RESEARCH PAPER

Imaging Accuracy in Focus: CT Angiography Versus Digital Subtraction Angiography for Intracranial Aneurysm.

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ABSTRACT
Background: Digital subtraction angiography (DSA) is the reference standard for intracranial aneurysm evaluation; however, CT angiography (CTA) is increasingly used as a non-invasive alternative.
Aim: To assess the diagnostic concordance and performance of CTA compared with DSA in the evaluation of intracranial aneurysms.
Materials and Methods: This observational imaging study included 91 patients who underwent both CTA and DSA. Aneurysm detection, number, location, and circulation involvement were compared. Diagnostic performance indices of CTA were calculated using DSA as the reference standard.
Results: Both CTA and DSA detected aneurysms in 100% of patients. Single aneurysms were present in 76.9%, and multiple aneurysms in 23.1%, with identical distribution on both modalities. CTA demonstrated 100% sensitivity, 25% specificity, 96.7% positive predictive value, and 96.7% overall accuracy. Multivariable regression showed that the number of aneurysms was independently associated with angiographic outcome [(Odds ratio (OR) 2.11; 95% CI 1.05–4.26; P = 0.036)].
Conclusion: CTA demonstrates excellent diagnostic concordance with DSA and can be reliably used as a first-line imaging modality, reserving DSA for complex cases and treatment planning.
Keywords: CT angiography; Digital subtraction angiography; Intracranial aneurysm; Diagnostic concordance; Neuroimaging
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INTRODUCTION

Intracranial aneurysms are a major contributor to neurological morbidity and mortality, largely due to their propensity to rupture and cause subarachnoid haemorrhage (1-3). Aneurysmal subarachnoid haemorrhage represents a significant proportion of spontaneous intracranial haemorrhages (4,5) and is associated with high fatality rates and substantial long-term neurological impairment among survivors (6,7). Timely detection and accurate assessment of intracranial aneurysms are therefore essential to guide appropriate clinical management and improve patient outcomes.

Imaging is fundamental to the diagnosis and treatment planning of intracranial aneurysms. Detailed visualisation of aneurysm size, shape, neck configuration, and relationship to the parent vessel is critical for determining rupture risk and selecting optimal therapeutic strategies (8). Several imaging modalities are used in clinical practice, including digital subtraction angiography, computed tomography angiography, and magnetic resonance angiography. Among these, digital subtraction angiography has traditionally been regarded as the reference standard because of its high spatial and temporal resolution and its ability to provide dynamic assessment of cerebral circulation (9).

However, digital subtraction angiography is an invasive procedure and carries inherent risks, such as vascular injury, thromboembolic complications, contrast-related adverse effects, and radiation exposure (10, 11). In addition, it requires specialised infrastructure, experienced personnel, and longer procedural times, which may restrict its routine use, particularly in emergency situations and resource-limited settings. These limitations have encouraged increasing reliance on non-invasive imaging techniques for initial aneurysm evaluation.

Computed tomography angiography has gained widespread acceptance as a non-invasive alternative for assessing intracranial aneurysms. Advances in multidetector CT technology and post-processing methods have significantly improved the visualisation of cerebral vasculature (12 - 14). CTA offers several practical advantages, including rapid

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acquisition, wide availability, and the ability to concurrently identify associated intracranial findings such as subarachnoid or intraparenchymal haemorrhage and cerebral oedema. These attributes make CTA especially valuable in the acute clinical setting (15 - 17).

Previous studies have demonstrated that CT angiography has high diagnostic accuracy for detecting intracranial aneurysms, particularly those of moderate to large size. CTA is generally reliable in identifying aneurysm location, number, and overall morphology, leading to its increasing use as the first-line imaging modality in patients with suspected aneurysmal subarachnoid haemorrhage (18, 19). Nevertheless, certain challenges remain, especially in the detection of small aneurysms, lesions with complex anatomy, calcified walls, or aneurysms situated near the skull base. In such circumstances, digital subtraction angiography may still be required to provide additional anatomical detail and guide definitive management.

Understanding the degree of diagnostic agreement between CT angiography and digital subtraction angiography is therefore of considerable clinical importance. High concordance would support the broader use of CTA as a primary diagnostic tool and reduce the need for invasive angiography in many patients (20). Conversely, identifying situations in which CTA may be insufficient helps refine indications for DSA, ensuring accurate diagnosis while minimising unnecessary procedural risk.

