Journal of Surgery and Medicine
e-ISSN=2602-2079

Comparison of computerized tomography angiography and digital subtraction angiography in aneurysmal subarachnoid hemorrhage

Şeyho Cem Yücetaş [1], Hakan Kaya [2], Safiye Kafadar [3], Süleyman Kılınç [1], İrem Karataş [4], Hüseyin Kafadar [5]

[1] Department of Neurosurgery, Adiyaman University Education and Research Hospital, Adiyaman, Turkey
[2] Department of Cardiology, Adiyaman University Education and Research Hospital, Adiyaman, Turkey
[3] Department of Radiology, Adiyaman University Education and Research Hospital, Adiyaman, Turkey
[4] Pamukkale University, Medical School, Denizli, Turkey
[5] Department of Forensic Medicine, Adiyaman University Education and Research Hospital, Adiyaman, Turkey

ORCID ID of the author(s)

ŞCY: 0000-0002-2891-1805
HK: 0000-0002-5925-5150
SK: 0000-0003-4070-9615
SK: 0000-0001-6421-724X
İK: 0000-0001-7808-4978
HK: 0000-0002-6844-7517

Corresponding Author
Hüseyin Kafadar
Adıyaman Univesity, Department of Forensic Medicine, Adıyaman, Turkey
E-mail: dr.hkafadar@gmail.com

Ethics Committee Approval
Adiyaman University Ethical Committee, date, and number: 18.05.2020 /2020/5-19
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

Financial Disclosure
The authors declared that this study has received no financial support.

Published
2021 March 19

Abstract

Background/Aim: A subarachnoid hemorrhage (SAH) usually occurs between the ages of 45-60 years and its prevalence is 2-32 per hundred thousand. Approximately 70-80% of SAHs develop as a result of aneurismal hemorrhage. Studies examining the two methods in the literature are insufficient. The goal of this study was to compare CT angiography (CTA) and digital subtraction angiography (DSA) in the management of patients with aneurysmal subarachnoid hemorrhage (ASH).
Method: In this retrospective cohort study, the CTA and DSA records of patients who were followed up due to aneurysmal SAH were retrospectively examined. The location and size of the aneurysm were measured. The patients were transported to the DSA unit within 1-12 hours once they stabilized and the records of the patients who underwent DSA for Anterior Communicating Artery (Ant.Com.A), Basilar Artery (BA), MCA and Posterior Communicating Artery (Post.Com.A.) for diagnostic purposes were assessed.
Results: Our study included a total of 69 aneurysm cases complying with our criteria. Twenty-four (34.8%) were at the Ant.Com.A, 6 (8.7%) were at the BA, 32 (46.4%) were at the MCA and 7 (10.1%) were at the Post.Com.A. When the alignment between DSA and CTA results was examined according to the location, eighteen cases with Ant.Com.A aneurysm, and eighteen cases with MCA aneurysm were coherent, while six and fourteen cases of Ant.Com.A and MCA aneurysm, respectively, were not (p>0,05). An analysis in terms of size revealed that DSA was more sensitive in patients with aneurysms <1 cm, while both DSA and CTA showed equal rates of sensitivity in aneurysms>1 cm. Overall, no significant difference was found (Ҡ=-0.075, -0.120; π= -0.107, -0.200; *P*=0.600) between DSA and CTA in terms of accuracy of showing aneurysmal location (Ҡ=-0.050, π= -0.076; *P*=0.650).
Conclusion: In SAH due to aneurysms, CTA can be preferred, and treatment can be planned based on its results because it is more accessible and cheaper, does not require specially trained physicians and technicians, enables easier control of post-operative brain CT, and reduces patient referrals between health institutions for diagnostic purposes.

Keywords: Subarachnoid hemorrhage, Aneurysm, CT angiography, DSA

How to cite: Yücetaş 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.

Introduction

Approximately 70-80% of subarachnoid hemorrhages (SAH) develop due to aneurysmal hemorrhage [1, 2]. SAH usually occurs between the ages of 45-60 years and its prevalence is 2-32 per hundred thousand [3]. Ninety percent of patients with SAH due to aneurismal hemorrhage visit the emergency room with complaints of severe headache, and these patients may exhibit signs of increased intracranial pressure. Overall mortality rate in patients with SAH is over 70%. In bleeding aneurysms, rebleeding risk is 50% within the first 6 months, while the bleeding risk of non-bleeding aneurysms is 1% within the first year [4].

