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Perfusion Deficits and Association with Clinical Outcome in Patients with Anterior Choroidal Artery Stroke

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Abstract

Background and Purpose—Anterior choroidal artery (AChA) strokes have a varied pattern of tissue injury, prognosis and clinical outcome. It is unclear whether perfusion deficit in AChA stroke is associated with the clinical outcome. This study aims to determine the frequency of perfusion abnormalities in AChA stroke and association with clinical outcome.

Methods—The study cohort was derived from ischemic stroke patients admitted to two stroke centers between July 2001 and July 2014. All patients received an acute magnetic resonance imaging (MRI) scan. Patients with ischemic stroke restricted to the AChA territory were included in the study. Lesion size was measured as the largest diameter on DWI or ADC and divided into two groups (<20 mm or ≥20 mm). Group comparisons were performed among patients with and without perfusion abnormalities and based on diffusion diameter. Favorable clinical outcome was defined as discharge to home.

Results—One hundred twenty patients were included in the study. Perfusion deficits were identified in 67% of patients. The admit National Institute of Health Stroke Scale (NIHSS) was higher in patients with perfusion abnormalities ($p=0.027$). Diameter lesion size on DWI was larger among patients with a perfusion deficit median [IQR], 1.63 [1.3–2.0] as compared to those without 1.18 [1.0–1.7], $p<0.0001$. Patients with a perfusion deficit were less likely to be discharged to home than those without (36% vs. 60%, $p=0.013$).

Conclusions—Two thirds of patients with an AChA stroke have a perfusion deficit on MRI, higher admit NIHSS, and larger DWI lesion size at presentation.

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Keywords

Stroke; Magnetic Resonance Imaging; Tissue Plasminogen Activator

Introduction

The AChA typically arises from the posterior wall of the internal carotid artery distal to the origin of the posterior communicating artery and proximal to the intracranial carotid bifurcation¹. AChA has perforating branches that supply several anatomic regions including the internal capsule, posterior part of putamen, medial part of globus pallidum, posterior corona radiata, optic radiations, optic tract, crus cerebri and medial temporal lobe². The pattern of tissue injury and clinical syndromes of AChA strokes vary widely³.

The most common clinical presentation is motor hemiparesis and lacunar-type sensorimotor syndrome⁴. Higher cortical symptoms can result from AChA lesion. Ischemic strokes of the right AChA territory may cause contralateral spatial hemineglect and constructional apraxia; those on the dominant hemisphere may result in a speech and language disorder. Bilateral AChA stroke may cause pseudobulbar mutism, bilateral facial weakness and changes in affect^{5–8}. Bilateral involvement of the lateral geniculate bodies may cause distinctive visual field abnormality resembling hourglass-shaped defects⁹.

The outcome after AChA stroke has been associated with severity of the stroke at presentation including higher admission (NIHSS), infarct size, infarcts involving cortical regions, superficial versus deep territories, bilateral lesions, and fiber disruption as determined by fractional anisotropy^{10–11}. To date, there is limited data on the prevalence of perfusion abnormalities in patients with AChA strokes and whether these abnormalities are associated with worse clinical outcome^{10–14}. The primary goal of this study was to determine the frequency of perfusion abnormalities in patients with AChA stroke and the association with clinical outcome.

Methods

The study population was derived from a cohort of ischemic stroke patients admitted to one of two stroke centers (MedStar Washington Hospital Center, Washington, DC; Suburban Hospital, Bethesda, MD) between July 2001 and July 2014. MR imaging was performed using 1.5T (Twinspeed, General Electric), 3T (Skyra, Siemens) or 3T (Achieva, Philips) clinical scanners. All patients received MRI studies prior to any acute intervention including intravenous (IV) thrombolysis. The MRI studies were used for treatment decision making. The acute MRI studies included diffusion weighted imaging (DWI), apparent diffusion coefficient (ADC) and perfusion weighted imaging (PWI) including scanner produced Mean Transit Time (MTT) or Time To Peak (TTP) maps MRI studies (Figure 1 and 2). The parameters for the PWI gradient-echo planar series included 20 contiguous axial oblique slices with single-dose gadolinium contrast injection of 0.1 mmol/kg of gadolinium (gadolinium-DTPA; Magnevist; Bayer Schering Pharma) through a power injector using 25–40 phase measurements, TR/TE=1500–2200/45 ms, acquisition matrix of 64×64–128×128–256×256, 7 mm slice thickness, and 22–24 cm FOV. The mean transit time (MTT) maps

