Diagnostic efficacy value in terms of sensitivity and specificity of imaging modalities in detecting the abdominal aortic aneurysm: a systematic review

Abdullah O. Alamoudi, Syed Haque,
Shankar Srinivasan* and Dinesh P. Mital

Department of Health Informatics,
School of Health Related Professions,
University of Medicine and Dentistry of New Jersey,
Newark, 07107-3001, New Jersey, USA
Fax: 973-972-8540
E-mail: alamouao@shrp.rutgers.edu
E-mail: haque@shrp.rutgers.edu
E-mail: srinivsh@shrp.rutgers.edu
E-mail: mitaldp@shrp.rutgers.edu
*Corresponding author

Abstract: The purpose of this study was to examine whether duplex ultrasonography (DUS) or MR angiography (MRA) or CT angiography (CTA) is more applicable to use as alternative modality in terms of sensitivity and specificity for detection of abdominal aortic aneurysm (AAA). A search of the medical databases was performed for describing AAA evaluation and detection. Twenty eight studies were found and met the selection criteria. Diameter of aneurysms was categorised by size: ≤ 2.5 cm of the aneurysm diameter. For aneurisms ≤ 2.5 cm, the mean reported sensitivities and specificities were DUS: 81% and 91.1%; CTA: 84.3% and 98.4%; MRA: 95.8% and 95.8%, respectively compared DSA as gold standard. MRA has the highest sensitivity and CTA has the highest specificity reported diagnostic accuracy in detecting the aneurysm ≤ 2.5 cm of AAA diameter and they could be used as a reliable alternative modality to invasive DSA.

Keywords: abdominal aortic aneurysm; AAA; CT angiography; CTA; digital subtraction angiography; duplex ultrasonography; DUS; MR angiography; MRA.

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Biographical notes: Abdullah O. Alamoudi is currently a PhD student in UMDNJ and Lecturer at Majmaah University in Saudi Arabia, His research interests in the fields of medical imaging, imaging informatics, and medical education.

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Syed Haque is Professor and Chair of the Department of Health Informatics at UMDNJ. His interest areas include healthcare outcomes measurement and research and healthcare data mining. He has published extensively in journals and in several conferences and has also served as chair in several international conferences.

Shankar Srinivasan is currently an Associate Professor in UMDNJ's Health Informatics Department and has taught in universities in Singapore and Australia. His research interests are mainly in the areas of healthcare data analysis, neuro-fuzzy systems and enterprise wide healthcare web services. He has published in various international conference proceedings and journals.

Dinesh P. Mital is a Professor in the Health Informatics Department at Rutgers, USA. His areas of research include biomedical signal and image processing, clinical decision support systems, neural and fuzzy logic based applications, and artificial intelligence. He has published over 250 technical papers in various international conferences and journals.

1 Introduction

Abdominal aortic aneurysm (AAA) occurs as a result of accumulation of plaque in the aorta, the main function of aorta is to circulate blood to the abdomen and lower regions of the body. Due to this accumulation within the aorta, this circulation is altered and greatly impaired. AAA is a fatal and life-threatening condition all around the world (Smelser et al., 2010). This disease is more prevalent in males, particularly over 65 years rather than in females. The leading factors contributing to the incidence of AAA includes smoking, high cholesterol, emphysema, obesity and high blood pressure (Wong et al., 2007).

The size of AAA in transverse dimensions ranges from 2.5 cm to 6 cm (Powell et al., 2008). Examination of infra-renal portion of abdominal aorta reveals the localised enlargement within the vessels, increases its thickness up to 50% than that of normal one's (Vorp and Geest, 2005). The type of aneurysm can be judged by its shape exhibiting fusiform and saccular pattern. In fusiform type of aneurysm there is presence of bulges and balloons on all the corners of aorta, whereas in saccular aneurysm there is presence of ballooning or bulging only at one end (Pappu et al., 2008). Aortic dissection, arterial embolism, heart attack, aortic rupture, and kidney failure results from the widening of the artery (McEniery et al., 2009; Mehta et al., 2011; O'Donnell et al., 2007; Pappu et al., 2008).

The duplex ultrasonography (DUS), CT angiography (CTA) and MR angiography (MRA) are the techniques in determining AAA as non-invasive imaging techniques, whereas DSA is invasive imaging modalities (Anderson, 2001). Among all, the DSA has been used as a gold standard for detecting AAA (Golzarian and Valenti, 2006). Although each of the modalities has both pros and cons. Nevertheless, medical imaging procedures to detect AAA are quite variables in term of diagnostic value. DSA is used as an early diagnostic tool for AAA, through which one can easily know the size and confirm the diagnosis. In stable patients with the aortic rupture and acute abdominal symptoms CTA may be helpful. In patients who are allergic to the iodinated contrast media used in CTA, MRA is a better choice as a diagnostic tool (Haulon et al., 2001).

Despite the technical advancements, it is still unclear whether these modalities are able to reach the diagnostic accuracy required to replace invasive angiography which is been used as a gold standard technique to diagnose AAA. Thus, the aim of this project to perform a systematic review and determine whether one or more of these modalities might advantageously replace DSA to assess AAA.

2 Treatment options

Treatment strategies include placing a dilated segment of aorta with a prosthetic graft, as it is a definitive treatment for the disease and can be helpful in preventing the rupturing of aneurysm. To determine a patient medically is a candidate for graft replacement following factors need to be considered, it includes general health, risk of rupture of aneurysm, expectancy of life, outcome of invasive procedures on patient's health and quality of life after undergoing procedure.

