

Maximizing CT Perfusion Coverage for “Whole Territory” Stroke Assessment

By Michael H. Lev, MD, Director, Emergency Neuroradiology and Neurovascular Lab; Shahmir Kamalian, MD, Research Fellow, Neuroradiology; and Frederick McNulty, RT (R) (CT), Emergency Radiology CAT Scan, Massachusetts General Hospital

Introduction

GE Healthcare CT Perfusion™ 4 software offers robust automated post-processing, tissue classification (visualization of infarct core and salvageable penumbra), and reliable quantification of blood flow, blood volume, mean transit time, and contrast arrival delay or T0, over an extended 80-mm coverage when used with GE VolumeShuttle™ CT perfusion acquisition mode.

In addition to up to 24% less radiation dose, VolumeShuttle provides twice the brain coverage for a single bolus of contrast, which is both necessary for effective stroke work up, and sufficient for triage to available approved therapies and clinical trials.¹

Massachusetts General Hospital has been successfully implementing a simple yet complete stroke work up consisting of:

1. Unenhanced head CT to exclude hemorrhage or large completed infarct;
2. CT angiogram (CTA) of the head, neck, arch, and heart (optional in patients presenting with atrial fibrillation) to assess for vessel occlusion, stenosis, or left atrial/ventricular thrombus; and,
3. “Whole territory” CT perfusion using VolumeShuttle acquisition mode.

MRI is typically also obtained, when time permits, for sensitive evaluation of infarct core with diffusion-weighted imaging. CTA is performed prior to CT perfusion to identify the precise level of occlusion, which serves as a guide to accurately center the VolumeShuttle imaging coverage for the CT perfusion portion of the scan. VolumeShuttle provides 80 mm of vertical (“z-direction”) coverage, which is optimized by accurate centering, and allows for imaging of the entire anterior or posterior circulation territory, with overlap.

This coverage is sufficient for accurate clinical diagnosis and therapy, and is achieved at up to 24% less radiation dose than a 40 mm CT perfusion acquisition.

1. Schaefer PW, Barak ER, Kamalian S, Gharai LR, Schwamm L, Gonzalez RG, Lev MH. Quantitative Assessment of Core/Penumbra Mismatch in Acute Stroke. CT and MR Perfusion Imaging Are Strongly Correlated When Sufficient Brain Volume Is Imaged. *Stroke*. 2008 Nov;39 (11): 2986-92. Epub 2008 Aug 21 .

Case 1

Patient history

74-year old female with past medical history of atrial flutter presented with right-sided weakness, severe aphasia, and left gaze deviation. IV tPA was given two hours after symptoms onset, with improvement in aphasia, although CTA showed persistent occlusion of the left Middle Cerebral Artery (superior division, see arrow in Figure 1) following treatment. Based on the CTA level of occlusion, CT perfusion scan was performed throughout the entire anterior circulation territory (see scout image in Figure 2) using VolumeShuttle mode for complete 80-mm coverage.

Acquisition protocol

- Scan types performed: unenhanced CT, CT angiogram (CTA) of extracranial carotid arteries and Circle-of-Willis (COW), anterior circulation CT perfusion, MRI, follow-up unenhanced CT
- GE advanced applications used to diagnose: CT Perfusion™ 4 Multi-Organ – Brain Stroke Automatic protocol (post-processing used a pixel spatial averaging default value of 10)

Scanner	LightSpeed® VCT XT*
Scan protocol	Perfusion
Scan type/slice thickness	VolumeShuttle/16 images per 5 mm
Coverage	80 mm
Rotation time	0.4 sec
Total elapsed time	90 sec
Total X-ray exposure time	24 sec
mAs	200 (500 mA at 0.4 sec gantry rotation)
kVp	80
Recon kernel	Standard
SFOV	Head
DFOV	25