were calculated as the first moment of the time concentration curves divided by the zeroeth moment with no arterial input correction or deconvolution. The time to peak (TTP) maps were calculated as the time from gadolinium arrival to the time of maximal parenchymal concentration. The DWI and PWI series were acquired co-localized over the entire brain with a superior to inferior coverage of 14 cm. Patients with DWI or ADC changes restricted to the AChA territory and consistent with acute ischemic stroke according to previously published territory maps were included in the study². Patients were excluded if the DWI was negative for acute ischemia, not restricted to AChA territory or the MTT or TTP images were not performed or uninterpretable. An independent rater assessed the quality of the perfusion maps and performed the approximate perfusion volume measurements. The rater viewed the images using IntelViewer™ (Intelrad Medical Systems), a radiology application, and placed the two perpendicular linear diameter measurements, “A” and “B”, on the slices with the largest MTT lesion area, and then calculated the approximate volume using a “ABC/2” formula where “C” was the product of the slice thickness and the total number of slices containing the lesion¹⁵. All MRI studies were reviewed by at least two independent readers, blinded to clinical data including clinical outcome, for perfusion deficit, defined as visually confirmed reduced perfusion, determined using visual assessment. A third rater was used for tie breakers. Ischemic lesion size was measured as the largest diameter on DWI or ADC and stratified by size (<20 mm or ≥20 mm). Group comparisons were performed among patients with and without perfusion abnormalities and based on diffusion diameter. Perfusion deficit was defined as visually confirmed reduced perfusion. Onset was calculated as the time interval between last seen normal and triage. Statistical analysis for subgroup comparisons was performed with Chi-squared or Mann-Whitney tests as indicated (IBM SPSS Statistics v19). Favorable clinical outcome was defined as discharge to home. Local institutional review board approvals were obtained for use of clinical and research data.

Results

Overall, 179 patients were identified with AChA stroke. Of those, 59 patients were excluded from the study due to perfusion imaging not performed (n=53 patients) and uninterpretable PWI data (n=6 patients). One hundred twenty patients were included in the study. The mean age was 67 (± 15.3 yrs.), 57% were male, and 42% were Caucasian. The rates of stroke risk factors were hypertension (86%), hyperlipidemia (48%), diabetes (33%), prior ischemic stroke (23%) and atrial fibrillation (18%) (Table). The median [IQR] admit NIHSS was 5 [2–8] and 25% of the patients received IV tPA. The median onset time was not significantly different (p=0.89) for patients with a perfusion deficit, 331 minutes, versus those without, 300 minutes. The median length of stay at hospital was 4 days and 44% were discharged to home, 38% discharged to acute rehabilitation facility, and the remaining 16% to nursing home or other rehabilitation facility. Imaging studies revealed that 21% of patients had an ischemic lesion diameter >20 mm. Perfusion deficits were identified in 67% of patients with AChA stroke. The admit NIHSS was higher in patients with perfusion abnormalities (p=0.027). Diameter lesion size on DWI was larger among patients with a perfusion deficit median [IQR], 1.63 [1.3–2.0] as compared to those without 1.18 [1.0–1.7], p<0.0001. Patients without a perfusion deficit were significantly more likely to be treated with IV tPA,

(33% versus 17%, $p=0.048$). Patients with perfusion abnormalities tended to have a higher rate of prior ischemic stroke ($p=0.067$). Ischemic lesion size (median, IQR) was larger among patients with a perfusion deficit (1.63 cm; 1.3–2.0) as compared to those without (1.18 cm; 1.0–1.7) ($p<0.0001$). The median approximate perfusion volume was 1.25 mL [0.5–2.6]. Patients with a perfusion deficit were less likely to be discharged to home than those without (36% vs. 60%, $p=0.013$), possibly due to the increased rate of treatment with IV thrombolysis in these patients (33% versus 17%, $p=0.048$).