2.1 Open surgical repair

Open surgical repair was considered as a gold standard to treat AAA for approximately half century and has shown great success. This procedure is still used in many clinical centres. Moreover, the procedure is employed to retain the blood flow to the pelvis and legs through an implanted new vascular conduit (usually a synthetic fabric or expanded polytetrafluoroethylene) and it excludes the aortic aneurysm from the systemic circulation. Aneurysm sac is incised leading to elimination of mural thrombus and ligating patent branch vessels like superior mesenteric or inferior mesenteric artery which have their origin from aneurismal sac. Select appropriate size of graft then suture it with the artery present at proximal and distal segments of aneurysm, in final stages close the decompressed aneurismal sac over the surface of synthetic graft material. These are the steps performed in the invasive procedure of surgery, the chances of mortality is 4% or less adopted for elective surgical repair, or 8.4% or more based on patients CVS stability (Ernst, 1993; Fenchel et al., 2006; Flu et al., 2009; Fojtik et al., 2007; Gelfand et al., 2006; Gilabert et al., 2012; Golledge et al., 2011; Golzarian and Valenti, 2006; Goyen et al., 2002; Gray et al., 2012; Greenhalgh et al., 2005; Greenhalgh et al., 2004; Habets et al., 2013; Harris et al., 2000; Haulon et al., 2001; Hessel et al., 1981; Hirsch et al., 2006; Ho and Corse, 2003; Iezzi et al., 2009; Iino et al., 2002; Isenbarger et al., 2003; Joseph, 2007; Khalil et al., 2007; Laissy et al., 2002; Lawrence et al., 1999). Haemorrhage and septic conditions can be the cause of mortality.

2.2 Endovascular aneurysm repair

In medically unfit patients certain attempts were made to lower the risk of surgeries by making use of milder forms of invasive techniques of AAA. In past minimally invasive methods were online restricted to the repairment of intra-renal aneurysm, but at present these techniques also allow the extension to the suprarenal aorta (Yao and Eskandari, 2012; May et al., 1994). As an alternative of replacing graft through lengthy procedures by undergoing general anesthesia, there is a thin-walled device pushed into catheter, by which it enters in the femoral artery under local aesthetic procedure. The endovascular aneurysm repair (EVAR) and the Dutch Randomised Endovascular Aneurysm Management (DREAM) trials were performed to calculate the endovascular repair of AAA, it showed a mortality of 30 days than the conventional open repair (Greenhalgh et al., 2004; Habets et al., 2013; Harris et al., 2000; Haulon et al., 2001; Hessel et al., 1981; Hirsch et al., 2006; Ho and Corse, 2003; Iezzi et al., 2009; Iino et al., 2002; Isenbarger et al., 2003; Joseph, 2007; Khalil et al., 2007; Laissy et al., 2002; Lawrence et al., 1999; Lyon et al., 2004; Marenzi et al., 2003; May et al., 1994; McEniery et al., 2009; Mehta et al., 2011; O'Donnell et al., 2007; Pappu et al., 2008; Powell et al., 2008; Prinssen et al., 2004). In European countries, the EVAR trial 1 is the largest trial conducted for endovascular versus open surgery repair of AAA conducted by including 1,082 patients from different central (Greenhalgh et al., 2004). For 1.7% EVAR proved to be fatal within just 30 days where as in other's case it benefitted the subjects. Among all the trail, 4.7% of subjects were treated with open surgery. EVAR also showed lesser in-hospital mortality in contrast to open repair. In DREAM trials, comparison of open and endovascular repair of AAA summarised that endovascular repair is preferred in open repair within the initial 30 days of the procedure (Prinssen et al., 2004). The randomised control trials which were conducted showed that the trial is indicated in patients who can undergo both EVAR and open surgery. There is less chances of mortality in and adverse effects in endovascular repair. Therefore, it is the most appropriate technique and shows significant reduction in complications. According to EUROSTAR (The European Collaborators Registry on Stent-Graft Techniques for AAA), repair generated report for the assessment of quality of adjusted life expectancy post operatively for endovascular repair of AAA and open surgical repair, open surgery is the treatment of choice in younger age group and is showing better prognosis (Habets et al., 2013). It also proved that EVAR is a better option is case of elderly patients over 70 year, particularly who are male having compromised health for consecutive three months. In unfit patients, EVAR still plays a useful role in providing intervention in AAA patients (patients with cardiac disease, chronic obstructive pulmonary disease, diabetes, renal disease, cerebrovascular disease or peripheral artery disease). EVAR trial 2 conducted in the UK showed the instant endovascular repair is not capable of offering any advantage in mortality and quality of life in the initial four years after treatment (Greenhalgh et al., 2005). The current study by Brown et al. (2010) has proved that the incidence of cardiovascular events in EVAR is relatively low, and a patient's condition has nothing to do with this kind of intervention. It is generally thought that ill patients suffering from with cardiac disease, chronic obstructive pulmonary disease, diabetes, renal disease, cerebrovascular disease or peripheral artery disease are more prone to develop co-morbidities and cardiovascular incidences like myocardial infarction, stroke and atrial fibrillation. Above results concludes that the only way to reduce co-morbidities in patients is to improve their health as it should be of prime importance when aneurismal repair is of need. Many surprising results are obtained with EVAR and have shown many benefits in contrast to open surgery procedure (O'Donnell et al., 2007; Pappu et al., 2008; Powell et al., 2008; Prinssen et al., 2004; Raman et al., 2003; Smelser et al., 2010; Steffens et al., 2003; Stolzmann et al., 2008; Tayal et al., 2003; Toombs and Jing, 2000; Verhoeven et al., 2004). Thus, studies are being held to investigate the topic of endovascular repair of AAA in long-term and short-term basis. For the follow up of EVAR medical imaging techniques can be used, to keep a complete check on the complications that arise after the procedure is performed.

