Open Access
ISSN: 2663-9491 e-ISSN: 2789-6897

Diagnostic Performance of Computed Tomography Angiography for the Detection of Intracranial Ruptured Aneurysms in Patients with Spontaneous Subarachnoid Hemorrhage: Compared with Digital Subtraction Angiography

Yasna Kibria[1*], Nazrul Islam[2], Bishwajit Bhowmik[3], Tanbir Siddique[4], Shanta Islam Mou[5], Tania Kabir[6], Farzana Alam[7]

Received: 22 Apr 2026
Accepted: 30 Apr 2026
Published Online: 6 May 2026

Published by:
Gopalganj Medical College, Gopalganj, Bangladesh

*Corresponding Author

DOI: 10.5281/zenodo.20056426

Copyright © 2026 The Insight

This article is licensed under a Creative Commons Attribution 4.0 International License.

ABSTRACT

Background: *Subarachnoid hemorrhage (SAH) is a significant cause of morbidity and mortality. Early and accurate aneurysm detection and evaluation are essential for effective treatment planning. Computed tomography angiography (CTA) provides a rapid, non-invasive diagnostic option, but its accuracy needs comparison with digital subtraction angiography (DSA), which remains the gold standard.* ***Objective:*** *To compare the diagnostic accuracy of CTA with DSA for detecting intracranial aneurysms in patients with spontaneous SAH.* ***Methods & Materials:*** *Thirty patients with spontaneous SAH were enrolled following IRB approval and informed consent. All underwent CTA at BMU and DSA at DMCH within 48–72 hours. DSA served as the gold standard. The sensitivity, specificity, PPV, NPV, and accuracy of CTA for aneurysm detection were calculated against DSA.* ***Results:*** *The mean age was 52.2 ± 9.8 years (range 32–72), with the highest incidence in the 51–60-year group (36.7%). Females predominated (63.3%), yielding a male-to-female ratio of 1:1.7. Hypertension (76.7%) was the most common risk factor, followed by smoking (33.3%). The leading presenting features were thunderclap headache and neck stiffness (63.3% each). CTA detected 31 aneurysms in 27 patients (90.0%). DSA detected 34 aneurysms in 28 patients (93.3%). Diagnostic performance of CTA demonstrated 96.4% sensitivity, 100% specificity, 100% PPV, 66.7% NPV, and 96.7% diagnostic accuracy.* ***Conclusion:*** *CTA demonstrated excellent diagnostic accuracy, comparable to invasive DSA, in detecting intracranial aneurysms among spontaneous SAH patients.*

Keywords: *SAH, CTA, DSA, Intracranial aneurysm, Diagnostic performance, accuracy*

(The Insight 2026; 9(2): 240-245)

1. *Medical Officer, Department of Radiology & Imaging, National Institute of Neurosciences & Hospital, Dhaka, Bangladesh (ORCID: 0009-0000-5954-2742)*
2. *Professor & Chairman, Department of Radiology and Imaging, Bangladesh Medical University, Dhaka, Bangladesh*
3. *Professor, Department of Radiology & Imaging, Bangladesh Medical University, Dhaka, Bangladesh*
4. *Registrar, Endovascular and Stroke Surgery, Department of Neurosurgery, National Institute of Neurosciences & Hospital, Dhaka, Bangladesh*
5. *Radiologist, Department of Radiology & Imaging, 250 Bedded General Hospital, Khulna, Bangladesh*
6. *Medical Officer, OSD, DGHS, Dhaka, Bangladesh*
7. *Medical Officer, Department of Radiology & Imaging, National Gastroliver Institute and Hospital, Dhaka, Bangladesh*

