Comparative Diagnostic Role of Computed Tomography Angiography (CTA) and Noncontrast Magnetic Resonance Angiography (NC-MRA) in Evaluation of Cerebrovascular Accidents.

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ABSTRACT

Background: Cerebrovascular accidents (CVA) are a major cause of mortality and morbidity in middle and elderly age-groups. It can be ischemic or hemorrhagic and thrombotic or embolic. Digital subtraction angiography (DSA) is a gold standard investigation for evaluating patients with CVA. Due to invasive nature of DSA, computed tomography angiography (CTA) has long been used as a primary noninvasive imaging tool to evaluated patients with CVA. Angiography can also be performed with magnetic resonance imaging, both with & without contrast. Introduction: CTA serves as a primary noninvasive imaging tool in evaluation of patients with CVA as nearly half of these patients do not have treatable underlying cause. Due to increasing awareness regarding the radiation exposure, contrast-induced nephrotoxicity and iodine-sensitivity, magnetic resonance angiography (MRA) is gaining more and more attention. Noncontrast MRA (NC-MRA) can be performed utilizing 3D-time of flight sequence which provides results comparable to that of CTA. Hence, we performed a study to evaluate comparable role of NC-MRA and CTA. **Methods:** Fifty patients with cerebrovascular accidents were evaluated with CTA & NC-MRA in tandem on the same day. The results obtained were statistically evaluated and conclusions were drawn. **Results & Conclusions:** Detection of aneurysm in intracranial and stenoses in intracranial as well as extracranial vessels can be detected with good accuracy by NC-MRA. The results of NC-MRA was comparable to that obtained by CTA except in very small aneurysm (<3mm) and early stenosis (20-30%) which rarely affect immediate patient management. Hence, NC-MRA can be a good substitute to CTA especially in patients where iodinated contrast is relatively or absolutely contraindicated and in combination with routine protocol for stroke imaging.

Keywords: Computed tomography, magnetic resonance, angiography.

1

INTRODUCTION

Stroke is a common cause of morbidity and mortality, with cerebrovascular disease constituting the second most frequent cause of death worldwide.[1] While the burden of cerebrovascular disease in the developing world is receiving greater attention, yet its importance is highly underestimated.[2] Intracranial atherosclerotic disease is reaching greater clinical prominence as it represents a major burden of cerebrovascular disease worldwide.[3]

Stroke is a multifaceted clinical entity comprising several different syndromes; each has differing etiologies and varied pathophysiology. Stenosis of extracranial carotid arteries is usually incidental even in the presence of lacunar strokes but atherosclerosis of smaller cerebral arteries is a predominant identifiable cause of lacunar stroke.[4,5] As the largest intracranial artery, middle cerebral artery (MCA) is the most frequently involved in stroke and transient ischemic attacks. MCA stenosis appears to occur with lacunar striato-capsular infarcts due to occlusion of small perforating arteries by atheroemboli.[6,7] When one considers intracranial atherosclerotic disease, MCA disease can be defined as the presence of an atherosclerotic lesion within the MCA in the absence of cardiogenic embolism..[8]

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The common symptoms of stroke are loss of neurologic functions of movement, sensation, expression, cognition, and consciousness. Therefore, stroke or cerebral infarction should be suspected in any patient who may present with paresis, paralysis, dysphasia, confusion, drowsiness, or even coma.[9]

Rapid advance in medical imaging technology has resulted in an explosion of diagnostic tests and treatment strategies in the management of acute stroke. Each clinical scenario presents unique challenges related to risks and benefits of testing and therapy. The increasing evidence-based practice of clinical medicine necessitates that only appropriate tools be used in the diagnostic process and patient management.[10]

Computed tomography angiography (CTA) is the most common first-line diagnostic modality for vascular imaging in the setting of acute stroke.[11] CTA is not only widely available & well tolerated by majority of stroke patients but also can be obtained quickly after nonenhanced CT (NECT).[12]

The head NECT quickly helps the clinician to know whether the acute situation involves any form, & the degree of intracerebral hemorrhage.[13] Numerous studies revealed that CTA improves the prediction of final infarct size and clinical outcome when compared to NECT, more so in patients presenting ultra-early [<90 minutes from stroke symptom onset.[14]