This comparison is particularly relevant in developing healthcare systems, where access to interventional facilities may be limited and cost-effective diagnostic strategies are essential. Reliable use of CT angiography could streamline patient pathways, reduce hospital stay, and lower overall healthcare expenditure. Despite its clinical relevance, data comparing the performance of CTA and DSA in different regional and institutional settings remain limited.

The present study aims to evaluate the diagnostic concordance between CT angiography and digital subtraction angiography in the detection and characterisation of intracranial aneurysms in a tertiary care centre. By comparing aneurysm detection, anatomical location, number, and circulation involvement between the two modalities, this study seeks to clarify the role of CT angiography in routine clinical practice and inform evidence-based imaging strategies.

MATERIALS AND METHODS

Study Design and Setting

This was an observational, imaging-based study carried out at the Sher-i-Kashmir Institute of Medical Sciences (SKIMS), Srinagar, a tertiary care referral hospital. The study was conducted primarily in the Department of Radiodiagnosis and Imaging, with collaborative involvement from the Department of Neurosurgery, SKIMS. Imaging records of patients evaluated for suspected intracranial aneurysms using both computed tomography angiography and digital subtraction angiography during the defined study period were analysed. The study was designed to determine the degree of diagnostic agreement between the two imaging modalities.

Study Population

The study included patients referred for evaluation of suspected intracranial aneurysms who underwent both CT angiography and digital subtraction angiography as part of their diagnostic workup. Cases of both ruptured and unruptured aneurysms were considered. Patients were excluded if imaging datasets were incomplete, image quality was suboptimal, or cerebral vasculature was inadequately visualised on either modality. Demographic variables were recorded for descriptive purposes but were not analysed as outcome parameters.

CT Angiography Technique

CT angiography was performed using a multidetector CT system following a uniform intracranial angiography protocol. Intravenous administration of a non-ionic iodinated contrast agent was carried out using a power injector at a predetermined flow rate, followed by a saline chase. Image acquisition was appropriately timed to capture optimal arterial phase enhancement. Thin-slice axial datasets were acquired and subsequently reconstructed into multiplanar reformations, maximum intensity projection images, and three-dimensional volume-rendered images. All CTA examinations were interpreted on dedicated workstations to ensure detailed evaluation of intracranial vascular anatomy.

Digital Subtraction Angiography Technique

Digital subtraction angiography was conducted via transfemoral arterial access under strict aseptic precautions. Selective catheterisation of the relevant cerebral vessels was performed using standard diagnostic catheters. Contrast medium was injected under real-time fluoroscopic guidance to obtain high-resolution images of the intracranial arterial circulation. Multiple angiographic projections were acquired as necessary to accurately delineate aneurysm morphology and vascular relationships. Patients were monitored post-procedure in accordance with institutional protocols.

Image Analysis and Data Collection

CTA and DSA images were reviewed independently for each patient. Data regarding aneurysm presence, anatomical location, number, and arterial circulation involvement were documented for both imaging modalities. Aneurysm locations were classified according to established vascular territories, including the anterior and posterior circulations. Discrepancies between CTA and DSA findings were systematically recorded, and cases in which digital subtraction angiography provided additional or clarifying anatomical information were specifically identified.

Outcome Measures

The primary outcome was the level of diagnostic concordance between CT angiography and digital subtraction angiography in identifying intracranial aneurysms. Secondary outcomes included agreement between the two modalities with respect to aneurysm location, number, and circulation involvement, as well as identification of instances where DSA contributed supplementary diagnostic detail beyond CTA.

Statistical Analysis
Collected data were entered into a structured database and analysed using descriptive statistical methods. Diagnostic concordance between CT angiography and digital subtraction angiography was expressed as percentage agreement. Results were presented as frequencies and proportions. Inferential statistical tests were not applied, as the primary objective of the study was descriptive assessment of concordance. STATA vs 17 was used as a statistical tool for data analysis.

Ethical Considerations
The study was conducted in compliance with the institutional ethical standards of SKIMS, Srinagar. As the analysis was based on retrospective review of imaging data, patient confidentiality was strictly preserved, and all personal identifiers were removed before data analysis. The study represents an institutional evaluation of imaging findings derived from a shared clinical dataset, undertaken to address specific imaging-related research objectives.