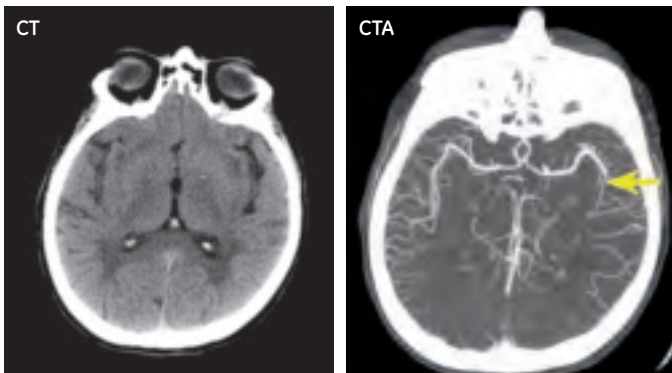
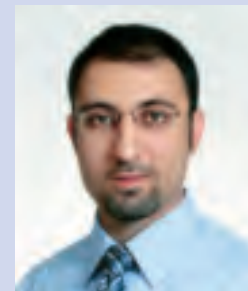


Figure 1



Michael H. Lev, MD, is a staff neuroradiologist, director of Emergency Neuroradiology, Neuro-CT, and director of the Radiology Neurovascular Laboratory at Massachusetts General Hospital, and associate professor of radiology at Harvard Medical School. He is board certified in both Internal Medicine (1989) and Radiology (1994), with a Certificate of Added Qualification in Neuroradiology (CAQ, 1996).

His major research interests are in the field of neurovascular imaging, with special emphasis on CT angiography and CT/MR perfusion imaging of acute stroke and carotid occlusive disease. He serves on the editorial board of the American Journal of Neuroradiology (<http://www.asnr.org/ajnr/>), and is a reviewer for numerous other radiology journals. He is neuroimaging project leader on the Partners HealthCare, NIH funded, Special Program of Translational Research in Acute Ischemic Stroke (SPOTRIAS) grant.



M. Shahmir Kamalian, MD, is a research fellow in the Department of Neuroradiology at Massachusetts General Hospital. He received his medical degree from Tehran University of Medical Sciences, where he also completed his internship. His experience includes nearly two years in the Emergency Department at Mehrad General Hospital (Tehran) and recently, a residency at Staten Island University Hospital.

Dr. Kamalian is a member of the RSNA, American Heart Association/American Stroke Association, Iranian American Medical Association, the International Brain Research Organization, and the Medical Council of I.R. of Iran.

*A premium LightSpeed VCT configuration.



Contrast protocol

Contrast 370 mg/ml strength
 Contrast injection rate 7 ml/sec
 Total contrast amount 45 cc
 Saline injection rate 4 ml/sec
 Total saline amount 45 cc

Findings and outcome

Admission CBV and CBF maps show a small infarct core with markedly decreased contrast delivery, and a matched admission DWI lesion. There is a moderately larger region of abnormal but less severely deranged CBF and MTT, consistent with ischemic penumbra (Figure 2). Because there was no vascular recanalization in this case, the infarct has progressed in size on the follow-up unenhanced CT scan, more closely matching in extent the admission penumbral lesion (Figure 3).