NECT which has 100% sensitivity for detecting intracerebral hemorrhage is the most widely used diagnostic tool for stroke imaging with ischemic stroke being its most important differential diagnosis.[15] CTA is a fast, thinly-collimated, a time-optimized opacification of vessels utilizing bolus of iodinated contrast performed with volumetric spiral CT examination.[16]

In acute ischemic stroke, CTA can reliably detect intracranial proximal arterial stenosis & occlusions,[17] helping in predicting functional outcome, final infarct size, and response to intravenous thrombolysis, thus facilitating decision-making for various intra-arterial rescue procedures.[18,19] In addition, CTA delineates quality of collateral circulation, thus improving the identification of ischemic areas not visualised on NECT.[20]

CTA is also highly accurate in determining the severity of atherosclerotic stenosis in the extracranial arteries, especially the carotid arteries, thus aiding selection of patients amenable for revascularization. Furthermore, it allows a differentiation between near-occlusions and complete occlusions and is valuable in the diagnosis of an extracranial arterial dissection. In comparison to digital subtraction angiography (DSA), CTA shows high sensitivity and specificity in the assessment of intracranial aneurysms in patients with subarachnoid hemorrhage [SAH], hence CTA is deployed as the initial investigation of choice in the diagnostic work-up of patients with suspected aneurysms and subarachnoid hemorrhage. In addition, CTA is now increasingly being used in the diagnostic work-up of an underlying cause of a spontaneous intracerebral hemorrhage, particularly in young patients, and to identify the “spot” sign that can select patients at greater risk of hematoma expansion, because contrast extravasation may occur with compromised vessel integrity.[21]

Not only CTA but also noncontrast Magnetic resonance angiography [NC-MRA] can be used as a noninvasive imaging tool for evaluating a vascular cause in case of subarachnoid hemorrhage or intraparenchymal hemorrhage. NC-MRA utilizes, time of flight [TOF] sequence in 2D / 3D modes with scan time of less than 5 minutes. The major advantages of 3D-TOF MRA are high spatial resolution [voxel size <1mm3], short scanning time and high signal to noise ratio (SNR), which are partially offset by a reduced sensitivity to slow flow.[22]

NC-MRA is a non-invasive and reliable tool to evaluate cerebral vascular disease but requires a cooperative patient with limitations in patients with pacemakers and aneurysm clips. Though studies have shown improvement in both diagnosis and clinical management when NC-MRA is added to the imaging protocol,[11,23,24] yet it does not form a part of routine imaging protocol of stroke imaging in all centers. MRA can track the changes in the vessel lumen with time.[25] Imaging of vessels can reliably answer questions about the mechanism of the stroke, whether it is thrombotic, embolic or homodynamic. It also assesses the risk of future events by identifying whether there is occlusive arterial disease, localizing the exact site of occlusion and by determining the pathology underlying the stroke such as atherosclerosis or dissection.[26] MRA can also identify other vascular lesions such as malformation, aneurysms and arterial compression.[24]

TOF-MRA does not require injection of a contrast medium and therefore constitutes an alternative for patients in whom contrast injection is contraindicated. Even though spatial resolution with TOF-MRA is high yet the volume covered is limited by vascular saturation artifact, thus making this technique more suitable for the evaluation of the intracranial rather than extracranial vasculature.[17,22]

TOF-MRA has an acceptable sensitivity for the depiction of intracranial steno-occlusive lesions compared with DSA and CTA. The less frequently used phase-contrast MRA (PC-MRA) that utilizes intravenous contrast administration may provide additional physiologic information like blood flow velocity and flow direction.[17,27]

Existing literature shows that MRA has a sensitivity of nearly 80% in categorizing stenotic / occlusive lesion.[17,28] CTA takes 60 seconds or less to perform and has higher spatial resolution than MRA, but lower than that of DSA. Major limitations of CTA include radiation exposure, time & skill involved in processing of the image, interpolation errors, contrast material entry phenomenon, need for optimized contrast gradient-injection timing, venous contamination in a region of interest, risks related to contrast injection and need for repeat scan with contrast injection in cases of image deterioration by motion artefacts. Since CTA is a vessel cast technique, it doesn't provides significant flow information.[17]

Hence, this study was undertaken to evaluate the diagnostic role of CTA and NC-MRA in the evaluation of cerebrovascular accidents.

