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Original Article

Radiology Section

Computed Tomography Angiography versus Magnetic Resonance Angiography of Brain in Evaluating Cerebrovascular Diseases: A Cross-sectional Study

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ABSTRACT

Introduction: In India, Cerebrovascular Disease (CVD) remains to be one of the leading causes of mortality and morbidity. In recent times, the imaging of cerebrovascular disorders has undergone various advancements with the advent of digital technologies. Two novel imaging modalities include Magnetic Resonance Angiography (MRA) and Computed Tomographic Angiography (CTA).

Aim: To assess and compare Computed Tomography Angiogram (CTA) brain vs non contrast MR angiogram brain in evaluation of CVD.

Materials and Methods: A cross-sectional observational study was conducted in the Department of Radiology, Arupadai Veedu Medical College and Hospital, Puducherry, India, from November 2020 to July 2022. All suspected cases of cerebrovascular accidents who were above 18 years of age were screened for the study. Finally, a total of 60 patients were recruited for the study. Demographic parameters like age, gender and occupation were collected. Past history of chronic illness, vitals, serum urea and creatinine were also assessed. MRA findings including stenosis, occlusion, and irregularity of vessels and features of stroke were assessed and compared to the findings on CTA images. Data was compiled and analysed using Statistical Package for the Social Sciences (SPSS) software version 19.0.

Results: A maximum of 26 (43.3%) participants were in the age group of 61-70 years of age and, 60% of the cases were males and 40% of the cases were females. Out of the 60 patients, 40 (80%) had characteristics of CVD based on CTA, and 47 (78.3%) of the individuals indicated of CVD based on MRA results. The differences between MRA and CTA for CVD alterations were significant (p-value <0.0001). MRA had a diagnostic efficacy of 95% and had a sensitivity and specificity of 95.8% and 91.7% respectively, with Positive Predictive Value (PPV) of 97.9%, and Negative Predictive Value (NPV) of 84.6% as compared to CTA.

Conclusion: The results of the present study demonstrate that MRA is equally effective as CTA in diagnosing cases with CVD.

Keywords: Intramural haematoma, Radiology, Stenosis, Stroke

INTRODUCTION

The CVD is a prevalent disease affecting the majority of the population. These include stroke, carotid artery stenosis, vertebral artery stenosis and intracranial vascular stenosis, aneurysms and vascular malformations [1,2]. Amongst all these diseases, stroke remains to be the most common form. The Global Burden of Disease (GBD) estimates for the year 2019 report the annual incidence of CVD to be 12.2 million [1]. Overall, a total of 101 million global population is affected by stroke resulting in a total of 6.55 million deaths worldwide, as a result of stroke [1]. Globally it is recognised as the second leading cause of death and a third major cause of disability, mortality and morbidity [2,3]. As per reports by American Heart Association (AHA), stroke can be attributed as the cause of death in 11.8% of total global deaths [4]. Each year stroke causes nearly 5.5 million deaths and 116.4 million Disability-Adjusted Life Years (DALYs) [5].

In India, stroke remains to be one of the leading causes of death as well as disability [6]. The prevalence of stroke in India is similar to or higher than in many Western countries [7,8,9]. Traditionally, cerebral angiography has been used for the evaluation and diagnosis of CVD, however, being an invasive procedure and with the emergence of modern imaging techniques like MRA and CTA, the role of cerebral angiography is diminishing [10]. Over the past few decades, the imaging of cerebrovascular disorders has undergone a phenomenal change with the emergence of newer imaging modalities like Digital Subtraction Angiography (DSA), Positron Emission Tomography (PET), etc., [11]. Amongst the various imaging modalities, in routine clinical practice, two imaging modalities, viz., CT and Magnetic Resonance imaging (MRI) are the most common techniques mainly used to visualise the brain parenchyma, vessels, and associated perfusion or blood flow patterns [12].

The use of CT and CTA is widely prevalent in imaging modality of the head and neck region and the intracranial and extracranial arteries. Non enhanced CT helps in the assessment of haemorrhage, the detection of chronic infarcts, and presence of arterial calcifications. All these help to assess the future stroke risk in the presence of atheroma [13]. CTA is able to detect steno-occlusive disease of the great vessels, cervical and intracranial vasculature [13]. The rapid availability of this facility in most hospitals and the visualisation of the complete trajectory of the vasculature from the aortic arch to the more peripheral intracranial arteries are the advantages of CTA. However, there are some limitations of the CTA imaging modality such as the requirement of ionising radiation and potential side-effects of the use of iodinated contrast which may result in allergic reactions and nephrotoxicity in some cases [12,13].