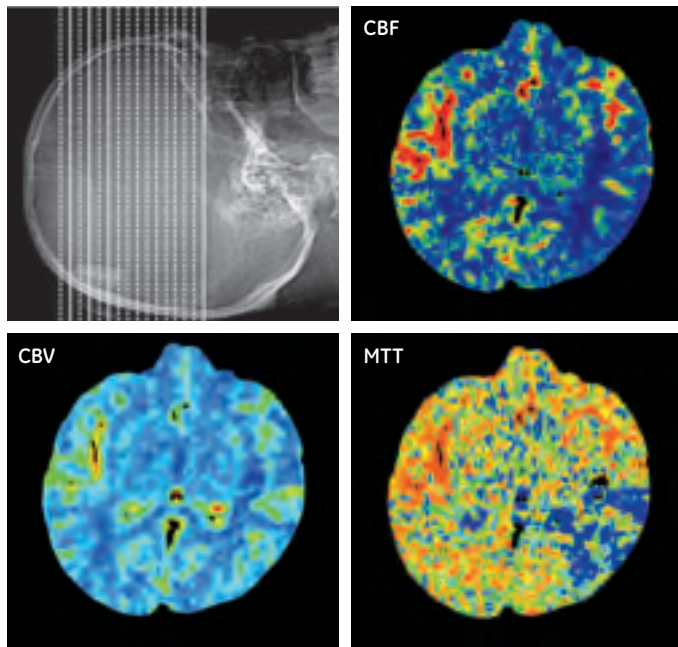


Figure 2

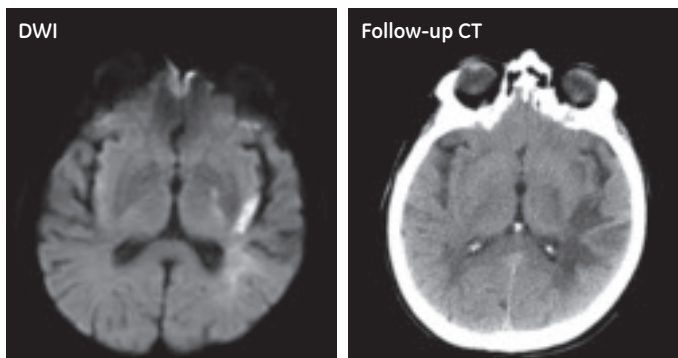


Figure 3

Case 2

Patient history

49-year old male presented with acute onset of aphasia and face/arm weakness. Admission NIHSS was 10. CTA showed a left Middle Cerebral Artery M1 occlusion (arrow, Figure 4) one and one-half hours after ictus. Based on the level of occlusion seen on the CTA, CT perfusion was performed throughout the entire anterior circulation using VolumeShuttle mode LightSpeed® VCT XT* scanning for 80 mm of vertical coverage (scout image, Figure 5). MRI was performed 15 minutes later.

Acquisition protocol

- Scan types performed: unenhanced CT, CTA of extracranial carotids and COW, CT perfusion, MRI, follow-up unenhanced CT
- GE advanced applications used to diagnose: CT Perfusion™ 4 Multi-Organ – Brain Stroke Automatic protocol (post-processing used a pixel spatial averaging default value of 10)

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 Scan protocol Perfusion
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 Recon kernel Standard
 SFOV Head
 DFOV 25

Contrast protocol

Contrast 370 mg/ml strength
 Contrast injection rate 7 ml/sec
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 Total saline amount 45 cc

*A premium LightSpeed VCT configuration.

Findings and outcome

Admission CBV and CBF maps show a small deep infarct core with markedly decreased contrast delivery and a matched admission DWI lesion. There is a larger region of abnormal but less severely deranged CBF and MTT, consistent with ischemic penumbra (Figure 5).

Perfusion mismatch and proximal large vessel occlusion seen on CTA necessitated intra-arterial (IA) thrombolysis. Successful recanalization of the left M1 occlusion, with residual cutoff

at the post rolandic branch, was achieved four-and-one-half hours after stroke onset (Figure 6). The patient was discharged to a rehabilitation hospital with NIHSS of five after four days. With recanalization there was no lesion growth; final infarct size, as shown in the follow-up CT, was similar to that of the admission MR DWI lesion (Figure 7), but less than that of the admission CBF/MTT penumbral lesions. Incidental note is made of small deep post-recanalization hemorrhage on follow-up CT.

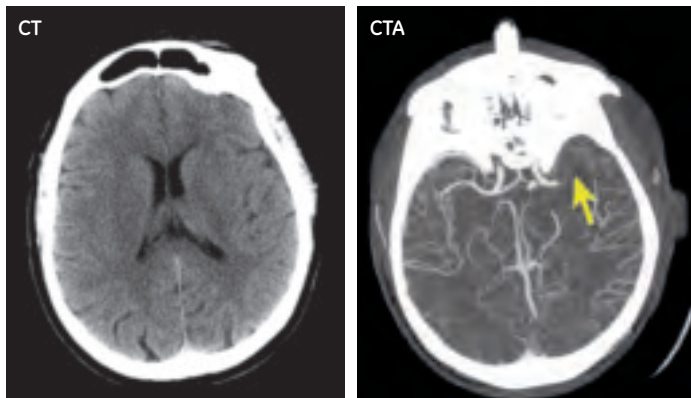


Figure 4

In addition to up to 24% less radiation dose, VolumeShuttle™ provides twice the brain coverage for a single bolus of contrast...

