International Journal of Research in Medical Sciences
Nayak RC et al. Int J Res Med Sci. 2024 Jun;12(6):1909-1914
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20241302

Original Research Article

The study of computed tomography angiography in the evaluation of acute stroke

Rakesh C. Nayak[1], Kushal B. Gehlot[1], Tarun K. Rahlot[2], Narendra R. Kardam[1], Mayank Choudhary[1]*, Pratik N. Naik[1]

[1]Department of Radiology, R.N.T. Medical College, Udaipur, Rajasthan, India
[2]Department of Neurology, R.N.T. Medical College, Udaipur, Rajasthan, India

Received: 20 April 2024
Revised: 08 May 2024
Accepted: 09 May 2024

***Correspondence:**
Dr. Mayank Choudhary,
E-mail: mayankchoudhary0788@gmail.com

ABSTRACT

Background: When it comes to residual lumen diameters and areas, calcifications, and stenose length, computed tomography angiography (CTA) offers genuinely anatomic, non-flow dependent information. Compared to traditional catheter arteriography, CTA is less costly, causes less discomfort to patients, and has a significantly lower risk of stroke and other vascular complications. Additionally, it is helpful when performing magnetic resonance (MR) is not recommended or is not possible. Generally speaking, CTA is more accessible than MR, particularly in emergency situations. As there are no limitations on the kind and quantity of related support equipment, such as intravenous pumps, ventilators, or monitoring hardware, CTA, in contrast to MR angiography (MRA), is well suited for the imaging of critically ill patients. Our goal was to assess how useful CT angiography is for determining the etiology of vessel occlusion and stroke.
Methods: Non enhancing CT scan of all patients was evaluated first for significant findings, after that contrast enhanced scan was evaluated and compared with non-enhancing CT scan. Direct volume rendering (dVR) is the most sophisticated method for 3D visualization. When dVR is used to create CT angiograms, the voxels of high attenuation containing information about bony structures are selected separately from those voxels with an attenuation between 100 and 300 HU containing information about contrast- enhanced vascular structures.
Results: We observed sensitivity of CTA in evaluation of acute stroke as 93.33%, specificity 80%, positive predictive value (PPV) 87.5% and negative predictive value (NPV) 88.88%.
Conclusions: CT angiography, when closely correlated with patients' clinical conditions, has the potential to become the screening method of choice for evaluating patients with significant vascular lesions amenable to acute intracranial transcatheter thrombolytic therapy.

Keywords: CTA, MRA, US, Angiography

INTRODUCTION

The World Health Organization defines a stroke as a clinical syndrome that includes quickly evolving clinical signs of a focal (or global, in the case of a coma) disruption of cerebral function that lasts longer than 24 hours or results in death with no discernible cause other than a vascular origin.[1] After myocardial infarction, stroke is the second most common cause of death worldwide; 6.2 million people died from stroke in 2015.[2]

There are four types of strokes: non-traumatic subarachnoid hemorrhage (5%), cerebral vein occlusion (1%), primary intracranial hemorrhage (15%), and cerebral infarction (80%). Eighty percent of strokes are ischemic strokes, which are the most common type of stroke. Hemorrhagic stroke is caused by a blood vessel rupturing and causing blood to spill into the intracranial cavity, while ischemic stroke is caused by a blood vessel blockage that restricts the blood supply to the brain.[3] The annual incidence of stroke in India is approximately 145 per 100,000 people in urban areas and 124 per 100,000 people in rural areas.[4]

A total 15-25 ml/100 g per minute is the critical cerebral blood flow level for the brain. Neurons die at levels below 10-15 ml/100 g per minute. A central, irreversibly infarcted tissue core known as the "penumbra" is encircled by a periphery of stunned cells following cerebral ischemia. The main goal of treatment is to salvage the penumbra.[5] Assessing the parenchyma, pipes (extracranial and intracranial circulation), perfusion, and penumbra is the aim of stroke imaging.[6] This method helps identify intravascular thrombi, distinguish salvageable from infarcted tissue, detect intracranial hemorrhage, choose the best course of treatment, and forecast the clinical outcome.[7]