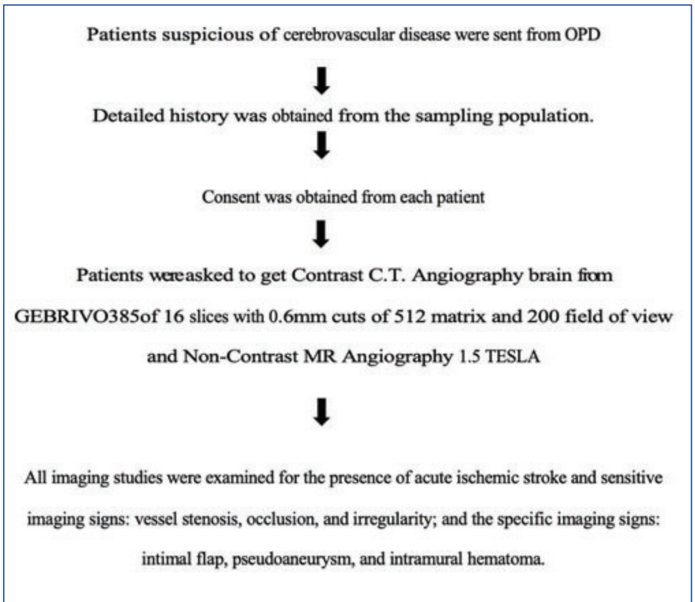
Magnetic resonance angiography is also useful for determining the severity of stenosis, vascular occlusion and collateral flow. Contrast-Enhanced (CE) MRA and Three-dimensional (3D) Time-of-Flight (TOF) techniques help to differentiate different types of carotid stenoses with high sensitivity and specificity. Three-dimensional TOF-MRA is highly accurate in the assessment of intracranial proximal stenoses and occlusions. MRA also helps to assess the collateral flow patterns in the circle of Willis. The use of MRA in establishing stroke aetiologies such as dissection, fibromuscular dysplasia and vasculitis has also been well-documented [14].

Thus, both these modalities have their peculiar characteristics and are being used as per convenience at different centres. Although, MRA is generally preferred over CTA for its ability to assess the parenchymal and other soft tissue changes more effectively and it is considered superior to CTA. However, emerging evidence shows that CTA is as effective as MRA and can be used interchangeably [15]. No doubt, the use of contrast helps to elucidate and differentiate tissue and vascular flow patterns more effectively hence, the use of contrast in CTA could help to achieve a comparable image quality as compared to MRI. From another point of view, it can be argued that the use of contrast can be avoided by using MRA in place of CTA, to achieve a comparable image.

Various studies in the past have employed the use of CTA and MRA to diagnose various soft and hard tissue abnormalities [13-15]. However, in a limited resource setting like the rural parts of India, where multiple imaging modalities are not available at all the locations and the choice of imaging modality is dependent on the availability and accessibility, these imaging modalities have not been assessed and compared. In rural locations, it is important that a trade-off between the alternatives is performed by comparing their advantages and disadvantages through the help of clinical evidence, which will eventually be cost-effective for the patients. Also, the present study is the first study to assess and compare the individual CVA findings such as vessel occlusion, intimal flap, and stenosis between CTA and MRA. Hence, the present study was planned to compare CT angiogram brain vs non contrast MR angiogram brain in the evaluation of CVD at a tertiary care centre in South India.

MATERIALS AND METHODS

A cross-sectional, observational study was conducted in the Department of Radiology in Arupadai Veedu Medical College Hospital, Puducherry, India, from November 2020 to July 2022. Ethical committee approval was obtained from the Institutional Human Ethics Committee (AV/IEC/2020/192). The study participants gave written informed consent. A total of 100 suspected cases of cerebrovascular accidents who were above 18 years of age were screened, out of which 60 were selected based on inclusion and exclusion criteria [Table/Fig-1].



[Table/Fig-1]: Study design flowchart.

Inclusion criteria: Suspected cases of all cerebrovascular accidents with related clinical symptoms including dizziness, nausea or vomiting, headache, confusion, disorientation or memory loss, numbness, weakness in an arm, leg, or the face, especially on one side, abnormal or slurred speech, loss of vision or difficulty seeing with CNS causes, loss of balance, loss of coordination or disability to walk were included in the study.