INTRODUCTION

Subarachnoid hemorrhage (SAH) continues to be a significant concern for the neurosurgical emergency unit. The annual incidence ranges from 10 to 16 per 100,000, and the incidence increases with age [1]. It is broadly classified into two categories: traumatic SAH and non-traumatic or spontaneous SAH [2]. The history of trauma is the most common etiological factor. The most common spontaneous causes are aneurysms (50-75%), vascular malformations, hypertension, and atherosclerosis [3,4]. Vascular variations are also recognized as contributors to aneurysms [5]. Intracranial aneurysms seldom rupture, but the risk increases with size. The 5-year cumulative rupture rates for aneurysms in the internal carotid artery, anterior communicating or anterior cerebral artery, or middle cerebral artery were 0%, 2. 6%, 14.5%, and 40% for aneurysms less than 7 mm, 7-12 mm, 13-24 mm, and 25 mm or greater, respectively [6]. SAH typically occurs between the ages of 45 and 60 [7]. A significant majority, around 90%, of individuals experiencing subarachnoid hemorrhage (SAH) resulting from aneurysmal rupture typically present themselves to the emergency department, expressing symptoms of intense headache. The fatality rate in people diagnosed with subarachnoid hemorrhage (SAH) exceeds 70%. The re-bleeding risk for bleeding aneurysms is 50% within the initial 6-month period, but the bleeding risk for non-bleeding aneurysms is 1% within the first year [8]. Subarachnoid hemorrhage due to aneurysm rupture is a critical clinical situation requiring highly experienced surgical and medical care [9]. In prospective and retrospective autopsy studies, the prevalence of risk of rupture of intracranial aneurysms was 3.6% and 0.4%, respectively, and in prospective and retrospective angiographic investigations, the prevalence was 6.0% and 3.7%, respectively [10]. Approximately 30% of patients display multiple aneurysms. Most aneurysms are minor and asymptomatic, but when an intracranial aneurysm ruptures, it typically bleeds into the

subarachnoid space, resulting in a subarachnoid hemorrhage (SAH), and less frequently into the brain parenchyma, resulting in a parenchymal hemorrhage (PHA) [11]. During the development of an aneurysm, it usually forms a neck with a dome. The length of the neck and the size of the dome are variable and are important factors in planning neurosurgical obliteration or endovascular embolization [12]. The goal of aneurysm treatment is to achieve a reliable and rapid occlusion while protecting the main arterial structures. The success of the treatment depends on several variables, including the patient's initial condition, the choice of treatment method, the timing, the expertise of the medical team, and the center's amenities. However, accurate evaluation of the aneurysm and surrounding tissues is one of the most significant predictors of treatment success [1]. Digital subtraction angiography (DSA) and computed tomography angiography (CTA) are the imaging modalities most commonly used for the diagnosis of intracranial aneurysms. CTA is a vascular imaging technique that entails obtaining a normal computed tomography (CT) scan while injecting intravenous contrast material. Due to the radio-opacity of the contrast material, it appears white on the CT image. A computer program analyzes the contrast-enhanced serial axial segments to generate a three-dimensional (3D) reconstruction of the vascular anatomy. The resultant dynamic images can be rotated to observe the image from multiple perspectives [13]. In the past 10 to 15 years, cerebral CTA has been increasingly used to diagnose intracranial aneurysm rupture early. CTA is more dependent on the technical parameters employed than on the patient. The total scanning duration is less than one minute, so most patients tolerate it well. CTA can be performed after a plain/ non-contrast CT scan. Positive CTA results can direct treatment administration [14]. Multi-detector CTA, a non-invasive technique, is important in accurately detecting aneurysms during emergency screening for SAH [15]. CTA is increasingly utilized in SAH diagnostic triage. A literature review reveals that 16-slice CTA has a high sensitivity, specificity, accuracy, PPV, and NPV (nearly reaching 100%) for aneurysms larger than 3 mm [16]. Nevertheless, CTA detects aneurysms smaller than 3 mm with a sensitivity spanning from 74% to 84% [15]. Overall sensitivity and specificity for 16-slice CTA per patient are 98.4% and 99.7%, respectively, and per aneurysm, they are 96.9% and 98%, respectively [17,18]. Overall, MD-CTA sensitivity, specificity, and accuracy on a per-aneurysm basis were 92.5%, 93.3%, and 92.6%, respectively, compared with DSA [19].

