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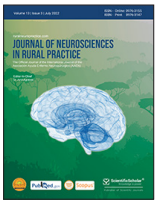

Original Article

Magnetic resonance imaging in the evaluation of the pathologies affecting large intracranial arteries

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ABSTRACT

Objectives: Our aim is to describe the utility of magnetic resonance imaging (MRI) in the evaluation of pathologies affecting large intracranial arteries.

Materials and Methods: We performed a prospective and observational study from 2018 to 2020 using 1.5 T MRI. Our study included 75 patients who were referred for MRI brain with clinical features of stroke or having tumors/infection involving large intracranial arteries (vertebral, basilar, and internal carotid arteries) on initial MRI. Correlation of MRI diagnosis was done with final diagnosis.

Results: Atherothrombosis was the most common pathology involving all the intracranial large arteries and was most commonly seen in elderly male patients. The second most common pathology involving the internal carotid, vertebral, and basilar arteries was tumors, dissection, and aneurysms, respectively. The most common artery involved by atherothrombosis, tumor, and infection/inflammation was internal carotid artery, whereas it was basilar artery and vertebral artery in cases of aneurysm and dissection, respectively.

Conclusion: MRI is an extremely useful modality to study large intracranial arteries. It is useful to demonstrate the site of abnormality, vessel lumen and caliber, vessel wall changes, and perivascular areas. This can help in arriving at correct diagnosis and thereby guide appropriate timely management.

Keywords: Magnetic resonance imaging (MRI), Atherothrombosis, Tumors

INTRODUCTION

Arterial disease is the most common cause of ischemic cerebrovascular accident which, in turn, is the most common cause of neurological disability. Up to 80% of strokes in India are ischemic in nature, of which intracranial atherothrombosis is the most common mechanism.[1] Apart from this, infections, inflammation, dissection, aneurysms, and tumors can affect large intracranial arteries. Accurate identification of these pathologies allows for appropriate timely management of these patients. Magnetic resonance imaging (MRI) is widely being used for the initial evaluation and characterization of various pathologies affecting the intracranial arteries. With the help of MRI, intracranial arterial pathologies can be accurately characterized for the required intervention.[2-6] Our objective was to identify the usefulness of basic MRI sequences during the initial MR examination in the evaluation of the patients with pathologies affecting large intracranial arteries such as internal carotid arteries (ICA), vertebral arteries (VA), and basilar artery (BA).

MATERIALS AND METHODS

A prospective and observational study was conducted in a tertiary hospital (Sri Ramachandra Institute of Higher Education and Research) over a period of 2.5 years from July 2018 to December 2020, in 75 patients who were referred for MRI brain in whom abnormalities involving the intracranial large arteries were demonstrated. Prior Institution Ethics Committee approval was obtained.

MRI was performed with a 1.5 T superconducting system (GE Signa HDX 1.5T) with an 8 Channel Neurovascular Array or 16 Channel Head-Neck Spine Coil.

Inclusion criteria

- Patients referred for MRI brain with MRA in whom abnormalities involving the large intracranial arteries (vertebral, basilar, and internal carotid arteries) were initially detected.

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Exclusion criteria

- Pathologies with isolated involvement of neck arteries, ACA, MCA, and PCA. However, pathologies involving intracranial large arteries in continuity with neck arteries, ACA, MCA, and PCA were included in the study
- Patients in whom final diagnosis was not available were excluded from the study.

Protocol

Conventional MR imaging of the brain was first performed with the following sequences: Axial T1, axial T1FS, axial T2, axial diffusion-weighted imaging (DWI), coronal T2 fluid-attenuated inversion, axial gradient-echo imaging, and three-dimensional time-of-flight MR angiogram (3D TOF-MRA). Axial T1FS (fat saturated) images and high-resolution T1 and T2 images were obtained in the same sitting when necessary. Intravenous contrast agents were administered wherever required. The contrast agent used was gadobenate dimeglumine (0.2 ml/kg). Post-contrast images were acquired using the axial, coronal, and sagittal post-contrast T1 images.

