Magnetic resonance angiography in assessment of anomalies of anterior cerebral artery in adults

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Abstract: Anomalies of anterior cerebral artery (ACA) include aplasia, hypoplasia and variations in number. Magnetic resonance angiography (MRA) is a non-invasive diagnostic technique for assessment of anomalies of cerebral arteries. The aim of the study was to determine the role of MRA in detection of variants of ACA in adults. This study is an observational retrospective study. This study included forty-nine adult cases (28 males and 21 females), mean age 48±12.9 SD with anomalies of ACA in MRA. Magnetic resonance imaging of the brain and MRA were done to all patients. Cerebral MRA and magnetic resonance images were evaluated for frequency and distribution of variants of anterior cerebral arteries, associated aneurysms and infarctions. Odds ratios (ORs) and relative risk were calculated to determine risk of occurrence of cerebral infarctions in patients with anomalies of ACA. Hypoplasia of ACA was the commonest anomaly of ACA (51% of cases). Risk of occurrence of cerebral infarctions was higher in cases with azygos variant (OR, 3.3; P=0.35) than in those with hypoplastic ACA (OR, 2; P=0.58). MRA was highly reliable in identification of different variants of ACA and concomitant vascular changes.

Key words: Anomalies, Anterior cerebral artery, Magnetic resonance angiography, Adults

Introduction

Anterior cerebral artery (ACA) is one of the main terminal branches of intracranial internal carotid artery (ICA) [1, 2]. ACA shares in the anterior circulation of circle of Willis (CW) [3, 4].

Anomalies or variants of ACA include aplasia, hypoplasia and variations in number [5, 6]. In reported studies, the commonest anomaly of ACA was aplasia or hypoplasia of A1 segment of ACA [7, 8].

Incidence of aplasia and hypoplasia of A1 segment of ACA were 6.7% and 3% respectively at magnetic resonance angiography (MRA) in adults [9, 10].

While in autopsy, hypoplasia of ACA was discovered in 10% of cases and aplasia was noted in 2% of cases [11].

Many studies stated that anomalies of ACA were related to serious clinical implications due to co-existence of aneurysms and brain infarctions with ACA variants especially with azygos ACA as a consequence of hemodynamic instability [12-15].

MRA is a crucial non-invasive imaging modality in defining anomalies of cerebral arteries and any associated intracranial aneurysms [16-18].

Aim of the study

To determine the role of MRA in detection of variants of ACA in adults.

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Materials and Methods

This study is a retrospective observational cohort study. Institutional ethical approval was not necessary due to retrospective nature of the study. The study included 49 adult human subjects with ACA anomalies on brain MRA examinations. The study was conducted during the period from February 2015 till April 2023.

Of 74 brain MRA cases, forty nine cases were with anomalies of ACA in cerebral MRA and twenty five cases were with normal brain MRA. The cases were referred from outpatient clinics to department of Radiodiagnosis in Kasr Alainy Hospital, Cairo University. All cases performed magnetic resonance imaging (MRI) of the brain and cerebral MRA on 1.5 Tesla (Achieva; Philips Medical System) using head coil.

Data acquisition

MRI brain: Axial T1WI: Time of repetition/time of echo (TR/TE): 488/15, T2WI: 3,732/100, FLAIR: TR/TE/time of inversion (TI): 6,000/120/2,000, coronal T2 and sagittal T2. Field of view 24 cm, 256×256 matrix, 6 mm slices thickness, 1.5 mm slice gap.

Three-dimension time of flight MRA (3D TOF MRA): TR/TE: 25/6.9, flip 20, 160 slices. Field of view: 160 mm, thickness 1 mm, and matrix: 512×512. Maximum intensity projection (MIP) axial images were generated.

3D TOF MRA and maximum intensity projection images were evaluated for anomalies of the ACA, associated aneurysms and ICA stenosis. Magnetic resonance brain images were reviewed for any associated brain infarctions.

All procedures followed were in accordance with the ethical standards of code of ethics of the World Medical Association (Declaration of Helsinki).

Inclusion criteria

First, adult patients with ACA anomalies detected by brain MRA. Second, patients with variations of ACA with and without accompanying brain lesions.

Exclusion criteria

First, cases without variations of ACA in brain MRA. Second, cases with anomalies of anterior communicating artery (AcomA). Third, children, post-operative cases, patients with metallic implants and aneurysmal clips.

