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Before emergency aneurysm surgery, CTA or DSA? A single center experience

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Abstract. – OBJECTIVE: Subarachnoid hemorrhage (SAH) due to an intracranial aneurysm is a life-threatening surgical emergency. After the diagnosis of SAH, physicians should find the reason for the bleeding. CT- Angiography (CTA) and Digital Subtraction Angiography (DSA) are techniques used to visualize the aneurysm. However, which one will surgeons prefer? In this study, we have compared these two radiological examinations.

PATIENTS AND METHODS: This study includes 58 patients diagnosed with SAH and intracranial aneurysm diagnosis based on CTA (n=30) and DSA (n=28). We evaluated the patients according to demographic properties, CTA and DAS findings, aneurysm location, Fisher score, postoperative complications, and Glasgow outcome score.

RESULTS: The most common location of aneurysms was the M1 level (48.3%). Patients in the DSA group had significantly more extended hospital stays (*p*= 0.021). There was no statistically significant difference between the two groups in complications.

CONCLUSIONS: Enhanced CT Technologies provide higher fidelity images and shorten hospital stays. With CTA, surgeons may gain time for an emergency surgical procedure. Despite the fact that DSA remains a significant factor in aneurysm diagnosis, DSA is an invasive procedure and needs more time to diagnose.

Key Words:
Subarachnoid hemorrhage, CT-Angiography, DSA, Aneurysm, Glasgow outcome score.

Abbreviations

Subarachnoid hemorrhage: SAH; Computer Tomography Angiography: CTA; Digital Subtraction Angiography: DSA; CT: Computer Tomography; American Heart Association/American Stroke Association: AHA/ASA; Posterior inferior cerebellar artery: PICA; Middle Cerebral Artery: MCA; Three dimensional: 3D.

Introduction

Subarachnoid hemorrhage (SAH) is a typical result of an intracranial aneurysm with an 80-90% rate. The prevalence of intracranial aneurysms in the average population is 2-3%. The annual rupture rate of an unruptured intracranial aneurysm is 0.5-1.4%[1]. Small aneurysms (<5 mm) have low rupture risk, and observation is adequate for those aneurysms[2]. Even today, despite enhanced surgical techniques, SAH has high morbidity and mortality rate. 50% of SAH patients die within the first month after bleeding. And a ruptured aneurysm may bleed again. When these severe risks are evaluated, it is easy to understand a fast and effective treatment approach. The efficiency of the treatment is determined by the correct diagnosis, which will guide the surgery. Early and effective surgery will reduce the risk of rebleeding and save lives[1-5]. Computer Tomography Angiography (CTA) can be a safe, minimally invasive, fast imaging way, and digital subtraction angiography (DSA) is an invasive and gold-standard imaging technique that can guide neurosurgeons for emergency aneurysm surgery. This study aimed to compare 58 aneurysmatic SAH patients according to demographic properties, radiological examination (DSA or CTA), Fisher score, Glasgow outcome score, aneurysm type, dimension, and location.

Conventional CT is the first step and a routine examination to detect SAH, and it is 90% sensitive, easily applicable, fast, and cheap. But conventional CT gives only an idea about the aneurysms according to the hemorrhage shape. Therefore, the further diagnostic examination should be done. Nowadays, CTA is a more popular radiological method because of technological development despite the early 90's article written by Görzer et al[6].

Patients and Methods

Patients

Our institutional Ethics Committee approved this retrospective study, and informed consent

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was obtained from all patients. Between January 2019 and November 2022, 85 SAH patients were referred to our clinic and were included in our study. Inclusion and exclusion criteria were illustrated in Figure 1. 58 patients were eligible for the final assessment. Excluded patients were: 3 patients had both diagnostic imaging (CTA and DSA); 2 patients had the non-diagnostic quality of CTA owing to motion artifacts, and 2 patients refused the surgery. Demographic features, Fisher grading scale, score, CTA and DSA findings, localization of the aneurysm, complication after surgery, hospital stay, and Glasgow Outcome Scale were recorded for each patient.

Imaging

All CT examinations were performed with a 320-row computed tomography system (Aquillon ONE, Canon Medical Systems, Kanagawa, Japan). Imaging parameters were 120 kVp, 250 mAs, FOV of 25 cm, reconstruction matrix of 512 × 512, and slice thickness of 1 mm. All patients received iopromide as an intravenous contrast medium (Ultravist 300, Bayer Healthcare, Berlin, Germany) with a dose of 2 mL/kg up to 100 mL administered using a power injector. Images were transferred to the workstation (Syngo *via* 60A, Siemens Healthcare, Erlangen, Germany). All CTAs were assessed *via* multiplanar reconstruction by a single radiologist with 14 years of experience in neuroradiology. DSA data were retrieved from radiology reports. In CTA, the number, size, and location of aneurysms were recorded for each patient.