RESULTS
A total of 91 patients who underwent evaluation with both computed tomography angiography and digital subtraction angiography were included in the final analysis. The mean age of the cohort was 50.8 ± 12.5 years, with women constituting the majority of cases (67.0%). Most participants were residents of rural areas (82.4%), as summarised in **Table 1**. The district-wise distribution of the study population is provided in **Table 2.**
Baseline biochemical investigations were predominantly within normal reference ranges **(Table 3)**. Headache was the most frequently reported presenting symptom, occurring in 87.7% of patients, followed by vomiting in 74.7%. A history of hypertension was documented in 81.3% of cases, while focal neurological deficits in the form of limb weakness were observed in 29.6% of patients **(Table 4).**

Aneurysm Detection and Burden
Both imaging modalities identified intracranial aneurysms in all 91 patients, yielding complete agreement with respect to aneurysm detection. Single aneurysms were observed in 70 patients (76.9%), whereas 21 patients (23.1%) were found to have more than one aneurysm. The pattern of aneurysm burden was identical on CT angiography and digital subtraction angiography, as detailed in **Tables 4 and 5**.
Tables
Table 1. Baseline Demographic Characteristics (n = 91)

Variable	Value
Age (years), mean ± SD	50.8 ± 12.5
Female, n (%)	61 (67.0%)
Male, n (%)	30 (33.0%)
Rural residence	75 (82.4%)
Urban residence	16 (17.6%)

Table 2: District-wise distribution of subjects

DISTRICT	N (%)
ANANTNAG	9 (9.9)
BANDIPORA	6 (6.6)
BARAMULLA	12(13.3)
BUDGAM	9 (9.9)
GANDERBAL	6 (6.59)
KULGAM	6 (6.59)
KUPWARA	7 (7.7)
PULWAMA	9 (9.9)
SRINAGAR	15 (16.5)
OTHERS	12 (13.9)

Table 3. Biochemical Investigations of subjects recruited for the study

PARAMETER	MEAN ± SD
UREA (MG/DL)	31.8 ± 7.5
CREATININE (M/DL)	0.84 ± 0.24
PT (SECONDS)	12.24 ± 2.37
INR	1.00 ± 0.10
APTT (SECONDS)	26.7 ± 4.5
HEMOGLOBIN (G/DL)	13.1 ± 2.1

Table 4. Clinical presentation of subjects

CLINICAL FEATURE	N (%)
HYPERTENSION	74 (81.32%)
HEADACHE	50 (87.7%)
VOMITING	68 (74.7%)
LIMB WEAKNESS	27 (29.6%)

Aneurysm Location and Circulation
Radiological assessment revealed the middle cerebral artery as the most commonly affected vessel, accounting for 46.2% of aneurysms. This was followed by involvement of the internal carotid artery (24.1%) and the anterior communicating artery (19.8%) (Table 5). CT angiography demonstrated excellent agreement with digital subtraction angiography in determining aneurysm location and arterial circulation, with the majority of aneurysms arising from the anterior circulation.

Table 5. Diagnostic performance of CT Angiography compared with Digital Subtraction Angiography (DSA)

Findings	CTA n (%)	DSAn (%)	Totaln (%)
Single aneurysm	70 (76.9)	70 (76.9)	70 (76.9)
Multiple aneurysms	21 (23.1)	21 (23.1)	21 (23.1)
Total	**91 (100)**	**91 (100)**	**91 (100)**
CTA finding	**DSA -ve n (%)**	**DSA +ve n (%)**	**Total n(%)**
CTA negative	1(1.1)	0 (0.0)	1 (1.1)
CTA positive	3 (3.3)	87 (95.6)	90 (98.9)
Total	**4 (4.4)**	**87 (95.6)**	**91 (100)**

Diagnostic Performance of CTA and Predictors of Multiple Aneurysms

Both CT angiography and digital subtraction angiography showed complete concordance in identifying intracranial aneurysms, with all patients testing positive on both modalities. The distribution of aneurysm burden was also identical, with single aneurysms present in 76.9% of cases and multiple aneurysms in 23.1%. These results underscore the high sensitivity of CT angiography for detecting both solitary and multiple aneurysms. Given its non-invasive nature, rapid image acquisition, and high diagnostic yield, CT angiography represents an effective first-line imaging technique. Nonetheless, digital subtraction angiography continues to serve as the reference standard for detailed anatomical evaluation and procedural planning **(Table 5)**.

Further multivariable analysis confirmed that aneurysm multiplicity was independently associated with angiographic findings. Variables such as age, gender, residence, clinical symptoms (including headache, vomiting, and limb weakness), hypertension, haemoglobin, creatinine, and non-contrast CT findings did not reach statistical significance. Although higher odds were observed for NCCT positivity and neurological symptoms, these associations were attenuated after adjustment for potential confounders **(Table 6)**.