Statistics

Odds ratios and relative risk were calculated to determine risk of occurrence of cerebral infarctions in patients with different types of ACA anomalies using Fisher's exact test. Data were expressed as number and percentage of cases. Chi square test was used to assess the association between cate-
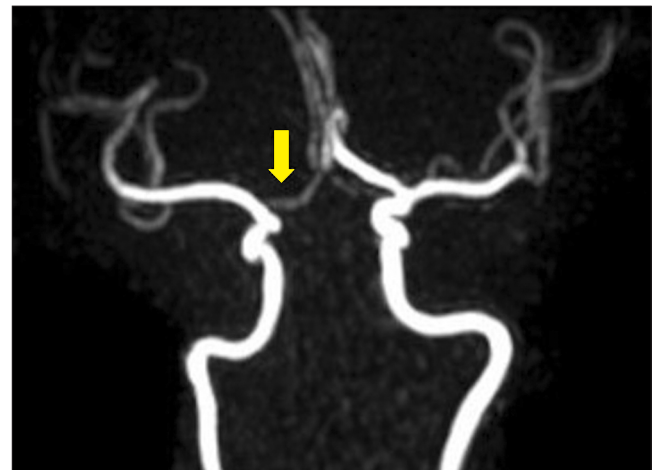

Fig. 1. Magnetic resonance angiography of both ICA and cerebral branches in a 64-year-old male patient. Hypoplastic A1 segment of right ACA (arrow). ICA, internal carotid artery; ACA, anterior cerebral artery.

Table 1. Frequency, distribution of anomalies of ACA and associated vascular abnormalities (n=49)

ACA variants	Cases	Sex (male:female)	Age	Site (right:left)	Associated aneurysms	Associated infarctions	Associated ICA stenosis
Hypoplasia (A1 segment)	25 (51.02)	15:10	47.5±11.6	23:2	-	2 cases with contralateral ACA infarctions (8)	2 (8)
Aplasia (A1 segment)	15 (30.6)	8:7	48.9±11.29	11:4	-	-	-
Azygos (A2 segment)	7 (14.28)	4:3	44±17	-	1 (14.28)	1 case with bilateral frontal infarctions (14.28)	2 (28.56)
Bihemispheric (A2 segment)	2 (4.08)	1:1	70.5±10.6	1:1	-	-	-
Total cases	49 (100.0)	28:21	48.4±12.9	35:7 and 7 azygos	1 (2)	3 (6.12)	4 (8.16)

Values are presented as number (%) or mean±SD. ACA, anterior cerebral artery; ICA, internal carotid artery.

gorical variables. A *P*-value <0.05 was considered significant. Statistical analysis was performed with Statistical Package for the Social Sciences (IBM SPSS Statistics version 29; IBM Co.).

Results

The commonest anomaly of ACA in the current study was hypoplasia of A1 precommunicating segment of ACA which was predominantly right sided (Table 1, Fig. 1).

Insignificant association between morphological variants of ACA and patients' sex was noted (Table 2).

Although insignificant association between azygos, hypoplastic ACA and cerebral infarctions was observed, but risk of occurrence of brain infarctions was higher in patients with azygos ACA than that in hypoplastic ACA (Table 3).

Multiple MRA views were mandatory to identify common trunk of bihemispheric variant of ACA (Fig. 2).

One case with saccular aneurysm was noted within distal A2 segment of azygos ACA representing 2% of total patients with ACA anomalies (Table 1).

Combined anomalies of anterior and posterior circulation of CW were noted in five cases (10.2%) with ACA anomalies which were combined aplastic/hypoplastic A1 segment of ACA and hypoplastic proximal posterior cerebral artery (PCA).

Discussion

In the current study, hypoplastic ACA was the commonest anomaly of ACA which was in discordance with Uchino et al. [19], who deduced that aplastic ACA was the commonest variation of ACA. Also, the former study had limitations in detection of bihemispheric ACA. In the present study, bihemispheric ACA was the least common variant of ACA.
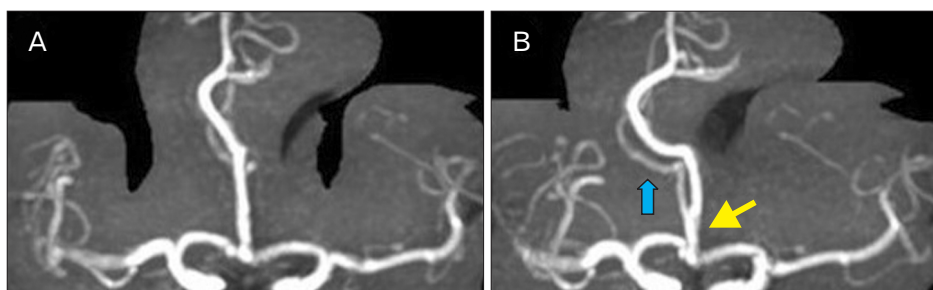
In the present study, cases with right sided hypoplastic ACA were more common than left sided cases with high male preponderance which coincided with other studies [20, 21].

