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FREQUENCY AND CHARACTERIZATION OF CEREBRAL ANEURYSM ON COMPUTED TOMOGRAPHY ANGIOGRAPHY IN A TERTIARY CARE SETTING OF LAHORE

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ABSTRACT

Background: Cerebral aneurysms are important cerebrovascular abnormalities that may remain clinically silent until rupture, resulting in significant morbidity and mortality. Computed Tomography Angiography (CTA) has become a widely utilized non-invasive imaging modality for the detection and characterization of intracranial aneurysms. However, local data regarding the frequency and radiological characteristics of cerebral aneurysms remain limited.

Objective: To determine the frequency of cerebral aneurysms detected on CTA and to evaluate their anatomical location, parent vessel involvement, and size distribution in patients undergoing neurovascular imaging at a tertiary care hospital in Lahore.

Methods: This cross-sectional descriptive study was conducted at the Department of Radiology, Doctors Hospital & Medical Centre, Lahore, over a six-month period. A total of 120 adult patients undergoing neurovascular CTA were enrolled using non-probability consecutive sampling. CTA examinations were performed using a 128-slice multidetector CT scanner. Images were independently reviewed by two experienced radiologists. Data were analyzed using SPSS version 26.0. Descriptive statistics were calculated, and associations between categorical variables were assessed using the Chi-square test or Fisher's Exact Test, with a p-value <0.05 considered statistically significant.

Results: Cerebral aneurysms were detected in 47 of 120 patients, yielding a frequency of 39.2%. The mean age of patients with aneurysms was 54.6 ± 11.8 years. The anterior communicating artery was the most commonly involved vessel (29.8%), followed by the middle cerebral artery (25.5%) and posterior communicating artery (17.0%). The mean aneurysm size was 6.9 ± 3.7 mm. Medium-sized aneurysms (5–10 mm) constituted 44.7% of cases, while small and large aneurysms accounted for 40.4% and 14.9%, respectively. A significant association was observed between aneurysm location and size category ($p = 0.041$).

Conclusion: CTA demonstrated high utility in the detection and characterization of cerebral aneurysms. Anterior circulation aneurysms predominated, with most lesions measuring less than 10 mm. The findings provide valuable local evidence to support diagnostic evaluation and clinical risk assessment of cerebral aneurysms.

KEYWORDS: Aneurysm, Intracranial; Cerebral Angiography; Computed Tomography Angiography; Diagnostic Imaging; Intracranial Hemorrhages; Neuroimaging; Tomography, X-Ray Computed

INTRODUCTION

Cerebral aneurysms are abnormal focal dilatations of intracranial arteries that arise due to structural weakness within the vessel wall and are recognized as an important cause of neurological morbidity and mortality worldwide. Although many aneurysms remain asymptomatic throughout life, their rupture can result in subarachnoid hemorrhage, a devastating neurological event associated with high rates of disability and death(Mkhize et al., 2023). The clinical significance of cerebral aneurysms lies not only in their potential to rupture but also in the challenges associated with their timely detection, risk stratification, and management. Advances in neurovascular imaging have considerably improved the ability to identify aneurysms before catastrophic complications occur, thereby creating opportunities for early intervention and improved patient outcomes(Diab et al., 2023).

The prevalence of unruptured intracranial aneurysms in the general population has been estimated to range between 2% and 5%, although variations have been reported across different geographic regions and patient populations. Increasing utilization of advanced neuroimaging techniques has led to a growing number of incidentally detected

aneurysms during investigations performed for headaches, dizziness, stroke, cranial nerve deficits, and other neurological complaints(Aburto-Murrieta et al., 2025). The burden of aneurysmal disease is expected to rise further with improved access to imaging facilities and greater awareness among clinicians regarding cerebrovascular disorders. Consequently, accurate characterization of aneurysms has become a critical component of contemporary neurovascular practice(Elsebaie et al., 2022).

Among the available imaging modalities, Computed Tomography Angiography (CTA) has emerged as a valuable diagnostic tool for the evaluation of cerebral vasculature. The technique offers rapid image acquisition, wide availability, high spatial resolution, and excellent visualization of intracranial arteries. Modern multidetector CT scanners permit detailed assessment of vascular anatomy through multiplanar and three-dimensional reconstructions, enabling reliable detection of aneurysms even in anatomically complex regions(Ismail et al., 2023). Compared with conventional catheter angiography, CTA is less invasive and more readily accessible, making it particularly useful in emergency settings where rapid diagnosis is essential. The diagnostic accuracy of CTA has improved substantially over the past decade, allowing clinicians to identify aneurysm morphology, size, neck configuration, and relationship to adjacent vessels with a high degree of confidence(Kamphuis et al., 2025).