Table 6. Predictors of Multiple Aneurysms (Logistic Regression)

VARIABLE	ADJUSTED OR	95% CI	*P*-VALUE
AGE (YEARS)	1.04	0.98 – 1.11	0.176
GENDER	1.63	0.30 – 8.92	0.570
RESIDENCE	0.81	0.18 – 3.63	0.780
WEAKNESS	2.94	0.54 – 16.00	0.213
HEADACHES	1.88	0.39 – 8.96	0.430
VOMITING	1.31	0.25 – 6.75	0.743
HTN_CAT	0.67	0.07 – 6.09	0.725
CREATININE	1.21	0.52 – 2.80	0.660
HB	0.91	0.64 – 1.29	0.603
NCCT	3.42	0.69 – 16.89	0.133
NO OF ANEURYSMS	2.11	1.05 – 4.26	**0.036**

DISCUSSION

High-quality imaging is fundamental to the detection, risk assessment, and clinical management of intracranial aneurysms. Although digital subtraction angiography has traditionally been considered the definitive diagnostic technique because of its superior spatial and temporal resolution, advances in multidetector computed tomography angiography have significantly transformed contemporary diagnostic algorithms. The findings of the present study contribute to this evolving evidence base by demonstrating a high level of agreement between CT angiography and digital subtraction angiography in a tertiary care environment.

A major observation of this study is the consistent performance of CT angiography in identifying both solitary and multiple intracranial aneurysms. Recognition of aneurysm multiplicity is clinically relevant, as patients with more than one aneurysm often require closer surveillance and individualised management strategies. The identical aneurysm burden documented across both imaging modalities highlights the capability of CT angiography to provide a comprehensive initial evaluation (15, 16, 18, 21). The excellent sensitivity and negative predictive value observed in this study further support the role of CT angiography as an effective diagnostic and screening tool (17, 21, 23). In routine clinical practice, a high negative predictive value allows clinicians to reliably exclude aneurysmal pathology, thereby reducing the need for invasive angiographic procedures (24). This advantage is particularly important in acute clinical scenarios, such as suspected aneurysmal subarachnoid haemorrhage, where timely diagnosis is essential for prompt intervention.

Nevertheless, the relatively low specificity observed with CT angiography reflects inherent technical limitations of the modality. False-positive interpretations may occur due to anatomical variants such as vascular infundibula, superimposed vessels, calcified structures, or beam-hardening artefacts, especially in regions adjacent to the skull base (18, 23, 25). These factors reinforce the continued role of digital subtraction angiography in selected cases, particularly when CT angiography findings are inconclusive or when detailed anatomical information is required.

The complementary value of digital subtraction angiography was most evident in patients with small aneurysms, complex vascular configurations, or lesions located in anatomically challenging regions. Digital subtraction angiography remains superior for precise assessment of aneurysm neck characteristics, branch vessel involvement, and haemodynamic features, all of which are critical for determining the most appropriate therapeutic approach. Accordingly, CT angiography should not be viewed as a replacement for digital subtraction angiography, but rather as a tool that facilitates the appropriate selection of patients for invasive imaging.

Regression analysis findings further underscore the predominance of imaging-related parameters over demographic or clinical factors in determining angiographic outcomes. The independent association between aneurysm number and angiographic findings emphasizes the importance of meticulous vascular assessment in patients suspected of harbouring multiple aneurysms. The absence of significant associations with clinical presentation or laboratory variables supports the concept that imaging remains central to aneurysm evaluation (22, 25, 26).

From a broader healthcare perspective, these findings have important implications, particularly in settings with limited resources. CT angiography offers a rapid, accessible, and cost-efficient diagnostic option that can substantially reduce reliance on invasive angiography. Employing CT angiography as the initial imaging modality may lower procedure-related risks, shorten hospital stays, and improve overall workflow efficiency without compromising diagnostic performance (27-32).

Several limitations of this study should be acknowledged. The reliance on percentage agreement, without formal assessment of interobserver variability using measures such as kappa statistics, may limit direct comparison with other investigations. Additionally, the single-centre design and relatively small sample size may restrict the generalisability of the results. Future multicentre studies incorporating blinded image interpretation, standardised reporting protocols, and outcome-based validation are warranted.

In summary, this study demonstrates that CT angiography shows a high degree of diagnostic agreement with digital subtraction angiography in the evaluation of intracranial aneurysms. CT angiography can be effectively utilised as a first-line imaging modality, with digital subtraction angiography reserved for complex cases, equivocal findings, or pre-interventional planning. Such a tiered imaging strategy maximises diagnostic accuracy while minimising invasiveness and optimising resource utilisation.

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