Aims and Objectives

To compare the diagnostic role of computed tomography angiography (CTA) and non-contrast magnetic resonance angiography (NC-MRA) in evaluation of cerebrovascular accidents.

MATERIALS & METHODS

The present study was conducted in the Department of Radiodiagnosis, Teerthanker Mahaveer Medical College & Research Centre, Moradabad.

After obtaining approval from the Board of Studies of the Department and Institutional Ethical Committee, a prospective, double-blind, randomized comparative study was carried out among 50 patients over a period of one & a half year.

The patients included in the study were those presenting to emergency / outpatient departments of Teerthanker Mahaveer Medical College and who were referred for computed tomography / CT angiography. Patient underwent CTA & NC-MRA in tandem to compare the two diagnostic imaging modalities.

3D-CTA was obtained by intravenous injection of 70ml non-ionic contrast medium at a rate of 4.5ml/s for 15 seconds followed by injection at 1.0ml/minute for another 25 second to enhance the visibility of the blood vessels. Bolus tracking method is used for optimal acquisition of images after obtaining appropriate consent from the patients following proper explanations related to possible reactions caused intravenous contrast injection.

MRA images were obtained at 0.8-to 1.0 mm thickness with a 60-section slab by using 3D-TOF sequence.

After obtaining CTA and MRA, the results were compared statistically. The p-value less than 0.05 is considered to be statistically significant.

Inclusion Criteria

- All the patients coming to our department for NECT/CTA with symptoms related to cerebrovascular accidents will be included.

Exclusion Criteria

- Patients with clinical history/NECT head with obvious trauma.
- Pregnant women
- Patients having a previous history of severe contrast reaction
- Patients having absolute contraindications for MRI like pacemakers, cochlear implants, steel implants, etc.

RESULTS

[Table 1] shows the distribution of cases according to sex. Our study revealed predominance of male patients.

Table 1: Distribution of cases according to sex.

Gender	Frequency	Percentage
Female	22	44.0%
Male	28	56.0%
Total	50	100.0%

In the current study, 28 (56.0%) males and 22 (44.0%) females were included in the study population. This was similar to the study by Lell et al,[29] in which Fifty patients were taken (34 men, 16 women) were included. Nguyen-Huynhet al,[30] had a study in which there were 38.5% females and 61.5% were males. Radwan et al,[31] had 49 males and 35 females in their study. All the above studies has sex distribution of patients similar to our study. However, in the study by Hirari et al,[32] a total of 18 patients (8 men and 10 women) were included which was different from our study.

[Table 2] shows the distribution of cases according to age. The mean age of male was 50.54±14.06 years, female was 50.75±15.38 and over-all study population was 50.02±14.05 years.

Table 2: Distribution of cases according to age

	Age	
Gender	Mean	Std. Deviation
Male	50.54	14.06
Female	50.75	15.38
Over-all	50.02	14.05
p-value	0.201#	

Unpaired t-test # Non-significant difference

In our study, the mean age of male was 50.54±14.06 years; female was 50.75±15.38 years and over-all study population was 50.02±14.05 years. This was similar to the study by Nguyen-Huynh et al, in which, the mean age of patients was 60 years with a range of 30 to 85 years. Another study by Hirari et al,[32] had a age range of the study population between 43–78years with a mean age of 68 years which was similar to our study.

[Table 3] and [Figures 1-3] show comparison of detection of Aneurysm, Stenosis and Occlusion with CTA & MRA. The distribution of detection of Aneurysm, Stenosis and Occlusion was compared between CTA and MRA using the Chi-square test.

The detection of Aneurysm was significantly more with CTA in comparison to MRA. Among cases reported, 48.0% were diagnosed as normal on CTA & 58.0% on MRA; 26.0% were diagnosed as Aneurysm on CTA & 18.0% on MRA; 16.0% were diagnosed as Stenosis on CTA & 14.0% on MRA and 10.0% were diagnosed as Occlusion on CTA and 10.0% on MRA.