Aneurysm size and anatomical location are among the most important factors influencing clinical decision-making and rupture risk assessment. Previous studies have demonstrated that larger aneurysms generally possess a greater likelihood of rupture; however, aneurysms of smaller dimensions may also carry substantial risk depending on their vascular territory and hemodynamic environment(Sameer et al., 2025). Certain locations, particularly within the anterior communicating artery, posterior communicating artery, middle cerebral artery, and internal carotid artery circulation, have been consistently associated with a higher frequency of aneurysm formation. Detailed evaluation of these characteristics is essential for determining appropriate management strategies, including surveillance, endovascular treatment, or surgical intervention(Zaidi et al., 2023).

Despite the growing importance of cerebral aneurysm detection, substantial variations exist in the reported frequency and distribution of aneurysms across different populations. Genetic predisposition, demographic factors, lifestyle-related risk factors, and regional healthcare practices may all influence disease patterns. Most of the available evidence originates from developed countries, whereas data from South Asian populations remain comparatively limited(Xie et al., 2024). In Pakistan, only a small number of studies have examined the epidemiological and radiological characteristics of cerebral aneurysms, and the majority have focused on patients presenting with subarachnoid hemorrhage rather than broader populations undergoing CTA evaluation. As a result, important information regarding aneurysm frequency, vessel involvement, anatomical distribution, and size characteristics in local clinical settings remains insufficiently documented(Caliskan and Oncel, 2021, Hu et al., 2024, Abbas et al., 2022).

Lahore represents one of the largest metropolitan centers in Pakistan, with tertiary care hospitals increasingly utilizing advanced neuroimaging for the assessment of cerebrovascular diseases. However, there is a notable lack of published data describing the burden and imaging characteristics of cerebral aneurysms within this population. Understanding local disease patterns is essential because such information can contribute to evidence-based diagnostic pathways, facilitate early recognition of high-risk aneurysms, and support clinical decision-making among radiologists, neurologists, and neurosurgeons. Furthermore, institution-specific data may help identify trends relevant to regional healthcare planning and resource allocation(Begum et al., 2022).

In view of the limited local literature and the expanding role of CTA in neurovascular imaging, there is a need to systematically evaluate the frequency and radiological characteristics of cerebral aneurysms in patients undergoing CTA in a tertiary care setting. Therefore, the present study is designed to determine the frequency of cerebral aneurysms detected on Computed Tomography Angiography at the Radiology Department of Doctors Hospital, Lahore, and to comprehensively assess their anatomical location, parent vessel involvement, and size distribution. The findings are expected to provide valuable local evidence that may enhance diagnostic accuracy, improve risk assessment, and contribute to the optimization of patient management strategies in cerebrovascular disease.

METHODOLOGY

This cross-sectional descriptive study was conducted at the Department of Radiology, Doctors Hospital & Medical Centre, Lahore, a tertiary care institution equipped with advanced neuroimaging facilities and a dedicated Computed Tomography Angiography (CTA) service. The study was carried out over a period of six months following approval of the research synopsis (CPSP/REU/RAD-2022-090-3946 on October 30, 2025). All procedures were performed in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment, and strict confidentiality of patient information was maintained throughout the study.

The study population comprised adult patients referred to the radiology department for neurovascular CTA because of clinical suspicion of cerebral aneurysm or related cerebrovascular pathology. Both male and female patients aged 18 years and above were eligible for inclusion. Patients undergoing CTA during the study period who fulfilled the eligibility criteria and provided informed consent were recruited consecutively. Individuals with poor-quality CTA

examinations resulting from significant motion artifacts, incomplete image acquisition, or technical limitations that compromised diagnostic interpretation were excluded. Patients with known cerebral arteriovenous malformations or other vascular abnormalities that could mimic aneurysmal dilatation on imaging were also excluded to minimize diagnostic ambiguity. Similarly, patients with a history of previously treated cerebral aneurysms, including surgical clipping or endovascular coiling, were not included in the study. Individuals who declined participation or withdrew consent at any stage were also excluded from analysis(Hou et al., 2024, Shigematsu et al., 2024).