Exclusion criteria: All patients who did not give consent for the study, pregnant women, myocardial infraction, renal impairment (serum creatinine more than 1.5 mg/dL), patients with any electrically, magnetically, or mechanically activated implants (pacemaker, biostimulators, neurostimulators), patients having claustrophobia and allergy to contrast were excluded from the present study.

Sample size calculation: Sample size was calculated to be 60, using Cohen's Kappa (Agreement test), $N=P_0-P_e/1-P_e$, where N=Sample size, P_0 is the proportion of pair exhibiting agreement P_e is the proportion of expected to exhibit agreement by chance alone. Thus, perfect agreement is rated k=1 and agreement rated by chance is exhibited by k=0. The calculated sample size was N=60 for 95% level of confidence and margin of the error was 5%.

Study Procedure

Demographic parameters like age, gender, and occupation were collected. Clinical symptoms like headache, nausea and vomiting, memory loss, numbness, weakness in limbs, slurred speech, visual difficulty, and loss of coordination were assessed. Past history of chronic illness, vitals, serum urea and creatinine were also assessed. All the patients underwent both CTA and MRA scans and the findings included stenosis, occlusion, and irregularity of vessels and features of stroke. The MRA technique employed in the present study was a TOF-MRA.

STATISTICAL ANALYSIS

Microsoft excel software was used to enter the data, and Statistical Package for the Social Sciences (SPSS) software version 19.0 was used to analyse the data. For continuous variables, descriptive statistics were generated, including mean, and standard deviation, and for categorical variables proportions (percent) were used. To verify the theory, Chi-square test was applied. A p-value <0.05 was considered statistically significant.

RESULTS

Among patients with CVD, a maximum of 43.3% of the participants were between 61-70 years of age. Based on the sex distribution 60% of the cases were males and 40% of the cases were females in the present study [Table/Fig-2].

Demographic variables		Frequency (n)	Percentage (%)
Age	≤50 years	04	6.7
	51-60 years	19	31.7
	61-70 years	26	43.3
	>70 years	11	18.3
Gender	Male	36	60.0
	Female	24	40.0
Occupational status	Employed	14	23.3
	Unemployed	22	36.7
	Housewife	24	40.0

[Table/Fig-2]: Frequency and percentage of demographic variables in the study population.

Based on the presenting symptoms among the patients, most of the cases had dizziness (85%), followed by headache (71.7%), numbness (70%) and weakness in limbs (58.3%) as the common symptoms in descending order [Table/Fig-3]. Diabetes mellitus was present among 61.7% of the patients, while hypertension was found to be present among 68.3% of the cases in the present study [Table/Fig-4]. On assessing the heart rate of the patients 70% of the patients had normal heart rate while 11.7% of the patients had tachycardia and 18% of the patients were found to have bradycardia [Table/Fig-5]. The mean serum creatinine and mean serum urea levels among the study participants were 45.7±14.7 μmol/L and 1.0±0.09 mmol/L, respectively.

Presenting symptoms	Frequency (n)	Percentage (%)
Dizziness	51	85.0
Headache	43	71.7
Nausea and vomiting	21	35.0
Disorientation	18	30.0
Memory loss	04	6.7
Numbness	42	70.0
Weakness in limbs	35	58.3
Slurred speech	31	51.7
Difficulty in vision	06	10.0
Loss of balance	08	13.3
Loss of coordination	19	31.7

[Table/Fig-3]: Presenting clinical symptoms in the study population.

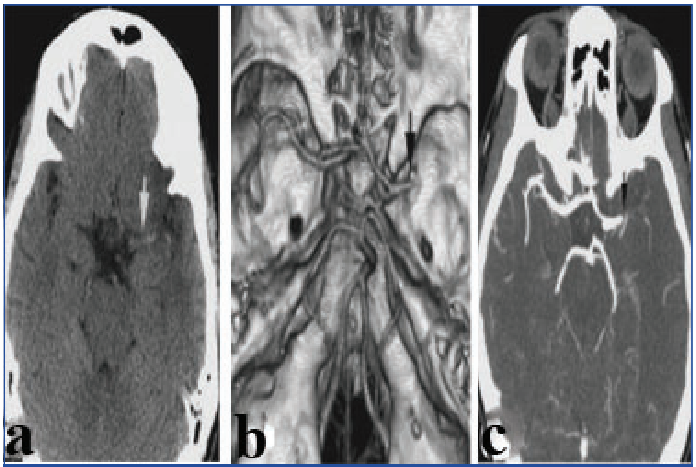
History of chronic illnesses	Frequency (n)	Percentage (%)
Diabetes mellitus		
Present	37	61.7
Absent	23	38.3
Hypertension		
Present	41	58.6
Absent	29	41.4
Dyslipidemia		
Present	33	47.1
Absent	37	52.9
Cardiovascular diseases		
Present	26	43.3
Absent	34	56.7