METHODS & MATERIALS

Analytical, cross-sectional design was conducted in Department of Radiology & Imaging, Bangladesh Medical University, Dhaka, in collaboration with the Department of Neurosurgery, Dhaka Medical College and Hospital, Dhaka from April 2023 to June 2025 the target sample size was 30. Adult patients with spontaneous SAH detected by cranial non-contrast (plain) CT scans with clinical suspicion of harboring intracranial aneurysms, admitted to the Department of Neurosurgery, DMCH.

Inclusion criteria:

- Adult (≥18 years) patients of both sexes
- Patients with spontaneous SAH detected by a non-contrast cranial CT scan
- Patient/patient's legal guardian is willing to give informed written consent for the study

Exclusion criteria:

- SAH with intracerebral hemorrhage
- Aneurysms associated with AVM
- Postoperative or post-coiling patients with recurrence/residual aneurysms
- Patient with a history of bleeding disorder or anticoagulant therapy
- Patient with comorbid conditions- Severe renal failure, Cardiac failure, etc
- Previous allergic reaction to contrast media.
- Pregnant and lactating patient

Data collection technique

A pretested data collection sheet was used to collect data. Patient information was obtained using an information sheet that included a questionnaire, clinical findings, and radiological findings.

Statistical analysis of data

Data were organized in a master sheet. Continuous variables were summarized as mean and standard deviation, while nominal/categorical variables were summarized as proportions (%). The t-test was used for continuous variables, whereas Fisher's exact test was used for nominal/categorical variables. Sensitivity, specificity, positive predictive value, negative predictive value, and CTA diagnostic accuracy were calculated per standard formulae. p-value < 0.05 was considered significant. Statistical analysis was carried out by using the Statistical Package for Social Sciences (SPSS) version 26.0.

Ethical Consideration

Before the commencement of this study, proper permission was obtained from the departments and institutes concerned for this study and the respective authorities (IRB) approved the research protocol. All the patients included in this study were informed about the risks and benefits of the study. Proper informed written consent was obtained from the guardians or patients in an easily understandable local language. It was ensured that all information and records were kept confidential.

RESULTS

Table I shows that the majority of the patients with spontaneous SAH were in the 51–60 years' age group, accounting for 36.7% of the study population. This was followed by the 41–50 years' group with 33.3%, while patients aged over 60 years constituted 16.7%. The lowest frequency was observed in the 30–40 years' group (13.3%). The majority of the study population, accounting for 63.3% of the patients with spontaneous subarachnoid hemorrhage, while males comprised 36.7%.

Table I: Age distribution of the study patients (*n*=30)

Age group (years)	Frequency (N)	Percentage (%)
30-40	4	13.3
41-50	10	33.3
51-60	11	36.7
61-72	5	16.7
Mean ± SD	52.2±9.82	

Total	30	100.0
Sex		
Male	11	36.7
Female	19	63.3
Ratio	1:1.7	

Table II shows the distribution of the study patients according to their clinical features. Thunderclap headache and neck pain or stiffness were the most common presenting symptoms, each reported in 63.3% of patients. Photophobia was present in 60.0% of cases, while vomiting and nausea were reported in 56.7% of patients each. Loss of consciousness was the least common symptom, observed in 40.0% of patients.

Table II: Distribution of the study patients by clinical features (*n*=30)

Clinical features	Frequency (N)	Percentage (%)
Thunderclap headache	19	63.3
Neck pain or stiffness	19	63.3
Photophobia	18	60.0
Vomiting	17	56.7
Nausea	17	56.7
Loss of consciousness	12	40.0