Surgical Procedure

All patients underwent microsurgical clipping operations under general anesthesia in the first 12 hours after diagnosis. During surgery, low blood pressure was obtained, and neurological status with neuro-monitorization. Pterional craniotomy was made on all 58 patients. After Sylvian dissection, vascular anatomy was exposed, and the dome of the aneurysm was found. Proximal temporary clipping was made to suitable patients for dissecting the aneurysm in less than 2-5 minutes. After obtaining adequate visualization of the dome and surrounding vessels, microvascular clipping was applied. Papaverine 2 cc was used to prevent vasospasm due to surgical manipulations. After establishing hemostasis, dura sutured water tightly, and the wound closed adequately. All patients' post-operative follow-up is made in the neurosurgery intensive care unit. Post-operative CT and CTA angiography were performed within the first 3 hours.

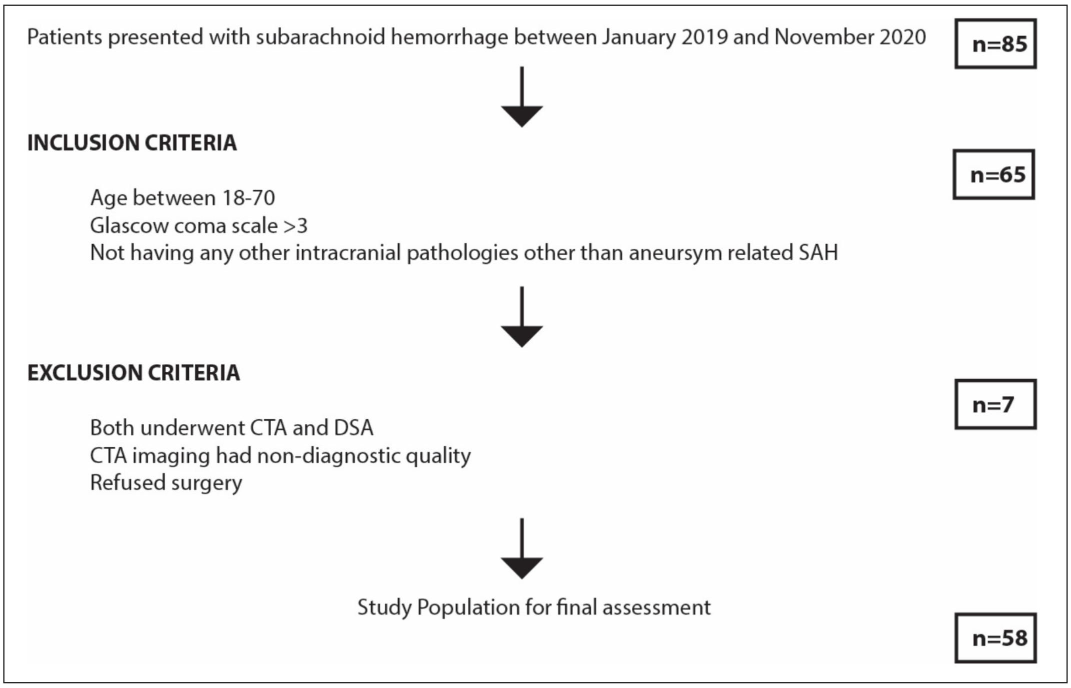

Figure 1. Inclusion and exclusion criteria belong to the study population.

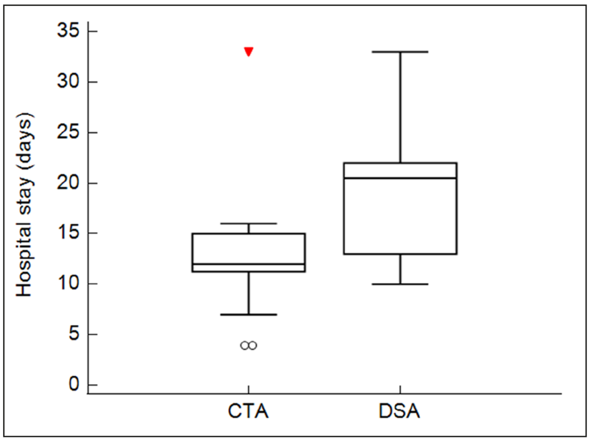

Figure 2. Box-and-whisker plot shows the hospital stay duration in both groups.

Statistical Analysis

Summary statistics of all participants were obtained based on the means or medians and standard deviations or ranges. The distribution of normality was assessed with D'Agostino-Pearson test. Nominal categorical variables were evaluated with Fisher exact test. Continuous variables with normal distribution belonging to two groups were compared using the Student's *t*-test whereas the non-normal distribution was compared using the Mann Whitney U test. A two-tailed $p<0.05$ was considered statistically significant. All statistical analyses were performed using Medcalc statistics software (MedCalc, ver. 20 trial, Ostend, Belgium).

