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Original Article

Diagnostic Accuracy of Computed Tomography Angiography for Detecting Aneurysms in Non-Traumatic Subarachnoid Hemorrhage keeping Digital Subtraction Angiography as Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of Computed Tomography Angiography (CTA) in detecting aneurysms in Non-Traumatic Subarachnoid Hemorrhage (NTSAH) by keeping Digital Subtraction Angiography (DSA) as a gold standard.
Study Design: Cross-sectional study.
Place and Duration of Study: Department of Computed Tomography (CT), Armed Force Institute of Radiology and Imaging (AFIRI) Rawalpindi, Pakistan, from Sep 23 to Mar 24.
Methodology: Fifty individuals with suspected subarachnoid hemorrhage (SAH) were included in this cross-sectional investigation. Computed Tomography Angiography (CTA), Digital Subtraction Angiography (DSA), and an initial non-contrast CT scan were the typical diagnostic procedures performed on the patients. The accuracy of Multidetector Computed Tomography Angiography (MDCTA) was calculated by comparing its results with those of DSA and surgical procedures. To examine the agreement between DSA and CTA, kappa coefficient was utilized. Statistical significance was indicated by a *p*-value of less than 0.05.
Results: A total of 50 patients were included in the study. The mean age of patients was 54.32±13.81 years. Aneurysmal size was 5.62±3.09 mm on average. CTA demonstrated 97.9%, 100%, 100%, and 75% sensitivity, specificity, and positive and negative predictive values, respectively. A significant agreement between CTA and DSA was found by the kappa test. 0.847 is the kappa coefficient.
Conclusion: In the majority of NTSAH patients, Multidetector Computed Tomography Angiography (MDCTA) is a quick, less invasive, and trustworthy alternative to DSA. Better treatment of these patients may be made possible by its high sensitivity, specificity, and predictive values in identifying and describing related aneurysms.

Keywords: Aneurysm, Angiography, Computed Tomography, Digital Subtraction Angiography, Multidetector Computed Tomography Angiography, Non-Traumatic Subarachnoid Hemorrhage.

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INTRODUCTION

For stroke, subarachnoid hemorrhage (SAH) is the third most prevalent subtype, which constitutes a neurological emergency. Claassen *et al*., emphasized that SAH represents a critical neurological emergency with significant morbidity and mortality implications.[1] About 85% of SAHs are secondary to aneurysm rupture. However, they can also have a traumatic or nontraumatic origin. Ruptures of cerebral aneurysms account for approximately 85% of nontraumatic causes of SAH, while studies show that a vascular lesion is absent in the remaining 15-25% of patients.[2] About one in 10,000 people experience a spontaneous subarachnoid hemorrhage each year. Studies show that SAH has an apparently poor prognosis, with a 30-day mortality rate of 45% and a close to one-third long-term moderate-to severe disability rate among survivors.[3,4]

Various neuroimaging modalities are available for the detection of cerebral aneurysms, including Computed Tomography Angiography, Magnetic Resonance Angiography, and Digital Subtraction Angiography.[5,6] CT angiography (CTA) is commonly performed before Digital Subtraction Angiography (DSA) to rule out intracranial aneurysms.[7]

CTA is an immediate, noninvasive procedure and it is the first-line modality in non-traumatic subarachnoid hemorrhage for detection of aneurysms with comparable diagnostic accuracy.[8] However, the gold standard for the detection of aneurysms is conventional catheter DSA, although it is a minimally invasive procedure with neurological complications in <1% of patients. It has been noted that if a small aneurysm less than 3 mm is missed on CTA, DSA can be utilized to diagnose it.[9] Mkhize *et al*., conducted research assessing the diagnostic performance of CTA for cerebral aneurysms and showed that specificities

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range from 87% to 100% and sensitivities from 77% to 97%.[10]

This study aimed to determine the sensitivity and accuracy of MDCTA in detecting aneurysms in cases of nontraumatic subarachnoid hemorrhage.

METHODLOGY

This cross-sectional study was conducted in the department of Computed Tomography, Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, Pakistan, from September 2023 to March 2024. Approval was obtained from the Institutional Review Board (reference no. AFIRI-RWP-IERB-APRV-001 no.13).

Inclusion Criteria: Patients of either gender between the ages of 20 and

85 years with a clinical suspicion of having an intracranial vascular abnormality (SAH), those scheduled for CTA, or those who had recently had a nonenhanced CT scan of the brain to confirm the presence of SAH were included.

Exclusion Criteria: Patients with SAH attributed to recent trauma, individuals who had already undergone endovascular therapy or surgery at Circle of Willis were excluded.