[Table/Fig-4]: Past history of chronic illnesses among study participants.

Variables		Frequency (n)	Percentage (%)
Heart rate	Bradycardia	11	18.0
	Normal	42	70.0
	Tachycardia	07	11.7
Blood pressure	Normal	15	25.0
	Prehypertensive	13	21.7
	Hypertensive	32	53.3
Serum creatinine	Normal	60	100.0
	Elevated	00	0.0
Serum urea	Normal	58	96.7
	Elevated	02	3.3

[Table/Fig-5]: Assessment of vitals and biochemical parameters among the study population.

Based on CTA findings 51.7% of the cases had vessel stenosis. On CTA findings, vessel occlusion was present among 18.3% of the cases [Table/Fig-6,7]. On assessing the specific imaging signs, 26.7% of the participants had intimal flap on CTA findings, while 20.0% of the participants had pseudoaneurysm and 16.7% of the cases had intramural haematoma [Table/Fig-7]. Likewise, based on MRA findings, vessel stenosis was noted in 45% of the cases. Vessel occlusion was noted among 21.7% of the cases. Based on the specific imaging signs, 21.7% of the participants had intimal flap, while 13.3% of the participants had pseudoaneurysm and 15.0% of the cases reported intramural haematoma [Table/Fig-8].



[Table/Fig-6]: CTA in intracranial arterial occulusion.

CTA findings	Frequency (n)	Percentage (%)
Vessel stenosis		
Present	31	51.7
Absent	29	48.3
Vessel occlusion		
Present	11	18.3
Absent	49	81.7
Vessel irregularity		
Present	19	31.7
Absent	41	68.3
Intimal flap		
Present	16	26.7
Absent	44	73.3
Pseudoaneurysm		
Present	12	20.0
Absent	48	80.0
Intramural haematoma		
Present	10	16.7
Absent	50	83.3

[Table/Fig-7]: Vessel stenosis, vessel occlusion and vessel irregularity among the study population through the CTA findings.

MRA findings	Frequency (n)	Percentage (%)
Vessel stenosis		
Present	27	45.0
Absent	33	55.0
Vessel occlusion		
Present	13	21.7
Absent	47	78.3
Vessel irregularity		
Present	16	26.7
Absent	44	73.3
Intimal flap		
Present	13	21.7
Absent	47	78.3
Pseudoaneurysm		
Present	08	13.3
Absent	52	86.7
Intramural haematoma		
Present	09	15.0
Absent	51	85.0

[Table/Fig-8]: Vessel stenosis, vessel occlusion and vessel irregularity among the study population through the MRA findings.

Among 47 cases with CVA findings in MRA, 46 cases were found to have CVA changes in CTA also, while among 13 cases for which MRA showed no signs of CVD, two cases had CVD changes in CTA. There was a significant association noted for CVD changes between MRA and CTA with a p-value <0.0001 [Table/Fig-9]. Based on the diagnostic test criteria, sensitivity of MRA was found to be 95.8%, specificity was noted as 91.7% [Table/Fig-10].

MR Angiography (MRA)	Cerebrovascular Disease (CVD) CTA-Gold standard		Total, n (%)	p-value
	Present, n (%)	Absent, n (%)		
Present	46 (76.7)	01 (1.7)	47 (78.3)	**<0.0001**
Absent	02 (3.3)	11 (18.3)	13 (21.7)	
Total	48 (80)	12 (20)	60 (100)	

[Table/Fig-9]: Association between MRA and CTA for CVD among the study participants.
The p-value in bold font indicates statistically sigificant values

Diagnostic parameters	Value	Reference range
Sensitivity	95.8%	85.8-99.5%
Specificity	91.7%	61.5-99.8%
Positive Predictive Value (PPV)	97.9%	87.6-99.7%
Negative Predictive Value (NPV)	84.6%	58.4-95.6%
Diagnostic efficacy	95%	86.1-99%

[Table/Fig-10]: Diagnostic parameters of the MRA test.

