Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v6i7.1879
*Biol. Clin. Sci. Res. J., Volume 6(7), **2025**: 1879*
Original Research Article

Diagnostic and Therapeutic Role of Spiral CT Angiography in Intracerebral Aneurysms Presenting with Acute Subarachnoid Haemorrhage

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(Received, 14th March 2025, Accepted 15th July 2025, Published 31st July 2025)

Abstract: *Subarachnoid haemorrhage (SAH), which is usually due to the rupture of the intracranial aneurysms, is a severe disease, which is a neurological emergency that requires efficient and reliable diagnosis. Computed Tomography Angiography (CTA) has proved an important non-invasive screening tool in the diagnosis of vascular abnormalities of the brain.* ***Objective:*** *This research was based on the diagnostic value of spiral CTA in detecting intracranial aneurysms in patients discharged with acute spontaneous subarachnoid haemorrhage.* ***Methods:*** *Bands of the 30 patients with non-traumatic SAH who were admitted due to presenting SAH and finally verified on emergency non-contrast CT were examined during a prospective descriptive study. Each of the patients was identified by CTA using a Toshiba Aquilion 16-isce multidetector CT scanner. Pre-contrast, as well as post-contrast images were taken, and 3D reconstructions were provided, which consist of maximum intensity projection (MIP) and volume-rendered imaging. Information on aneurysms was gathered in terms of size, shape, multiplicity, location, and findings connected to the aneurysms, i.e., vasospasm and infarction.* ***Results:*** *This CT angiography was able to detect intracranial aneurysms in every patient. Anterior circulation encompassed 83.3% of all the aneurysms, and the most frequent one, which occurred at the anterior communicating artery. The vast majority of aneurysms were between 3 and 7 mm. CTA was also used, which also showed related complications such as the presence of 30% and infarctions of 10%. The modality was found to be very sensitive to aneurysms that are 3 mm and upwards.* ***Conclusion:*** *Spiral CTA is a fast, dependable, and noninvasive imaging method with high diagnostic value in identifying intracranial aneurysms in the acute SAH. It plays a critical role in early diagnosis, treatment planning, and enhancement of patient outcomes. It can be discussed as one of the main imaging modalities used in assessing emergency neurovascular.*
Keywords: Aneurysm, Brain, Computed Tomography Angiography (CTA), Diagnosis, Intracranial, Non-invasive, Spiral CT, Subarachnoid Haemorrhage (SAH), Toshiba Aquilion, Vascular Abnormalities

[***How to Cite:*** Anjum S, Rana S, Sattar A, Jalal MLA. Diagnostic and therapeutic role of spiral CT angiography in intracerebral aneurysms presenting with acute subarachnoid haemorrhage. *Biol. Clin. Sci. Res. J.*, **2025;** 6(7): 121-124. doi: https://doi.org/10.54112/bcsrj.v6i7.1879]