Table 3: Comparison of detection of Aneurysm, Stenosis and Occlusion with CTA & MRA

	CTA	MRA
Normal	24	29
	48.0%	58.0%
Aneurysm	13	9
	26.0%	18.0%
Stenosis	8	7
	16.0%	14.0%
Occlusion	5	5
	10.0%	10.0%
Chi-square value = 2.265, p-value = 0.037*		

* Significant difference

Table 4: Comparison of detection of Occlusion between CTA and MRA with different arteries

Occlusion	CTA	MRA
Middle cerebral artery artery (MCA)	2	2
	40.0%	40.0%
Circle of Willis	2	2
	40.0%	40.0%
Posterior cerebral artery Cerebcerebral artery (PCA)	1	1
	20.0%	20.0%

Table 5: Comparison between CTA & MRA in detection of aneurysm

Aneurysm	CTA	MRA
Anterior Cerebral Artery (ACA)	8	6
	61.5%	44.8%
Vertebral artery	1	1
	7.7%	7.7%
Middle cerebral artery (MCA)	2	1
	15.4%	7.4%
Posterior communicating Artery artery (PCOM)	1	0
	7.7%	0%
Anterior inferior cerebellar Artery artery (AICA)	1	1
	7.7%	7.7%

[Table 4] shows comparison of detection of Occlusion between CTA and MRA with different arteries. There was no significant difference in the detection of Aneurysm of different arteries with CTA and MRA. [Table 5] shows comparison between CTA & MRA in detection of aneurysm. The detection of four aneurysms were missed on MRA as two were small in size (less than 3mm) at origin of ACA and two aneurysms were not confidently diagnosed because of motion blurring due to altered sensorium of the patient.

[Table 6] shows comparison of CTA & MRA in detection of stenosis in various arteries involved in the study. One case of stenosis of ICA was missed on MRA having non-significant stenosis of approximately 18%.

Table 6: Comparison of detection of Stenosis between CTA and MRA

STENOSIS	CTA	MRA
Posterior inferior cerebellar artery (PICA)	4	4
	57.1%	57.1%
Internal carotid artery (ICA)	3	2
	42.9%	28.6%

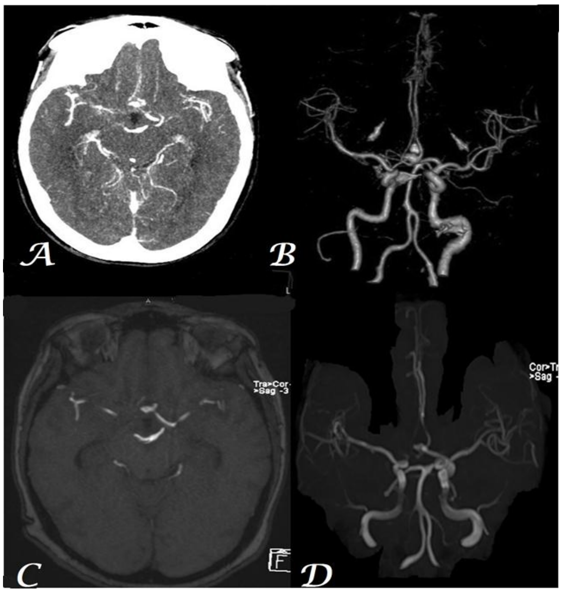

Figure 1: CTA (A – source image & B – Volume-rendered) and non-contrast MR TOF (C - axial & D – MIP) images show left ACA (A1)–AComA Junction aneurysm of 9X5mm in size. Neck of aneurysm is 6mm with SAH in anterior interhemispheric fissure.

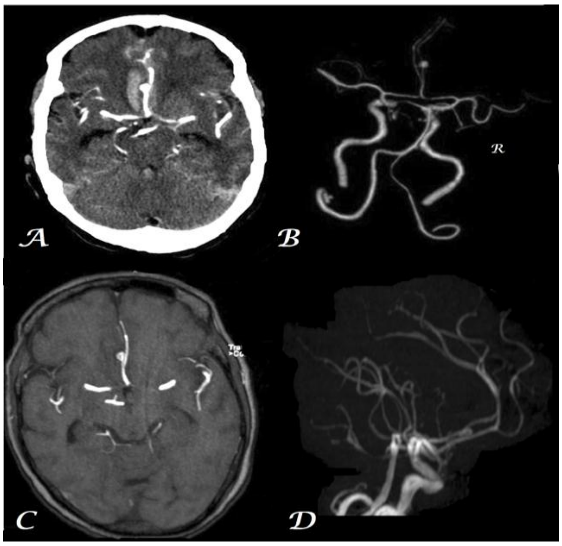

Figure 2: CTA (A – source image & B – Volume-rendered) and non-contrast MR TOF (C - axial & D – MIP) images show saccular aneurysm arising from right ACA (A2 segment)

