Comparative Analysis of Computerized Tomography Angiography and Digital Subtraction Angiography in Patients with Subarachnoid Haemorrhage due to Non-Traumatic Aneurysmal Rupture

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Abstract: ***Introduction**: Subarachnoid hemorrhage (SAH) typically occurs in individuals aged 45 to 60, with a prevalence of 2 to 32 cases per 100, 000 people. Approximately 70 to 80% of SAHs result from the rupture of aneurysms. Both CT angiography (CTA) and digital subtraction angiography (DSA) play crucial roles in diagnosis and treatment. However, there is a lack of comprehensive studies comparing these two techniques. This study aims to evaluate the effectiveness of CT angiography (CTA) versus digital subtraction angiography (DSA) in managing patients with aneurysmal subarachnoid hemorrhage (ASH). **Aims and objectives**: In this study, we retrospectively analyzed the CTA and DSA records of patients monitored for aneurysmal SAH. We measured the location and size of the aneurysms. After stabilizing, patients were transported to the DSA unit within 1 to 12 hours. We assessed the records of those who underwent DSA for diagnostic purposes involving the Anterior Communicating Artery (Ant. Com. A), Basilar Artery (BA), Middle Cerebral Artery (MCA), and Posterior Communicating Artery (Post. Com. A.). **Materials and methods**: In this retrospective cohort study, we evaluated the CTA and DSA records of patients treated for aneurysmal SAH at the Vydehi Institute of Medical sciences from 1st January 2023, to 30th December 2023. Data collection was conducted using the hospital's Picture Archiving and Communications System (PACS). Inclusion criteria included: spontaneous SAH, confirmed aneurysm diagnosis, hospitalization in either the intensive care unit or ward, and completion of both CTA and DSA scans. Patients with traumatic subarachnoid hemorrhage, hypertensive thalamic hemorrhage, tumoral hemorrhage, post - infarct hemorrhage, arteriovenous hemorrhages, and those with negative results on both DSA and CTA were excluded from the study. **Results**: Our study included a total of 60 aneurysm cases that met our inclusion criteria. Among these, 21 cases (35%) were located at the Anterior Communicating Artery (Ant. Com. A), 5 cases (8.3%) at the Basilar Artery (BA), 28 cases (46.6%) at the Middle Cerebral Artery (MCA), and 6 cases (10. %) at the Posterior Communicating Artery (Post. Com. A). When examining the alignment between DSA and CTA results based on aneurysm location, we found that 18 cases with Ant. Com. A aneurysms and 18 cases with MCA aneurysms were consistent. In contrast, 6 cases of Ant. Com. A and 14 cases of MCA aneurysms showed discrepancies ($p > 0.05$). Analysis of aneurysm size indicated that DSA was more sensitive for detecting aneurysms smaller than 1 cm, while both DSA and CTA exhibited similar sensitivity rates for aneurysms larger than 1 cm. Overall, no significant difference was observed between DSA and CTA in accurately identifying aneurysmal locations. **Conclusion**: In cases of SAH caused by aneurysms, CTA is often preferable due to its accessibility and cost - effectiveness. It does not require specially trained physicians or technicians, allows for easier monitoring with post - operative brain CT, and minimizes the need for patient referrals between healthcare facilities for diagnostic purposes. Treatment can be planned based on CTA results, making it a practical choice in these situations.*

Keywords: Subarachnoid hemorrhage, Aneurysm, CT angiography, DSA

1. Introduction

Approximately 70 - 80% of subarachnoid hemorrhages (SAH) result from aneurysmal hemorrhage [1, 2]. SAH typically occurs in individuals aged 45 to 60, with a prevalence of 2 to 32 cases per 100, 000 [3]. About 90% of patients with aneurysmal SAH present to emergency rooms with severe headaches, often accompanied by signs of increased intracranial pressure. The overall mortality rate for SAH exceeds 70%. In cases of bleeding aneurysms, the risk of rebleeding is 50% within the first six months, while the risk for non - bleeding aneurysms is 1% over the first year [4].

Some cases of spontaneous intracerebral hemorrhage are attributed to brain aneurysms. When these patients arrive at the emergency room or outpatient clinic, they typically undergo cranial computed tomography angiography (CTA) followed by digital subtraction angiography (DSA) to rule out aneurysms [5]. Usually, cranial CT or CTA is performed first due to its ease and practicality [6]. CT scans performed within the first 12 hours can detect hemorrhage with an accuracy of 98 - 100%. Both CTA and DSA are recommended for assessing aneurysms, each with its own advantages and disadvantages. While FLAIR MRI has been increasingly utilized, DSA is currently regarded as the most effective diagnostic modality, particularly for visualizing aneurysms in complex anatomical locations [7]. According to DSA imaging, 10 - 20% of aneurysms are found to be multiple [8].