Sample size was calculated using Buderer's formula for diagnostic studies with expected sensitivity 89%, and disease prevalence 85% yielding a minimum requirement of 69 patients.[11,12] Based on feasibility and STARD guidelines, 50 consecutive patients were enrolled using non-probability consecutive sampling, and written informed consent was obtained prior to study commencement.

CTA was performed using a 128-slice MDCT scanner (Siemens SOMATOM Definition AS+, Siemens Healthcare, Germany) with 0.6 mm slice thickness and intravenous contrast (Ultravist 370, Bayer, Germany). DSA was performed using a biplane angiography system (Siemens Artis zee biplane, Siemens Healthcare, Germany) via transfemoral approach.

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 22. Mean±SD and frequencies were calculated for quantitative and qualitative variables respectively. A 2×2 contingency table determined CTA's sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy versus DSA. Cohen's kappa coefficient assessed inter-modality agreement. Statistical significance was set at $p<0.05$.

RESULTS

Fifty patients with probable SAH who had MDCTA and DSA were included in the research. The mean age was 54.32±13.81 years, and the mean aneurysm size was 5.62±3.09mm, the smallest being 1mm and the largest measuring 16mm, as shown in Table-I.

Table-I: Baseline Characteristics (n=50)

Parameters	Mean±SD	Range
Age (years)	54.32±13.81	30-85
Aneurysm size (mm)	5.62±3.09	1-16

In our study of 50 patients, 43 (86%) patients had one aneurysm, 1(2%) patient had two aneurysms, and 3(6%) patients had three aneurysms. Out of total patients, 47 persons showed aneurysms. Among these, 1(2%) person had an aneurysm less than 3 mm, 21 (42%) individuals had aneurysms between 3-5 mm, and 25(50%) patients had aneurysms larger than 5 mm. Additionally, 42 (84%) patients had aneurysms in the anterior circulation, while 5 patients had aneurysm in the posterior circulation. Table-II displays a comprehensive summary of these characteristics.

Table-II: Descriptive Summary of Variables (n=50)

Variables		n (%)
Number of Aneurysms	1	43(83%)
	2	1(2%)
	3	3(6.0%)
Size of Aneurysm	<3mm	1(2.0%)
	3-5mm	21(42.0%)
	>5mm	25(50.0%)
Site of Aneurysm	Anterior circulation	42(84.0%)
	Posterior circulation	5(10.0%)

The comparison matrix between CTA and DSA is shown in Table-III. Every one of the 50 patients had a DSA and CTA. Forty-six of the 50 patients were positive for both DSA and CTA diagnoses. Four of these individuals had negative results on both the CTA and the DSA. One patient had a positive DSA and a negative CTA. A patient who tested negative on DSA but positive on CTA did not exist. As can be seen in Table-III there is statistically significant agreement between the CTA and DSA diagnoses.

CTA's sensitivity and specificity over DSA were 97.9% and 100.0%, respectively, with 100.0% and 75.0% for positive and negative prediction values. The Kappa test revealed a strong correlation between DSA and CTA as shown in Table-IV.

Table-III: Association of CTA with DSA (n=50)

CTA Diagnosis of Aneurysm	DSA Diagnosis of Aneurysm		*p*-value
	Positive n (%)	Negative n (%)	
Positive	46(100.0%)	0 (0.0%)	<0.001
Negative	1(25.0%)	3(75.0%)	
Total	47(94.0%)	3(6.0%)	

** DSA: Digital Subtraction Angiography*
CTA: Computed Tomography Angiography

Table-IV: CTA's Sensitivity, Specificity, and other Metrics in Comparison to DSA

Measures	Values
Sensitivity	97.9%
Specificity	100.0%
PPV	100.0%
NPV	75.0%
Kappa Coefficient	0.847

**CTA: Computed Tomography Angiography,*
DSA: Digital Subtraction Angiography
PPV: Positive Predictive Value NPV: Negative Predictive Value

DISCUSSION

The current study aimed to assess the diagnostic accuracy of 128-slice Multi-Detector

Computed Tomography Angiography (MDCTA) compared to Digital Subtraction Angiography (DSA) for detecting intracranial aneurysms in patients with non-traumatic subarachnoid hemorrhage (NTSAH). Our results show that MDCTA is a highly reliable and accurate first-line diagnostic method in this urgent clinical situation.