Discussion

The major finding of this study is that two thirds of patients with an AChA stroke have a perfusion deficit, and is associated with a clinically more severe stroke and a larger DWI lesion size on presentation. Despite the difficulty in visualizing the AChA strokes on both DWI and PWI in addition to retrospective and non-controlled study design, this study showed the significant of such perfusion deficit findings of AChA stroke on acute MRI. Authors did also look at mRS at day 90 but the available data was severely limited and was not included in the final outcome.

Few studies have evaluated independent predictors of clinical outcome in AChA stroke. Ois et al ³ reported that AChA infarcts have different prognosis than cortical ischemic strokes.

In their series, patients with large AChA infarcts (≥ 20 mm) had a higher association with an embolic source and worse clinical outcome than those with smaller AChA ischemic lesions. Palomeras et al ⁷ found that AChA infarcts involved the superficial territory were associated with poor prognosis. An analysis of AChA infarcts using diffusion tensor pyramidal tractography revealed that fiber disruption and involvement of the corticospinal tract were associated with worse outcome ¹¹. Derflinger et al ¹⁴ could not find reasonable predictors of clinical outcome in AChA stroke likely due to small sample size in their series. Neurological fluctuating course in AChA stroke is a well-known phenomenon and commonly associated with neurological deterioration^{11, 14}. Our finding suggests that patients with perfusion deficits confirmed by multiple reviewers may have an unstable ischemic core, resulting in higher rate of clinical worsening due to expanding of the initial perfusion deficit which subsequently leads to further growth of the ischemic zone. Although these findings need further confirmation, our results show clinical relevance of multimodal MRI in identification of patients with AChA stroke with perfusion deficit who are at risk of disease progression and unfavorable neurological outcome.

Conclusions

Two thirds of patients with an AChA stroke have a perfusion deficit on MRI, higher admit NIHSS, and larger DWI lesion size at presentation.

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Figure 1.
DWI and paired PWI (MTT) images showing AChA ischemic strokes with positive perfusion deficits (arrows)

Figure 2.
DWI and paired PWI (MTT) images showing AChA ischemic strokes with no associated perfusion deficits

Table**Patient Characteristics**

Characteristics	Total Population (N=120)	Perfusion Positive (N=80)	Perfusion Negative (N=40)	p-value
Age (yrs)	67 ($\pm$ 15.3)	66 ($\pm$ 15.3)	68 ($\pm$ 15.2)	0.391
Gender (Male) % (n)	57% (68)	60% (48)	50% (20)	0.299
Race (White) % (n)	42% (50)	38% (30)	50% (20)	0.211
Hypertension % (n)	86% (103)	87% (70)	90% (36)	0.635
Hyperlipidemia % (n)	48% (58)	45% (36)	55% (22)	0.303
Diabetes % (n)	33% (40)	30% (24)	38% (15)	0.38
Prior stroke % (n)	23% (28)	18% (14)	33% (13)	0.067
Atrial fibrillation % (n)	18% (22)	10% (8)	15% (6)	0.423
Admit NIHSS median [IQR25–75]	5 [2–8]	6 [3–8]	4 [2–6]	0.027
Received IV tPA % (n)	25% (30)	17% (14)	33% (13)	0.048
Discharge to home % (n)	44% (53)	36% (29)	60% (24)	0.013
MR Imaging Variables				
Perfusion Abnormality % (n)	67% (80)	100%	0% (0)	n/a
Perfusion Approximate Volume (mL) median [IQR25–75]	n/a	1.25 [0.5–2.6]	n/a	n/a
DWI Lesion size (cm) median [IQR25–75]	1.43 [1.2–1.8]	1.63 [1.3–2.0]	1.18 [1.0–1.7]	<0.0001