The sensitivities of CTA and MRI for detecting aneurysms larger than 3 mm are 95% and 94%, respectively, with sensitivity decreasing as aneurysm size diminishes [9]. CTA has an error rate of about 15%, while DSA, although considered more sensitive when optimally performed, has an error rate of 16%. CTA is non - invasive and cost - effective, while DSA requires specialized hospital facilities, trained personnel, and is more expensive, making it unavailable in many centers [10].

Aim: This study was conducted at a tertiary care institute to compare the effectiveness of CTA and DSA in diagnosing and monitoring patients with SAH.

2. Materials and Methods

In this retrospective cohort study, the CTA and DSA records of patients followed up due to aneurysmal SAH at the Vydehi Institute of Medical sciences from 1st January 2023, to 30 th December 2023 were evaluated retrospectively. Data collection were performed through the Picture Archiving and Communications System (PACS) of the hospital. Criteria for inclusion were as follows: Spontaneous SAH, diagnosis of aneurysm, hospitalization in the intensive care unit or the ward, and having underwent CTA and DSA scan. Patients with traumatic subarachnoid hemorrhage, hypertensive thalamic hemorrhage, tumoral hemorrhage, post - infarct hemorrhage, arterio - venous hemorrhages, and negative results in both DSA and CTA were not included in the study. Patients who visited the emergency room of our hospital with a SAH diagnosis were administered contrast agent and CTA scan Study was performed within 5 - 10 seconds. In cases with aneurysm, the location and size of the aneurysm were measured. After stabilization, the patient was transported into the DSA unit within 1 - 12 hours, and 4 - vessel DSA was performed with ioheksol, an opaque agent, and recorded for diagnostic purposes.

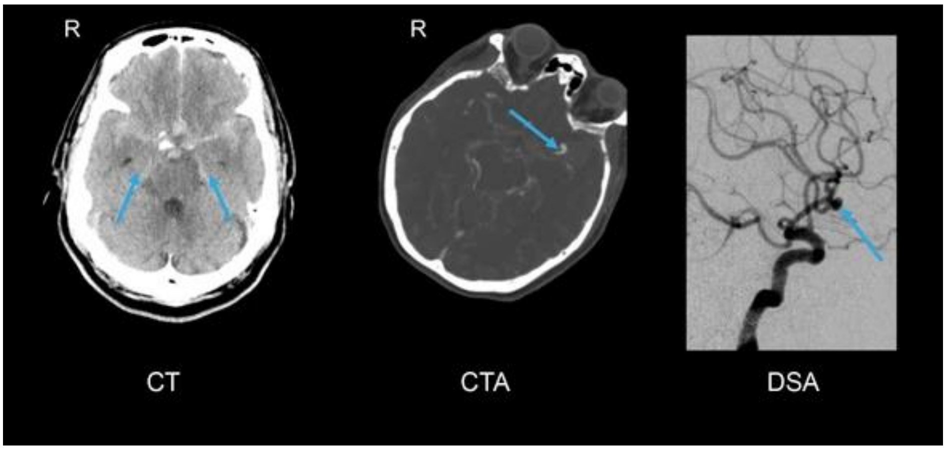

Figure 1: Showing pictures of CT brain, CT angio and DSA

3. Results

Statistical analysis

The agreement between the CTA and DSA methods was evaluated using Kappa and Phi statistics. Categorical variables were presented as percentages. A 95% confidence level was applied, with $P < 0.05$ considered statistically significant. Among these, 21 cases (35%) were located at the Anterior Communicating Artery (Ant. Com. A), 5 cases (8.3%) at the Basilar Artery (BA), 28 cases (46.6%) at the Middle Cerebral Artery (MCA), and 6 cases (10. %) at the Posterior Communicating Artery (Post. Com. A).