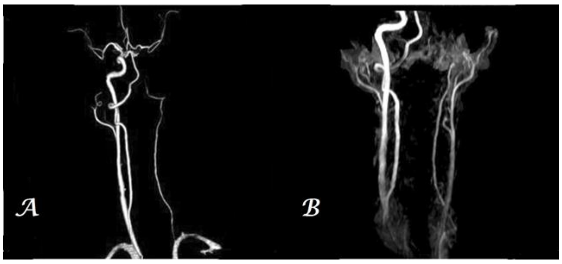

Figure 3: Volume Rendered CTA (A) and 3DTOF MIP MRA (B) images shows Partial stenosis of left CCA with non-visualization of distal segment of left ICA representing thrombosis.

In the current study, Posterior inferior cerebellar artery (PICA) was the most commonly affected artery with stenosis and Middle cerebral artery (MCA) was the most commonly involved with occlusion. In the study by Hirari et al,[32] there were four lesions in the internal carotid artery, nine lesions in the middle cerebral artery, and five lesions in the vertebral artery among patient with the angiographic steno occlusive lesions. This was different from the present study.

In the current study, Middle cerebral artery (MCA) was the most commonly involved with occlusion similar to study by Radwan et al,[31] Occlusions were most common in MCAs (n= 45) followed by PCAs (n= 9). In the study by Radwan et al,[31] affection with occlusion or with stenosis was mostly seen in MCAs followed by affection of arterial segments of PCAs. The intra-cranial arterial segments least affected were ACAs. The authors found that all ACA affected were multiple simultaneous involvement of arterial territories with no isolated ACA affection.

In the current study, posterior inferior cerebellar artery (PICA) was the most commonly affected artery with stenosis. This was quite similar to the study by Radwan et al,[31] of 31 arterial segments with stenosis seen, mainly affected were the arterial territories of PCAs (n= 16).

These results go with the reported findings of studies by Anneet et al,[33] and Moustafa et al.[34] where the majority of strokes was found to be due to affection of the MCA territory followed by the PCA territory. This most commonly reflects the relative distribution of total blood supply of brain. The ACA usually possesses good collateral flow through its paired contralateral vessel, and thus isolated ACA infarcts are rare.[33,34]

Shrier et al,[35] reported that greater than 80% of arterial steno-occlusive lesions identified by CT, CT angiography, MR imaging, or MR angiography occurred in a PCA or MCA distribution. This is consistent with the known prevalence of atheroembolic disease.

DISCUSSION

In our study, 48.0% of patients were diagnosed as normal on CTA while 58.0% on MRA; 26.0% were diagnosed as Aneurysm on CTA while 18.0% on MRA; 16.0% were diagnosed as Stenosis on CTA while 14.0% on MRA and 10.0% were diagnosed as Occlusion on CTA and 10.0% on MRA.

In the present study, the aneurysm was most commonly reported in anterior cerebral artery (ACA); occlusion in middle cerebral artery (MCA) and stenosis in posterior inferior cerebellar artery (PICA).

In our study the detection of aneurysm was significantly more with CTA in comparison to MRA. Out of four aneurysms that were missed on MRA, two were smaller than 3mm and other two were missed because of the motion blurring as the patient were in altered sensorium. One case of stenosis of ICA that was missed on MRA had non-significant stenosis of approximately 18%. Nam K. Yoon et al,[36] in their study revealed that current multi-detector scanners have a spatial resolution that can reliably diagnose aneurysms greater than 4 mm with nearly 100% sensitivity.