The technique for neuro-vasculature diagnostic imaging is catheter angiography. Nevertheless, it is costly, invasive, and carries a 1.5% to 2% risk of major morbidity and death. Because of these shortcomings, non-invasive or minimally invasive methods have been developed. For this purpose, color Doppler ultrasound (CDUS) and/or magnetic resonance angiography (MRA) have become the accepted standard non-invasive techniques. With the introduction of helical CT a few years ago, CT angiography (CTA) has grown in importance as an additional method for assessing the neuro-vasculature.[8] Compared to CTA, MRA has a number of disadvantages, such as occasionally longer examination times that lead to motion artifacts, pulsation artifacts, turbulent flow, in-plane flow that appears to cause exaggerated stenosis, and inadequate display of calcium and bony landmarks. Furthermore, using MRA to assess the post-operative status of patients wearing metallic clips and stents can be challenging.[9]

A highly cooperative patient is necessary for MRA, which is a non-invasive and reliable method of evaluating cerebral vascular disease. Patients with pacemakers and aneurysm clips cannot have MRA performed on them. In the detection of arterial anatomy in the circle of Willis (COW), CT angiography has recently been demonstrated to be a dependable substitute for MRA. It has also demonstrated promise in the assessment of carotid bifurcation disease, intracranial aneurysms, and vascular malformations.

When it comes to residual lumen diameters and areas, calcifications, and the length of stenoses, CTA offers truly anatomic, non-flow dependent data that flow-dependent methods like MRA and ultrasound (US) cannot. Compared to traditional catheter arteriography, CTA is less costly, causes less discomfort to patients, and has a significantly lower risk of stroke and other vascular complications. In cases where MR is not appropriate or cannot be done, it is also helpful.

Generally speaking, CTA is more accessible than MR, particularly in emergency situations. As there are no limitations on the kind and quantity of related support equipment, such as intravenous pumps, ventilators, or monitoring hardware, CTA, in contrast to MRA, is well suited for the imaging of critically ill patients. Compared to MRA, CT scan acquisition is faster, so motion artifacts are less likely to occur in CTA.[8]

Aims and objectives

Aims and objectives were to evaluate the role of CT angiography in the assessment of stroke and etiology in term of vessel occlusion, and to determine vascular anatomy and compare with DSA in available cases.

METHODS

Hospital based prospective study of 50 patients of all age group who was referred for CTA examination in the radiodiagnosis department of R.N.T. Medical College Udaipur, from April 2022 to March 2023 for acute stroke over a period of one year, after approval from ethical committee were subjected to study.

Informed consent was obtained from all patients. All examinations were performed on Siemens 128 slice somatom definition AS scanner. Scout film was taken of all patients, then non enhancing CT scan was taken. After that intravenous contrast study of head was done under aseptic precautions by intravenous administration of iodine-based contrast agent in quantity calculated as per patients' weight.

Non enhancing CT scan of all patients was evaluated first for significant findings, after that contrast enhanced scan was evaluated and compared with non-enhancing CT scan. At the end of study results was evaluated for various differentials for stroke.

A total of 50 patients included in this study after satisfying the inclusion and exclusion criteria.

Inclusion criteria

Patients of all age groups irrespective of sex, clinically suspected of ischemic stroke who presented to department of radiodiagnosis, for cerebral CTA were included in the study.

Exclusion criteria

Patients not consenting for study. Patients with intracranial tumors. Evidence of intracerebral hemorrhage on NCCT and conditions which would contra-indicate the routine use of CT contrast agent e.g. allergy, and renal failure were excluded from the study.

Imaging technique of CTA

Patient preparation and pre-requisite

NPO 3-4 hours before the exam. Not severely allergic or asthmatic. Recent renal function test (RFT) must be normal; 1 week - in patients; 3 months - diabetic patients; 6 months - non diabetic patients. Sedation if needed.