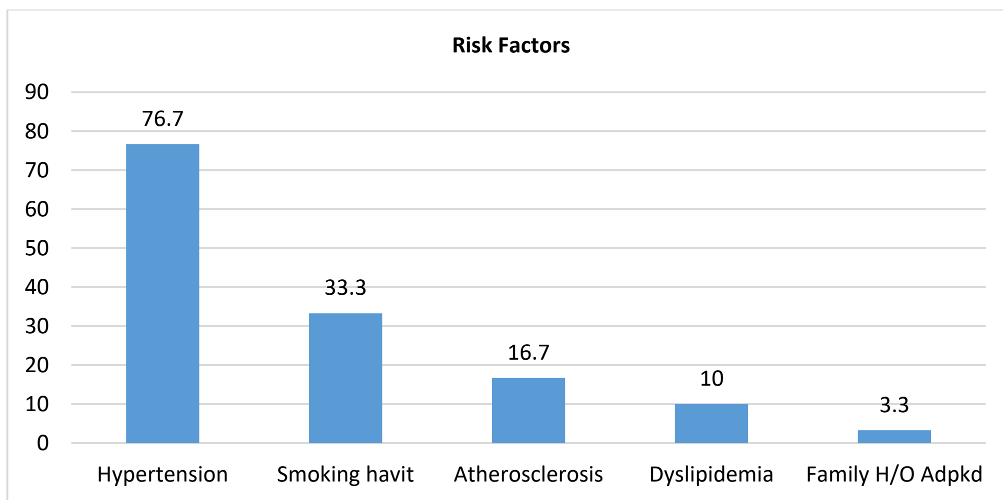

Figure 1: Bar diagram showing the important risk factors of the study participants (*n*=30)

Figure 1 presents the distribution of study patients according to their key risk factors. Hypertension was the most prevalent risk factor, observed in 76.7% of patients. Smoking habit was present in 33.3% followed by atherosclerosis and dyslipidemia, which were present in 16.7% & 10.0% of patients, respectively. Family history of autosomal dominant polycystic kidney disease (ADPKD) was the least common, found in only 3.3% of cases.

Table III shows the distribution of study patients by the modified Fisher Grading scale for SAH on plain cranial CT scan. Grade 1 SAH was observed in 53.33% of patients, while grade 2 SAH was seen in only 3.33% of patients. 26.67% patients showed grade 3, and 16.67 % patients showed grade 4 SAH.

Table III: Distribution of the study patients by modified Fisher Grading scale for SAH in plain cranial CT scan (*n*=30)

Grade	Modified Fisher	Frequency (N)	Percentage (%)
1	Thin SAH, no IVH	16	53.33
2	Thin SAH, with IVH	01	3.33
3	Thick SAH, no IVH	08	26.67
4	Thick SAH, with IVH	05	16.67

Table IV shows the distribution of aneurysms among the study participants as detected by CTA and DSA. Both modalities revealed that the majority of patients had a single aneurysm, 76.7% by CTA and 83.3% by DSA, indicating that a solitary aneurysm was the most common. Multiple aneurysms were detected in 10.0% of patients by both CTA and DSA. No aneurysm was reported in 10.0% of patients by CTA and in 6.7% by DSA.

Table IV: Distributions of the number of aneurysms among spontaneous SAH patients in CTA and DSA (*n*=30)

Number of Aneurysms	CTA	DSA
Single aneurysm	24(76.7%)	25(83.3%)
Multiple aneurysm	3(10.0%)	3(10.0%)
No aneurysm	3(10.0%)	2(6.7%)
Total	30(100.0%)	30(100.0%)

Table V shows the distribution of aneurysms according to their anatomical locations as detected by CTA and DSA. The majority of aneurysms were located in the anterior circulation, comprising a total of 26 in number (83.9%) by CTA and a total of 28 in number (82.4%) by DSA. Within the anterior circulation, the anterior communicating artery (ACOM) was the most common site, detecting 11 aneurysms by both CTA (35.5%) and by DSA (32.4%).

Table V: Distribution of the aneurysms by anatomical locations in CTA and DSA (*n*=30)

Anatomical Location	CTA (N=31)	DSA (N=34)
Anterior circulation	26(83.9%)	28(82.4%)
ACOM	11(35.5%)	11(32.4%)
MCA	7(22.6%)	7(20.6%)
ACA	6(19.4%)	6(17.6%)
ICA	2(6.5%)	3(8.8%)
Ophthalmic artery	0(0.0%)	1(2.9%)
Posterior circulation	5(16.1%)	6(17.6%)
Basilar artery	2(6.5%)	2(5.9%)
Vertebral artery	2(6.5%)	2(5.9%)
PCOM	1(3.2%)	2(5.9%)

Table VI shows the distribution of aneurysm shapes as detected by CTA and DSA. Saccular aneurysms were the predominant type, accounting for 90.3% of aneurysms detected by CTA and 91.2% detected by DSA.