A meta-analysis of MRA studies for evaluating aneurysms demonstrated that contrast-enhanced MRA (CE-MRA) and TOF had similar sensitivity for detection of aneurysms. The ability to eliminate flow-related artefacts and spin saturation on contrast enhanced MRA makes the CE-MRA better than TOF sequences. Lack of venous contrast contamination and higher spatial resolution, make detection of small branch vessels on 3T MRA better than CTA. Despite these findings, MRA is generally not the diagnostic test of choice for the evaluation of cerebral aneurysms in the acute settings. Many studies evaluating the sensitivity of MRA for detection of cerebral aneurysms found a trend towards significance in detection of smaller aneurysms better on 3T versus 1.5T scanners ($p = 0.054$). Although the above study showed that the aneurysm which were smaller than 5mm were missed in 90% cases and aneurysm of size of less than 3mm had a pooled sensitivity of 86%.[37]

In the study done by Kim et al,[38] MCA stenosis was found to be the most common type of atherosclerotic lesions in approximately one-third of stroke patients. The most likely explanation is MCA is the largest and the most direct branch of the ICA and is therefore the most one subjected to embolism.

In acute ischemic stroke, CTA can reliably detect intracranial proximal arterial occlusions and stenosis.[17] The presence of a proximal arterial occlusion on CTA predicts functional outcome, final infarct size, and response to intravenous thrombolysis, thus facilitating decision making for intra-arterial rescue procedures.[18,19] In addition, CTA can provide information regarding the quality of collateral circulation and may improve the sensitivity to identify ischemic areas not seen on non-enhanced CT.[20]

For evaluation of a stroke patient, not only MRI but also all other imaging modalities cannot define in which patients vessel occlusion will persist and in which patient's vessel recanalization will occur. MRI can provide key information about recanalization, patients who can benefit from recanalization and where there is no tissue at risk of ischemic disease at all but only excessive risk of hemorrhage due to thrombolytic therapy.[39]

In the present study, there was 100.0% agreement in the detection of occlusion with MRA & CTA and 87.5% in detection of stenosis with MRA when compared to CTA. Multiple studies have shown good correlation MR angiography with conventional angiography in depicting steno-occlusive disease of proximal intracranial arteries,[28,40-43] even though MRA has a potential of overestimating the stenosis. According to above studies, MRA has a sensitivity of 80–100% & specificity of 80-99% in identification of diseased vessels of proximal intracranial arteries.

MRA is an attractive technique for screening intracranial stenosis for following reasons:

- MRA can be obtained relatively quickly can be performed concurrently with brain MR imaging in patients with potential stroke helping to take quick treatment decisions, whether to initiate intensive medical therapy for stroke prevention.
- Using maximum intensity projection (MIP) images from MRA simulate images obtained with conventional angiography, thereby allowing measurements to be obtained in the same locations and projections.
- MRA with sensitivity and specificity ranging from 80% to 100% and 89% to 95%, respectively, is comparable with conventional angiography when assessing intracranial stenosis.[32,44-46]
- MRA is not subject to the challenge of separating a high-density contrast-enhanced lumen from adjacent calcification and bone inherent in the evaluation of CTA of the head.
- Since TOF MRA does not require contrast injection, risks like contrast-induced nephropathy, allergic reactions, etc. are avoided.
- CTA if suboptimal due to venous contamination or motion / bone artefacts cannot be repeated due to the need for contrast injection. However, NC-MRA can be easily repeated.

CTA has been also found to be highly accurate in determining the severity of atherosclerotic stenoses in the extracranial arteries, especially the carotid arteries, thus aiding selection of patients amenable for revascularization.19 Furthermore, it allows a differentiation between near-occlusions and complete occlusions and is valuable in the diagnosis of an extracranial arterial dissection.[20]

Anzalone et al,[47] and Scarabino et al,[48] did not see any significant difference in sensitivity and specificity between TOF and CEMRA in detection of carotid artery stenosis at 1.5T. In contrast, Fellner et al found 3DTOF to be more accurate then CEMRA.[49] Townsend et al, however revealed that CEMRA tend to overestimate the severity of carotid stenosis compared to 3DTOF at 1.5T.[50]

One of the study among 22 patients with acute strokes in the posterior circulation found that CT angiography (CTA) reliably detected lesions in the basilar system, but had difficulty in identifying stenosis in the vertebral system and was not as accurate as Digital subtraction angiography (DSA) for detecting stenosis in the posterior circulation.[51]

Latest studies demonstrate clinical effectiveness of CTA in evaluation of atherosclerotic narrowing of lumen of extracranial carotid artery bifurcation with high sensitivity and specificity.[52-55] In contrast, the clinical application of CT angiography in intracranial vasculatures has been more limited than that of extracranial carotid artery studies.[35,56-60]

Katz et al,[60] concluded that CTA is highly sensitive in detection of arterial anatomies in the circle of Willis. Knauth et al,[57] in their study revealed that CTA can correctly identify trunk occlusions of basilar, internal carotid and middle cerebral arteries. Recently, Skutta et al,[59] concluded that CTA is a reliable method in grading intracranial steno-occlusive lesions, with the exception of the petrous segment of the carotid artery.