Patient position

Supine with their arms by their side.

Scout

Mid-chest to vertex.

Scan extent

Aortic arch to vertex.

Scan direction

Caudocranial can be performed to minimize venous contamination in the head portion of the scan, often utilized in slower scanners.

Contrast injection considerations/technique

Monitoring slice (region of interest), distal part of arch of aorta, threshold 100 HU.

Injection

A total of 50-75 ml of non-ionic iodinated contrast with a 100 ml saline chaser at 4.5/5 ml/s. When possible, patients should be well hydrated. An intravenous access should be established. A 20-gauge or larger antecubital intravenous (IV) catheter should be placed, ideally on the right side, to accommodate an optimal rate of 4 or 5 ml per second of iodinated contrast media.

All catheters used for the CTA examination should first be tested with a rapidly injected bolus of sterile saline to ensure that the venous access is secure and can accommodate the rapid bolus, minimizing the risk of contrast medium extravasations.

Examination techniques

Prior to acquiring the CTA, an unenhanced helical CT acquisition should be obtained for detecting mural or extravascular haemorrhage, mapping of arterial calcification, or localization of the anatomy of interest.

The section thickness for this preliminary CT acquisition is application dependent, but should not exceed 5 mm.

The radiation exposure to the patient should be minimized within the limits of acceptable image quality, including optimization of kVp and mAs.

If infants and children are being imaged, there should be written guidelines for acceptable CT radiation exposure, including weight-appropriate or age- appropriate guidelines to reflect the as-low-as- reasonably-achievable (ALARA) principle.

If available, dose modulation and iterative reconstruction approaches should be used, with appropriate targeted signal-to-noise ratio.

Image reconstruction

To reduce image noise, images may be reconstructed slightly thicker than the detector collimation, for example with a 0.75-mm section thickness from a data set acquired with 0.6-mm detector collimation.

Overlapping image reconstruction should always be performed to improve 3D post-processing.

The reconstruction algorithm influences the spatial resolution in plane.

The ideal algorithm would combine low image noise and sharp edge definition, maintaining good low-contrast.

Soft algorithm reduces image noise and allow smooth surfaces with rendering techniques, improving the visualization of aneurysms and vascular malformations.

Sharper algorithm improves edge definition and reduce blooming effects from calcifications, necessary for stenosis measurements, at the expense of higher image noise.

Image post procedure techniques

Several image processing techniques for CT angiography are currently being used clinically.

Image processing involves traditional operations such as: multi-planar reformation (MPR), maximum intensity projection (MIP), shaded surface display (SSD), and direct volume rendering (dVR).

MPR

The quality of the MPR reconstructions depends on the voxel size. With the use of isometric data (i.e., voxels have the same depth, length, and height), all images are of the same quality as the basic source images.

In contrast to MIP and the 3D methods discussed later, the reconstructed planes contain all information that is contained in the source images. Therefore, MPR should always be the method of first choice for the further examination of CT angiography data. A variant of MPR is curved planar reformation.

Curved planar reformation provides a 2D image that is created by sampling CT volume data along a predefined curved plane. This technique is employed to display tortuous structures.

MIP

The term MIP means that from any given angle of view, only the brightest voxels of a volume are collected and used to create an image.

Therefore, MIP is not a 3D method, as it creates 2D images in which voxels from different locations within the volume are collapsed into one plane. Thus, depth information is lost and it is not possible to tell whether a structure is located in the front or back on the basis of a single MIP image.

dVR

dVR is the most sophisticated method for 3D visualization.

The basic principle is to select several groups of voxels according to their attenuation in Hounsfield units and to assign them a color and a so-called opacity.

When dVR is used to create CT angiograms, the voxels of high attenuation containing information about bony structures are selected separately from those voxels with an attenuation between 100 and 300 HU containing information about contrast- enhanced vascular structures.

This selection allows the creation of 3D images showing red arteries and white bone.

Use of a low opacity can result in the creation of transparent objects (e.g., it is possible to make intracranial arteries visible beneath a layer of skull bone).

