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RESEARCH ARTICLE

Comparing the Diagnostic Performance of CT and MRI in Evaluating Abdominal Aortic Aneurysms: A Systematic Review

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Abstract: ***Background***: This systematic review was to evaluate the abdominal aortic aneurysms (AAA), with diagnostic modalities of CT and MRI.A systematic search was conducted following PRISMA guidelines across multiple databases. 6115articles in total had been searched by making use of PubMed, SCOPUS, Prospero, Elsevier Science Direct, Cochrane library, Wiley online library, Elsevier Science Direct, Cinahl, Ovid Medline, and grey literature. Four studies meeting inclusion criteria were included for analysis. Data extraction included patient characteristics, imaging modalities used, techniques employed, and outcomes assessed. Quality assessment had been performed by utilizing QUADAS (Quality Assessment of Diagnostic Accuracy Studies) tool.MRI consistently emerged as a superior diagnostic tool compared to CT, USG, and angiography in evaluating AAA. MRI provided precise measurements and accurate evaluations, particularly in defining anatomic details without contrast material and avoiding potential distortions induced by conventional CT methods. USG (Ultrasonography) proved reliable for initial diagnosis and monitoring but lacked precision in measuring AAA parameters. This systematic review highlights MRI's superiority in diagnosing and evaluating AAA compared to other imaging modalities. While more investigation is required in validating these findings as well as optimising imaging procedures, clinicians can consider MRI as a preferred modality for AAA assessment, especially when precise measurements are crucial for treatment decisions.

Keywords: Abdominal aortic aneurysm (AAA), Ultrasonography (USG), Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Angiography

INTRODUCTION

AAA develops because of plaque buildup within aorta, that plays a vital function in circulating blood to the abdomen and lower body regions. This accumulation disrupts and significantly impairs blood circulation. AAA poses a fatal and life-threatening risk globally, with higher prevalence observed in males, particularly those over 65 years of age, compared to females [1]. Major contributing factors to AAA incidence include obesity, high cholesterol levels, emphysema, smoking, as well as hypertension [2, 3].The transverse dimensions of AAA typically range from 2.5 cm to 6 cm [4]. Evaluation of infra-renal segment of abdominal aorta indicates localized enlargement within vessels, increasing thickness by up to 50% on comparing it with normal [4]. Aneurysm’s type can be identified by its form, which may manifest as either fusiform or saccular. In a fusiform aneurysm, bulges and balloons are present at all corners of the aorta, however in a saccular aneurysm, bulging or ballooning occurs only at 1 end [5, 6]. The widening of the artery can lead to complications such as arterial embolism, aortic dissection, heart attack, kidney failure along with aortic rupture [7,8,9].

MRA (MR angiography), CTA (CT angiography), as well as DUS (Duplex USG) have been non-invasive imaging procedures commonly employed to diagnose AAA, whereas DSA (digital subtraction angiography) has been an invasive modality [10]. DSA has traditionally served as the gold standard for AAA detection [11]. However, each modality has its advantages and limitations, leading to variability in diagnostic value among medical imaging procedures for AAA detection. DSA is particularly used as early diagnostic tool to determine AAA size as well as to confirm diagnosis. In stable individuals with acute abdominal symptoms as well as aortic rupture, CTA might be beneficial. For individuals with iodinated contrast media allergies during CTA, MRA presents preferable alternative for diagnostic purposes [12].

AAA diagnosis frequently occurs incidentally, frequently when an abdominal pulsatile mass is detected. In certain instances, patients may present with symptoms including peripheral vascular insufficiency or lumbar pain. In rare cases, after rupturing asymptomatic aneurysm may manifest dramatically [13, 14]. Diagnostic imaging techniques have been indispensable for confirming clinical diagnosis as well as assessing aneurysm’s size as well as its impact on neighbouring structures. Contrast-enhanced CT (computed tomography) is valuable for assessing extent of the aneurysm, although it may not always provide precise visualization of the involvement of visceral arteries [15].

Magnetic resonance imaging (MRI) holds broad applications in cardiovascular pathology due to its ability to differentiate vascular structures without the need for contrast injection and to examine them in various spatial planes. MRI offers valuable insights into the location, extent, and renal involvement as well as iliac arteries, along with thrombosis presence. Additionally, it is a non-invasive procedure [15, 16].Intent of this systematic review had been to examine limitations as well as possibilities of MRI in AAA's detection, on comparing with CT diagnostic modalities.