Bash et al,[17] had examined the accuracy of CTA for detecting and quantifying intracranial stenosis compared with MRA and DSA among 28 subjects. The authors reported that CTA had a higher sensitivity and positive predictive value than MRA using DSA as the gold standard. In a separate analysis putting CTA and DSA images side by side, the authors found that in cases with possible slow flow in the posterior circulation, CTA was superior to DSA in detecting vessel patency.

A study by Nederkoorn et al,[61] comparing TOF-MRA with gold-standard DSA, the sensitivity of former in detecting severe stenosis was 92.2% with specificity of 75.7%. CE-MRA tended to overestimate stenosis compared with DSA by a mean bias of 2.4–3.8% according to U-King-Im et al.[62] Performance of MRA is dependent on multiple factors including spatial resolution, type of sequence, interpolation algorithms, and implementation details,[49] making the comparison of results with different MRA techniques difficult.

MRA has some potential pitfalls which can be summarised as follows:[23,52,60]

- As its technique depends on flowing blood to generate contrast; hence decreased flow distal to stenosis, leading to a false-positive diagnosis of occlusion or vascular irregularity.
- Vessels near the sphenoid sinus are subject to false narrowing or non visualization because of large susceptibility gradient present in this area.[63] However, no case was incorrectly assessed because of this artifact in our study. Skutta et al58 also reported that this problem was observed in only few cases, resulting in a superiority of MRA over CTA in this region.

- Accelerated flow in carotid siphon with loss of laminar flow & resultant intravoxel dephasing also contributes to signal loss in C2 & C3 portions of internal carotid artery, making it difficult to evaluate narrowing of this segment of the vessel.[63]
- MR angiograms of severely stenotic vessels often show an apparent discontinuity in a vessel. The flow void results from intravoxel spin dephasing and the acceleration of spins through the area of stenosis.64 These artifacts were also observed in the study by Hirari et al,[32] resulting in overestimation of stenosis based on MR angiography alone. This was not seen on CTA.
- MIP algorithm create some artifacts in imaging of patients with stenosis.65 It causes an apparent decrease in vessel diameter and an artificial lengthening of stenotic portion.[66] Combined evaluation of both MIP images and source images is more reliable than study of MIP images alone for assessing the severity of intracranial stenosis.[28]

Image quality influences concordance but lesser than the type of technique applied. CTA provides higher overall image quality compared with contrast enhanced MRA (CEMRA) and TOF-MRA. The motion artefacts have been found more commonly among 3D-TOF-MRA because of prolonged acquisition time and limited volume coverage. Tapering vessel walls at the edge of the scan volume may be found on MIP images because of reduction of signal intensity due to increased spin saturation. Image quality in CE-MRA is highly dependent on correct contrast bolus timing and imaging parameters.[29]

The findings of the study by Hirari et al32 proved that combined MRA and CTA enable highly accurate diagnosis of steno-occlusive disease in all major intracranial arteries. The additional use of CTA reduces the tendency of overestimating stenosis at MRA and improved the specificity for detecting stenosis of 50% or more. In their study, out of 35 arterial segments with suspected steno-occlusive diseases revealed by MRA, 33 segments (95%) were accurately interpreted with additional use of CTA. Combined MRA and CTA did have accuracy equal to that of DSA for measuring the stenosis and depiction of the occlusion of the major intracranial arteries.

The CTA has limitations in delineating the lumen of the artery with circumferential wall calcification. To minimize, analysis in conjunction with the axial source images may be useful.[67] Dense circumferential calcification of arterial wall interfere with the evaluation of the arterial lumen on MPR images of CTA. However, sophisticated software can be used to remove mural calcifications when volume-rendered images of extracranial carotid artery are generated.[68]

Because MRA more correctly revealed calcified stenotic lumens than did CTA, former was found to be more useful than CTA in the study by Hirari et al for the evaluation of the lumens of vessels with circumferential calcification.