The etiology of spontaneous intracerebral hemorrhage in some patients is brain aneurysms. When patients with spontaneous intracerebral hemorrhage visit the emergency room or the polyclinic, these patients must first undergo cranial computed tomography angiography (CTA) and then digital subtraction angiography (DSA) scan to rule out aneurysm [5]. Usually, cranial CT or CTA scan is performed first since it is easier and more practical [6]. When CT scan is performed within the first 12 hours, it shows the hemorrhage at a rate of 98-100%. Both CTA and DSA are recommended methods for investigating the presence of an aneurysm. Obviously, both imaging methods have their specific advantages and disadvantages. We know that FLAIR MRI has also been used recently. However, it is currently believed that the best diagnostic modality is DSA [7], which yields better images of aneurysms in deep and complex anatomical locations. Based on DSA imaging, 10-20% of aneurysms are multiple [8].

The sensitivities of CTA and MRI are 95% and 94%, respectively, in aneurysms over 3 mm. Sensitivity reduces as size decreases [9]. An error rate of 15% is observed in CT angiography. It is argued that DSA is more sensitive when performed ideally; however, it also involves an error rate of 16%. No intervention is required for CT angiography and it is cheap, while DSA requires a special unit at the hospital, specifically trained personnel, and physicians. DSA is a costly diagnostic modality which is not available in most centers [10].

The aim of the present study is to compare CTA and DSA for the diagnosis and follow-up of patients with SAH.

Materials and methods

In this retrospective cohort study, the CTA and DSA records of patients followed up due to aneurysmal SAH in Adiyaman Training and Research Hospital Neurosurgery Clinic between 30.06.2017-01.04.2020 were evaluated retrospectively. Data collection were performed through the Picture Archiving and Communications System (PACS) of the hospital. Approval was obtained from Adiyaman University Ethics committee on 18.05.2020 with the decision number 2020/5-19 prior to starting the study. 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 0,625-2,5 ml of contrast agent and CTA scan 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.

Statistical analysis

SPSS 25.0 (IBM Corporation, Armonk, New York, United States) software was used to analyze the variables. The compliance between the CTA and DSA methods were evaluated by Kappa and Phi statistics. Categorical variables were presented in percentage. Variables were examined with 95% reliability level, and $P<0.05$ was considered statistically significant.

Results

A total of sixty-nine aneurysm cases (Alpha (α) error: 0.05, Beta (ß) error: 90%, Strength of Study: 0.90) were included in our study. Power analysis and sample size calculation were performed with Gx POWER 3.1.9.7 program. Twenty-four (34.8%) of these aneurysms were at the Ant.Com.A, 6 (8.7%) were at the BA, 32 (46.4%) were at the MCA and 7 (10.1%) were at the Post.Com.A. Among patients who underwent DSA and CTA, 17 (24.6%) and 13 (18.8%) patients, respectively, were not diagnosed with aneurysm, while 52 (75.4%) and 56 (81.2%), respectively, were (Tables 1, 2).

Table 1: Distribution of the aneurysm locations and sizes

	n	%
Location		
AntComA	24	34.8%
BA	6	8.7%
MCA	32	46.4%
PComA	7	10.1%
DSA		
Absent	17	24.6%
Present	52	75.4%
CT angiography		
Absent	13	18.8%
Present	56	81.2%
Size		
< 1 cm	33	47.8%
> 1 cm	36	52.2%

Table 2: DSA and BT angiography diagnosis rates

	DSA	CT angiography		Total	Ꝁ (SE)	π	*P*-value
		Absent n (Row %) (Column %)	Present n (Row %) (Column %)				
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, Ꝁ: Kappa Coefficient, π: Phi Coefficient, SE: Standard Error

The sensitivities of DSA and CTA were examined with regards to location. The results of 18 aneurysms at the Ant.Com.A, and 18 aneurysms at the MCA were accurate, while those of 6 and 14 cases, respectively, were not. No significant difference was found between the sensitivities of the two modalities with regards to location (Ꝁ=-0.075, -0.120; π= -0.107, -0.200; P=0.600, 0.258, respectively). Aneurysms at the BA+P Com. region were mildly more accurately shown by DSA compared to CTA.