MATERIALS AND METHODS

SEARCH STRATEGY

This systematic review was conducted using PRISMA guidelines (Figure 1). 6115articles in total had been searched by making use of PubMed, SCOPUS, Elsevier Science Direct, Cochrane library, Wiley online library, Elsevier Science Direct, Cinahl, Prospero, as well as Grey literature among which 4articles are part of this systematic evaluation.

A combination of the following keywords used are 'Abdominal aortic aneurysm', 'CT performed', MRI performed'.

ELIGIBILITY CRITERIA:

INCLUSION CRITERIA:

1. Studies published in the English language
2. Full-text articles
3. Comparing CT and MRI in AAA

EXCLUSION CRITERIA:

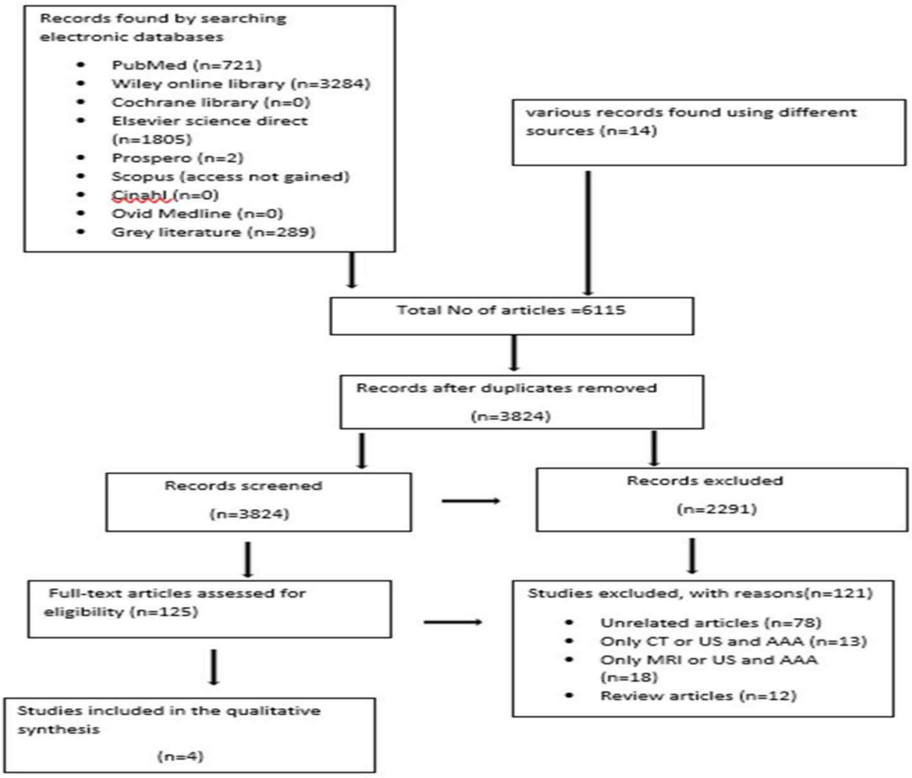
1. Unrelated articles
2. Only abstracts available
3. Comparing US and any other modalities in AAA
4. Review articles, case reports or series and cross-sectional studies are excluded

DATA EXTRACTION:

Data extracted from 1985 to 2024. The information was collected utilizing the methodologies and techniques established in the study. This extracted data aimed to ascertain specific attributes within each study, including the year of publication, patient count, and demographics such as age and sex, as well as the diagnostic methods used in imaging modalities.

QUALITY ASSESSMENT METHODS:

Assessment of every qualifying study's quality had been conducted utilizing QUADAS tool. This equipment, known for its established validity in evaluating diagnostic studies, comprises 14 questions. These inquiries encompass various aspects such as the representativeness of the patient spectrum, clarity of selection criteria description, and meticulous examination of the reference standard employed in research.



RESULTS AND OBSERVATIONS:

Study Selection and Screening A total of 6,115 articles were identified from major databases: PubMed, Elsevier Science Direct, Wiley Online Library, Cochrane Library, Prospero and grey literature. After duplicate records (n = 2,291) were removed, 3,824 articles were left for screening. About 2,291 records were excluded based on title and abstract review. A total of 1,533 full-text articles were screened, from which 121 articles were excluded for unrelated study topic (n = 78), no full text available (n = 13), comparisons of imaging other than CT and MRI (n = 18), and review articles and case series (n = 12). Four studies were finally included in the systematic review, as they met the inclusion criteria.