Introduction

Subarachnoid haemorrhage (SAH), mostly attributed to the rupture of an intracranial aneurysm (ICA), is a very dangerous neurological emergency with high morbidity and mortality rates (1, 2). It has been reported in literature that SAH aetiology can be either nontraumatic (about 85% are secondary to aneurysm rupture) or traumatic (3). Moreover, it constitutes about 5% of all strokes, and it is underdiagnosed or misdiagnosed, especially in acute conditions (4). Timely detection and localisation of aneurysms are essential for informed therapeutic decisions and improved patient prognosis. The digital subtraction angiography (DSA) has traditionally been viewed as the so-called gold standard in the diagnosis and characterisation of ICAs, because it offers high spatial resolution and dynamic imaging of vascular structures (5). Nevertheless, DSA is intrusive, laborious, and can be accident-prone, such as thromboembolic occurrences and contrast-induced reactions (6).
Non-invasive imaging techniques, particularly cross-sectional imaging, have played a significant role in the diagnosis of suspected ICAs in acute SAH over the past few years. Among those, multidetector computed tomography angiography (MDCTA) has proven to be a potential plan, as it has fast acquisition capabilities, high spatial resolution, and post-processing in three dimensions. The studies have shown that MDCTA has a close accuracy in diagnosis with DSA, with a sensitivity of 93-100 per cent and specificity nearly 100 per cent in aneurysms greater than 3 mm (7, 8). The visualization of aneurysms is also improved by the addition of three-dimensional volume rendering and maximum intensity projection (MIP), making it possible to accurately examine the morphology and neck measurements along with spatial relationships of the aneurysms to other vessels (9).
The effectiveness of spiral CT angiography in emergencies, particularly in cases of acute neurological worsening, is crucial due to its availability and time-saving properties in such patients. The use of MDCTA in the identification of aneurysms that caused SAH has been verified in several studies, which asserted its usefulness beyond the diagnosis into preoperative planning (10). In addition, some other findings, like vasospasm, infarction, and hydrocephalus, which are critical to the overall management, have been revealed to be effective with MDCTA (11). Nonetheless, other limitations include a lack of precision in identifying tiny-sized aneurysms (<3 mm) and potential issues with using bone artefacts around the skull base, among others. Additionally, the need to fine-tune the scan for adequate quality contrast is necessary (12).
Another non-invasive procedure, which is frequently utilised in the imaging of the intracranial vasculature, is magnetic resonance angiography (MRA). When compared to MDCTA, MRA has the advantage of not having ionizing radiation and iodinated contrast agent but suffers from low sensitivity and spatial resolution, especially in acute clinical settings (13). Additionally, MRA takes up more time to acquire, and it is prone to motion artefacts; thus, it is not applicable in patients who are highly unstable or uncooperative (14).
Considering these aspects, it can be stated that spiral CT angiography has become recognised more and more frequently as the first-line diagnostic test of ICAs in acute SAH. It provides detailed information on its morphology, enabling effective and quick decision-making for clipping or coiling surgery (15). However, as the evidence on the use of this approach grows, most of the current studies share similar limitations, including small sample sizes, regional bias, and the absence of standard procedures between different institutions. Moreover, only limited research has been devoted to a critical appraisal of the standalone diagnostic and management utility of spiral CTA when considered under the low-resource setting, where the use of DSA might be limited.

Thus, the current research aims to assess the sensitivity and specificity of spiral CT angiography in the diagnosis of intracranial aneurysms in patients with acute subarachnoid hemorrhage. This study aims to identify an intraoperative/DSA outcome with the imaging findings to conclude whether spiral CTA can be used as a non-invasive and accurate substitute for DSA in diagnosing and managing acute neurovascular emergencies early and planning the management.

Methodology

This is a prospective descriptive study carried out on patients with spontaneous acute subarachnoid haemorrhage (SAH) who were referred to undergo computed tomography angiography (CTA) to determine possible vascular malformations in the brain as a possible cause. The researchers conducted the research at a tertiary care radiology department that had multidetector CT imaging capability.

The study has recruited a total of 30 patients with a revealed diagnosis of spontaneous acute SAH on non-contrast emergency CT scans. The inclusion criteria included adult patients who were clinically stable and referred to CTA to estimate the existence of intracranial aneurysms. Patients with renal impairment, hypersensitivity to iodinated contrast agents, or patient presentation as hemodynamically unstable could not be imaged and were set aside as exclusion criteria.

All of the patients signed written informed consent before the imaging procedure was conducted. When the patient was unconscious or unable to give consent, they gave consent through an immediate family member or legal guardian. The participants were made aware of all the possible risks, such as contrast-induced nephropathy and allergic reactions. The renal function was ascertained before the use of the contrast by determining the level of serum creatinine and blood urea; patients were removed in cases where values were not within the normal range.

CTA was performed using a Toshiba Aquilion 16-slice multi-detector computed tomography (MDCT). The first CT scan was the non-contrast CT, which was performed in the craniovertebral junction to the vertex parallel to the orbitomeatal line by the following scan parameters: rotation time 0.5 second, reconstruction interval 0.5 mm at a voltage of 120 V and 300 mAs with an approximate acquisition time of 7 seconds.