DISCUSSION

In the study, among patients with CVD, about 43.3% of the participants were between 61-70 years of age. This was in concurrence with the study done by Vermeer SE et al., who reported that subclinical CVD was diagnosed in a population over age of 65 years [16]. Hence, it can be inferred that the population between 61-70 years are more likely prone to be at the risk of developing CVD. Based on the sex distribution, 60% of the cases were males and 40% of the cases were females in the present study. Kapral MK et al., in their study reported that as the age progresses, men become more prone for developing adverse CVD effects than females [17]. This can be attributed to the biological differences in the hormones, where oestrogen has the potency of producing vasodilation and increased blood flow, which is contradictory to the effects of testosterone [17]. On assessing the occupational status, 23.3% of the cases were employed, whereas 36.7% of the cases were noted as unemployed. Occupational status influences the risk for CVD due to high amounts of stress among the unemployed individuals.

Diabetes mellitus was present among 61.7% of the CVD patients, while hypertension was found to be present among 68.3% of the cases in the present study. This was in association with the results of Yang R et al., who also showed a positive association between CVD and diabetes [18]. Hypertension is also associated with increased risk of stroke, as it is an important aetiological factor for atrial fibrillation and for acute myocardial infarction and left ventricular clot formation; with attendant risk of cerebroembolic stroke [19]. Jones WJ et al., also reported that hypertensive individuals are more prone to developing cerebroembolic events and increased blood pressure beyond the cerebral flow rate to result in the occurrence of cerebral encephalopathy [20]. In the present study, serum creatinine was noted to be normal among all the cases of CVD. Wannamethee SG et al., demonstrated that elevated serum creatinine has been associated with increased mortality in hypertensive persons, the elderly, and patients with myocardial infarction, which may pose a higher risk for CVD [21].

The results of the present study was in harmony with the study done by Graham BR et al., who demonstrated that CTA was the most preferred imaging modality for the detection of vessel wall abnormalities and haematomas, owing to its many advantages [22]. Apart from assessing the vessel wall anatomy, CTA is also designed to provide additional information on delayed collateral backfilling and thrombus extent, which further influences acute stroke decision-making for clinicians. The results of the present study also reflect similar findings. MRA has been the imaging modality of choice to detect certain cases of vessel wall abnormalities, as it does not necessitate the use of a contrast agent and also provides information even in extensively stenosed blood vessels. Additionally, it provides information about the blood flow and patency of the vessel in CVD cases [23]. There was a significant association noted for CVD changes between MRA and CTA, which was similar to the results of Graham BR et al., who demonstrated that CTA detects changes not only in the vessel anatomy but also detects the flow rate and patency of each vessel [22].

Based on the diagnostic test criteria, the diagnostic efficacy of the MRA test was 95% in the current study. The findings of the present study were comparable with the findings of Parashar S et al., who assessed the function of Non Contrast-MRA (NC-MRA) and CTA [23]. They claimed that NC-MRA can accurately detect stenoses in intracranial as well as extracranial arteries and aneurysms in intracranial aneurysms. With the exception of extremely tiny aneurysms and early stenosis (20-30%), which infrequently affect immediate patient care, the results of NC-MRA were equivalent to those obtained by CTA. As a result, NC-MRA can be a good alternative to CTA, particularly in individuals for whom iodinated contrast is generally or categorically prohibited, and when used in conjunction with standard stroke imaging strategy. Alons IM et al., observed that although CTA had a low diagnostic yield in cases with severe headache, normal neurological examination, and normal NCCT, its use in an emergency situation may be justified due to potential therapeutic benefits [24]. Another study by Ma J et al., demonstrated that CTA had more specificity compared to the other imaging modalities [25]. To assess the sensitivity of CTA, T2 Weighted- MRI (T2w-MRI) and MRA, Gross BA et al., analysed 125 cases with AVMs. CTA, MRI, and MRA had overall sensitivities of 90%, 89%, and 74%, respectively [26]. When compared to MRA, the sensitivity of CTA was noticeably higher. The detection of big AVMs was 100% sensitive with both CTA and MRI which was similar to the results of the present study.

