjunct to computed tomography in the	Not a relevant intervention and/or comparator

	preoperative assessment of patients with abdominal aortic aneurysm	
Willmann (2003)	Aortoiliac and renal arteries: prospective intraindividual comparison of contrast-enhanced three-dimensional MR angiography and multi-detector row CT angiography	Not the correct population/condition of interest (no suspicion of AAA in population definition)
Wilmink (2002)	Accuracy of serial screening for abdominal aortic aneurysms by ultrasound	Not a relevant intervention and/or comparator
Wyers (2003)	Endovascular repair of abdominal aortic aneurysm without preoperative arteriography	Not a relevant intervention and/or comparator

Economic studies

Study	Primary reason for exclusion
Sonnex et al. (2012). Imaging diseases of the aorta by MRI: a cost-effectiveness analysis of contrast-enhanced studies compared to non-contrast enhanced angiographic studies. Journal of Cardiovascular Magnetic Resonance, 14(S1): 45.	Not a cost–utility analysis.

Appendix I – 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.