In aneurysms <1 cm in size, the aneurysm was accurately shown in 10 patients, while the contrary was true in 23 cases. A significantly negative correlation was found between aneurysm size and the accuracy of the imaging modality (Ꝁ=-0.419, π= -0.503; P=0.004). This means that although DSA was more sensitive in aneurysms under 1 cm, both methods were more sensitive in identifying aneurysms over 1 cm (Ꝁ=-0.050, π= -0.076; P=0.650).

When all cases were examined, the aneurysms of thirty-nine cases were shown accurately while those of 30 cases were not. DSA and CTA showed aneurysms at the Ant.Com.A. and MCA equally accurately, while DSA provided mildly superior results in showing aneurysms at the Basilar Artery and P.Com.A. regions (Ꝁ=-0.271, π= -0.275; P=0.022).

Discussion

Morgani and Buimid discovered that aneurysmal bubbles in brain vessels caused hemorrhage in the 18th century. Egas and Monis introduced cerebral angiography in 1927. The first internal carotid artery aneurysm surgery was performed in 1931, which was followed by the first surgery to clip an aneurysm in 1939. In later stages, microvascular surgeries were performed with microscopes, and additional endovascular treatments have been used for the last 10 years [4]. SAHs mainly occur due to trauma; however, the most common reason for spontaneous SAHs is aneurysm. Aneurysms occur because of dilatation of the vessel due to pulsation at the weakest segment of the vessel wall. Various factors, such as hypertension, smoking, alcohol use and hereditary variables contribute to the formation of an aneurysm. Aneurysms are classified based on their sizes and shapes as follows: Small (10 mm and smaller), large (10-25 mm), giant (over 25 mm), saccular, fusiform, and dissecting [11]. Most are found in the anterior communicating artery, middle cerebral artery, posterior communicating and basilar artery, in decreasing order [4]. The anatomical distributions of our patients' aneurysms were in line with the literature, such that Ant. Com. A. was the most common aneurysmal location in our study group. CTA, MRI-FLAIR and DSA are diagnostic modalities of aneurysm. CTA can be used to image intracranial and extracranial structures [11]. The timing of contrast must be adjusted carefully especially during angiography to yield useful images. Although it is a noninvasive method, contrast is administered to these patients. Compared to MRI angiography, CT angiography produces less artifact, is faster, and easier to perform in intubated patients. It is less time-consuming, cheaper and facilitates scanning patients with pacemakers or other metals. Another feature of CTA is that it provides the best images which show the relationship between aneurysms, vessels, and bone structures [13,14]. CTA was performed first in our patients due to its easiness, cost-effectiveness, and ability to show the relationship with bony structures. MRI angiography was used in unclear or exceptional cases. Embolus, bleeding, encephalopathy, and headache are encountered less frequently in CTA compared to DSA [15]. It also shows the calcifications in the aneurysm neck or vascular structures. In CTA, 100cc 60% Meglumine diatrizoate is administered in bolus form, and scanning is performed in 1- or 1.5-mm sections which can then be converted to 3D form [6]. Patients with SAH who visited the emergency room of our hospital were administered 50cc of the contrast agent ioheksol, after which CTA and 3D imaging were performed by the radiologist within 5-10 seconds. The location and size of the aneurysm were measured. In our cases, vascular calcifications, or calcifications around the aneurysm were also occasionally found.

DSA is used in carotid end-arterectomy, bypasses involving the superficial temporal artery and middle cerebral artery, for the detection of intracerebral aneurysms and during endovascular coiling [16]. We only scanned four vessel angiographies in our patients for diagnostic purposes and checked the location and size of cerebral aneurysm. DSA may yield 25% negative results in subarachnoid hemorrhage [17]. In the study conducted by Paez Granda [10], it has been reported that DSA may be mistaken at a rate of 15%. In the study conducted by Zwanzger et al. [8] it has been emphasized that CTA and DSA have separate advantages based on location. Pozzi-Mucelli [18] reported no significant differences between CTA and DSA. In our study, we observed that CTA was more accurate in some locations, while DSA was better in anatomically complex and deep aneurysms. DSA scans may present better results; however, it is difficult to perform and requires a specialist, a trained team and separate radiological equipment. It is also more expensive. DSA has more side effects compared to CT angiography and MRI angiography, and it may cause cortical blindness, bilateral amblyopia or amaurosis, impairment in eye movements, headache, memory loss, aphasia, hemiparesis, mental function disorder, coordination disorder, confusion, seizure or even coma. Although most of these complications recover within 12 hours, they may last for a few weeks [19-21]. In the study conducted by Miao Li et al. [22], cortical blindness is observed more commonly in patients with chronic hypertension. As Tan et al. [23] emphasized in their study, hemodynamics and some severe chronic diseases must not be present in patients to safely perform a DSA scan. These comorbidities present less risk in CT angiography. Our patients had particularly high Glasgow coma scores and those we could evaluate in terms of consciousness had headache, nausea, and vomiting, and temporary short-term confusion. One patient experienced a seizure in the follow-up period and no patient became comatose.