The sample size was calculated using the standard formula for estimating a population proportion. Based on previously published local data reporting a frequency of cerebral aneurysms of 81.3% among patients undergoing CTA evaluation for subarachnoid hemorrhage, a confidence level of 95%, and a margin of error of 7%, the minimum required sample size was determined to be 118 participants. To ensure adequate representation and account for any incomplete data, a final sample size of 120 patients was enrolled. A non-probability consecutive sampling technique was employed, whereby all eligible patients presenting during the study period were included until the desired sample size was achieved(Shoukat et al., 2024, Huguenard et al., 2022).

Following enrollment, demographic and clinical information, including age, gender, presenting symptoms, and indication for CTA examination, was recorded on a structured data collection proforma specifically designed for the study. All participants underwent contrast-enhanced CTA of the cerebral circulation using a 128-slice multidetector CT scanner. Imaging acquisition was performed according to the department's standardized neurovascular protocol to ensure consistency and optimal image quality. Intravenous iodinated contrast material was administered using a power injector at a predefined flow rate, followed by image acquisition during the arterial phase. Raw image data were reconstructed in axial, coronal, and sagittal planes, with additional three-dimensional volume-rendered and maximum-intensity projection reconstructions generated to facilitate comprehensive vascular assessment.

The acquired images were independently reviewed by two consultant radiologists with substantial experience in neuroradiology. Cerebral aneurysms were identified based on the presence of a localized saccular, fusiform, or multilobulated outpouching arising from an intracranial artery and demonstrating continuity with the parent vessel. Patient-level frequency was calculated based on the presence of at least one cerebral aneurysm on CTA. As all aneurysm-positive patients had a single aneurysm, patient-level and aneurysm-level analyses were equivalent for anatomical location, parent vessel involvement, and size categorization. For each detected aneurysm, detailed radiological characteristics were documented, including anatomical location, parent vessel of origin, and maximal aneurysm diameter. Measurements were obtained in millimeters using electronic calipers on multiplanar reconstructed images, with the widest measurable dimension considered the aneurysm size. For analytical purposes, aneurysms were categorized as small (<5 mm), medium (5–10 mm), or large (>10 mm). In cases where differences arose between the two radiologists regarding aneurysm detection or characterization, a consensus review was undertaken to establish a final diagnosis and ensure diagnostic consistency(Teranishi et al., 2024).

All collected data were coded and entered into the Statistical Package for Social Sciences (SPSS) version 26.0 for analysis. Data cleaning and verification procedures were performed before statistical evaluation. Descriptive statistics were used to summarize the demographic and radiological characteristics of the study population. Continuous variables such as age and aneurysm size were presented as mean ± standard deviation or median with interquartile range where appropriate. Categorical variables, including gender, aneurysm presence, anatomical location, vessel involvement, and aneurysm size categories, were expressed as frequencies and percentages. Inferential statistical analyses were conducted where relevant to explore associations between study variables. The Chi-square test or Fisher's Exact Test was applied for comparison of categorical variables, depending on data distribution and expected cell frequencies. A p-value of less than 0.05 was considered statistically significant. The findings were presented in tables and figures where appropriate to provide a comprehensive overview of the frequency and radiological characteristics of cerebral aneurysms detected by CTA in the study population.

RESULTS

A total of 120 patients underwent Computed Tomography Angiography (CTA) during the study period and fulfilled the eligibility criteria. The mean age of the study population was 51.8 ± 13.4 years (range: 19–82 years). There were 68 (56.7%) males and 52 (43.3%) females. Cerebral aneurysms were detected in 47 patients, yielding an overall frequency of 39.2% on CTA examination (Table 1). All 47 aneurysm-positive patients had a single cerebral aneurysm; therefore, the anatomical location and size distribution analyses were performed on 47 aneurysms corresponding to 47 patients. Among patients with detected aneurysms, the mean age was 54.6 ± 11.8 years, while the majority belonged to the age group of 41–60 years (48.9%). Aneurysm detection was slightly higher among females (44.2%) compared to males (35.3%), although the association between gender and aneurysm presence did not reach statistical significance ($\chi^2 = 1.02$, $p = 0.312$).