Statistical analysis

The collected data were analyzed with IBM Statistical Package for the Social Sciences for Windows version 22. Descriptive statistics such as mean and standard deviation were calculated for quantitative variables, frequency, and proportion for categorical variables. For normally distributed quantitative parameters, the mean values were compared between the study groups using paired sample *t*-test. The categorical parameters were tested with Chi-square test between two groups. $P < 0.05$ was considered statistically significant.

RESULTS

Out of the 75 patients studied, 49 were male patients. Males were most affected in the 6th decade (13/49 – 26.5%) and females in the 4th decade (8/26 – 30.7%). Males were more often affected by atherosclerosis (33/38 – 86.8%) and infective pathologies (4/4 – 100%) while infective pathologies showed a female preponderance (3/4 – 75%).

Age-wise distribution of the pathologies is shown in [Table 1]. Infective pathologies most commonly seen in the 8th decade (3/4 – 75%), atherothrombosis in the 7th decade (13/38 – 34.2%), aneurysms in the 6th decade (4/9 – 44.4%), inflammatory pathologies in the 5th decade (2/4 – 50%), and dissection (2/3 – 66.7%) and tumors (6/15 – 40%) in the 4th decade.

The distribution of the various pathologies affecting the intracranial large arteries is depicted in [Table 2]. Among the atherothrombosis affecting the large intracranial arteries, ICA (24/38 – 63.2%) was the most common affected artery followed by VA (8/38 – 21.1%). Among the aneurysms, BA (5/8 – 62.5%) was the most commonly affected artery followed by the ICA (2/8 – 25%); thrombosed aneurysms were more common (5/8 – 62.5%) than non-thrombosed aneurysms (3/8 – 37.5%) and these thrombosed aneurysms were also more common in the BA (3/5 – 60%); saccular aneurysm was more common (6/8 – 75%) than the fusiform type (2/8 – 25%). Among the dissections, VA (2/3 – 66.7%) was the most common affected artery followed by ICA (1/3 – 33.3%). Infection/inflammation (8/8 – 100%) and tumors (15/15 – 100%) involved only the ICA.

Among the different pathologies affecting the vertebral artery, atherothrombosis was the most common pathology (8/13 – 61%) followed by dissection (2/13 – 15.4%) and aneurysms (2/13 – 15.4%); in the BA, it was atherothrombosis (6/12 – 50%) followed by aneurysms (5/12 – 42%); in the internal carotid artery, it was atherothrombosis (24/50 – 48%) followed by tumors (15/50 – 30%). The cavernous segment was the most common segment affected in the internal carotid artery.

Among the tumors affecting the large intracranial arteries, pituitary macroadenoma (9/15 – 50%) was the most common tumor followed by meningioma (2/15 – 13.3%). Malignant otitis externa (3/4 – 75%) was the most common infective etiology affecting the large intracranial arteries followed by skull base osteomyelitis (1/4 – 25%). Two cases of secondary vasculitis, one case of moyamoya disease and one case of Tolosa-Hunt syndrome constituted the four inflammatory pathologies affecting the large intracranial arteries. Reversible cerebral vasoconstriction syndrome constituted the two vasospasm-related pathologies.

We found acute infarcts to be the most common brain parenchymal abnormality associated with intracranial arterial pathologies (36/43 – 84%) followed by chronic infarcts (5/43 – 11.6%). Examples of the MRI findings in these patients are shown in [Figures 1-3].

DISCUSSION

The present study evaluated various pathologies of the large intracranial arteries in patients referred for MRI brain with clinical features of stroke or imaging findings of tumors/infection/inflammation/vasospasm involving the large intracranial arteries on initial MRI investigation.

The male preponderance (1.8:1) was mainly due to increased incidence of atherothrombosis among the males. Males were most affected in the 6th decade (26.5 %) and female patients were most affected in the 4th decade (30.7 %). This was also mainly due to the high prevalence of the atherothrombosis (which commonly affected the older age groups) among

Table 1: Age-wise distribution of pathologies.

