Arterial Lesions on CT Angiography are Not Precise Forecasters of PWI and DWI Mismatches in Acute Ischemic Stroke

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Purpose: The goal of thrombolytic therapy in acute ischemic stroke is to reperfuse brain tissue that is not irreversible damaged. However, at the present time, it is only approved when given within 4.5-hour from last known well [1-3]. Hence, fewer than 5% [4,5] of acute stroke patients receive it. Lately, some stroke researchers have suggested that instead of relying on an often ill-defined "time" clock for triage; one should use the presence of potentially salvageable tissue to decide to give thrombolytic therapy. Perfusion-weighted MRI (PWI) has been postulated to play this role [6-8]. Furthermore, some argue that the presence or absence of proximal arterial stenosis or occlusion on vascular imaging predicts the occurrence of diffusion-weighted MRI (DWI) and PWI mismatch. To evaluate the importance of PWI, we analyzed the relationship between arterial occlusion and/or stenosis on CT angiography (CTA) and DWI and PWI mismatch.

Subjects & Methods: We retrospectively studied 95 ischemic stroke patients who received intracranial CTAs, DWI and PWI within 12h of the time when they were last seen well, treated with neither intravenous nor intra-arterial recanalization intervention nor experimental therapy, had DWI lesions > 1 cm^3 and had follow-up imaging ≥ 4 days from acute stroke. Based on CTA, patients were divided into two groups: those with proximal occlusion or visually estimated stenosis ≥ 50%, in the stroke territory, and those with no such CTA finding. Proximal occlusion/stenosis included intracranial internal carotid artery (ICA), first and second segments (M1 or M2) of the middle cerebral artery (MCA), first segment (A1) of the anterior cerebral artery (ACA), basilar artery and/or forth segment (V4) of the vertebral artery. PWI data were processed using deconvolution of automatically selected arterial input functions using oscillation index regularized singular value decomposition [9]. Two parametric perfusion maps were evaluated: mean transit time (MTT) and time to the maximum value of the residue function (Tmax). Lesion volumes on DWI (subjective visible lesion), Tmax (threshold of ≥ 6 sec [10]) and MTT (subjective visible lesions) were manually delineated. Follow-up (FU) lesions were manually outlined (subjective visible lesion) on either FLAIR MRI or non-contrast CT. Spurious holes within the MTT, DWI, and FU lesions from using visually determined thresholds (Display, MNI, McGill University) were filled using an automated algorithm. All images were co-registered to the acute PWI maps (MNI Autoreg [11]). Mismatch was defined as (PWI-DWI)/DWI > 20% and PWI-DWI ≥ 10 cm^3 [12], where PWI was MTT or Tmax. Continuous variables were compared using two-tailed Wilcoxon rank-sum tests while categorical variables were compared using two-tailed Fisher's Exact test.

Results: Demographic and imaging results are shown in the Table. Figure shows right intracranial internal carotid artery on the CTA, acute DWI, acute MTT and Tmax, and 31-day Follow-up image. Despite total occlusion of the ICA, neither DWI-PWI mismatch (on either MTT or Tmax) was present, nor did infarct volume increase on FU. The sensitivity of proximal occlusion/stenosis in predicting DWI-PWI mismatch was 84% [95% confidence interval: 72-92%] for MTT, and 85% [73-93%] for Tmax. The specificity of occlusion/stenosis in predicting mismatch was 67% [48-81%] for MTT and 68% [49-82%] for Tmax.

Conclusions: Although patients with proximal occlusion or stenosis on CTA were significantly more likely to have DWI and PWI mismatch, mismatch was seen in one third of patients without occlusion or stenosis. Additionally, approximately 20% of patients with proximal occlusion or stenosis did not exhibit mismatch. PWI therefore provides complementary information not readily available on CTA, which may be critical for deciding whether to offer extended time-window thrombolytic therapy to acute stroke patients.

Table 1: Demographic and imaging analysis in patients with proximal occlusion or stenosis ≥ 50% vs. others vascular findings. Values are mean±SD or median [IQR]. *P<0.05

	Proximal Occlusion (N=63)	No Proximal Occlusion (N=32)	P-value
Age (years)	64.5±17.7	61.4±16.5	0.40
Sex (%male)	60%	72%	0.37
Admission NIHSS*	8 [4-15]	3 [2-6]	0.002
Time-to-MRI (h)	5.9±2.6	5.8±3.0	0.80
Time-to-FU (days)*	21.3±23.7	36.7±29.0	0.02
Follow-up Type (%MR)*	67%%	88%	0.047
DWI lesion (cm^3)*	14.7 [4.3–47.2]	7.4 [1.4–16.9]	0.003
FU lesion (cm^3)*	26.4 [7.7–89.9]	7.7 [2.3–18.4]	0.0002
MTT lesion (cm^3)*	86.2 [36.9–160.3]	16.3 [1.9–31.7]	<0.0001
Tmax lesion (cm^3)*	69.2 [24.9–126.7]	7.5 [0.7–19.3]	<0.0001
MTT mismatch (Prevalence)*	83% (52/63)	31% (10/32)	<0.0001
Tmax mismatch (Prevalence)*	83% (52/63)	28% (9/32)	<0.0001

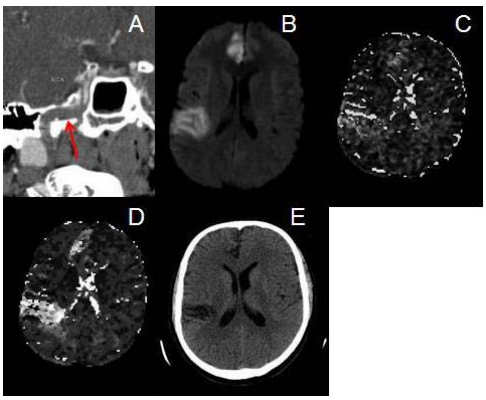

Figure: (A) Total occlusion of right intracranial ICA (arrow), (B) DWI showing acute strokes in the posterior branch of right MCA and right ACA territories, (C) Acute MTT and (D) acute Tmax matching DWI lesion. (E) Follow-up CT showing no lesion growth.

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