2.2.1 Image visualisation pre-operative EVAR

Successful endovascular AAA repair based on stent's proximal and distal to non-dilated portions of iliac arteries and aorta then it adds up to the success of endovascular AAA. Performing diagnostic imaging prior to AAA stent-graft placement is helpful in determining the morphological suitability for the type of stent grafting as it gives the estimation of stent-graft. Axial CT images verify the maximum aneurysm circumference including the lumen of the patient and his thrombus. Extra information and relationships can be assessed by 2D and 3D reconstructions. They give visualisations and determine the part of CTA in planning of EVAR.

2.2.2 Image visualisation post-operative EVAR

Spiral computed tomography (CT) angiography has been confirmed as the best imaging procedure in accessing preoperative patient and aortic stent-graft surveillance. The accomplishment of endovascular stent-graft repair of AAA is successfully based on imaging techniques.

3 Materials and Methods

3.1 Searching of publication

Five databases have been accessed (Web of Knowledge, SCOPUS, Science Direct, PubMed, Medline and ProQuest) for English language publications from 2000-2013. The following keywords have been used for the search: (DSA; or DUS; or MRA; or CTA or Multislice) and AAA. The search was limited to human subjects. A statistical appraisal of the literature has been used on the use of DUS, CTA, and MRA for the assessment of AAA. The reference lists of identified articles were checked to obtain additional articles. Studies were included if they met all of the following criteria:

a patients undergoing DUS, CTA, MRA examinations

b studies included at least ten patients

c a comparison among finding at MRA, CTA and DUS in terms of sensitivity, specificity was performed.

3.2 Data extraction

The data was gathered from the study design and procedure techniques. The purpose of this extracted data was to identify the following characteristics in each study: year of publication, number of patients, patient age and sex, imaging techniques used in each modality, the sensitivity and specificity as shown in Table 5.

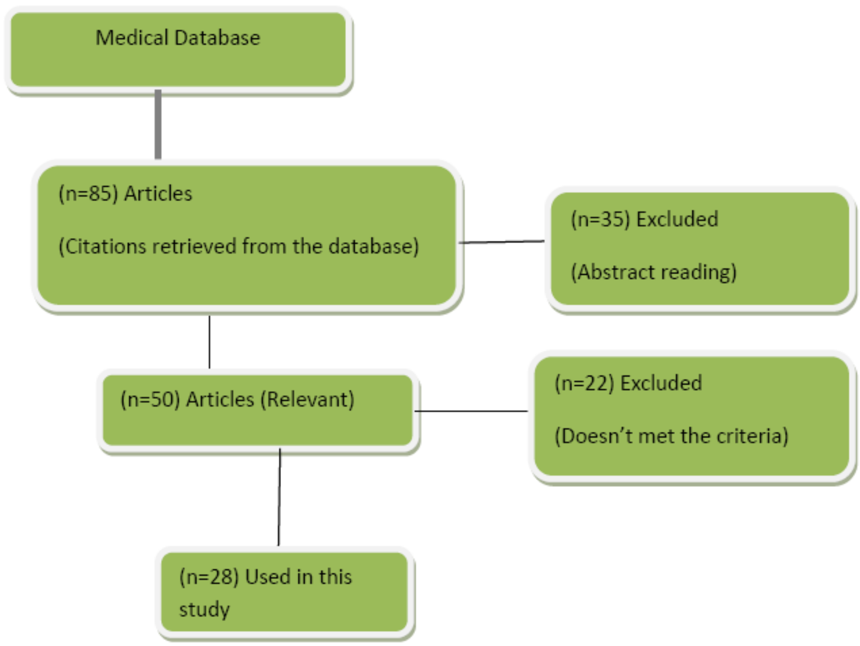
3.3 Statistical analysis

The different data of patients such as their condition, sensitivity, and specificity of each modality were entered into a Microsoft Excel and SAS version 9.3 (Statistical Analysis Software) for extra analysis (Figures 2 and 3).

4 Results

Articles selected were those published between 2000 and 2013, which met the study criteria. A total of 28 articles have been included, providers a total of 2,284 patients, with a mean age is 66.2 years. The distribution includes 88% males and 12% females. The results of the database searches are given in Figure 1. Some articles were present in more than one database.