Age * Pathology cross-tabulation										
Age	Pathology							Total	χ^2 value	*P*-value
	Atherothrombosis	Infection	Inflammation	Tumor	Aneurysms	Dissection	Others			
0–10	0	0	1	0	0	0	0	1		
21–30	1	0	0	1	0	0	1	3		
31–40	0	0	0	6	2	2	0	10		
41–50	5	0	2	4	2	0	1	14	79.723	0.000
51–60	10	0	1	2	4	1	0	18		
61–70	13	1	0	1	0	0	0	15		
71–80	9	3	0	1	1	0	0	14		
Total	38	4	4	15	9	3	2	75		

Table 2: Pathologies affecting each artery.

Pathology	Artery			Total
	Vertebral	Basilar	Internal carotid	
Atherothrombosis	8	6	24	38
Infection	-	-	4	4
Inflammation	-	-	4	4
Tumor	-	-	15	15
Aneurysms	2	5	2	9
Dissection	2	-	1	3
Others	1	1	-	2
Total	13	12	50	75

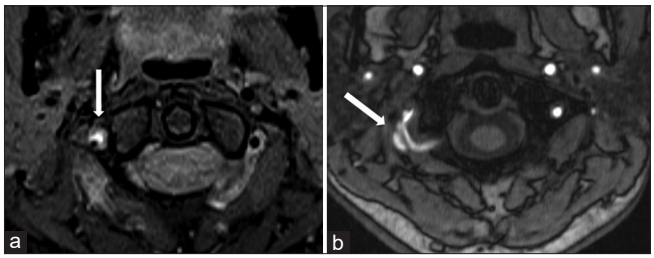

Figure 1: Right vertebral artery dissection. MRI of a 50-year-old hypertensive male with the complaints of acute giddiness and slurring of speech shows crescent-shaped hyperintense hematoma on axial T1fs image around the anterior aspect of the narrowed right vertebral artery (arrow in a) and a thick dissection flap on axial 3D TOF image (arrow in b).

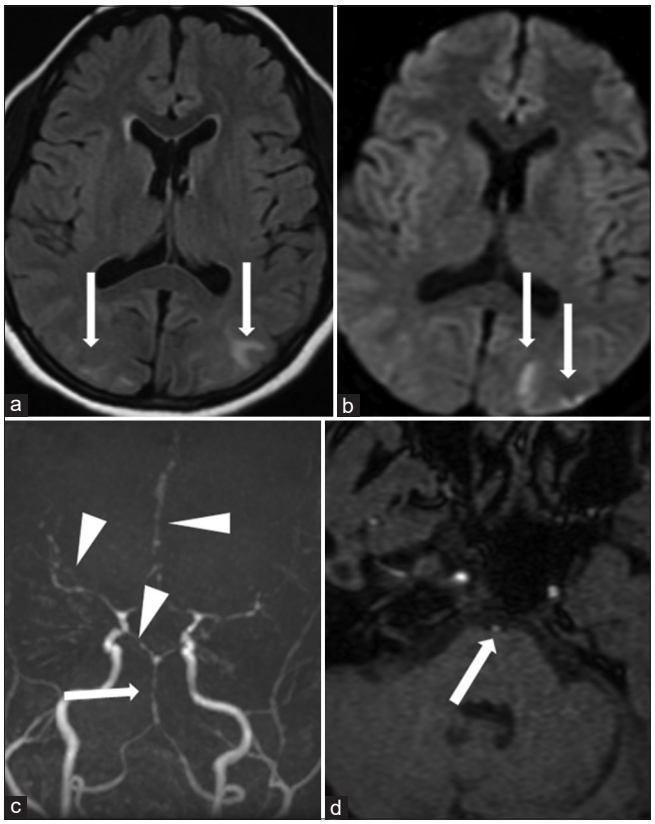

Figure 2: Reversible cerebral vasoconstriction syndrome. MRI brain of a 21-year-old female with the complaints of acute headache and blurred vision shows patchy areas of T2 fluid-attenuated inversion (FLAIR) hyperintensity in the bilateral occipital lobes (arrows in a), with few of them showing diffusion restriction (arrows in b); 3D TOF images shows diffuse thinning and beading of the basilar artery (arrow in c and d), and all the cerebral arteries (arrowheads in c). The patient was treated with antiepileptic and steroids and showed improvement.

males (86.8%) than females (13.2%). This finding correlates with the findings of the study done by Wityk *et al.*[7] about the influence of race, sex, risk factors on atherosclerotic lesions using transcranial Doppler, duplex ultrasound, and MRA. They found that men were more likely to have intracranial atherosclerotic pathologies than women. We also noted that infective pathologies of these arteries commonly affect the males (100%) but inflammatory pathologies commonly affect the females (75%). Other pathologies of these arteries in our study had no significant gender differences in incidence.