As an immediate follow-up to the non-contrast scan, the contrast agent, 80 mL of Iopamiro (Iodinated), was given intravenously through a power injector with a flow rate of 3.5 mL/s through the antecubital vein. An arterial bolus tracing method was involved to maximise arterial enhancement. The region of interest (ROI) was placed in the internal carotid artery, and spiral scanning was controlled automatically when a level of 80 Hounsfield units (HU) was obtained.

The obtained source images were moved to the Vitrea 3.9 workstation to be processed. An initial assessment was carried out as a thorough reading of axial images. Thereupon, maximum intensity projections (MIP) 2D and 3D volume-rendered (VR) images were created. All scans were reviewed by a consultant radiologist with an interest in neuroimaging. Important results such as the existence and quantity of aneurysms, their morphology (mass, neck width, direction), origin of the parent vessels, and the course of collateral circulation, including the circle of Willis, were found. Other results were also observed, including the distribution of haemorrhage, vasospasm, and infarcts.

The procedure of data collection was divided into two:

- Part I: Demographic and clinical features, i.e., age, sex, and presenting symptoms of the patient (e.g., epilepsy, headache, loss of consciousness, neurological deficit).
- Part II: Aneurysmal features such as location, multiplicity, maximum diameter, and neck size.

A standardised pro forma had been used to record all data in this research. The measurements of quantitative variables were obtained in millimetres using imaging software tools. The value of spiral CT angiography as a diagnostic test was evaluated based on the quality of aneurysmal imaging and its utility in informing therapeutic management.

The collected data were pooled into a Microsoft Excel sheet, followed by analysis through IBM SPSS Statistics (version 25). The descriptive statistics were used to summarise the demographics of patients, the clinical presentation, as well as the characteristics of aneurysms. Continuous data, including the patient's age, aneurysm size, and neck diameter, were obtained as mean and standard deviation. Categorical data, such as aneurysm locations, the presence of multiple aneurysms, and the occurrence of haemorrhage or infarction, were reported as frequency and percentage.

Results

A total of 30 patients with the diagnosis of intracranial aneurysm based on CT angiography (CTA) were included in the present study, with an age range between 20 and 80 years (mean age: 50 years). It was more common among females, with a male-to-female ratio of 1:1.5. The presenting symptom was most often a headache, occurring in 73% of patients, followed by loss of consciousness in 17%. It was further noted that 50% of the cohort reported nausea and vomiting, with seizures being the fourth common presentation. Motor deficits were experienced in about 25% of patients.

CTA managed to identify 36 aneurysms out of 30 patients. These include four patients with double aneurysms: two with aneurysms with common roots of the parent arteries, and two with aneurysms on different parent vessels—three of the patients contained within themselves three aneurysms of diverse vascular origin.

Data depicted in Table II revealed that 88.9% were found in the anterior circulation. Namely, 15 (41.7%) aneurysms were situated at the anterior communicating artery (ACOM), 9 (25%) at the middle cerebral artery (MCA), 5 (13.9%) at the distal internal carotid artery (ICA), and 3 (8.3%) at the posterior communicating artery (PCOM). The posterior circulation aneurysms accounted for 11.1% of the total, comprising three vertebro-posterior inferior cerebellar artery (V-PICA) aneurysms and one posterior cerebral artery (PCA) aneurysm.

In terms of the size of the aneurysms, CTA detected seven aneurysms (19.4%) whose width was 3 mm, and five aneurysms (13.9%) exceeding 10 mm of the estimated diameter. The average maximum diameter of an aneurysm was 6.2 mm, and the biggest diameter was 20 mm (an ACOM aneurysm), as shown in Table III. CTA also did a good job in outlining the aneurysm necks in 91.7% of the cases. Aneurysms with a narrow neck (<= 3 mm) were present in about 50% of cases. Nevertheless, the necks were not seen in three ACOM aneurysms because the confluence of the anterior cerebral arteries was too complex anatomically.

Besides diagnosis of the aneurysm, the CTA also led to notification of some complications present in some of the patients, including intracerebral haemorrhage (20%), vascular spasm (15%), and infarction (16%).