Table VI: Distribution of the shape of the detected aneurysms in CTA and DSA (*n*=30)

Aneurysm Shape	CTA (N=31)	DSA (N=34)
Saccular	28(90.3%)	31(91.2%)
Fusiform	3(9.7%)	3(8.8%)
Total	31(100.0%)	34(100.0%)

Table VII shows the distribution of aneurysm size as detected by CTA and DSA. The majority of aneurysms were medium-sized (5–12 mm), comprising 90.3% of total aneurysms by CTA and 79.4% by DSA. Small aneurysms (≤4 mm) were a relatively uncommon finding in CTA, detecting only 1 (3.2%) aneurysm, measuring 2.8x2.5 mm, noted at ACOM. Meanwhile, 4(11.7%) small aneurysms were detected by DSA; 3 of them were missed by CTA.

Table VII: Distribution of the size of the detected aneurysms in CTA and DSA (*n*=30)

Size of the aneurysms	CTA (N=31)	DSA (N=34)
Small aneurysm (≤4mm)	1(3.2%)	4(11.7%)
Medium aneurysm (5 - 12 mm)	28(90.3%)	27(79.4%)
Large aneurysm (≥13 mm)	1(3.2%)	2(5.8%)
Giant aneurysm (>25 mm)	1(3.2%)	1(2.9%)

Table VIII shows the distribution of aneurysm morphology as detected by CTA and DSA. Aneurysmal lobulation and bleb/tit were observed in CTA as accurately as DSA, each of them detecting a total of 8 lobulated aneurysms and 5 aneurysms with bleb. CTA detected 2 (6.5 %) aneurysms with calcified walls and 1 (3.2%) aneurysm having intraluminal thrombus.

Table VIII: Distribution of other important morphologies of the aneurysms detected with CTA and DSA (*n*=30)

Angiogram findings	CTA (N=31)	DSA (N=34)
Lobulation	8(25.8%)	8(23.5%)
Bleb/tit	5(16.1%)	5(14.7%)
Calcification	2(6.5%)	0
Thrombus	1(3.2%)	0

Table IX shows the comparison of saccular aneurysm size parameters between CTA and DSA. The mean dome-to-neck ratio of 28 saccular aneurysms detected by CTA was 2.09 ± 0.67, and that of 31 saccular aneurysms detected by DSA was 2.12 ± 0.70. The mean aspect ratio of 28 saccular aneurysms detected by CTA was 2.47 ± 1.07, and that of 31 saccular aneurysms detected by DSA was 2.58 ± 1.12.

Table IX: Comparison of dome-neck ratio and aspect ratio of saccular aneurysms detected with CTA and DSA (*n*=30)

Parameter	CTA (N=28)	DSA (N=31)	p-value
Dome-Neck Ratio (Mean ± SD)	2.09±0.67	2.12±0.70	0.85
Aspect Ratio (Mean ± SD)	2.47±1.07	2.58±1.12	0.71

Table X shows the diagnostic performance of CTA compared with DSA, the gold standard, for detecting intracranial aneurysms on a per-patient basis. CTA demonstrated very high sensitivity (96.4%) and perfect specificity (100.0%). The positive predictive value (PPV) was 100.0%, confirming that all aneurysms identified by CTA were true aneurysms. The negative predictive value (NPV), however, was comparatively lower, 66.7%, reflecting that a few aneurysm cases were missed by CTA.

Table X: Diagnostic Performance of CTA in Comparison to DSA for the Detection of Intracranial Ruptured Aneurysms (*n*=30)

CTA findings	DSA findings		Total
	Aneurysm Positive	Aneurysm Negative	
Aneurysm Positive	27 (True Positive)	0 (False Positive)	27
Aneurysm Negative	1 (False Negative)	2 (True Negative)	3
Total	28	2	30
Diagnostic validity test	Values	95% CI	
Sensitivity	96.4%	81.6% to 99.9%	
Specificity	100.0%	15.8% to 100.0%	
Positive Likelihood Ratio	-	-	
Negative Likelihood Ratio	0.04	0.01 to 0.24	
Positive Predictive Value	100.0%	87.2% to 100.0%	
Negative Predictive Value	66.7%	22.5% to 93.2%	
Accuracy	96.7%	82.7% to 99.9%	