The symptoms of these patients start with severe headache, and may continue with nausea, vomiting, confusion, double vision, and seizures. Patients with an aneurysm may experience complications such as rebleeding, hydrocephalus, vasospasm, and hyponatremia [24]. There are two approaches for treating these patients. The first one is clipping the aneurysm by microdissection using microscope under open surgery, and the other one is endovascular coiling which has improved within the last 10 years [25]. For classification of these patients, brain CT and Fisher scale, Hunt and Hess scale, modified Rankin score and World Federation of Neurological Surgeons (WFNS) scales are used [26].

The limitations of the study are the small number of cases, its single center design, and the lack of follow-up after two years.

Conclusion

CTA, MRI angiography or DSA can be performed to rule out aneurysm in a patient presenting with SAH. CTA is the fastest and cheapest diagnostic method with no less reliability than other methods and it provides better images in some locations. We wanted to emphasize that CTA scan must be the first imaging choice and treatment can be planned based on its results. This way, patient referrals between health institutions for DSA may be reduced, and DSA can be performed in brain-CT-negative and deep aneurysms. CTA is more common among health institutions, cheaper, does not require specially trained physicians and technicians, and enables easier obtainment of postoperative control brain CT.

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. Iki Y, Morofuji Y, Kanamoto T, Horie N, Izumo T, Anda T, et al. Traumatic Middle Meningeal Arteriovenous Fistula of Non-fractured Site Detected by Four-dimensional Computed Tomography Angiography: A Case Report. NMC Case Rep J. 2020;7(2):57-61.
13. 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.
14. Wong H, Hodgson L, Banfield J, Shankar JJS. Digital Subtraction Angiography for CT Angiogram Negative Haemorrhages. Can J Neurol Sci. 2018;45(5):522-6.
15. 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.
16. Little JR, Furlan AJ, Modic MT, Bryerton B, Weinstein MA. Intravenous digital subtraction angiography: application to cerebrovascular surgery. Neurosurgery. 1981;9(2):129-36.
17. 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.
18. Pozzi-Mucelli F, Bruni S, Doddi M, Calgaro A, Braini M, Cova MJ. Detection of intracranial aneurysms with 64 channel multidetector row computed tomography: comparison with digital subtraction angiography. Radiol. 2007;64(1):15-26.
19. 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.
20. Al-Smadi AS, Elmokadem A, Shaibani A, Hurley MC, Potts MB, Jahromi BS, et al. Adjunctive Efficacy of Intra-Arterial Conebeam CT Angiography Relativeto DSA in the Diagnosis and Surgical Planning of Micro-Arteriovenous Malformations. AJNR Am J Neuroradiol. 2018;39(9):1689-95.
21. Dündar TT, Kitiş S, Abdallah A, Yurtsever İ, Gülen B. Evaluation of the platelet volume index as a prognostic factor after aneurysmal subarachnoid hemorrhage. J Surg Med. 2019;3(9):685-8.
22. Li M, Liang H, Liu C, Liu H, Zheng Y, Shi W, et al. Risk Factors of Transient Cortical Blindness After Cerebral Angiography: A Multicenter Study. Neurol. 2019;10:1005.
23. 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.
24. 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.
25. 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.
26. 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.
27. Kim HJ, Lee SW, Lee TH, Kim YS. Huge Intramural Hematoma in a Thrombosed Middle Cerebral Artery Aneurysm: A Case Report. J Cerebrovasc Endovasc Neurosurg. 2015;17(3):234-8.

This paper has been checked for language accuracy by JOSAM editors.
The National Library of Medicine (NLM) citation style guide has been used in this paper.