The anatomical distribution of aneurysms demonstrated a predominance of lesions involving the anterior circulation. The anterior communicating artery (AComA) represented the most common site, accounting for 14 (29.8%) aneurysms, followed by the middle cerebral artery (MCA) in 12 (25.5%) cases and the posterior communicating artery

(PComA) in 8 (17.0%) cases. Internal carotid artery aneurysms constituted 7 (14.9%) cases, whereas basilar artery and vertebral artery aneurysms were less frequently encountered. Details regarding anatomical distribution and parent vessel involvement are presented in Table 2. Assessment of aneurysm size revealed a mean aneurysm diameter of 6.9 ± 3.7 mm (range: 2.1–18.6 mm). Small aneurysms (<5 mm) were identified in 19 (40.4%) patients, medium-sized aneurysms (5–10 mm) in 21 (44.7%) patients, and large aneurysms (>10 mm) in 7 (14.9%) patients. Medium-sized aneurysms represented the most frequent category observed on CTA (Table 3).

When aneurysm size categories were compared across anatomical locations, large aneurysms were more frequently observed within the internal carotid artery and basilar artery territories. Conversely, most aneurysms involving the anterior communicating artery were classified as small or medium in size. A statistically significant association was observed between aneurysm location and aneurysm size category (Fisher's Exact Test, $p = 0.041$). The distribution of aneurysm locations is illustrated in Figure 1, which demonstrates the predominance of anterior communicating artery and middle cerebral artery aneurysms. Figure 2 depicts the relative frequency of aneurysm size categories, highlighting the predominance of medium-sized lesions. No procedure-related complications were reported during CTA acquisition, and image quality was considered diagnostically adequate in all enrolled patients included in the final analysis.

Table 1. Frequency of Cerebral Aneurysms Detected on CTA (n = 120)

Variable	Frequency (n)	Percentage (%)
Cerebral aneurysm present	47	39.2
Cerebral aneurysm absent	73	60.8
Total	120	100

Table 2. Anatomical Location and Parent Vessel Involvement of Cerebral Aneurysms (n = 47)

Vessel / Location	Frequency (n)	Percentage (%)
Anterior Communicating Artery (AComA)	14	29.8
Middle Cerebral Artery (MCA)	12	25.5
Posterior Communicating Artery (PComA)	8	17.0
Internal Carotid Artery (ICA)	7	14.9
Basilar Artery	4	8.5
Vertebral Artery	2	4.3
Total	47	100

Table 3. Size Distribution of Cerebral Aneurysms (n = 47)

Aneurysm Size Category	Frequency (n)	Percentage (%)
Small (<5 mm)	19	40.4
Medium (5–10 mm)	21	44.7
Large (>10 mm)	7	14.9
Total	47	100

Table 4. Association Between Aneurysm Location and Size Category (n = 47)

Anatomical Location	Small <5 mm n (%)	Medium 5–10 mm n (%)	Large >10 mm n (%)	Total
AComA	7 (50.0)	6 (42.9)	1 (7.1)	14
MCA	3 (25.0)	9 (75.0)	0 (0.0)	12
PComA	5 (62.5)	3 (37.5)	0 (0.0)	8
ICA	2 (28.6)	2 (28.6)	3 (42.9)	7
Basilar	1 (25.0)	1 (25.0)	2 (50.0)	4
Vertebral	1 (50.0)	0 (0.0)	1 (50.0)	2
Total	19 (40.4)	21 (44.7)	7 (14.9)	47

DISCUSSION

The present study evaluated the frequency and radiological characteristics of cerebral aneurysms detected on Computed Tomography Angiography in patients undergoing neurovascular imaging at a tertiary care hospital in Lahore. Among 120 patients included in the analysis, cerebral aneurysms were identified in 47 individuals, resulting in an overall frequency of 39.2%. This finding highlighted the substantial diagnostic yield of CTA in patients presenting with clinical suspicion of cerebrovascular pathology and reinforced its value as a primary non-invasive imaging modality for aneurysm detection. The frequency observed in the current study was lower than the 81.3% prevalence reported in a local study involving patients with confirmed subarachnoid hemorrhage. This difference was

expected because the present investigation included all patients referred for neurovascular CTA based on clinical suspicion, whereas previous studies focused primarily on high-risk populations already presenting with aneurysmal hemorrhage. International studies evaluating broader neurovascular populations have reported aneurysm detection rates ranging from 20% to 45%, placing the findings of the present study within the expected range. The variation in reported frequencies across studies may be attributed to differences in patient selection criteria, imaging indications, demographic characteristics, and healthcare referral patterns(Wei et al., 2024, Krystkiewicz et al., 2021).