In Transient Ischaemic Attack cases (TIA), Förster A et al., and Förster A et al., evaluated the identification of acute ischaemic lesions on CT and MRI [27,28]. A 95.7% of cases had no acute pathology, and 4.3% may have had an acute infarction, according to a preliminary CT scan. The authors concluded that acute MRI is preferable to CT for confirming the likely ischaemic nature and determining the aetiology in TIA cases. For the imaging of Vertebrobasilar Dolichoectasia (VBD), Förster A et al., and Förster A et al., compared CT/CTA with MRI/MRA [27,28]. They discovered very good agreement between CTA and TOF-MRA for the basal artery's measured diameter and observed height (BA). The greatest transverse diameter and length of the BA also showed a high degree of consistency between the two. Both CTA and TOF-MRA were equally effective at detecting luminal thrombus. Small confined calcifications could be found with CT, but perifocal brainstem oedema could only be seen with MRI. The study's findings demonstrated a high degree of compatibility between CT/CTA and MRI/TOF-MRA in the diagnosis of VBD.

Gamal GH examined the sensitivity of Contrast-enhanced-MRI (CE-MRI) and CTA for the identification of cerebral aneurysm in individuals with non traumatic subarachnoid haemorrhage [29]. In 25 individuals, a total of 22 aneurysms were found. There were 15 cases with a single aneurysm, two cases with two aneurysms, one patient with three aneurysms, and no aneurysms were discovered in seven individuals. Aneurysms' size, location and detection were determined by interpreting CE-MRA and CTA angiograms. The authors concluded that CTA and CE-MRA both performed similarly.

For the purpose of detecting CVR in intracranial DAVFs Lin YH et al., evaluated the diagnostic precision of CTA and MRI/MRA [30]. According to their findings, the specificities and sensitivity of each CTA indicator ranged from 79-94% and 62-96%, respectively. The authors demonstrated that, for the evaluation of CVR detection in intracranial DAVFs, CTA was on par with, or perhaps slightly superior to, MRI/MRA.

According to the results of the study by Feng Y and Shu SJ, MRA and CTA combined allow for a very precise identification of steno-occlusive disease in all major cerebral arteries, which was concurrent with the results of the present study. The extra use of CTA improves the specificity for detecting stenosis of 50% or more and decreases the tendency of overestimating stenosis at MRA. Out of 35 arterial segments in their investigation with suspected steno-occlusive disorders identified by MRA, 33 segments (95%) were correctly interpreted with the help of supplementary CTA. The accuracy of combined MRA and CTA for measuring stenosis and showing blockage of the major intracranial arteries was comparable to that of DSA. With calcification on the circumferential wall, the CTA has trouble defining the arterial lumen. The evaluation of the arterial lumen on MPR pictures of CTA is hampered by dense circumferential calcification of the arterial wall, which may be reduced by analysis in conjunction with the axial source images [31].

In comparison to CT, the availability of MR in acute settings is noticeably lower in most Institutions. Additionally, CT scanning does not require any specialised life-support or monitoring equipment, and cases can easily be seen when inside the bigger CT gantry. Cases that can safely undergo CTA, which is less expensive than MRA, include individuals who have pacemakers, aneurysm clips, or other metallic implants, which are contraindications to MRA. However, CTA is also subjected to certain limitations such as the requirement of ionising radiation and potential side-effects of the use of iodinated contrast (allergic reactions, nephrotoxicity). Another limitation of CTA is poor soft tissue contrast owing to which subtle lesions in brain parenchyma cannot be detected easily, and the inability to evaluate the vessels around the bones owing to beam-hardening artifacts. Exposure to radiation also happens to be one of the disadvantages associated with the use of CTA and is often one of the barriers in its use in cerebrovascular imaging. In such cases, these limitations can be overcome with the use of MRA imaging modality for the diagnosis of cases with cerebrovascular injury.

Limitation(s)

Recruitment of only adults as a study population, lack of 3 Tesla (3T)-MRI, since it is better in the evaluation of CVA, and lack of comparison with gold standard DSA.

CONCLUSION(S)

In the present study, MRA presented similar findings, when compared to CTA in diagnosing CVD. The differences between MRA and CTA for CVD alterations were shown to be significant. Additionally, MRA also demonstrated significant diagnostic efficacy, which was very similar to CTA. Thus, the authors inferred that MRA is equally effective as CTA in diagnosing cases with CVD.

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