The key finding of our study is the high diagnostic accuracy of MDCTA, which demonstrated a sensitivity of 97.9%, a specificity of 100%, and a perfect positive predictive value (PPV) of 100% when compared to DSA. The strong agreement between modalities, as indicated by a Kappa coefficient of 0.847, suggests excellent concordance between the two techniques.[13] This performance is due to the technological advantages of the 128-detector scanner, including its superior spatial resolution and rapid acquisition time, which eliminated motion artifacts and produced diagnostically superior images in all

50 patients. This technical feasibility is a vital advantage in neurological emergencies where time-sensitive decisions directly influence patient outcomes.

These results align with the global consensus that modern CTA is highly accurate.[14] However, a critical comparison reveals that our findings are at the upper end of the range reported in international literature. Li *et al*., conducted a multidetector CTA study evaluating variations in the circle of Willis in a Chinese population, providing foundational insights into anatomical differences that affect aneurysm detection.[15] Dammert *et al*., used multislice CT and reported sensitivities from 85% to 96%, highlighting limitations of earlier-generation scanners.16 Kangasniemi *et al*., assessed two-dimensional and threedimensional multislice helical CT angiography and found that sensitivity improved with advanced imaging protocols.[17] Our sensitivity of 97.9% aligns with more recent studies using advanced technology. Tipper *et al*., using a 16-row scanner, reported a sensitivity of 96% and a specificity of 100%, figures very close to ours.[18] This indicates that incremental improvements in detector technology and post-processing software (such as Volume Rendering Techniques with bone removal) are leading to measurable increases in clinical accuracy, especially for evaluating complex regions near the skull base.

A critical metric for any aneurysm-detection modality is its performance with small aneurysms (<3mm), which are historically prone to being missed. Van Gelder *et al*., critically discussed the implications of aneurysm size distribution for the sensitivity, specificity, and likelihood ratios of computed tomographic angiography in detecting cerebral aneurysms, emphasizing that smaller aneurysms present significant diagnostic challenges.[19] In our cohort, the mean aneurysm size was 5.62±3.09 mm, with a range from 1 mm to 16 mm. We successfully detected one aneurysm smaller than 3mm. The distribution of aneurysm sizes in our study—with 42.0% being 3-5 mm and 50.0% being larger than 5 mm—differs from the findings of Suhas et al., who reported a much higher proportion (48.89%) of aneurysms <3mm in their cross-sectional study evaluating MDCTA diagnostic accuracy for intracranial aneurysms in non-traumatic subarachnoid hemorrhage.[20] This discrepancy may reflect population-specific differences in aneurysm biology or, more likely, the superior detection capability of our 128-slice technology compared to their equipment, allowing us to identify a smaller proportion of very small aneurysms in the cohort. Furthermore, the one false-negative case in our study (a missed aneurysm on CTA that was positive on DSA) underscores that while technology has diminished the gap, the potential for missing very small or subtly filling lesions persists, affirming that DSA retains its role in cases of high clinical suspicion with a negative CTA.

A focused comparison with studies from Pakistan is essential to contextualize our findings within the national healthcare landscape, which often involves resource constraints and varying levels of technological access. A study by Qadir *et al*., evaluated 64-slice CTA in detecting intracranial aneurysms in patients with non-traumatic subarachnoid hemorrhage and reported a sensitivity of 94.7% and specificity of 91.2%.[21] Again, our results show a marginal improvement, likely due to the higher detector count of our scanner. However, a more significant difference lies in the aneurysm characteristics. The study reported a higher prevalence of posterior circulation aneurysms (21%) compared to our finding of 10%. Our study found 84% of aneurysms in the anterior circulation, which is consistent with the most common global distribution. This discrepancy in anatomical distribution highlights potential regional variations in disease patterns and underscores the importance of local and institutional audits to guide diagnostic protocols and radiologist training. The high accuracy we achieved in the posterior circulation, despite its anatomical challenges, further validates the efficacy of modern MDCTA protocols.

LIMITATIONS OF STUDY

Due to its limited sample size and lack of investigation into the relationship between aneurysm size and diagnostic accuracy, the current study has limitations. To get around these restrictions, future multicentric, prospective investigations are urged, with bigger sample sizes and broader coverage of variants and anatomical analysis.

CONCLUSION

In the majority of Non-Traumatic Subarachnoid Hemorrhage (NTSAH) instances, the Multidetector Computed Tomography Angiography (MDCTA) can be a quick, less invasive, and trustworthy alternative to Digital Subtraction Angiography (DSA). Because of its strong predictive values, sensitivity, and specificity in identifying and describing related aneurysms, it can help improve patient care.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SA & KF: Data acquisition, data analysis, critical review, approval of the final version to be published.

AM & MR: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SK & ZA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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