Our study correlates with that of Kumar *et al.*,[8] wherein the malignant otitis externa (which was the most common infective etiology in our study) showed male predominance with male-to-female ratio of 8:1.

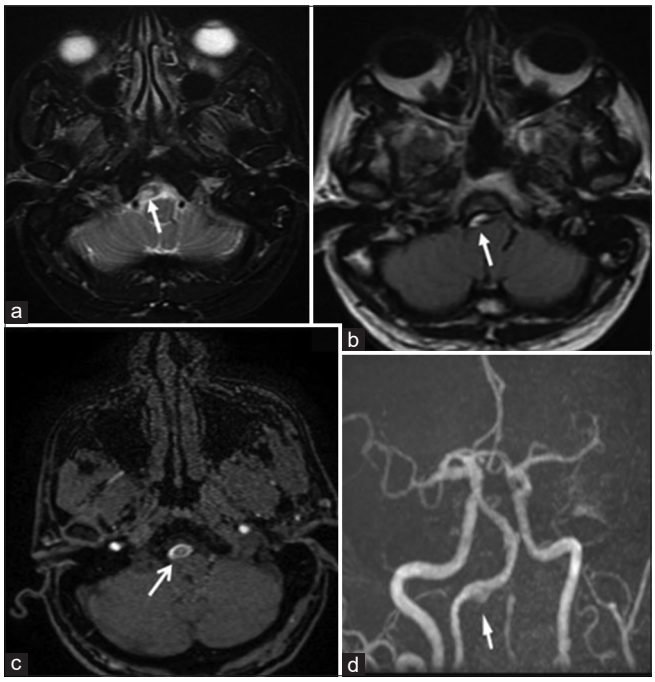

Figure 3: Partially thrombosed fusiform aneurysm. A 55 year old male presented with acute headache shows loss of flow void with mild fusiform dilatation (arrow) of the V4 segment of right vertebral artery on T2/T2 FLAIR images (a and b). Time of Flight (TOF) images (c and d) show peripheral partial flow with fusiform dilatation (arrow) of the V4 segment of the right vertebral artery.

The age of the subjects in our study ranged between 10 and 80 years, with a mean age of 54.9 years (most commonly in the 5th decade). Among the different pathologies affecting the large intracranial arteries, infective pathologies (most commonly in the 8th decade), atherothrombosis (most commonly in the 7th decade), and aneurysms (most commonly in the 6th decade) were commonly seen in an older age group, whereas inflammatory pathologies (most commonly in the 5th decade), dissection (most commonly in the 4th decade), and tumors (most commonly in the 4th decade) were commonly seen in the middle age. Our study correlates with the study done by Borhani-Haghighi *et al*.[9] wherein the mean age was 66.7 ± 10.3 years in stroke patients with large artery disease. It also correlates with the study done by Kumar *et al*.,[8] wherein malignant otitis externa (most common infective etiology in our study) showed the maximum incidence in old age. Likewise similar to our study, mean age of patients with intracranial arterial dissection was 40 years in the study done by Debette *et al*.[10]

It was noted that atherothrombosis was the most common pathology involving the major intracranial arteries (vertebral, basilar, and internal carotid artery) in 50.7% of our subjects followed by tumors involving 20% of subjects. It was also found out that atherothrombosis was the single most common pathology in cases of pathologies affecting each individual arteries. Our study correlates with that of Bos *et al*.[11] wherein they have quantified the volume of intracranial atherosclerosis using non-enhanced computed tomography and found that intracranial atherosclerosis is highly prevalent and occurs in over 80% of older persons.