Selecting only a small group of voxels with a high opacity allows creation of a “virtual endoscopic” view in which the thin layer of voxels resembles the vessel wall.

Statistical analysis

The diagnostic accuracy for mammography and sonomammography was calculated individually and in combination, in terms of sensitivity, specificity, positive predictive value and negative predictive value.

RESULTS

Clinical wise distribution in our study is depicted in Table 1. Hemiplegia was the commonest presenting feature (54%), followed by headache (34%), vomiting (32%), facial weakness (16%) and gait disturbance (14%).

Table 1: Clinical presentation.

Clinical presentation	No. of patients	Percentage of cases
Hemiplegia	27	54
Facial weakness	8	16
Gait disturbance	7	14
Headache	17	34
Vomiting	16	32

In our study, 19 (38%) patients suffered from MCA territory infarction. Among these patients, 13 (68.42%) suffered from left sided MCA infarction; 5 (26.31%) suffered from right sided MCA infarction and 1 (5.2%) suffered from bilateral MCA infarction.

In our study, 10 (20%) patients suffered from PCA territory infarction. Among these patients, 6 (60%) suffered from right sided PCA infarction and 4 (40%) suffered from left sided PCA infarction.

In our study, 3 (6%) patients suffered from ACA territory infarction. Among these patients, 2 (66.67%) suffered from right sided ACA infarction and 1 (33.33%) suffered from left sided ACA infarction (Table 2).

Table 2: MCA territory infarcts.

Site of involvement	Right		Left		Bilateral	
Territory infarcts	**No.**	**%**	**No.**	**%**	**No.**	**%**
MCA	5	26.31	13	68.42	1	5.2
PCA	6	60	4	40	0	0
ACA	2	66.67	1	33.33	0	0

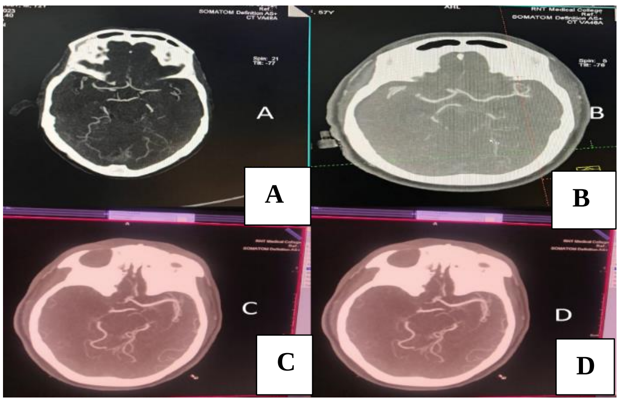

Figure 1: (A) Left MCA, (B) left PCA, (C) right MCA, and (D) right PCA.

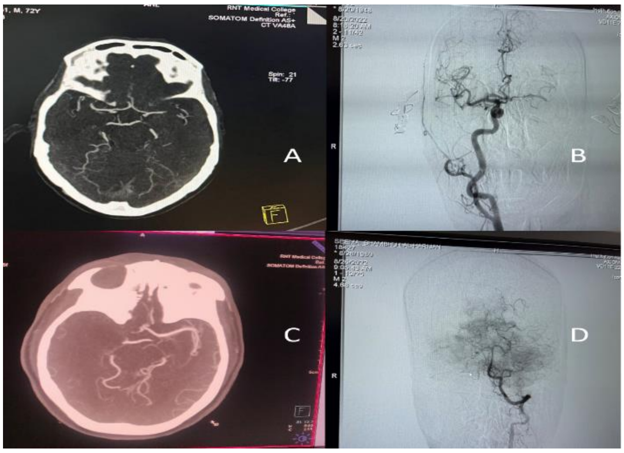

Figure 2 (A-D): Comparison left MCA occlusion found on both CTA and DSA comparison of right MCA occlusion on CTA with same findings on DSA.

Table 3: Overall accuracy of CTA compared to DSA in evaluation of vessels occlusion (CTA occlusion cases=32).