DISCUSSION

This study was designed as a cross-sectional investigation to compare the diagnostic performance of Computed Tomography Angiography (CTA) with Digital Subtraction Angiography (DSA) in detecting intracranial aneurysms among patients presenting with spontaneous subarachnoid hemorrhage (SAH). In the present study, the mean age of patients presenting with spontaneous subarachnoid hemorrhage (SAH) was 52.2 ± 9.82 years, ranging from 32 to 72 years. The majority of cases (36.7%) were concentrated in the 51–60-year age group, followed closely by the 41–50-year group. This distribution reflects the well-established epidemiological pattern in which aneurysmal SAH predominantly affects individuals in mid to late adulthood. Chowdhury *et al*. similarly reported that most of their SAH patients were between 41 and 60 years of age, with an average age of 53.33 ± 11.1 years, reinforcing the age-associated susceptibility to aneurysmal rupture [20]. In comparison, Rumi *et al*. documented a slightly older mean age of 58.53 ± 7.54 years, with the highest prevalence among patients aged 60 to 72 years [21]. In the present study, 63.3% of patients diagnosed with spontaneous subarachnoid hemorrhage (SAH) were female and 36.7% were male, resulting in a male-to-female ratio of approximately 1:1.7. This observation is consistent with a growing body of evidence indicating a female predominance in aneurysmal SAH. Chowdhury *et al.* similarly reported a female majority (58%) with a male-to-female ratio of 1:1.38 in their cohort, while Begum *et al*. found that 50% of their aneurysmal SAH patients were female [20, 22]. In our study, the most prevalent comorbidity was hypertension (76.7%), followed by smoking habits in 33.3% of patients. These findings align with those reported by Mohammad *et al*., who identified hypertension in 73% and smoking in 37% of aneurysmal SAH cases in the Bangladeshi population [23]. Only one (3.3%) of our patients had a family history of ADPKD. Sanchis *et al.* showed that the prevalence of intracranial aneurysms in ADPKD is around 8–12%, which is four times greater than in the general population [24]. Regarding the thickness of the hemorrhagic accumulation, thin SAH predominates compared to thick SAH. IVH was observed in 6 patients (20.0%). We have done modified Fisher grading to assess the severity of SAH. Grade 1, grade 2, grade 3, and grade 4 SAH were observed in 53.33%, 3.33%, 26.67% & 16.67% of patients, respectively. These findings are consistent with prior research, including the study by Mohammad *et al.*, who reported focal hemorrhage in 85% of aneurysmal SAH cases and IVH in 18%, closely aligning with the current study's data [23]. Within the anterior circulation, the anterior communicating artery (ACOM) was the most common site, detecting 11 aneurysms by both CTA (35.5%) and by DSA (32.4%). This was followed by aneurysms in the middle cerebral artery (MCA) (22.6% by CTA vs. 20.6% by DSA), the anterior cerebral artery (ACA) (19.4% vs. 17.6%), and the internal carotid artery (ICA) (6.5% vs. 8.8%). Saccular aneurysms were the predominant type, accounting for 90.3% of aneurysms detected by CTA and 91.2% detected by DSA. Fusiform aneurysms were much less commonly observed; a total of 3 fusiform aneurysms were detected by CTA, as many as by DSA. In this study, most aneurysms were medium-sized (5–12 mm), making up 90.3% of all aneurysms by CTA and 79.4% by DSA. Small aneurysms (≤4 mm) were relatively uncommon on CTA, with only 1 detected aneurysm (3.2%) measuring 2.8x2.5 mm at ACOM. Meanwhile, DSA detected 4 (11.7%) small aneurysms; 3 of these were missed by CTA. In our analysis, DSA identified 28 aneurysm-positive cases and 2 aneurysm-negative cases. CTA detected 27 of the aneurysm-positive cases (96.4%) and had 2 aneurysm-negative cases, while missing only 1 aneurysm-positive patient as a false negative (3.6%). DSA identified a total of 34 aneurysms in 28 aneurysm-positive patients, and CTA detected a total of 31 aneurysms in 27 aneurysm-positive patients. CTA could not detect 3 aneurysms, which were detected by DSA later on, resulting in 3 false negative aneurysms. 2 cases were negative for aneurysm in both CTA and DSA, resulting in true negatives. CTA identified 27 out of 28 aneurysms confirmed by DSA, yielding a sensitivity of