Table 1: Distribution of the aneurysm locations and sizes

	n	%
Location: Ant Com A	21	35%
BA	5	8.3%
MCA	28	46.6%
PComA	6	10%
DSA: Absent	15	25%
Present	45	75%
CTAngio: Absent	11	18.3%
Present	49	81.6%
Size: <1cm	29	48.3%
>1 cm	31	51.6%

The sensitivities of DSA and CTA were assessed in relation to aneurysm location. Both methods accurately identified 18 aneurysms at the Anterior Communicating Artery (Ant. Com. A) and 18 at the Middle Cerebral Artery (MCA). However, discrepancies were noted in 6 and 14 cases, respectively. No significant difference was observed in the sensitivities of the two modalities by location ($\kappa = -0.075, -0.120$; $\pi = -0.107, -0.200$; $P = 0.600, 0.258$). Notably, DSA demonstrated slightly greater accuracy for aneurysms located in the Basilar Artery and Posterior Communicating Artery (P. Com. A) regions. For aneurysms smaller than 1 cm, DSA accurately identified 10 cases, while 23 cases were misidentified. A significant negative correlation was found between aneurysm size and the accuracy of imaging ($\kappa = -0.419$, $\pi = -0.503$; $P = 0.004$). This indicates that, while DSA was more sensitive for aneurysms under 1 cm, both modalities showed greater sensitivity for those larger than 1 cm ($\kappa = -0.050$, $\pi = -0.076$; $P = 0.650$).

Table 2: DSA and CT angiography Rates

	DSA		CT angiography Absent n (Row %) (Column %)	CT angiography Present n (Row %) (Column %)	Total	Ƙ (SE)	π	*P*-value
Location	AntComA							
		Absent	0	5 (100) (21.7)	5 (20.8)	-0.075 (0.065)	-0.107	0.600
		Present	1 (5.3) (100)	18 (94.7) (78.3)	19 (79.2)			
		Total	1 (4.2)	23 (95.8)	24 (100)			
	BA+PComA							
		Absent	0	0	0 (0)	-	-	-
		Present	10 (76.9) (100)	3 (23.1) (100)	13 (100)			
		Total	10 (76.9)	3 (23.1)	13 (100)			
	MCA							
		Absent	0	12 (100) (40)	12 (37.5)	-0.120 (0.078)	-0.200	0.258
		Present	2 (10) (100)	18 (90) (60)	20 (62.5)			
		Total	2 (6.3)	30 (93.8)	32 (100)			
Size	< 1 cm							
		Absent	0	16 (100) (61.5)	16 (48.5)	-0.419 (0.125)	-0.503	0.004
		Present	7 (41.2) (100)	10 (58.8) (38.5)	17 (51.5)			
		Total	7 (21.2)	26 (78.8)	33 (100)			
	> 1 cm							
		Absent	0	1 (100) (3.3)	1 (2.8)	-0.050 (0.044)	-0.076	0.650
		Present	6 (17.1) (100)	29 (82.9) (96.7)	35 (97.2)			
		Total	6 (16.7)	30 (83.3)	36 (100)			
Total								
		Absent	0	17 (100) (30.4)	17 (24.6)	-0.271 (0.050)	-0.275	0.022
		Present	13 (25) (100)	39 (75) (69.6)	52 (75.4)			
		Total	13 (18.8)	56 (81.2)	69 (100)			

Kappa Statistics test, Ƙ: Kappa Coefficient, π: Phi Coefficient, SE: Standard Error

In total, 34 aneurysms were accurately shown across all cases, while 26 were not. DSA and CTA demonstrated equal accuracy for aneurysms at the Ant. Com. A and MCA, but DSA yielded slightly better results for aneurysms at the Basilar Artery and P. Com. A regions (κ = - 0.271, π = - 0.275; P = 0.022).

4. Discussion

Morgani and Buimid first identified that aneurysmal bubbles in brain vessels could cause hemorrhage in the 18th century. Egas and Monis introduced cerebral angiography in 1927, followed by the first internal carotid artery aneurysm surgery in 1931, and the first aneurysm clipping in 1939. Over the years, advancements have included microvascular surgeries using microscopes and endovascular treatments, which have evolved significantly in the last decade [4].

While SAHs primarily occur due to trauma, the most common cause of spontaneous SAHs is aneurysms. Aneurysms result from the dilation of blood vessels at their weakest points due to pulsation. Contributing factors include hypertension, smoking, alcohol use, and genetic predisposition. Aneurysms are classified by size and shape: small (≤10 mm), large (10 - 25 mm), giant (>25 mm), saccular, fusiform, and dissecting [11]. Most aneurysms are found in the anterior communicating artery, middle cerebral artery, posterior communicating artery, and basilar artery, in that order [4]. Our study's anatomical distribution of aneurysms aligned with existing literature, with the anterior communicating artery being the most common location.