Figure 1 Flow chart studies through the review process (meta-analysis) (see online version for colours)



Note: n, number

Figure 2 Column chart of AAA in term of sensitivity and specificity (see online version for colours)

Figure 3 The SAS system generating UNIVARIATE procedure (see online version for colours)

The SAS System

The UNIVARIATE Procedure
Variable: Sensitivity

Moments			
N	3	Sum Weights	3
Mean	87.0333333	Sum Observations	261.1
Std Deviation	7.76938436	Variance	60.3633333
Skewness	1.38719369	Kurtosis	.
Uncorrected SS	22845.13	Corrected SS	120.726667
Coeff Variation	8.92690658	Std Error Mean	4.48565615

Basic Statistical Measures			
Location		Variability	
Mean	87.03333	Std Deviation	7.76938
Median	84.30000	Variance	60.36333
Mode	.	Range	14.80000
		Interquartile Range	14.80000

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	19.40259	Pr > |t|	0.0026
Sign	M	1.5	Pr >= |M|	0.2500
Signed Rank	S	3	Pr >= |S|	0.2500

Figure 3 The SAS system generating UNIVARIATE procedure (continued) (see online version for colours)

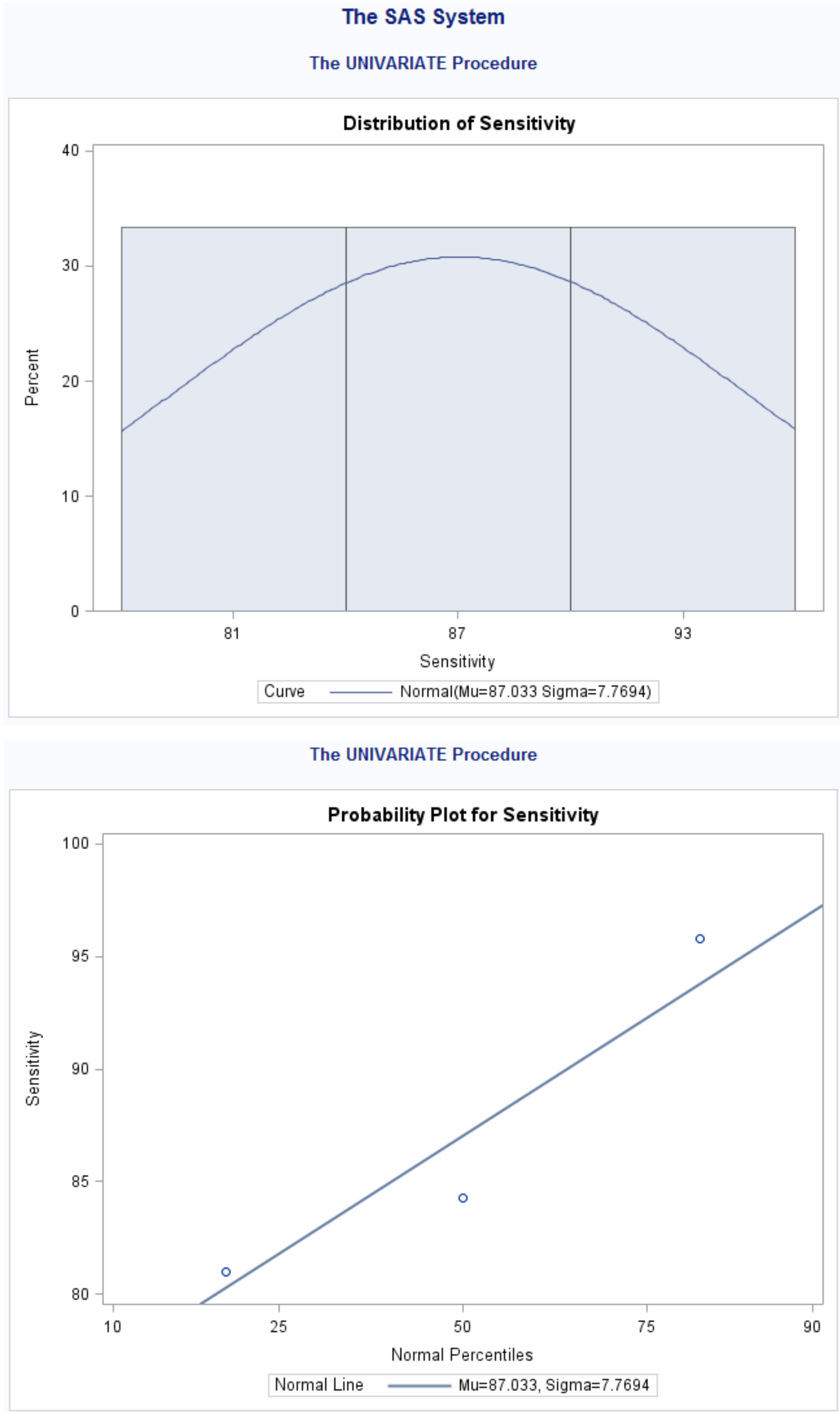


Figure 3 The SAS system generating UNIVARIATE procedure (continued) (see online version for colours)

The UNIVARIATE Procedure
Variable: Specificity

Moments			
N	3	Sum Weights	3
Mean	95.1	Sum Observations	285.3
Std Deviation	3.7	Variance	13.69
Skewness	-0.8208793	Kurtosis	.
Uncorrected SS	27159.41	Corrected SS	27.38
Coeff Variation	3.89064143	Std Error Mean	2.136196

Basic Statistical Measures			
Location		Variability	
Mean	95.10000	Std Deviation	3.70000
Median	95.80000	Variance	13.69000
Mode	.	Range	7.30000
		Interquartile Range	7.30000