Table 1 illustrates characteristics and outcomes of included studies. On comparing with various imaging modalities for evaluating AAAs, it is evident that MRI stands out for its accuracy and precision. While CT remains a common diagnostic tool, especially with advancements in helical scanning technology, MRI offers distinct advantages, particularly in providing detailed measurements and avoiding potential distortions induced by conventional CT methods. USG also plays a significant role, particularly in initial diagnosis and monitoring, but its limitations become apparent in cases requiring precise measurements. Overall, MRI emerges as a valuable alternative to CT, offering comparable reliability while potentially mitigating certain drawbacks associated with other imaging modalities.

Table 1.Characteristics of the Four Studies Included In This Systematic Review

AUTHOR NAME AND YEAR	PATIENT CHARACTERISTICS	IMAGING MODALITY USED	TECHNIQUE	OUTCOME
Eugenio et al 1995 [16]	27 Patients ages ranging from 58 to 86 years and all patients are male	CT, USG, MRI, Angiography	**CT:** GE 8800 scanner was used for imaging CT. Axial section of 1 cm thickness and interval varies between 1 to 2 cm **USG:** Axial and longitudinal planes were used for imaging **MRI:** About MRI technique is not mentioned **ANGIOGRAPHY:** Angiography is also not mentioned in this study	Compared with all imaging modalities MRI provides more accurate information in examining AAA
Paolo Pavone et al 1990 [17]	35 Patients ages ranging from 59 to 79 years among that 29 patients were male and 6 were females	CT, USG, MRI, Angiography	**CT:** CT scans were conducted using a third-generation Siemens Somaton 2 machine. The abdomen was imaged with contiguous sections, each eight millimeters thick, while a contrast agent was rapidly infused **USG:** Imaging was performed under a 3.5-5MHZ sectorial or linear probe. Axial and longitudinal planes were used for imaging the abdomen **MRI:** MRI examinations were conducted utilizing a 0.5superconductive unit (Esatom5000, Esaote Biomedica, Italy). Images were acquired on a minimum of two orthogonal planes using T1 sequences and T2 sequences. The slice thickness varied among 8-10mm **ANGIOGRAPHY:** Angiography was conducted using an axillary approach in four cases and a femoral approach in 23cases. Additionally, translumbar contrast injection had been performed in eight cases	Through a comparison of these various techniques, we confirmed the MRI's effectiveness as a diagnostic tool for accurately evaluating aneurysms
Azevedo et al 2005 [18]	60 Patients ages ranging from 53 to 81 years among	CT, USG, MRI	**CT:** The CT images were captured using a GE Hi-Speed instrument, with scans ranging from 5-	USG proves reliable in diagnosing and

	that 48 patients were male and 12 were females		10mm both after as well as before contrast injection (2mL/kg) **USG:** GE 500 machine equipped with a 3.5MHz convex transducer was employed for the ultrasound (USG) imaging, capturing both transverse and longitudinal scans **MRI:** For MRI GE Signa 1.5Tesla instruments were used. 3D reconstruction had been conducted utilizing Advantage Workstation for Windows, version4.0. Patient preparation included a 4-hour fasting period as well as an intravenous injection of gadolinium-DTPA medium (30mL, 0.2mmol/kg)	monitoring AAAs, but Conventional CT may induce length measurement distortions in aortic dilatations. Conversely, MRI offers precise measurements for all parameters studied, proving highly valuable for evaluating AAA
Joseph et al 2020 [19]	230 Patients were selected and all patients were male	CT, MRI	**CT:** CT examinations were conducted helically using multidetector scanners. While CT examinations were performed across various platforms, the vast majority, approximately 90%, had been executed on GE scanners with a 120kVp tube potential. Automatic tube current modulation had been applied to all examinations, and axial images were reconstructed with thickness ranging from 1 to 5 mm **MRI:** Black blood MRI data were obtained at 3T using a MAGNETOM Skyra system from Siemens Healthcare, Erlangen, Germany. The acquisition employed a 3D T1-weighted fast spin echo sequence. Scan parameters included TR/TE of 800ms/20 ms, a 32×32cm 2 FOV(field of view), 52coronal slices, and an echo train length of60. The resolution was 1.3mm isotropic, and the scan duration was 7minutes	MRI technique is equivalent to CT in finding both reproducibility as well as accuracy of measuring AAA diameter