Variables	No. of cases	
	Occlusion	Non occlusion
Total DSA	16	9
DSA occluded	14	1
DSA not occluded	2	8
Total	32	18

DISCUSSION

The gender difference is an important parameter in assessing the stroke epidemiology as there are inherent differences in the pathophysiology and the age of presentation as well as mortality by stroke, while females have a later age of presentation males' mean age of incident is early however the mortality by stroke in females rank higher as compared to their male counterpart.[10,11] The studies on stroke with their female participants' percentage is mentioned below.

In our present study majority of the patients were from the age group of more than 60 years, also the mean age of the study participants was 61.46 years, in the study by Bhattacharya et al the mean age of study participants the mean age of study participants was 61 years, a similar prospective study which was registry based in north India showed the mean age of stroke or around 58±15 years, in the other studies too, the mean age of the stroke patients was more or less in the similar range and thus findings of our study was in concurrence with the previously done studies.[12]

On close observation we can see that the most while the males were more in greater in 70 years' age group, females were more in the age group of more than 60, also females were lesser in number in all the early age groups which points to the male preponderance of early onset stroke which has already been discussed and has been previously found by the other studies.[13]

Vascular territory

In our study, the most commonly affected vascular territory was the MCA, which accounted for 38% (19 cases) of all infarcts. It was further observed that the left MCA (68% - 13 patients) was more commonly involved. Naess et al in their study concurred with our finding that the left MCA territory was more often affected as compared to right MCA territory.[14] This observation was found mostly among male subjects. It was postulated that lateralization of cortical functions and atherosclerotic disease in the left carotid artery or a combination of both may be the basis for predominant left carotid involvement.[15]

PCA territory was affected in 10 patients (20%), among them 6 (60%) patients showing right sided involvement and 4 (40%) patients showing left sided involvement.

ACA territory was affected in 3 (6%) patients suffered from ACA territory infarct, 2 (66.67%) among these patients suffered right sided ACA infarct and 1 (33.33%) patient showing left sided involvement.

In our study, anterior circulation was involved in 22 (68.75%) patients, whereas posterior circulation strokes were 10 (31.25%) in number. There were no patients with both anterior and posterior circulation involvement in this study. Simonetti et al in their study of 2,768 AIS cases, 507 (18%) were located in the posterior circulation, 1,931 (70%) in the anterior circulation, and 330 (12%) involved both.[16]

We included 50 patients with acute ischemic stroke who have undergone CTA, and 25 patients of them undergone DSA imaging for comparison who did not receive intravenous thrombolysis. Vascular images of CTA (index test) were compared to DSA (reference standard) in patients with acute ischemic stroke and were categorized into presence or absence of arterial occlusion. The implication was that the utilization of CTA for screening purposes may lead to slightly increased proportions of patients for unnecessary DSA.

Out of 50 patients who had undergone for CTA, vessel occlusions were found in 32 cases, and there was no occlusion in 18 patients.

Out of those 32 patients (CTA occluded) ,16 patients undergone DSA, in which 14 patients were having same finding as in CTA and 2 patients found normal.

Out of 18 patients (CTA non-occluded), 9 patients undergone DSA, in which 8 patients were showing same finding as CTA, but 1 patient found to have occlusion.

Therefore, by applying appropriate statistics we found that the sensitivity of CTA in evaluation of acute stroke was found to be 93.33%, specificity of 80%, positive predictive value 87.5% and negative predictive value 88.88%. The sensitivity of our study was found to be close to the study conducted by Lee et al who showed sensitivity of 96.0%, specificity 88.6%, positive predictive value 91.1% and negative predictive value 95.1%.[17]

We strived to study the common territory of vascular involvement in ischemic stroke and the common risk factors leading to stroke. We have further studied the CT angiography findings in patients with acute ischemic infarct and compared with DSA who were referred for CT angiography examination in the radiodiagnosis department of R.N.T. Medical College Udaipur.