Tests for Location: Mu0=0				
Test	Statistic		p Value	
Student's t	t	44.51839	Pr > |t|	0.0005
Sign	M	1.5	Pr >= |M|	0.2500
Signed Rank	S	3	Pr >= |S|	0.2500

The SAS System

The UNIVARIATE Procedure

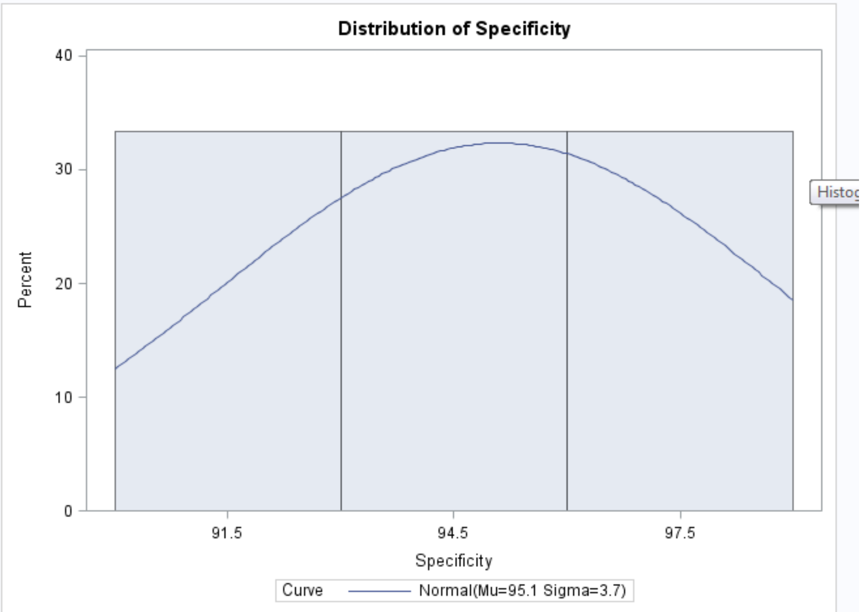
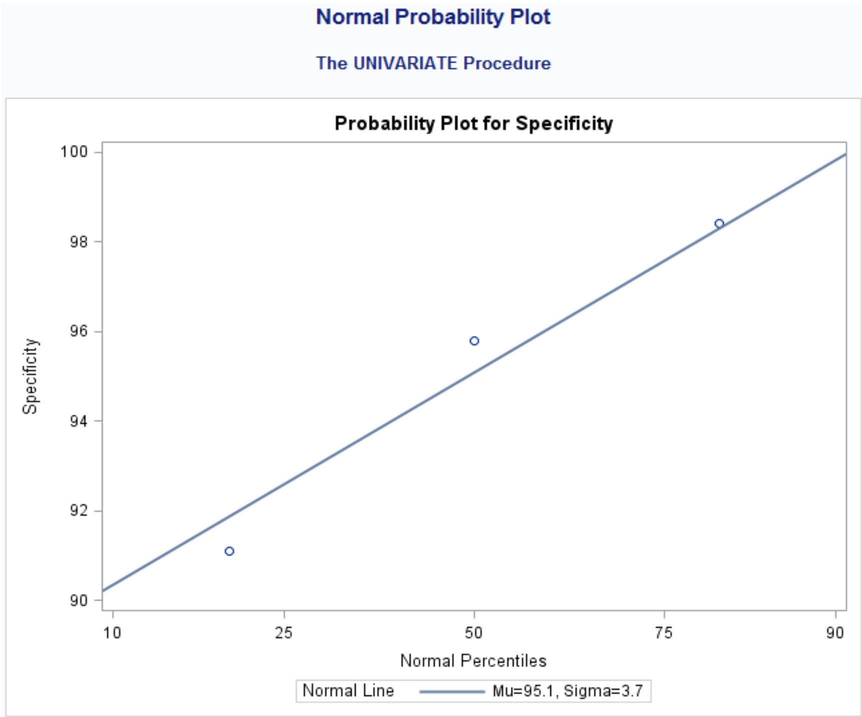


Figure 3 The SAS system generating UNIVARIATE procedure (continued) (see online version for colours)



4.1 Observers involved in these studies

For all of the studies accessed more than one observer was involved in the assessment of images. The observers were blinded to the results of DSA examination while evaluating images acquired with CTA, DUS and MRA. The sensitivity and specificity of the imaging modalities was assessed as the median of the figures provided in the various studies. These outcomes are shown in Table 1.

Table 1 Pooled sensitivity and specificity of DUS, CTA and MRA for the detection of AAA compared to DSA

Modality	*Number of patient*	*Sensitivity*	*Specificity*
	D ≤ 2.5 (cm)	*D ≤ 2.5 (%)*	*D ≤ 2.5 (%)*
DUS	1161	81.	91.1
CTA	367	84.3	98.4
MRA	195	95.8	95.8

Note: D = diameter

4.2 DSA digital subtraction angiography as gold standard

The digital subtraction angiography (DSA) is a two-dimensional method and was used as the first line of management for the investigation of patients with AAA and is still considered as a gold standard. DSA is still thought to be the world wide accepted technique for carrying out interventional procedures. Furthermore, the accuracy of DSA is served as reference tool for non-invasive diagnostic modalities such as DUS, MRA and CTA. In spite of being the gold standard, DSA has some flaws (Hirsch et al., 2006; Hessel et al., 1981):

