# Initial Experience with Upfront Arterial and Perfusion Imaging among Ischemic Stroke Patients Presenting within the 4.5-hour Time Window

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*Background:* Although perfusion imaging is being evaluated as a tool to select acute ischemic stroke patients who are most likely to benefit from reperfusion therapies beyond the standard time windows, there are limited data on the utility of perfusion imaging within the intravenous (IV) thrombolytic time window. *Methods:* A new stroke imaging protocol was initiated at Emory University Hospital including computed tomographic angiography (CTA) and computed tomographic perfusion (CTP). All patients presenting within 4.5 hours from last known normal time with suspected stroke were prospectively identified. Impact of CTA and CTP on the clinical management was recorded prospectively by stroke team members. *Results:* During the study period, 87 patients met eligibility criteria for the CTA/CTP protocol, of which 83 (95%) underwent this upfront comprehensive imaging protocol and 30 (34%) received IV thrombolytics. Overall, stroke team members reported that CTA and/or CTP aided their clinical management in 39 (47%) cases, including aiding in identification of a nonstroke diagnosis (n = 18), triage to the neurologic intensive care unit (n = 9), early triage to endovascular therapy (n = 4), and initiation of IV thrombolytic for low National Institutes of Health Stroke Scale score with large vessel occlusion (n = 3). Door to needle time ≤60 minutes was achieved in only 18% of patients receiving IV thrombolysis during the study period, but had improved to 44% in the subsequent 6-month period. *Conclusions:* An upfront CTA/CTP protocol aided stroke team decision-making in nearly half of cases. Implementation of a CTA/CTP protocol was associated with a learning curve of 6 months before door to needle time ≤60 minutes returned to similar rates as the pre-CTA/CTP protocol. **Key Words:** Acute stroke—computed tomographic perfusion—tissue plasminogen activator—revascularization.


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Received August 9, 2012; revision received November 25, 2012; accepted December 15, 2012.

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1052-3057/$ - see front matter



http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2012.12.008

Stroke is one of the leading causes of death and disability in the United States.[1] Approximately 795,000 new strokes occur each year in the United States, with ischemic stroke representing 87% of cases.[1] Stroke is also considered the leading cause of long-term disability in the United States, with estimated direct and indirect cost of $73.7 billion in 2010.[1–3]

The current mainstay for acute ischemic stroke care is based on early reperfusion of the occluded blood vessel.

The only pharmacologic treatment for acute ischemic stroke approved by the U.S. Food and Drug Administration (FDA) remains intravenous (IV) recombinant tissue plasminogen activator (rt-PA) for patients presenting within 3 hours from their time last seen normal (TLSN).[4] Benefits with IV rt-PA have been shown in patients treated out to 4.5 hours, although treatment within the 3- to 4.5-hour time window has not received FDA approval.[5]

Noncontrast computed tomography (NC-CT) is widely available for the evaluation of acute stroke patients to assess for intracerebral hemorrhage, yet despite the availability and sensitivity in detecting blood, NC-CT has limited sensitivity in detecting large artery occlusion and provides limited ability to detect the extent of salvageable tissue (penumbra) compared to irreversibly damaged areas (infarct core).[6] Although a National Institute of Health Stroke Scale (NIHSS) score ≥10 on clinical examination has been shown to predict the presence of a proximal arterial occlusion, this cutoff is associated with a poor negative predictive value and excludes the majority of acute ischemic stroke patients who present with low to moderate NIHSS scores.[7]

Computed tomographic angiography (CTA) and computed tomographic perfusion (CTP) use a contrast-bolus tracking technique that is widely available and rapidly accessible in emergency departments. CTA has been shown to identify large vessel occlusions (LVOs) with high sensitivity and specificity, and CTP has been validated as a tool to predict final infarct volume as detected by diffusion-weighted magnetic resonance imaging (MRI).[8] While CTA/CTP is commonly considered a useful tool for selecting acute ischemic stroke patients who are most likely to benefit from reperfusion therapies beyond the standard time windows, there are limited data on the utility of this multimodal imaging within the IV thrombolytic time window (≤4.5 hours). The objective of our study was to determine the utility of CTA/CTP in altering decision making of acute stroke patients presenting within 4.5-hour time window.

## Methods

### *Patients*

All patients presenting within 4.5 hours from TLSN to the Emory University Hospital emergency department with suspected stroke were retrospectively identified from July 1 to December 31, 2010. Patient identification was obtained from the acute stroke paging system list for the study period and cross-matched with patient lists from stroke team medical providers for completeness. The study methods were reviewed and approved by the Emory University Institutional Review Board. Patients provided consented before CTA/CTP based on our institutional guidelines. Whenever a patient was not able to give consent, consent was obtained from next of kin.

### *CTA/CTP Acquisition and Analysis*

A comprehensive stroke imaging protocol was initiated at Emory University Hospital on July 1, 2010 to include CTA of the head and neck and CTP of the head after NC-CT, using a General Electric 64-slice VCT Lightspeed Scanner (GE Healthcare, Waukesha, WI). Patients with point-of-care (POC) creatinine >1.7, allergy to contrast dye, current metformin use, pregnancy, intracranial hemorrhage on NC-CT scan of the head, or who declined consent were excluded from the protocol. All patients underwent the same imaging acquisition and analysis protocol. CTP was acquired in cine mode with 2 separate injections of 40 to 45 cc nonionic iodinated intravenous contrast. Two separate slabs, each with 8 contiguous 5-mm sections covering 4 cm of brain were acquired with 1-second temporal resolution carried over 45 seconds of dynamic bolus passage.

### *Clinical Data Review*

Impact of CTA and CTP on clinical management was recorded concurrently by stroke team members involved in the care of the acute stroke patient. The impact of CTA and CTP on decision making was grouped into the following categories:

- Low NIHSS with evidence of LVO on CTA influencing decision to give IV rt-PA
- Evidence of LVO on CTA and evidence of diminished cerebral blood volume in more than one-third middle cerebral artery (MCA) territory influenced decision to proceed to endovascular therapy
- Evidence of LVO on CTA with CTP evidence of diminished cerebral blood volume in more than one-third MCA territory influenced excluding patient from endovascular therapy
- Evidence of a normal CTA and CTP in a patient presenting with a hemispheric syndrome assisting in the early determination of a stroke mimic and avoiding administration of IV rt-PA (e.g., seizure, nonphysiologic)
- Evidence of a LVO on CTA with diminished cerebral blood volume in more than one-third MCA territory on CTP providing early guidance on overall care plan including decision on a do not resuscitate code status
- Evidence of suspected symptomatic high-grade atherosclerotic stenosis on CTA influencing acute medical management (e.g., dual antiplatelet therapy, blood pressure management)
- Evidence of a LVO on CTA and preserved cerebral blood volume on CTP influencing decision to admit patient for intensive monitoring (e.g., neurologic intensive care unit or step-down unit) when the patient would have otherwise been placed in a stroke unit floor bed