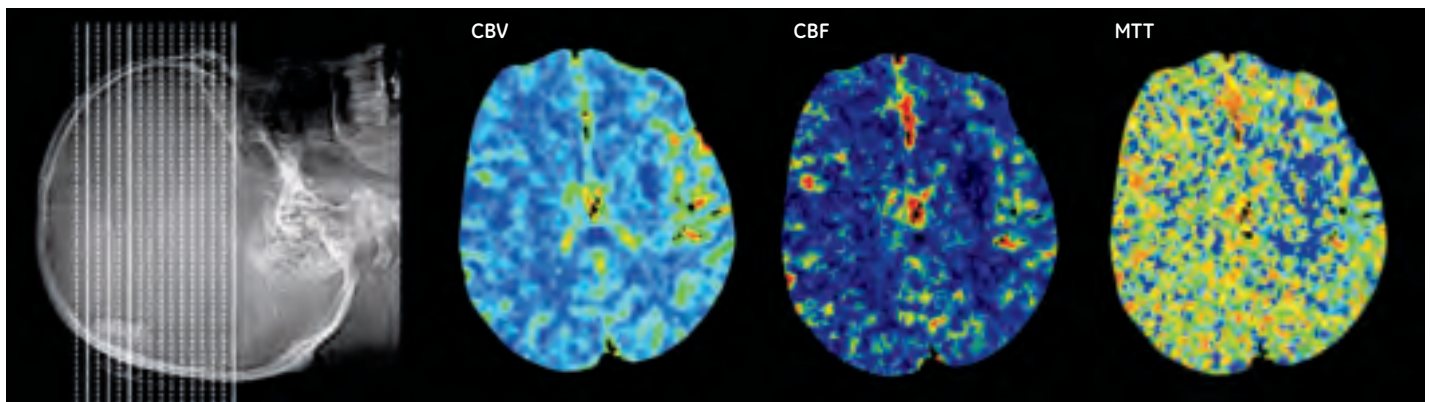


Figure 5

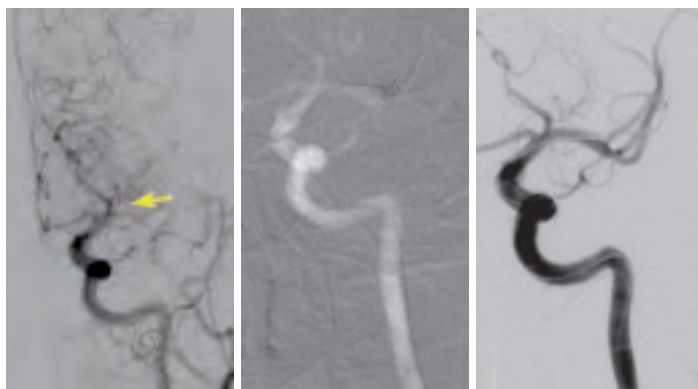


Figure 6. Angiography

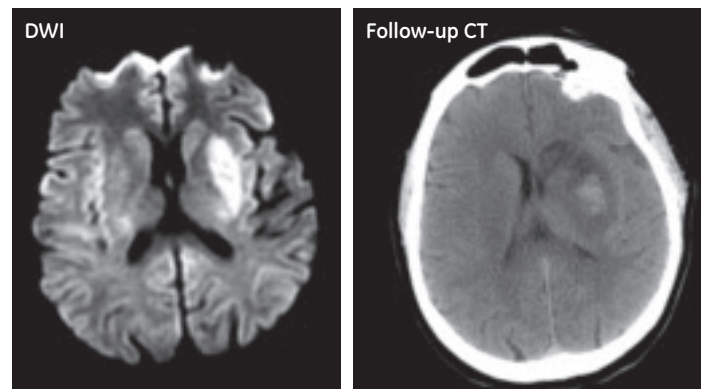


Figure 7



Case 3

Patient history

46-year old male with history of hypertension presented with sudden onset of severe vertigo, nausea, and vomiting. He was brought to the hospital 2 hours and 15 minutes after symptom onset with an NIHSS of three. CTA showed probable dissection of the dominant distal extracranial left vertebral artery (Figure 8). Unenhanced CT showed early ischemic hypodensity. Based on the CTA results, CT perfusion was performed throughout the entire posterior fossa using VolumeShuttle mode LightSpeed® VCT XT* scanning for 80 mm of vertical coverage (scout image, Figure 9).