Results

The mean age of the study population was 50±13.4 years, and 26 of the patients were female (44.8%). Demographic and study data belong to study groups, and corresponding *p*-values were presented in Table I. The most common location of the aneurysm was the M1 level (48.3%), of which 35.7% of the CTA group and 60% of the DSA group had.

The study population's median hospital stay was 15 days (range: 4-33 days.). There was a statistically significant difference between the DSA and CTA groups, as the DSA group had significantly more extended hospital stays ($p= 0.021$) (Figure 2).

The complication rate in the postoperative period was 58.6% in the study population. The most common complications were intracranial hemorrhage (20.7%) and hydrocephalus (13.8%). There was no statistically significant difference between the groups regarding the complication rates ($p=0.070$) (Figure 3).

Discussion

According to the results of our study, both CTA and DSA were adequate for surgical decisions. But DSA imaging took more time than CTA imaging, as expected, but the outcome of the patients was higher in the DSA group. This might be associated with the lower neurological status of the patients and the need for emergency surgery as soon as possible, making the outcome lower than DSA. But in all cases, we have found the aneurysms and vessels surrounding or arising from the aneurysm the same as radiological imaging. DSA provided better results in arising vessels from the aneurysm, and CTA gave sufficient information about the calcification of the aneurysm. Similar to Kato's study, CTA is a reliable alternative to DSA[7].

Today DSA is the gold standard radiological examination in intracranial aneurysm detection and evaluation. Nevertheless, this examination has a few disadvantages. It is not fast as a CT scan, requires a team to be performed, has complication risks because it is an invasive technique and finally patient takes radiation in higher doses[8]. Patients at the onset should be referred to an enhanced hospital with a neurologically experienced radiology facility[1]. These disadvantages don't change its importance, but another radiological examination requirement arises to perform emergency aneurysm surgery at once.

Table I. Demographic and study data belong to DSA and CTA groups and corresponding *p*-values.

	DSA (n= 28)	CTA (n= 30)	*p*-value
Age ± SD	46.2±13.3	50.6±12.8	0.204
Gender F/M	1	0.76	0.614
Median maximum diameter, mm (95% CI for the median)	5.4 (3.94-9.97)	7 (6-10)	0.228
Median Fisher Score (95% CI for the median)	1.5 (1-4)	3 (1-4)	0.497