The qualitative assessment of the included studies was carried out according to the QUADAS (Quality Assessment of Diagnostic Accuracy Studies) tool (Table 2). The four studies all demonstrated a low risk of bias on patient spectrum, selection criteria, execution of index test and reference standard. However, some uncertainty seen in partial verification bias and reference standard review bias uncertainty. There were no significant concerns for test interpretation bias or withdrawals. The diagnostic performance outcomes are substantiated by the methodological rigor of the included studies.

Table 2: Quadas Analysis of Studies Included In This Systematic Review

ITEM	Eugenio et al 1995 [17]	Paolo Pavone et al 1990[18]	Azevedo et al 2005[19]	Joseph et al 2020 [20]
Spectrum composition	+	+	+	+
Selection criteria	+	+	+	+
Reference standard	+	+	+	+
Disease progression bias	+	+	+	+
Partial verification bias	?	?	+	+

Differential verification	+	+	+	-
Incorporation bias	+	+	+	+
Index test execution	+	+	+	+
Reference standard execution	+	+	+	+
Test review bias	+	+	+	+
Reference standard Review bias	?	?	?	?
Clinical review bias	+	+	+	+
Uninterpretable test results	+	+	+	+
Withdrawals	+	+	+	+

Table 2 shows QUADAS analysis of the included Studies. It is categorized as Yes "+ ", No "-" and Unclear "?"

DISCUSSION

This systematic review evaluates imaging modalities' effectiveness to diagnosis as well as AAA evaluation. Included studies utilized CT, USG, MRI, as well as angiography as imaging techniques. The review assessed the accuracy and precision of these modalities in detecting and measuring AAA.

Table 1 outlines outcomes as well as characteristics of research, highlighting strengths and limitations of each imaging modality. MRI consistently emerges as a superior diagnostic tool, providing precise measurements and accurate evaluations of AAA compared to CT, USG, and angiography. While CT remains widely used, especially with advancements in helical scanning technology, it may induce length measurement distortions in aortic dilatations, potentially impacting diagnostic accuracy. On the other hand, USG is reliable for initial diagnosis and monitoring but may lack precision in measuring AAA parameters.

Eugenio et al in the year 1995 reported that on comparing with CT, USG, MRI, as well as Angiography in evaluating AAA. Classification proposed by Lee and colleagues was employed to compare measurements obtained from MRI with those from CT as well as USG. The study found excellent agreement among the three imaging modalities in quantifying the maximum diameter of the aneurysm, indicating that any of these modalities could serve this purpose effectively. The study found excellent agreement among the three imaging modalities in quantifying the maximum diameter of the aneurysm, indicating that any of these modalities could serve this purpose effectively. Additionally, MRI offered advantages over CT in terms of defining anatomic details without the need for contrast material, which sometimes led to inadequate opacification in CT scans. MRI also required less imaging time and did not involve ionizing radiation, making it a preferred choice for a comprehensive assessment of AAA [17].

Paolo Pavone et al in the year 1990 reported that comparison of CT, USG, MRI, and Angiography in the evaluation of AAA. AAAs are prevalent, with reporting an incidence of up to 2% in earlier populations. Early detection is crucial, as elective resection carries a surgical mortality rate ranging from 2-5% and increases significantly to 12-20% in asymptomatic patients, and up to 50-60% in cases of rupture. However, in the present series, MRI has proven effective in defining AAAs. Clinically suspected aneurysms were confirmed by all imaging modalities. Both CT and MR accurately measured the external aneurysm diameter, with comparable results also obtained through the US, although potential overestimation has been noted in the US due to oblique scanning, particularly in obese patients or those with extensive bowel gas. CT enables differentiation between the patent lumen and intraluminal thrombus, particularly following the administration of contrast agents. MRI, on the other hand, distinguishes between them based on signal void related to hematic flow. Additionally, MRI's axial T1-weighted sequences reveal detectable signal intensity in the patent lumen, aiding in the differentiation from peripheral thrombus. Longitudinal extension of the aneurysm is better evaluated through MRI's coronal and sagittal images compared to axial CT images, similar to findings obtained with angiography. MRI exhibits high accuracy in detecting the involvement of renal and iliac arteries, with coronal scans providing improved visualization of renal artery origins. CT is beneficial for assessing iliac artery status, although its single axial view may not be optimal for detecting renal artery involvement in patients with infrarenal aneurysms and aortic tortuosity [18].