96.4%, a specificity of 100.0%, and an overall diagnostic accuracy of 96.7% on a per-patient basis, and a sensitivity of 91.2%, a specificity of 100% and an overall diagnostic accuracy of 91.7% on a per-aneurysm basis. These results indicate a robust diagnostic capability of CTA with excellent positive predictive value (100%), indicating all CTA-positive aneurysms were confirmed by DSA.These are in line with the findings by Mohammad *et al*., who reported similar CTA sensitivity (93.75%- on a per-patient basis & 94.74%- on a per-aneurysm basis), specificity (100%- on both bases), and overall accuracy (94.59%- on a per-patient basis & 95.35%- on a per-aneurysm basis) when calculated against DSA in SAH cases [23]. Yoon D. Y. *et al.,* found that the overall sensitivity, specificity, and accuracy of CTA on a per-aneurysm basis were 92.5%, 93.3%, and 92.6%, compared with DSA [19]. Additionally, Karamessini MT *et al*., demonstrated in their study that the sensitivity of CTA in the detection of all intracranial aneurysms was 88.7%, the specificity 100%, the PPV 100%, the NPV 80.7% and the accuracy 92.3% confirming CTA's reliability as a non-invasive alternative to DSA for initial aneurysm detection [25].

CONCLUSION

Diagnostic performance of CTA is good in terms of sensitivity, specificity, PPV, NPV, and accuracy, compared with DSA, for the detection of intracranial ruptured aneurysms in patients with spontaneous SAH.

FUNDING

No funding source.

CONFLICT OF INTEREST

None declared

ETHICAL CONSIDERATION

The study was approved by ethical review committee.