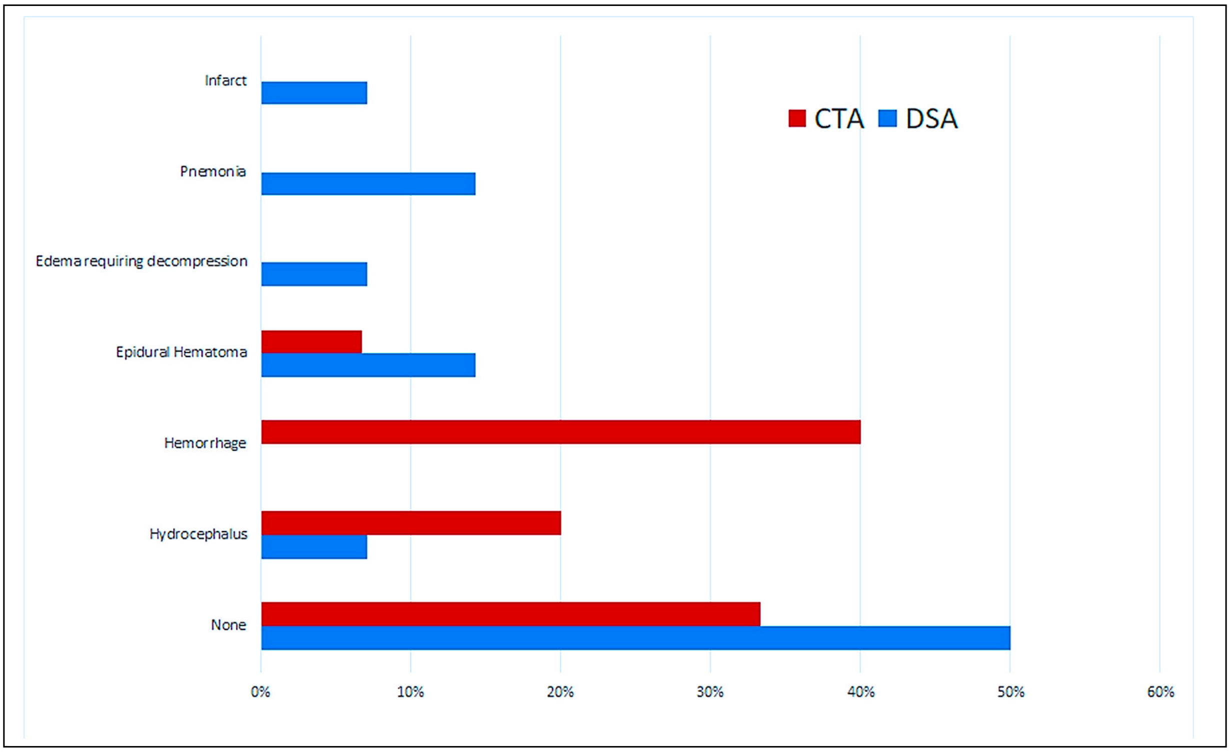

Figure 3. The bar graph shows complication rates in both groups.

DSA is an invasive procedure that could be associated with moderate or severe complication risks causing morbidity. Especially performing DSA in emergency cases like SAH or intracerebral hemorrhage complication risk is higher. Because of the complication risk of DSA, CTA may be the first line of examination[8]. Transient neurological events, hematomas, contrast agent allergy, and carotid vertebral - femoral artery dissections may happen during SA. Dion et al[9] and Willinsky et al[10] found higher risks in patients older than 55, hypertension, coronary artery disease, and peripheral vascular disease.

CTA is a modern, noninvasive, convenient, cheaper, fast, and reliable radiological examination in detecting and managing intracranial aneurysms. Besides its relative false negative results for small aneurysms, CTA doesn't have the complication risk as DSA[1,8]. CTA gives sufficient information about size, neck shape, calcification, interior thrombus, surrounding hematoma, and relationship with bony structures of the aneurysm[3]. But the accuracy level of CTA is also essential for surgical decisions. Many authors[11] have studied this issue. White et al[11] found 92% sensitive and 94% specific rates for CTA and explain that CTA is more favorable for more giant aneurysms.

CTA is insufficient for smaller and near the skull base aneurysms. Also, it is an accurate diagnostic tool for other intracranial aneurysms and can be the primary examination for imaging and treatment for patients presenting with SAH. The missing of a ruptured aneurysm in CTA is lower than 2%[1]. CTA can also give the sac/neck ratio information that will guide physicians in selecting endovascular or surgical treatment. At this point, importance of the CTA device shows itself, although according to older articles it was not an acceptable examination way for intracranial aneurysms because of its false negative results, even for AHA/ASA guidelines[6,12,13]. McKinney et al[13] found sensitivity of CTA <3 mm aneurysms 84% and >4 mm aneurysms 100% in a 4-channel multidetector device but 97% for all sizes in a 64-channel multidetector tomography device. The observer experience also raises the accuracy of CTA results[8]. Yang et al[2] studied small intracranial aneurysms and found a CTA accuracy of 96% even for small aneurysms and claimed that CTA sensitivity was a bit higher for small, ruptured aneurysms. Multi or single-detector technology, dual-energy, image acquisition protocol, injection timing of contrast agent, and the workstation to render images are decisive factors of CT device for better CTA results. Multi-detector technology is as sensitive as DSA for >3 mm aneurysms. Good image quality reduces missed aneurysms, especially for the ones <3 mm. Surrounding bony structures, uncommon locations like PICA, distal MCA, or anterior choroidal artery may cause false negative results[14,15]. Li et al[16] found sensitivity and specificity ratios as 100% for the aneurysms over 3 mm size and 93.7% -96.8% for the aneurysms under 3 mm size. Furthermore, SAH CTA can find the aneurysm sac better than DSA[16,17]. For CTA, information and images about the direction of the aneurysm are also adequate surgical experiences to prove this. 3D and dual-energy devices let physicians remove surrounding tissues like bones to preserve specific images[14,15,18].

Conclusions

Enhanced CT technologies, including 3D rendering, multidetector and dual-energy devices, give the experienced surgeon and radiologist sufficient data about intracranial aneurysms, sometimes more than DSA performed for a SAH patient. But DSA keeps its importance. CTA is a faster and cheaper examination method, and DSA may be the reason for more extended hospital stays. Furthermore, DSA is an invasive procedure and needs more time to diagnose.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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Informed Consent

Informed consent was obtained from all patients included in the study

Ethics Approval

The study protocol was approved by the Ethics Committee of the Faculty of Medicine of the Ataturk University and was conducted in accordance with the principles of the Declaration of Helsinki (B.30.2.ATA.0.01.00/663,27.10.2022/8:47).

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Authors' Contribution

Mete Zeynal: Planning, designing, data collection, literature survey, interpretation of the results. Ahmet Yalcin: Statistical analysis, conception of the work.

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