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ORIGINAL ARTICLE

Magnetic resonance angiography in evaluation of acute intracranial steno-occlusive arterial disease

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Abstract *Objectives:* Assessment of the diagnostic usefulness of MRA in evaluation of patients with acute intra cranial steno-occlusive arterial disease.
Patients and methods: 84 patients with acute intracranial steno-occlusive arterial disease were subjected to the following brain MRI protocol: Axials DWI, T1WI, T2WI, FLAIR, T2* Gradient Echo Imaging and 3D TOF MRA.
Results: Eighty four patients (M/F = 49/35) aged between 28 and 86 years. MRA findings of arterial segments correlated with location of the ischemic lesions described by different MRI sequences including the DWI in all cases (100%). MRA of the intracranial vessels revealed 60 arterial segments with occlusions/absent flow. Occlusions were most common in MCAs (n = 45) followed by PCAs (n = 9). 31 arterial segments with stenosis were seen, and they were mainly affecting arterial territories of PCAs (n = 16). Atheromatous plaques were identified at the Lt. ICA in 3 cases and in Rt. ICA in 2 cases, absent A1 segment of Rt. ACA (n = 12), absent A1 segment of Lt. ACA (n = 2), dominant Rt. VA (n = 6), dominant Lt. VA (n = 4) and Dolichoectasia of BA (n = 4).
Conclusions: MRA provides early detailed diagnosis of occlusive intracranial arterial disease through detection of exact site of arterial affection.

1. Introduction

Steno-occlusive arterial disease is the commonest cause of ischemic stroke all over the world where the thromboembolic causes account for about 85% of stroke cases (1). A high incidence of the disease was reported in African and Asian populations (2,3). Proper and accurate assessment of arterial diseases that underlie development of stroke is essential in patient management and follow-up (4).

Previously, assessment of atherosclerotic disease within intracranial vessels was not well-appreciated clinically. This might be due to the inability to visualize intracranial vessels non invasively or due to the greater emphasis on the more easily imaged carotid arteries (5). It was reported that intracranial

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vessel diseases may precede extracranial atherosclerosis. This sequence was suggested after noticing that substantial carotid stenosis is absent in a group of patients with intracranial atherosclerosis, while nearly all those with extracranial stenosis also had concomitant intracranial stenosis. Examining extracranial arteries without assessment of intracranial arteries will diagnose the arterial atherosclerosis in its advanced stages, while examining the intra cranial arteries will diagnose the disease in its early stages enabling the clinicians to intervene earlier (6,7).

The protocols of MR imaging in stroke patients are not standard across institutions (8). Adding magnetic resonance angiography (MRA) to the imaging protocol improves both diagnosis and clinical management (9,10). The sequence, however is not routinely done in stroke imaging in all centers. MRA can track the changes in the vessel lumen with time (11). Imaging of the 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 (12). MRA can also identify other vascular lesions such as malformation, aneurysms and arterial compression (9).

Time of flight (TOF) MRA technique gives the managing physician an idea of the overall cerebral vascular channel morphology and thus has an important prognostic and prophylactic value in the patient's management (13). Moreover, MRA has a potentially important role in appropriate patient selection for intra-arterial fibrinolysis, in patient's follow-up and monitoring of therapeutic efficacy (8,14). A normal or near-normal MRA of the intra cranial arteries can effectively exclude the possibility of a high-grade arterial stenosis (15,16).

The aim of the current study was to assess the diagnostic usefulness of MRA in evaluation of patients with intra cranial steno-occlusive disease.

2. Patients and methods

2.1. Patients

Overall 112 patients with symptoms indicative of acute ischemic cerebrovascular insult were originally enrolled into this study; *Inclusion Criteria were* patients who were imaged with MRI and MRA within 2 days of symptom onset. *Exclusion criteria* were patients who did not have MRA in their MRI protocol of examination ($n = 22$) and patients with a non-diagnostic MRA due to major artifacts ($n = 6$). Image and data analyses were done for 84 patients who fulfilled the criteria of acute intracranial steno-occlusive arterial disease. This prospective study was conducted in the University Hospital between March 2012 and September 2015 after approval of institutional board of ethics and obtaining informed consent.

2.2. Methods of examinations

All patients were subjected to the following:

(1) **Full history taking and clinical examination**: History was taken from the patients or informant. Neurological clinical examination was conducted to define the cerebral artery territory affected.

(2) **Radiological and Imaging Investigations**: Brain MRI was acquired within 2 days of onset, using 1.5-Tesla Philips Superconducting Magnet System (Gyroscan ACS-NT) power track 6000 at Assiut University Hospital according to the following protocol: Axials: Diffusion Weighted Imaging (DWI), T1 Weighted Imaging (T1WI), T2 Weighted Imaging (T2WI), Fluid Attenuated Inversion Recovery technique (FLAIR), $T2^*$ Gradient Echo Imaging and Three dimensional time of flight intra cranial MRA (3D TOF MRA).

2.2.1. Axial intracranial (3D TOF MRA)

Intra cranial MRA was performed for the vertebro-basilar system including the posterior cerebral arteries, the intracranial internal carotid system, including the middle cerebral and the anterior cerebral arteries, at level of circle of Willis, with settings of TR35, TE 7.2, Flip angle 20°, images interpolated to 1.5-mm slice thickness, matrix 200×512, field of view 20, scan time 6.18 min and superior saturation band. MRA images were processed with a maximum intensity projection 3 dimensional time-of-flight technique. Review of the source images with the post processing images (maximum intensity projection, MIP) was done to overcome any overestimation of the degree of stenosis or any possible artifacts from MIP images.

2.2.2. Image analysis

Assessment was done for the intracranial vessels: middle cerebral arteries (MCAs), anterior cerebral arteries (ACAs), intracranial internal carotid arteries (ICAs), posterior cerebral arteries (PCAs), vertebral arteries (VAs), and the basilar artery (BA). MRA findings which signify affection of intra cranial arteries were recorded as stenosis (segmental flow gap or luminal stenosis $> 50\%$), occlusion (non-visualized vessel segment with absent distal flow), atherosclerotic changes of the vessels and presence of plaques.

MRA findings were recorded and correlated with distribution of signal abnormalities seen in the MRI sequences. Arterial lesions corresponding to the location/territory of the recent infarcts on DWI were considered symptomatic.

2.3. Statistical methods

Descriptive statistical analysis was done with IBM SPSS Statistics software release 21, SPSS Inc., for windows (Microsoft). Data were collected, checked, coded and entered. Statistical methods included descriptive analysis such as mean $\pm$ standard deviation, number and percentage, frequencies, sensitivity and significant tests.

3. Results

Intracranial vessels of 84 patients with findings of acute intracranial steno-occlusive arterial disease were assessed using MRA. Forty-nine (58.3%) of patients were males and the remaining 35 (41.7%) were females, and their age ranged from 28 to 86 year with a mean age of 59.9 $\pm$ 9.7 year.

Sixty arterial segments with occlusions/absent flow within the arterial territories were detected. Occlusions were most common in Lt. MCA ($n = 26$); (absent flow at M1 segment ($n = 11$), M2 segment ($n = 8$) and M3 segment ($n = 7$), Rt.