- By using multiple projections sometimes we cannot measure hemodynamic importance.
- It may not always show patent crural vessels.
- It may give exaggerated length of occlusions.
- Since there techniques are able to offer 3D imaging, often eccentric lesions cannot be marked, axial imaging techniques (e.g., MRA and CTA) may suggest benefit for visualising these pathologies. Outcomes/adverse effects: almost 1.7% of the cases might show extreme complications; these complications can be reduced by improving the standards of catheter and guide wire technology (Hessel et al., 1981; Hirsch et al., 2006; Ho and Corse, 2003; Iezzi et al., 2009; Iino et al., 2002; Isenbarger et al., 2003; Joseph, 2007; Khalil et al., 2007; Laissy et al., 2002; Lawrence et al., 1999; Lyon et al., 2004; Marenzi et al., 2003; May et al., 1994; McEniery et al., 2009; Mehta et al., 2011; O'Donnell et al., 2007; Pappu et al., 2008; Powell et al., 2008; Prinssen et al., 2004; Raman et al., 2003; Smelser et al., 2010; Steffens et al., 2003; Stolzmann et al., 2008; Tayal et al., 2003; Toombs and Jing, 2000; Verhoeven et al., 2004; Von Segesser et al., 2002; Vorp and Geest, 2005; Waugh and Sacharias, 1992). There is 0.1% chances of extreme reactions by introduction of contrast medium in angiography, out of these reactions 0.7% can hinder the treatment of the sufferer and approximately 0.16% show the cases of mortality, this estimation was given by TASC II Consensus. Patients show incidence of sever renal dysfunction, low cardiac output, cases of dehydration and diabetes due to injection of a contrast. There is also risk of nephrotoxicity due indorsing a contrast media. According to some recent researches, usage of a low-osmolar contrast agent like iodixanol in patients with the risk of nephrotoxicity may greatly reduce the incidence of renal compromise (Aspelin et al., 2003; Bargellini et al., 2005; Biancari et al., 2013; Bierig and Jones, 2009; Brown et al., 2010; Cantisani et al., 2011; Choi and Kramer, 2002; Dent et al., 2007; Di Cesare et al., 2000; Elkouri et al., 2004; Engellau et al., 2003; Ernst, 1993; Fenchel et al., 2006; Flu et al., 2009; Fojtik et al., 2007; Gelfand et al., 2006; Gilabert et al., 2012; Golledge et al., 2011; Golzarian and Valenti, 2006; Goyen et al., 2002; Gray et al., 2012; Greenhalgh et al., 2005; Greenhalgh et al., 2004; Habets et al., 2013; Harris et al., 2000; Haulon et al., 2011; Hessel et al., 1981; Hirsch et al., 2006; Ho and Corse, 2003; Iezzi et al., 2009; Iino et al., 2002; Isenbarger et al., 2003). The studies suggest that vigorous hydration before injecting a contrast can be helpful to prevent the post-procedural retrogradation of the renal function. Beside, reduction in using contrast dose is highly recommended and important.

Table 2 The diagnostic efficacy values of DUS in detecting AAA

Modality	*Patient*				*Indication*	*AAA diameter (cm)*	*Sensitiv ity (%)*	*Specificity (%)*
DUS study	*Study year*	*Total number*	*M/F*	*Mean age*				
Golledge et al.	2011	337	337/-	69	To assess the diagnostic, prognostic and risk stratification potential of plasma diameter for AAA presences and growth.	2.5	85	6.
Flu et al.	2009	150	150/-	55	To evaluate the diagnostic accuracy of new portable DUS to automatic AAA detection.	> 3	90	94
Dent et al.	2007	120	NS	73	To consider DUS with suspected AAA.	> 3	96	100
Joseph	2007	NS	NS	60	ERU in detecting AAA.	> 3	100	100
Fojtik et al.	2007	NS	NS	NS	To diagnosis AAA by EMU.	3.5–5.5	94	100
Elkouri et al.	2004	125	113/12	76	To compare DUS and CTA for routine follow up of patient after EVAR of AAA.	< 2	25	89
Raman et al.	2003	281	246/35	73	To compare both CTA and CDU as surveillance to evaluate AAA.	4.5	43	96
Tayal et al.	2003	125	NS	66	To determine the presence of AAA.	3.1	100	98
Lyon et al.	2004	NS	NS	NS	False positive AAA on beside ERU.	4	100	100
Gray et al.	2012	145	122/23	77.1	To demonstrate that DUS can supplant CT as the postoperative EVAR.	5.5–5.6	100	85
Cantisani et al.	2011	108	92/31	63	To assess the accuracy of CDUS, CEUS, CTA&MRA in detecting endoleaks after EVAR.	4.9–5.9	58	93
Abbas	2012	91	NS	71	To determine the AortaScan AMI 9700 accuracy to detect AAA.	2.8	81	72

Notes: CDU, CDUS = colour flow duplex ultrasound scanning; CEUS = contrast-enhanced ultrasound; EAAR = endolumainal abdominal aneurysm repair; EMU = emergency medicine ultrasound; ERU = emergency ultrasound; EVAR = endovascular aneurysm repair; F = female; M = male; NS = not specified