Table 1: Distribution of Intracranial Aneurysms by Anatomical Location Detected on CTA

Aneurysm Location	CTA findings (n)
ACOM	15
MCA	9
ICA	5
PCOM	3
V-PICA	3
PCA	1
Total	36

(ACOM: Anterior Communicating Artery, MCA: Middle Cerebral Artery, ICA: Internal Carotid Artery, PCOM: Posterior Communicating Artery, V-PICA: Vertebral–Posterior Inferior Cerebellar Artery, PCA: Posterior Cerebral Artery)

Table 2: Frequency Distribution of Aneurysm Neck Size Detected by CTA

Neck Size (mm)	No. of Patients (%)
<2	7(19.4)

2.1-3	11(30.6)
3.1-4	4(11.1)
4.1-5	5(13.9)
>5.1	6(16.7)
Unclear	3(8.3)
Total	36(100)

Table 3: Frequency Distribution of Aneurysm Maximum Dimensions on CTA

Largest Dimension (mm)	No. of Patients (%)
3.1-4	9 (25.1)
4.1-5	7(19.4)
5.1-6	6(16.7)
6.1-7	2(5.6)
7.1-8	3(8.3)
8.1-9	3(8.3)
9.1-10	1(2.8)
>10	5(13.9)
Total	36(100)

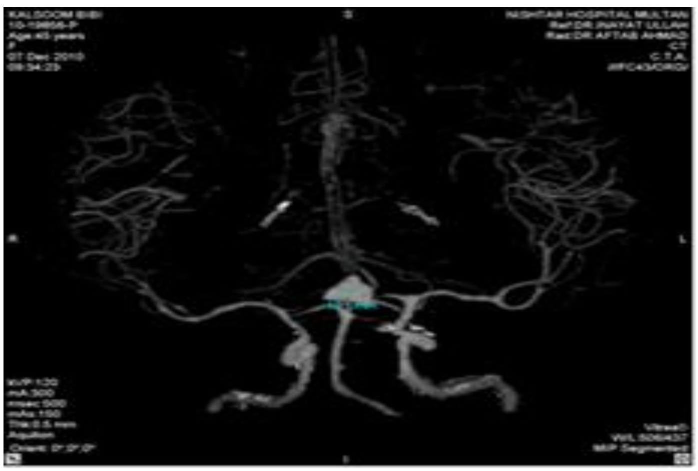

Figure 1: 45 years, Female, ACOM aneurysm

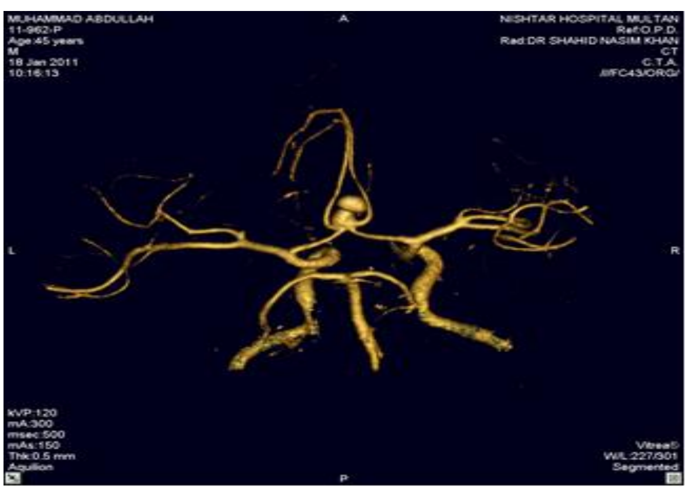

Figure 2: 45-year-old Male, ACOM aneurysm

Discussion

Results of the present study show that CTA has a good diagnostic yield of detecting intracranial aneurysms with very close sensitivity in the literature. Our female predominance (M: F = 1:1.5) as well as mean age (50 years) values agree with the global epidemiological patterns of aneurysmal subarachnoid haemorrhage (SAH) in which predominance of female sex and old age are considered as risk factors (16).