Diagnostic modalities for aneurysms include CTA, MRI - FLAIR, and DSA. CTA can image both intracranial and extracranial structures [11]. Careful timing of contrast administration during angiography is essential for obtaining clear images. Although CTA is non - invasive, it still requires contrast administration. Compared to MRI angiography, CTA produces fewer artifacts, is faster, and is easier to perform on intubated patients. It is also less time - consuming, more cost - effective, and accommodates patients with pacemakers or other metallic implants. Another advantage of CTA is its ability to clearly depict the relationship between aneurysms, blood vessels, and surrounding bone structures [12].

In our patients, CTA was performed first due to its accessibility, cost - effectiveness, and ability to visualize bony structures. MRI angiography was reserved for ambiguous or exceptional cases. Complications such as embolism, bleeding, encephalopathy, and headache are less common with CTA compared to DSA [13]. CTA can also reveal calcifications around the aneurysm or within vascular structures. In our protocol, contrast was administered in a bolus, with scanning performed in 1 - or 1.5 - mm sections, which could then be converted to 3D images. Patients with SAH in our hospital received 50 cc of the contrast agent iohexol, followed by CTA and 3D imaging performed by a radiologist within 5 - 10 seconds. The location and size of the aneurysms were measured, and vascular calcifications were occasionally noted.

DSA is used for carotid endarterectomy, bypasses involving the superficial temporal artery and middle cerebral artery, the detection of intracerebral aneurysms, and during endovascular coiling [14]. In our study, we performed four - vessel angiographies for diagnostic purposes to assess the location and size of cerebral aneurysms. DSA may yield up to 25% negative results in cases of subarachnoid hemorrhage [15]. Our findings indicated that while CTA was more accurate in some locations, DSA excelled in identifying anatomically complex and deep aneurysms. Although DSA may provide superior results, it is more challenging to perform and requires specialized personnel and equipment, making it more expensive. DSA is associated with a higher incidence of side effects compared to CTA and MRI angiography, potentially leading to complications such as cortical blindness, bilateral amblyopia, eye movement impairment, headache, memory loss, aphasia, hemiparesis, cognitive disturbances, coordination issues, confusion, seizures, or even coma. While most complications resolve within 12 hours, some may persist for weeks [16]. As emphasized by Tan et al. [17], patients should not have severe chronic conditions or hemodynamic instability to safely undergo DSA, as these factors pose less risk with CTA. In our study, patients exhibited relatively high Glasgow Coma Scale scores; those we could assess reported headaches, nausea, vomiting, and temporary confusion. One patient experienced a seizure during follow - up, but none became comatose.

Patients typically present with severe headaches, which may be accompanied by nausea, vomiting, confusion, double vision, and seizures. Complications from aneurysms may include rebleeding, hydrocephalus, vasospasm, and hyponatremia [18]. Treatment options include aneurysm clipping through microdissection in open surgery or endovascular coiling, which has seen significant advancements in the past decade [19]. Classification of these patients is based on brain CT and various scales, including the Fisher scale, Hunt and Hess scale, modified Rankin score, and the World Federation of Neurological Surgeons (WFNS) scale [20].

The limitations of our study include a small sample size, a single - center design, and the lack of follow - up beyond two years.

5. Conclusion

CTA, MRI angiography, or DSA can be used to rule out aneurysms in patients presenting with SAH. Among these, CTA is the fastest and most cost - effective diagnostic method, offering comparable reliability and superior imaging in certain locations. We emphasize that CTA should be the first choice for imaging, allowing treatment plans to be based on its findings. This approach can reduce the need for patient referrals to other health institutions for DSA, which can be reserved for cases where brain CT is negative or for deep aneurysms. CTA is widely available, less expensive, does not require specially trained personnel, and facilitates easier postoperative control with follow - up brain CT scans.