Table 3 The diagnostic efficacy values of CTA in detecting AAA

Modality	*Patient*				*Indication*	*AAA diameter (cm)*	*Sensitivity (%)*	*Specificity (%)*
CTA study	*Study year*	*Total number*	*M/F*	*Mean age*				
Alerci et al.	2009	43	41/2	72.3	To compare MRI and MDCT for EVAR.	< 5.5	58	100
Stolzmann et al.	2008	118	97/21	74	To assess the performance of DSCT in detection of endoleak after EAAAR.	4.4	100	97
Khalil et al.	2007	NS	NS	29	For detecting peri graft leakage.	6	83	100
Biancari et al.	2013	58	51/7	74.4	To evaluate the accuracy of CTA for suspected rupture of AAA.	7.8	98.3	94.9
AbuRahma et al.	2005	178	NS	74	To compare the ability of CTA and CDUS to detect AAA.	5.15	85	97
Iino et al.	2002	18	16/2	66.3	To assess the diagnostic ability of CTA in diagnostic AAA.	> 5	83	100
Cantisani et al.	2011	108	92/31	63	To assess the accuracy of CDUS, CEUS, CTA&MRA in detecting endoleaks after EVAR.	4.9–5.9	83	100

Notes: DSCT = dual-source computer tomography; EAAAR = endoleak after endovascular AAA; MDCT = multidetector comutered tomography

Table 4 The diagnostic efficacy values of MRA in detecting AAA

Modality	*Patient*				*Indication*	*AAA diameter (cm)*	*Sensitivity (%)*	*Specificity (%)*
MRA study	*Study year*	*Total number*	*M/F*	*Mean age*				
Alerci et al.	2009	43	41/2	72.3	To compare MRI and MDCT for EVAR	< 5.5	98	87
Fenchel et al.	2005	34	NS	NS	To evaluate the abdominal and peripheral vascular occlusive disease by using 1.5-T MRI.	3.78	96	96
Steffens et al.	2003	50	NS	NS	To evaluate step-table 3DCE of MRA with bolus changing.	> 5	100	99
Ho and Corse	2003	NS	NS	60	To study the accuracy of using contrast – enhanced MRA as a method for arterial evaluation.	3	94	98
Goyen et al.	2002	15	NS	NS	To develop and evaluate a self-developed rolling table platform at whole-body 3D MRA.	4	94	96
Choi et al.	2002	NS	NS	NS	To prove the value of determine the atherosclerotic plaque by using MRI.	> 4.5	85	92
Di Cesare et al.	2000	29	21/8	59.5	To verify the diagnostic potentialities of MRI.	> 3	100	100
Toombs and Jing	2000	NS	NS	NS	to update the reader on the current status of magnetic resonance and computed tomographic techniques in the evaluation of a variety of vascular disorders.	4	100	95
Cantisani et al.	2011	108	92/31	63	To assess the accuracy of CDUS, CEUS, CTA&MRA in detecting endoleaks after EVAR.	4.9–5.9	96	100

Notes: MRA = magnetic resonance angiography; MRI = magnetic resonance imaging; T = tesla unit

The methodology to reduce the contrast dose based on placing the catheter nearer to the area which is selected for imaging (selective angiography) and by using DSA techniques. It is unfortunate that we cannot exactly measure the link of dose and nephrotoxicity. Another data suggested that utilising preprocedural haemofiltration in the patients suffering from chronic renal failure (defined as a creatinine level > 2.0 mg/dL) might be minimised nephrotoxicity (Marenzi et al., 2003). In this technique, the subject is exposed to ionising radiations and is provided recovery facilities. Some complications like atheroemboli, arterial dissection and others like pseudo aneurysm, arteriovenous fistula and hematoma is also noticed. There are various techniques to overcome these problems, for instance using non-ionic contrast agent, DSA, intra-arterial pressure measurements across a stenosis with and without vasodilator, and more sophisticated image projection and retention. Alternatively, some other agents like carbon dioxide and magnetic resonance contrast agents (e.g., gadolinium) can be replaced the conventional contrast media.

4.3 DUS compared to MRA

A total of 1,482 patients, mean age 68.3 years, 91% male and 9% female were included in 12 studies are presented in Table 2. The detection of diameter of aneurysm ≤ 2.5 cm in DUS resulted in 81% for sensitivity and 91.1% for specificity compared to the sensitivity and specificity of MRA 95.8% and 95.8% respectively for ≤ 2.5 cm of AAA diameter.

4.4 CTA compared to MRA

The CTA studies which met the criteria were performed with different units with a range of slice capability. There were seven CTA studies, including 367 patients, with a mean age of 64.7 years 82% were male patients and 18% were females are presented in Table 3. The mean sensitivity and specificity of CTA in detecting ≤ 2.5 cm of AAA diameter were 84.3% and 98.4%, respectively compared to the sensitivity and specificity of MRA 95.8% and 95.8% for ≤ 2.5 cm of AAA diameter.

4.5 MRA compared to gold standard (DSA)

MRA scans were performed with 1.5 Tesla, nine studies met the criteria, including 195 patients, mean age 63.7 years, 79% male patients and 21% female are presented in Table 4. The sensitivity and specificity of MRA in detecting AAA with ≤ 2.5 cm diameter were 95.8% and 95.8%, respectively.