The most frequent clinical presentation was that of headache, as is expected since other studies have established this as one of the most characteristic clinical manifestations of aneurysmal rupture (17). It is worth noting that the frequency of seizures in our population was marginally higher than in other populations discussed in the literature, possibly due to delayed presentation or the presence of cortical irritation. CTA has shown 100% sensitivity in the detection of aneurysms in patients presenting with acute SAH. This result can be justified by the previous study underlining the high sensitivity of CTA in detecting aneurysms, especially with lesions that are larger than 3 mm (18). The researchers reported a 64% sensitivity of aneurysms <3 Mm, 83% 3-4 mm, 95% 5-12 mm, and 100%>13 mm. Likewise, Mkhize et al. (2023) suggested a 3 mm cut-off value below which sensitivity decreases significantly.

Aneurysms in our study were mainly of the anterior circulation (88.91%), especially ACOM (41.7%) and MCA (25%). Aneurysms of the ACOM (38%) and MCA (32%) were also associated with high incidence in Uysal et al. (2005). In contrast, the incidence of the posterior circulation aneurysm was only 9%, which was similar to that in our study (11.1%).

In addition to detecting aneurysms, CTA was also found beneficial in its ability to visualise aneurysmal necks, which are an essential component of both surgical and endovascular strategies. Multi-planar and 3D reconstructions can also be produced, which, to a great extent, help in surgical orientation and in choosing the right clipping strategy (19). Proper measurements of the dome-to-neck ratio and appropriate suitability of endovascular coiling using CTA are necessary.

Nevertheless, CTA is not free of limitations. It can mistakenly identify infundibular dilations or division of vessels as aneurysms, especially within such anatomically tricky areas like bifurcations of MCA or intracavernous ICA (20). Additionally, the detection of aneurysms by artefacts of vessel overlapping, kissing vessels, contamination of veins, and vasospasm may obscure the visualisation of the aneurysms (21). CTA will not reliably measure collateral flow like other tests, such as digital subtraction angiography (DSA).

However, CTA is a favourable first-line treatment in cases of sensitive patients with severe illness, or neurologically weak cases owing to its non-invasive character, fast acquisition, and low risk status. The 0.1-0.5% permanent neurologic complication (mean 0.3%) risk is still present with DSA (designated as the gold standard) according to the large-scale studies (20). In CTA, there is also reduced contrast load, and it applies to patients in life-support machinery.

To sum up, CTA is an efficient, non-invasive, and robust alternative to imaging for detecting the presence of aneurysms in the intracranial cavity and their morphological characteristics. It has a high level of diagnostic accuracy, particularly in anterior circulation aneurysms exceeding 3 mm, which enables its inclusion in typical SAH diagnostic procedures, especially in situations where rapid and safe results are crucial.

However, CTA has limitations, such as difficulties in detecting small aneurysms (<3 mm) and complex vascular anatomy. Despite this, it remains a highly sensitive and specific initial examination for aneurysms of 3 mm and larger. Future advancements in CTA resolution and image processing may further reduce reliance on invasive angiography, solidifying CTA's role in early intervention for patients with intracranial aneurysms.

Conclusion

Computer Tomography Angiography (CTA) demonstrates strong diagnostic ability in detecting and examining intracranial aneurysms, particularly in patients with acute subarachnoid haemorrhage. In this study, CTA successfully identified aneurysms, primarily in the anterior circulation, especially along the anterior communicating artery. It provided a detailed visualisation of aneurysm size, neck morphology, and complications like haemorrhage and vasospasm. CTA's precision in measuring aneurysm features is valuable for preoperative planning, helping to decide between surgical clipping and endovascular coiling. Its quick, non-invasive nature and capability for 3D reconstruction are advantageous compared to digital subtraction angiography (DSA), especially in emergencies or for high-risk patients.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

Funding

Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

SA (Assistant Professor), SR (Assistant Professor)

Review of Literature, Data entry, Data analysis, and drafting an article.
Study Design, manuscript review, and critical input.

AS (Professor), MLAJ (Associate Professor)

Conception of Study, Development of Research Methodology Design
Manuscript drafting, Study Design,

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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