Azevedo et al in the year 2005 reported Comparisons between the diagnostic accuracy of different radiological methods for measuring aneurysms. Conventional CT was initially introduced in 1980 for diagnosing, as well as preoperative and postoperative assessments of AAAs. It offered clear imaging depicting the size and extent of the aneurysm, the presence of intraluminal thrombi, calcifications, anatomical anomalies, ruptures, and inflammatory components. Unlike angiography, conventional CT provides comprehensive visualization of vessel lumens, walls, and adjacent structures. The examination is brief, typically taking only a few minutes, and while intravenous iodide contrast mediums can be used, they may pose risks of nephrotoxicity and allergic reactions. Helical computerized tomography (HCT) represents an advancement over conventional CT. It generates images more rapidly, requires lower radiation exposure and contrast volume for patients, and allows for 3D reconstruction. Moreover, HCT mitigates distortions caused by breathing movements, a common issue with other imaging modalities. MRI was developed in the late 1980s, is a relatively non-invasive technique utilizing a powerful magnetic field and tissue characteristics to produce images in multiple planes. Unlike other imaging methods, MRI does not involve radiation exposure, radio-opaque contrasts, or arterial catheterization, thus avoiding associated adverse effects. It provides detailed visualization of vessel structures, including aneurysm lumens, walls, and perivascular structures. However, patients with pacemakers or metallic devices are not suitable candidates for MRI due to potential harm from the magnetic field in such conditions [19, 20].

Joseph et al in the year 2020 reported that all CT examinations were conducted using helical acquisition on multidetector scanners, employing various standard institutional protocols tailored for contrast-enhanced CT. These protocols encompassed CT angiography, routine portal-venous phase CT, and multiphase CT assessments for hepatic, pancreatic, and renal masses. Consequently, the dataset reflects a broad spectrum of CT techniques, mirroring advancements in scanners and imaging technologies over the 14 years. While CT scans were performed on diverse platforms, the vast majority, approximately 90%, utilized GE scanners with a 120 kVp tube potential. Automatic tube current modulation was uniformly applied to all examinations, with axial images reconstructed at thicknesses ranging from 1 to 5 mm. MRI data 3T using a MAGNETOM Skyra system from Siemens Healthcare, Erlangen, Germany. A 3D T1-weighted fast spin-echo acquisition with DANTE blood suppression was employed, utilizing an 18-channel body coil during free breathing. The scan parameters were as follows: TR/TE = 800 ms/20 ms; field of view (FOV) of 32×32 cm^2; acquisition of 52 coronal slices; echo train length of 60; resolution set at 1.3 mm isotropic; with a scan duration of 7 minutes (during free breathing). This MRI technique is comparable to CT regarding the precision and consistency of measuring aneurysm diameter [21].

The advantage of MRI's superiority lies in its ability to offer detailed measurements without the distortions associated with conventional CT methods. The various research reports [22, 23] consistently support MRI as an effective diagnostic tool for AAA evaluation. MRI's precision in measuring AAA diameter and its reproducibility, as highlighted by Joseph et al. (2020), further emphasize its clinical utility.The findings of this systematic review have important clinical implications. Clinicians can rely on MRI as a preferred imaging modality for accurate diagnosis and evaluation of AAA, especially when precise measurements are crucial for treatment decisions. While CT and USG remain valuable in certain contexts, MRI offers distinct advantages in terms of accuracy and precision. Understanding the strengths and limitations of each imaging modality can guide clinicians in selecting the most appropriate approach for AAA evaluation, ultimately improving patient care and outcomes.

CONCLUSION

In conclusion, this systematic review underscores the superiority of MRI in diagnosing and evaluating AAAs compared to other imaging modalities. Despite variations in study methodologies and potential biases, the consistent findings across included studies support MRI's efficacy and reliability in AAA assessment. However, further research and validation are warranted to confirm these findings and optimize imaging strategies for AAA management.

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Conflict of interest

The author hereby declares that there is no conflict of interest

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