5 Discussion

Currently, DSA is regarded as the gold standard test for preoperative evaluation of aneurysms. Furthermore, it is only an invasive technique, and it is also associated with procedure-related complications. Nevertheless, imaging modalities, including DUS, CTA, and MRA have been studied with regard to their potential accuracy as alternative techniques to DSA. Previous results indicate that the non-invasive imaging modalities (CTA and MRA) have high diagnostic value in terms of sensitivity and specificity compared with also non-invasive medical imaging modalities (DUS) for detection of AAA. However, their value as alternative imaging techniques have yet to be determined to be able to recommend them as reliable after native modalities. The results so far are suggested that MRA is most reliable one in terms of sensitivity and specificity compared with DUS, CTA and closed to DSA diagnostic efficacy value. Recently, Alerci et al. (2009) in 2009 reported the results of a prospective, intraindividual comparison between contrast-enhanced MRA, with a high relaxivity MR contrast medium and 16-slice multidetector CTA. They showed superior sensitivity of MRA for the detection of endoleaks compared with CTA. Habets et al. (2013) have recently published a study to examine whether MRA or CTA is more sensitive for the endoleak detection in patient with AAA after EVAR. The study conducted that the MRI compared to CTA is more sensitive for the detection of *post*-EVAR. Moreover, the finding from this study has highly recommended using MRI in patient with AAA growth and with uncertain findings at CTA (Harris et al., 2000). The more surprising result that was published in 2011 by Cantisani et al. (2011) indicated that the accuracy result for MRA and CEUS in term of sensitivity and specificity are 96% and 100% respectively for both modalities.

In recent times, MRA has been much more widely investigated than DUS or CTA (Engellau et al., 2003). MRA is considered as the best alternative modalities to assess AAA. Studies have showed that the MRA is used when the patient is allergic to idionated contrast media required for CTA (Haulon et al., 2001).

However, MRA is extremely difficult to repeat it for reproducibility studies. Also, MRA is still not as universally available. Overall, MRA was found to demonstrate a high as diagnostic value compared to DUS, and CTA in terms of sensitivity. Thus, MRA could develop as an effective alternative to DSA for AAA assessment.

Although several studies have found that DUS has outcomes close to DSA in regard to their specificity to diagnose ≤ 2.5 cm of AAA diameter, overestimation may occur in the aneurysm segment due to signal loss, especially in those DUS techniques which do not involve a contrast agent during the examination of AAA (Von Segesser et al., 2002; Raman et al., 2003).

Recent evidence by Iezzi et al. in 2009 has shown that CEUS (Contrast-enhanced ultrasound) imaging significantly improved the diagnostic performance of unenhanced US studies in the detection of AAA with 97.5% and 81.8% of sensitivity and specificity respectively. The most striking result from the study is that CEUS imaging is reliable, non-invasive and fast compare to MRA and multislice CTA for AAA detection. Furthermore, a considerable amount of literature has been published on DUS. These studies investigated the advantages for detection of AAA and most of these studies concluded that the DUS can be easily repeated, fast and reliable tool to use (Bierig and Jones, 2009). Moreover, in the current researches by Gray et al. (2012) and Gilabert et al. (2012) in 2012 indicated that DUS can replace as tool following EVAR to measure the size of AAA without any loss accuracy of imaging. This significant improvement will serve as a base future studies for measuring the accuracy comparing DUS and DSA role in diagnosing AAA with suspected aneurysm higher than 2.5 cm in diameter of AAA (Gray et al., 2012; Gilabert et al., 2012).

On the other hand, Stolzman et al. (2008) reported that CTA had 98% accuracy in diagnosing AAA. In addition, a recent study by Biancari et al. (2013) found that CTA provided a significantly high sensitivity of 98.3% for the detection of aneurysm in both suspected rupture of AAA, in initial CTA assessment and *post hoc* CTA assessment. For patients who are able to progress to CTA, it has the advantage of also being to investigate the branches of the aorta during a more routine examination for AAA. Nevertheless, occasionally CTA is less accurate in the pre operation assessment of abdominal aorta in compression to other imaging techniques (Gelfand et al., 2006). Most frequently, CTA is used to delineate anatomy prior to treatment, either by surgery or an endoluminal grafting (Mehta et al., 2011). The review, however, has highlighted the fact that all the CTA studies suggest only moderate diagnostic value of CTA in term of sensitivity.

This study has some limitations that should be addressed. First, not all of the studies provided detailed of scanning protocols, number of true positive, true negatives noted which provide limitation to the analysis of study outcomes. Moreover, the studies were based on variable criteria for assessment of the AAA, thus, the analysis should be interpreted with caution. Uniform criterion is important for future studies.

6 Conclusions

To put it briefly, as it can be seen the review has showed that MRA has the highest diagnostic accuracy in terms of the sensitivity and CTA in term of specificity for detection $\leq$ 2.5 cm of AAA diameter, indicating as a reliable alternative to DSA. In contrast, DUS has moderate diagnostic efficacy (sensitivity and specificity) and their role in this aspect is yet to be clarified. Nevertheless, MRA examinations are non-invasive, safe and, therefore, preferable alternative in examining AAA patients.

CTA is providing more details about the anatomical structure of abdominal aorta. MRA and CTA can be used as an alternative to DSA, as they are non-invasive procedure and provided a significantly higher sensitivity and specificity. DSA role is just for planning surgical or endovascular repair. Finally, the diagnostic efficacy value (sensitivity and specificity) of DUS, CTA and MRA in detecting AAA have all been proven to be suitable in properly conducted studies. Also, before giving any conclusion it is necessary to investigate it further in details to review the depth of this analysis.

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