This study results are on at par with national and international stroke surveys. Distinct genetic, environmental or sociocultural factors are responsible for differences in pattern of stroke.

CONCLUSION

We have shown that CTA is a safe, convenient and accurate technique for the evaluation of vessels patency in acute stroke. CTA, when closely correlated with patients' clinical conditions, has the potential to become the screening method of choice for evaluating patients with significant vascular lesions amenable to acute intracranial transcatheter thrombolytic therapy.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Pandian JD, Sudhan P. Stroke Epidemiology and Stroke Care Services in India. J Stroke. 2013;15(3):128-34.
2. Smith WS, Johnston SC, Hemphill JC. Cerebrovascular disease, Harrison's principles of internal medicine. 20th Edition. Mc Graw Hill Education. 2018: 3068-3070.
3. Shetty PG, Jhaveri KS. Neurovascular application of CT angiography. Indian J Radiol Imaging. 2000;10:211-20.
4. Taylor FC, Kumar KS. Stroke in India fact sheet. South Asia network for chronic disease IIPH Hyderabad, Public Health Foundation of India. 2012;4.
5. Thurnher MM, Castillo M. Imaging in acute stroke. Eur Radiol. 2005;15(3):408-15.
6. Rowley HA. The four Ps of acute stroke imaging: parenchyma, pipes, perfusion and penumbra. AJNR Am J Neuroradiol. 2001;22(4):599-601.
7. Srinivasan A, Goyal M, Azri FA, Lun C. State of the art imaging of acute stroke. Radiographics. 2006;26:875-95.
8. Potter C, Vagal A, Goyal M, Nunez D, Leslie-Mazwi T, Lev M. CT for Treatment Selection in Acute Ischemic Stroke: A Code Stroke Primer. Radiographics. 2019;39(6):1717-38.
9. Shrier DA, Tanaka H, Numaguchi Y, Konno S, Patel U, Shibata D. CT angiography in the evaluation of acute stroke. AJNR Am J Neuroradiol. 1997;18(6):1011-20.
10. Rexrode KM, Madsen TE, Yu AYX, Carcel C, Lichtman JH, Miller EC. The Impact of Sex and Gender on Stroke. Circ Res. 2022;130(4):512-28.
11. Chapa DW, Akintade B, Thomas SA, Friedmann E. Gender differences in stroke, mortality, and hospitalization among patients with atrial fibrillation: A systematic review. Heart Lung J Crit Care. 2015;44(3):189-98.
12. Bhattacharya S, Saha SP, Basu A, Das SK. A 5 years prospective study of incidence, morbidity and mortality profile of stroke in a rural community of eastern India. J Indian Med Assoc. 2005;103(12):655-9.
13. Smajlović D. Strokes in young adults: epidemiology and prevention. Vasc Health Risk Manag. 2015;11:157-64.
14. Naess H, Waje U, Thomassen L, Myhr K. High incidence of infarction in the (L) cerebral hemisphere among young adults. J Stroke Cerebrovasc Dis. 2006;15(6):241-4.
15. Thrift AG, Dewey HM, Macdonell RAL, McNeil JJ, Donnan GA. Incidence of the major stroke subtypes. Initial findings from the North East Melbourne stroke incidence study (NEMESIS). Stroke. 2001;32:1732.
16. Goeggel Simonetti B, Rafay MF, Chung M, Lo WD, Beslow LA, Billinghurst LL, et al. Comparative study of posterior and anterior circulation stroke in childhood: Results from the International Pediatric Stroke Study. Neurology. 2020;94(4):e337-44.
17. Lee SJ, Liu B, Rane N, Mitchell P, Dowling R, Yan B. Correlation between CT angiography and digital subtraction angiography in acute ischemic strokes. Clin Neurol Neurosurg. 2021;200:106399.

Cite this article as: Nayak RC, Gehlot KB, Rahlot TK, Kardam NR, Choudhary M, Naik PN. The study of computed tomography angiography in the evaluation of acute stroke. Int J Res Med Sci 2024;12:1909-14.