REFERENCES

1. *Tamdogan T, Turkoz D. Comparison of computerized tomographic angiography (CTA) and digital subtraction angiography (DSA) in patients with subarachnoid hemorrhage: a retrospective analysis. Ann Med Res. 2020;27(12):3212.*
2. *Amantakul A, Vuthiwong W, Khiawsa N. The diagnostic yield of repeat computed tomography angiography in cases of spontaneous subarachnoid haemorrhage after negative initial digital subtraction angiography. Pol J Radiol. 2024;89: e179.*
3. *Rabinstein AA, Lanzino G. Aneurysmal subarachnoid hemorrhage: unanswered questions. Neurosurg Clin N Am. 2018;29(2):255–262. doi: 10.1016/j.nec.2018.01.001*
4. *Rouanet C, Silva GS. Aneurysmal subarachnoid hemorrhage: current concepts and updates. Arq Neuropsiquiatr. 2019;77(11):806–814.*
5. *Lazzaro MA, Ouyang B, Chen M. The role of the circle of Willis anomalies in cerebral aneurysm rupture. J Neurointerv Surg. 2012;4(1):22–26.*
6. *Wiebers DO. Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet. 2003;362(9378):103–110.*
7. *Ozdemir M, Bozkurt M, Kahiloglu G, Ugur HC, Egemen N. Treatment of subarachnoid hemorrhage and its complications. Ankara Univ Fac Med J. 2011;64(1):52–55.*
8. *Yucetaş ŞC, Kaya H, Kafadar S, Kılınç S, Karataş İ, Kafadar H. Comparison of computerized tomography angiography and digital subtraction angiography in aneurysmal subarachnoid hemorrhage. J Surg Med. 2021;5(3):280–283.*
9. *Zargar JI, Ramzan AU, Wani AA, Shaheen F, Malik NK, Nizami FA, et al. Diagnostic accuracy of computed tomographic angiography (CTA) in the management of aneurysmal subarachnoid hemorrhage (SAH). J Neurol Stroke. 2014;1(3):101–105.*
10. *Rinkel GJE, Djibuti M, Algra A, van Gijn J. Prevalence and risk of rupture of intracranial aneurysms: a systematic review. Stroke. 1998;29(1):251–256.*
11. *Wardlaw JM, White PM. The detection and management of unruptured intracranial aneurysms. Brain. 2000;123(2):205–221.*
12. *Kasper DL, Fauci AS, Hauser SL, Loscalzo J, Longo DL, Jameson JL. Harrison's principles of internal medicine. 19th ed. New York: McGraw-Hill Medical; 2015. p.1784.*
13. *Keedy A. An overview of intracranial aneurysms. McGill J Med. 2006;9(2):141–146.*
14. *Peker A, Peker E, Akmangit I, Erden I. Comparison of 64 detector cranial CT angiography with intra-arterial DSA for detection of intracranial aneurysms. Electron J Gen Med. 2014;11(3):136–140.*
15. *Prestigiacomo CJ, Sabit A, He W, Jethwa P, Gandhi C, Russin J. Three-dimensional CT angiography versus digital subtraction angiography in the detection of intracranial aneurysms in subarachnoid hemorrhage. J Neurointerv Surg. 2010;2(4):385–389.*
16. *Hacein-Bey L, Provenzale JM. Current imaging assessment and treatment of intracranial aneurysms. AJR Am J Roentgenol. 2011;196(1):32–44.*
17. *Donmez H, Serifov E, Kahriman G, Mavili E, Durak AC, Menkü A. Comparison of 16-row multislice CT angiography with conventional angiography for detection and evaluation of intracranial aneurysms. Eur J Radiol. 2011;80(2):455–461.*
18. *Menke J, Larsen J, Kallenberg K. Diagnosing cerebral aneurysms by computed tomographic angiography: meta-analysis. Ann Neurol. 2011;69(4):646–654.*
19. *Yoon DY, Lim KJ, Choi CS, Cho BM, Oh SM, Chang SK. Detection and characterization of intracranial aneurysms with 16-channel multidetector row CT angiography: a prospective comparison of volume-rendered images and digital subtraction angiography. AJNR Am J Neuroradiol. 2007;28(1):60–67.*
20. *Chowdhury M, Chowdhury M, Sarkar M, Ahmed KM, Kabir M, Haque M, et al. Computed tomography angiography (CTA) evaluation of spontaneous subarachnoid hemorrhage. J Natl Inst Neurosci Bangladesh. 2020;6(2):78–81. doi:10.3329/jninb. v6i2.50745*
21. *Rumi JUM, Haleem MA, Ahammed MB, Arifin S, Islam MR, Chowdhury FH. Comparison of 3D-computed tomographic angiography with digital subtraction angiography for detection of aneurysms among spontaneous subarachnoid haemorrhagic patients. J Natl Inst Neurosci Bangladesh. 2022;8(2):121–125.*
22. *Begum T, Orakzai ZJ, Khan M, Rokhan B, Kamran A, Akram MN. Diagnostic accuracy of three-dimensional digital subtraction angiography (3D DSA) in correlation with computed tomographic angiography (CTA) and magnetic resonance angiography (MRA) in evaluation of aneurysmal subarachnoid haemorrhage. Pak J Med Health Sci. 2022;16(5):1509.*
23. *Mohammad N, Rumi JUM, Khan SJ, Uddin K, Faruque PM. Diagnostic validity of 3D-computed tomographic angiography in spontaneous subarachnoid haemorrhage. J Natl Inst Neurosci Bangladesh. 2019;5(1):47–52.*
24. *Sanchis IM, Shukoor S, Irazabal MV, Madsen CD, Chebib FT, Hogan MC, et al. Presymptomatic screening for intracranial aneurysms in patients with autosomal dominant polycystic kidney disease. Clin J Am Soc Nephrol. 2019;14(8):1151.*
25. *Karamessini MT, Kagadis GC, Petsas T, Karnabatidis D, Konstantinou D, Sakellaropoulos GC, et al. CT angiography with three-dimensional techniques for the early diagnosis of intracranial aneurysms: comparison with intra-arterial DSA and surgical findings. Eur J Radiol. 2004;49(3):212–223.*