Zampakis et al. [22], investigated the role of computed tomography angiography in detection of cerebral arterial anomalies and found that hypoplastic ACA was more common than aplastic ACA with incidence of 27% and 9% respectively which was in agreement with the current study.

In the present study, there was no adult cases with triple ACA. Triple ACA, is a third artery that originates from AcomA with normal A2 segments of ACA presenting a rare incidence of 1.3% in MRA and autopsy studies [9, 23].

Some researchers identified the presence of few incidental cerebral aneurysms in association with azygos ACA reaching to 11% which accorded with the current study [19, 24, 25].

Infrequent incidence of cerebral infarctions 2% was re-

Table 2. Association between morphological variants of ACA and patients' sex

ACA variants	Male	Female	Chi-square value	*P*-value
Hypoplastic ACA	15 (60)	10 (40)	1.00	0.31
Aplastic ACA	8 (53.3)	7 (46.6)	0.06	0.79
Azygos ACA	4 (57.1)	3 (42.85)	0.14	0.71
Bihemispheric ACA	1 (50)	1 (50)	0.00	1.00
Total ACA variants	28 (57.1)	21 (42.85)	0.72	0.39

Values are presented as number (%). ACA, anterior cerebral artery.

Table 3. Statistical values for brain infarctions associated with azygos ACA and hypoplastic A1 segment of ACA

ACA anomaly	Associated infarctions (present/total)	Odds ratios for brain infarctions	95% confidence interval	Relative risk	*P*-value[a]
Azygos ACA	1/7 (14.28)	3.3	0.26, 42.6	3.0	0.35
Hypoplastic ACA	2/25 (8)	2.0	0.16, 23.6	1.91	0.58

Values are presented as number (%). ACA, anterior cerebral artery. [a]Fisher's exact test was used.

Fig. 2. Magnetic resonance angiography (MRA) of both intracranial ICA in a 63-year-old male patient with bihemispheric ACA. Antro-posterior (A) and right oblique (B) views of MRA revealed hypoplastic right ACA (blue arrow) and dominant left ACA arising from a common A2 trunk (yellow arrow). ICA, internal carotid artery; ACA, anterior cerebral artery.

ported by Uchino et al. [19], in association with ACA anomalies mostly with aplastic ACA. While in the current study, a slightly higher percentage of 6% was noted for ACA variants who sustained brain infarctions.

Clinically significant pathologies including brain strokes could be associated with azygos ACA. Anomalies of ACA could predispose to bilateral infarctions as in occluded azygos ACA or unilateral cerebral infarctions due to wandering of thrombi into the hypertrophied contralateral segment of ACA in cases with aplastic and hypoplastic ACA [26-28].

ICA stenosis and atherosclerosis have been described in association with anomalies of ACA especially with hypoplastic ACA [29, 30]. While in the current study, few cases with ICA stenosis existed together with hypoplastic and azygos ACA.

In a large cross sectional MRA study analyzed by Hindenes et al. [31], combined anomalous ACA and hypoplastic or missing proximal PCA was noted in 1.1% of cases with variations in CW. While in the current study, combined anomalies of ACA and hypoplastic proximal PCA were noted in 10% of cases with ACA anomalies. Inconsistency with the previous study was due to different sample population.

Limitations of the study were relatively small sample size and rarity of the cases. Strengths of the study were the foremost capabilities of brain MRA in evaluation of ACA variants by providing images of high definition and improved tissue contrast.

In conclusion, MRA was highly reliable in identification of different anomalies of ACA and concomitant vascular changes.

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Author Contributions

Conceptualization: NAAM. Data acquisition: NAAM. Data analysis or interpretation: NAAM. Drafting of the manuscript: NAAM. Critical revision of the manuscript: NAAM. Approval of the final version of the manuscript: NAAM.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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