We observed that among the atherothrombosis affecting the large intracranial arteries, ICA (63.2%) was the most common affected artery; among aneurysms, BA (62.5%) was the most commonly affected artery and VA (66.7%) was the commonest affected artery in cases of dissections. Our study correlates with the study done by Borhani-Haghighi *et al*.[9] wherein among the large intracranial arteries, atherothrombosis was most commonly seen in ICA (27.8 %) followed by BA (4.1 %). Our study also correlates with the study by Kanoto *et al*.[12] wherein occurrence of dissection was predominantly located in the VA. However, in case of aneurysms, BA preponderance did not correlate with many other studies like that of Imaizumi *et al*.,[13] in which the researchers found that aneurysms were most commonly seen in the ICA than in BA. This may be due to geographical variations influencing the prevalence of aneurysms and it needs to be analyzed further with more sample volumes in the future studies in our region.

We observed that all cases related to tumors, infection, and inflammation were seen affecting the ICA. Among the tumors affecting intracranial arteries, pituitary macroadenoma constituted the commonest tumor (60%) followed by meningioma (13%).

Of the infective lesions affecting the intracranial arteries, malignant otitis externa (75%) was the most common infection followed by skull base osteomyelitis (25%). There are multiple case reports of intracranial pseudoaneurysms complicating ear infections, such as ruptured petrous carotid pseudoaneurysm complicating malignant otitis externa (Telmesani[14]) and giant petrous carotid pseudoaneurysm complicating skull base osteomyelitis (Suma *et al*.[15]). Little *et al*.[16] retrospectively studied patients diagnosed with cranial invasive fungal disease and carotid involvement and found carotid events such as occlusion, aneurysm formation, vessel rupture, and cerebral infarcts occurred in 50% of cases.

Out of the four inflammatory pathologies affecting the large intracranial arteries in our study, two were secondary to vasculitis, one was due to moyamoya disease and another was Tolosa-Hunt syndrome. The two vasospasm-related pathologies affecting the large intracranial arteries were reversible cerebral vasoconstriction syndrome. Houkin *et al*.[17] studied patients with moyamoya disease confirmed by conventional angiography with comparison to MRA and found that MRA can be an alternative to conventional angiography in typical moyamoya disease cases. Mandell

et al.[18] concluded that MRI would demonstrate arterial wall enhancement in the central nervous system vasculitis but not in reversible cerebral vasoconstriction syndrome and suggested that MRI could enable differentiation between reversible cerebral vasoconstriction syndrome and central nervous system vasculitis. Acute infarcts (84%) were the most common brain abnormality associated with the intracranial arterial pathologies followed by chronic infarcts (12%).

As most of these patients with pathologies of the large intracranial arteries are critically ill and the examination time is required to be kept short, it is not always possible to do high-resolution vessel wall MRI sequences which need full patient cooperation and longer time to acquire the images.[19] Instead, basic MRI sequences can itself give necessary information to decide on appropriate management in most of these cases, as, for example, axial T1FS sequence is sensitive enough to pick up the crescent-shaped hyperintense acute intramural hematoma in the wall of the dissected artery [Figure 1] and rule out atherothrombosis as the cause of arterial occlusion or severe stenosis.

Although CT angiography can also give valuable information regarding these vascular pathologies, it involves the use of potentially nephrotoxic iodinated contrast medium which is usually advisable to be avoided in elderly patients (who are more prone for the commonest atherothrombotic arterial pathologies), in view of their common association with comorbidities such as diabetes and hypertension affecting the kidneys. Hence, in most of such cases, non-contrast basic MRI sequences such as 3D TOF MRA and axial T1FS can give the necessary information without the use of potentially nephrotoxic iodinated contrast medium.[20]

CONCLUSION

MRI is an extremely useful modality to evaluate the pathologies of large intracranial arteries. It is useful to demonstrate the site of abnormality, dimensions of vessel involvement, cause of the disease, and thereby help in timely management. Non-contrast short, fast MRI can be adequate in most of these patients, thereby avoiding the need of high resolution long slow MRI sequences in critically ill patients and also avoiding CT angiography using potentially nephrotoxic iodinated contrast media in old patients with possibility of already compromised renal function.

Declaration of patient consent

The authors certify that they have obtained all appropriate consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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