CTA often fails in depicting lumen of internal carotid artery within the cavernous sinus because the cavernous sinuses were opacified with contrast. This segment of internal carotid artery could not be differentiated from the cavernous sinus only when the arterial lumen was hyperattenuating to sinus.32 In contrast, MRA has often correctly depicts this segment of internal carotid artery. Thus, MRA and CTA complement each other in assessment of intracranial steno-occlusive diseases.[32]

CTA provides intracranial vascular map in few seconds with disadvantages of utilising ionizing radiation and iodinated contrast media with potential nephrotoxic effects. The iodinated contrast agents should be used with precaution in patients with risk factors such as renal insufficiency, congestive heart failure, and hypersensitivity to contrast material. 3D TOF-MRA on the other hand is performed without contrast medium and ionizing radiation. Few studies have reported higher sensitivity of TOF-MRA than CTA in demonstrating intracerebral arteries on MR equipment with high magnetic field.[25] Potential disadvantages of the MRA include relatively longer scanning time, susceptibility to motion artefacts and the contraindications of MRI examination.[69]

Recently, investigators have proposed using MRA and MR imaging along with hemodynamic and diffusion-weighted pulse sequences in the work-up of patients with acute stroke.[70,71] Diffusion and perfusion images are highly sensitive to early infarction and can be coupled with detailed vascular information provided by MRA angiography. The major limitation to this is higher scanning time favouring CT and CTA in the acute setting, thus minimizing the possibility of artefacts from patient motion.

The availability of MR in acute setting is markedly low compared to CT in majority of institutions. Also, no special life-support or monitoring equipment is necessary for CT scanning, and patients are easily seen when in the larger CT gantry. The patients with contraindications to MRA such as those with pacemakers, aneurysm clips, or other metallic implants, may safely undergo CTA which is less expensive than MRA.

Limitations of the Study

Our study has some of the following limitations:

- Small sample size affects the sensitivity and specificity of a technique.
- Time-of-flight MRA used in our study is good in detecting the flow disturbances due to stenosis but overestimates the severity of stenosis compared with CTA and conventional angiography.
- Lower spatial resolution of MRA leads to error in measurement of stenosis.
- The motion blurring effect causing suboptimal MRA images was due to reversing anesthetic effect given

to stabilize the patient before CTA. Hence higher chance of getting a good quality image is there when patient undergoes directly for MRA.

- Lack of 3T MR machine in our department as results of MRA are better than 1.5T in evaluating patients of cerebrovascular accident.
- Lack of comparison of MRA results with DSA as latter is a gold standard modality for evaluating patient with cerebrovascular accident.

CONCLUSION

In our study, MRA had excellent correlation with CTA data. Hence based on the results of our study we can conclude the following:

1. More than half of the patients with cerebrovascular disease have an underlying pathology.
2. Cerebrovascular accidents are commoner in males than females, with age predominance in 4th-6th decade.
3. Aneurysm is most common in anterior cerebral artery, occlusion in middle cerebral artery and stenosis in posterior inferior cerebellar artery (PICA).
4. Though MRA has a slightly higher false negative rate than CTA yet further evaluation may be needed only in high clinical suspicion of underlying disease.
5. Though CTA is better in detecting concurrent, clinically non-suspected, small aneurysms but still MRA can be used in emergency where the CTA may be contraindicated as aneurysms smaller than 3mm do not affect immediate management.
6. MRA is comparable in accuracy to CTA in detection of clinically-significant internal carotid artery stenosis.
7. MRA is as accurate as CTA in detecting occlusive disease of intracranial arteries.
8. Combined MRA and CTA provide substantially higher diagnostic information than MRA and CTA alone.

Summary

Among CTA and MRA, CTA has been the modality of choice for evaluating patient with known CVA for a long time in majority of the institutions. However due to its major limitations as contrast-injection, susceptibility to motion & ionising radiation exposure, non-contrast 3D MRA is gaining popularity. Though non-contrast MRA is limited by its ability to detect small aneurysm (<3mm), clinically-insignificant stenosis (20-30%), higher scan time and need for anaesthetic agent to stabilize the patient for optimal scan yet it can be used as a first investigation of choice for evaluating patients with cerebrovascular accident with comparable results as CTA especially when combined with routine stroke imaging.

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