Acquisition protocol

- Scan types performed: unenhanced CT, CTA of extracranial carotids and COW, CT perfusion, MRI, follow-up unenhanced CT
- GE advanced applications used to diagnose: CT Perfusion™ 4 Multi-Organ – Brain Stroke Automatic protocol (post-processing used a pixel spatial averaging default value of 10)

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 Scan protocol Perfusion
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 mAs200 (500 mA at 0.4 sec gantry rotation)
 kVp.....80
 Recon kernelStandard
 SFOVHead
 DFOV.....25

*A premium LightSpeed VCT configuration.

Contrast protocol

Contrast370 mg/ml strength
 Contrast injection rate 7 ml/sec
 Total contrast amount 45 cc
 Saline injection rate..... 4 ml/sec
 Total saline amount..... 45 cc

Findings and outcome

Ischemic lesions of both cerebellar hemispheres are present on the CBF, MTT and CBV maps (Figure 9), without a significant degree of mismatch. Given the low NIHSS and early ischemic signs on the unenhanced CT, thrombolytic therapy was deferred. The admission MR DWI and follow-up unenhanced CT findings matched the admission CT perfusion findings (Figure 10). ■

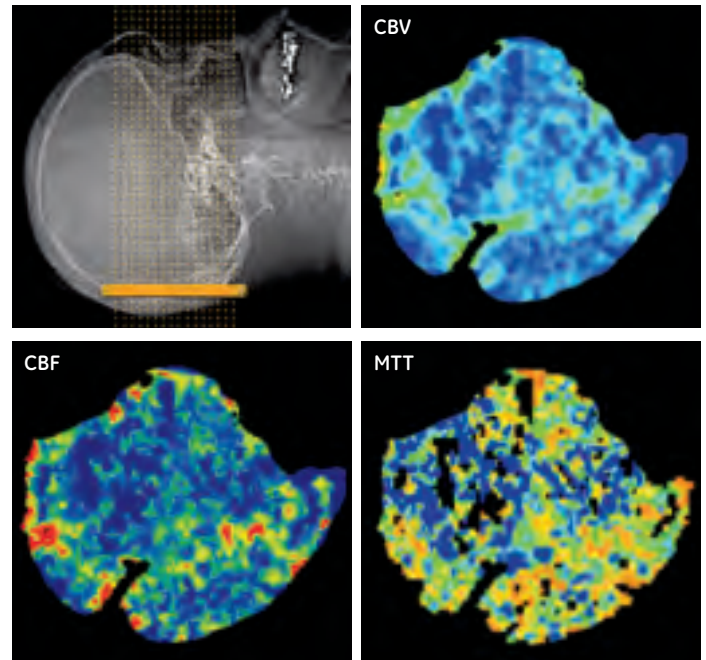


Figure 9

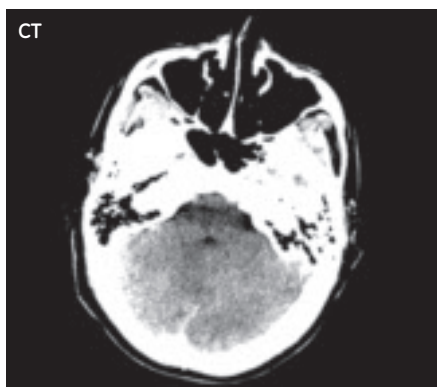


Figure 8

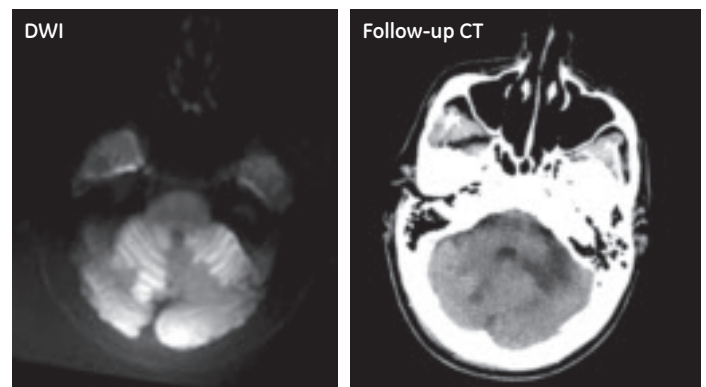


Figure 10