References

[1] Zuurbier C, Greving JP, Rinkel G, Ruigrok YM. Higher risk of intracranial aneurysms and subarachnoid haemorrhage in siblings of families with intracranial aneurysms. Eur Stroke J.2020; 5 (1): 73 - 7.
[2] Lepski G, Lobão CAF, Taylor S, MesquitaFilho PM, Tatagiba M. Reply: Intracranial aneurysm diameterand risk of rupture. Arq Neuropsiquiatr.2019; 77 (11): 840.
[3] Özdemir M, Bozkurt M, Kahiloğulları G, Uğur HÇ, Egemen N. Subaraknoid kanama ve komplikasyonlarının tedavisi. Journal of Ankara University Faculty of Medicine.2011; 64 (1): 52 - 5.
[4] Kocaeli H, Kofralı E. Anevrizmal subaraknoid kanama ve Komplikasyonları. Temel nöroşirürji 2010; 1: 803 - 14.
[5] Kurita M, Miyasaka Y, Ishiwata M, Kitahara T, Fujii K. Infectious aneurysm rerupture caused by delayed diagnosis: an operative case report. N Library of med.2008; 36 (7): 633 - 8.
[6] Angtuaco EJ, Binet EF. High - resolution computed tomography in intracranial aneurysms. Crit Rev Diagn Imaging.1986; 25 (2): 113 - 58.
[7] Wang X, Benson J, Jagadeesan B, McKinney AJ. Giant Cerebral Aneurysms: Comparing CTA, MRA, and Digital Subtraction Angiography Assessments. J Neuroimaging.2020; 30: 335 - 41. doi: 10.1111/jon.12712
[8] Zwanzger C, López - Rueda A, Campodónico D, Rosati S, BlascoJ, San Román L, et al. Usefulness of CT angiography for characterizing cerebral arteriovenous malformations presenting as hemorrhage: comparison with digital subtraction angiography. Radiologia.2020; 62 (5): 392 - 9. doi: 10.1016/j. rx.2020.01.006
[9] Dundar TT, Aralasmak A, Kitiş S, Yılmaz FT, Abdallah A. Comparison of Subtracted Computed Tomography from Computed Tomography Perfusion and Digital Subtraction Angiography in Residue Evaluation of Treated Intracranial Aneurysms. World Neurosurg.2019; 132: 746 - 51.
[10] Páez - Granda D. Subarachnoid haemorrhage with negative tomographic angiography without vasospasm: is it necessary to perform angiographic controls? Rev Neurol.2020; 70 (8): 287 - 92.
[11] Schattlo B, Fathi AR, Fandino J. Management of aneurysmal subarachnoid haemorrhage. Swiss Med Wkly.2014; 144: 13934.
[12] Chen LW, Lin CJ, Guo WY, Hung SC, Lee HJ, Chen KK, et al. Evaluating cerebral hemodynamics using quantitative digital subtraction angiography and flat - detector computed tomography perfusion imaging: A comparative study in patients with carotid stenosis. J Chin Med Assoc.2018; 81 (11): 977 - 84.
[13] Bender M, Bogdan G, Radančević D, Pejanović - Škobić N. Contrast - Induced Encephalopathy following Cerebral Angiography in a Hemodialysis Patient. Case Rep Neurol Med.2020: 3985231.
[14] Little JR, Furlan AJ, Modic MT, Bryerton B, Weinstein MA. Intravenous digital subtraction angiography: application to cerebrovascular surgery. Neurosurgery.1981; 9 (2): 129 - 36.
[15] Fang Y, Xu S, Lu J, Wu H, Zheng J, Lenahan C, et al. Validation and Comparison of Aneurysmal

Subarachnoid Hemorrhage Grading Scales in Angiogram - Negative Subarachnoid Hemorrhage Patients. BioMed Research International.2020: 1; 1 - 9. doi: 10.1155/2020/970723.
[16] Türk Y, Salmaslıoğlu A, Sasani H. The role of multislice computerized tomography angiography in assessing postoperative vascular complications in liver transplant patients. Turk J Med Sci.2019; 49 (4): 1212 - 20.
[17] Tan RY, Chong TT, Tsai FC, Pang SC, Lee KG, Gogna A, et al. A pilot study on adjunctive use of parametric colour - coded digital subtraction angiography in endovascular interventions of haemodialysis access. BMC Med Imaging.2018; 18 (1): 28 - 36. doi: 10.1186/s12880 - 018 - 0270 - 8.
[18] Wang TL, Wu CH, Chen CW, Tsai TH, Kung SS, Chao CH, et al. Bilaterally isolated abducens palsy after an aneurysm rupture is related with intracranial hypertension. Springer plus.2015; 4: 765.
[19] Luther E, McCarthy DJ, Brunet MC, Sur S, Chen SH, Sheinberg D, et al. Treatment and diagnosis of cerebral aneurysms in the post - International Subarachnoid Aneurysm Trial (ISAT) era: trends and outcomes. J Neurointerv Surg.2020; 12 (7): 682 - 7. doi: 10.1136/neurintsurg - 2019 - 015418.
[20] Hammer Janssen HA, Ranaie G, Yakubov E, Erbguth F, Holtmannspoetter M, Steiner HH. Dynamics of outcome after aneurysmal subarachnoid hemorrhage. Aging (Albany NY).2020; 12 (8): 7207 - 17. doi: 10.18632/aging.10306.