The mean age of patients with aneurysms in the current study was 54.6 ± 11.8 years, with the highest proportion observed between 41 and 60 years of age. This distribution was consistent with previous literature indicating that aneurysm formation becomes increasingly common during middle and late adulthood as cumulative vascular degeneration, hypertension, smoking exposure, and other risk factors exert their effects on arterial walls. A slightly higher proportion of aneurysms was observed among females compared with males; however, the difference was not statistically significant. Similar trends have been documented in multiple epidemiological studies where female predominance became more apparent after middle age, potentially reflecting hormonal influences on vascular integrity and remodeling(Amuluru et al., 2025). Analysis of aneurysm location revealed a clear predominance of anterior circulation aneurysms. The anterior communicating artery accounted for 29.8% of all aneurysms, followed by the middle cerebral artery (25.5%) and posterior communicating artery (17.0%). These findings closely paralleled observations from regional and international studies in which anterior communicating artery aneurysms consistently represented approximately 25%–35% of all detected lesions. The tendency for aneurysms to develop at arterial bifurcations within the anterior circulation has been attributed to increased hemodynamic stress, turbulent blood flow, and structural vulnerability of vessel walls at branching points. The relatively lower frequency of posterior circulation aneurysms observed in the present study was also consistent with published evidence, where such lesions generally constitute less than 10%–15% of all intracranial aneurysms(Allaw et al., 2025).

Assessment of aneurysm size demonstrated a mean diameter of 6.9 ± 3.7 mm. Medium-sized aneurysms measuring 5–10 mm represented the largest proportion of lesions (44.7%), followed by small aneurysms measuring less than 5 mm (40.4%). Large aneurysms greater than 10 mm accounted for only 14.9% of cases. Comparable distributions have been reported in previous CTA-based studies, where most detected aneurysms measured below 10 mm. The predominance of small and medium-sized lesions likely reflected increasing utilization of advanced imaging techniques that permit earlier diagnosis before substantial aneurysmal enlargement occurs. Nevertheless, the presence of several large aneurysms remained clinically important because aneurysm diameter continues to be regarded as one of the strongest predictors of rupture risk and adverse neurological outcomes(Allaw et al., 2025, Zaidi et al., 2023). A statistically significant association was identified between aneurysm location and size category ($p = 0.041$), suggesting that anatomical location may influence aneurysm growth patterns. Larger lesions were more frequently observed in the internal carotid and basilar artery territories, whereas anterior communicating artery aneurysms were predominantly small to medium in size. Similar observations have been reported elsewhere and support the concept that local hemodynamic forces and vessel geometry contribute to aneurysm progression. Although aneurysm size remains an important determinant of rupture risk, increasing evidence indicates that location, morphology, wall characteristics, and patient-specific factors collectively influence clinical behavior(Babichev et al., 2023, Mkhize et al., 2023).

Several strengths enhanced the validity of the present study. The use of a standardized CTA protocol with a 128-slice multidetector scanner ensured high-quality vascular imaging and accurate aneurysm characterization. Independent image interpretation by two experienced radiologists minimized observer-related variability and improved diagnostic reliability. Furthermore, the study generated local data from a tertiary care center in Lahore, addressing an important gap in the existing Pakistani literature regarding aneurysm frequency and imaging characteristics(Konovalov et al., 2024, Mkhize et al., 2023). Certain limitations should also be acknowledged. The study was conducted at a single center and included a relatively modest sample size, which may limit generalizability to the broader population. The cross-sectional design prevented assessment of aneurysm progression, rupture rates, and long-term clinical outcomes. Additionally, important risk factors such as hypertension, smoking status, family history, and comorbid vascular diseases were not evaluated in detail, restricting the ability to explore predictors of aneurysm formation and growth. Selection bias may also have been present because only patients referred for CTA were included(Haroon et al., 2023, Abbas et al., 2022).

Future multicenter studies involving larger and more diverse populations would provide more representative estimates of aneurysm burden in Pakistan. Longitudinal investigations incorporating clinical risk factors, aneurysm morphology, and outcome data would further enhance understanding of aneurysm behavior and rupture risk. Integration of advanced imaging techniques and artificial intelligence–assisted vascular analysis may also contribute to improved detection, characterization, and risk stratification of cerebral aneurysms in routine clinical practice.

CONCLUSION

Computed Tomography Angiography proved to be an effective and reliable modality for the detection and characterization of cerebral aneurysms in patients undergoing neurovascular evaluation. Cerebral aneurysms were identified in a substantial proportion of patients, with the anterior communicating artery being the most commonly involved vessel and medium-sized aneurysms representing the predominant size category. The study provides valuable local epidemiological data and supports the role of CTA in early diagnosis, risk assessment, and clinical decision-making for patients with suspected intracranial aneurysms in tertiary care settings.

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