**TECHNICAL PITFALLS OF CT PERFUSION**

*Patient motion.*

While slight motion can be automatically corrected by software algorithms, severe motion, such as head turning, can make apparent mismatch summary maps uninterpretable by showing core and penumbra lesions in non-anatomic locations. It is important to check patient motion profile in the automated report. If the motion is degrading only part of the scan, manual subtraction of the affected images of the CTP series followed by reprocessing may eliminate the need to repeat the scan. If motion artefacts are sufficiently severe to decrease the quality of the study, the radiologist and clinician should use the resulting results with extreme caution, or not use them at all to make revascularization decisions.

*Contrast bolus*.

An adequate contrast bolus is a prerequisite for a diagnostic CTP study.Shorter scans (~40 seconds) can result in large errors of core/penumbral calculations1, 2 , whereas longer scans (~90 seconds) may result in excess radiation. A scan duration of ~70 seconds (with decreased temporal frequency towards the end of the acquisition), is ideal for evaluating core and penumbra. The early truncation error may not be readily apparent to the user, as the colored maps may look normal; the reader must view the associated VOF and AIF curves (automatically produced in the report) to ensure that this is not missed. The ideal time density curve should have an adequate baseline, a wash in and a wash out phase. Other non-technical factors that can affect contrast bolus characteristics include comorbidities of low cardiac output, atrial fibrillation, cardiac arrhythmias, aortic dissection, severe proximal ICA stenosis, and ICA dissection; interpretation should be more tentative in the setting of these comorbidities. In patients for whom a risk of early truncation is suspected based on preexisting conditions or based on suboptimal time density curves, one might consider prolonging the scan time to get a more accurate result.

*CT scanner hardware.*

An important acquisition parameter in CTP is brain coverage along the Z axis (i.e., vertical coverage from the skull base to the vertex). Appropriate coverage is dependent on scanner hardware, including the number and width of detectors. Older generation CT scanners cover tissue slabs of 4 cm or less, and this requires two separate acquisition to achieve adequate spatial coverage. Newer generation scanners can either acquire adequate brain coverage through toggling table technique3 or cover the entire brain in one rotation (with 256/320 detector scanners). An 8 cm tissue slab coverage or higher is preferred to accurately measure core and mismatch volumes in the entire anterior circulation territory4.

*Radiation*.

The radiation dosage of a CTP study requires careful consideration and monitoring, particularly as we increase our utilization of this technique. Radiologists, technologists and physicists should optimize scanner settings and continually monitor radiation doses, particularly after any change in protocol or scanner hardware. One should be cognizant that a comprehensive stroke work up including NCCT, CTA, CTP and if indicated subsequent endovascular treatment, all contribute to the total radiation exposure. While these exposures are justified by the clinical benefits of acute reperfusion therapies, protocols to minimize radiation should be optimized at every step.

*Choice of arterial input, venous input and contralateral reference tissue*

It is important to check the automated choice of arterial input function (AIF) and venous input function (VIF) as these can affect the time density curves. The A2 segment of the anterior cerebral artery and the superior sagittal sinus are most commonly vessels selected for the AIF and VOF respectively. The automated softwares usually perform well in this regard, however sometimes may need additional manual postprocessing if there are errors of partial volume averaging resulting in inaccurate vascular selection. Error may also be introduced by the choice of reference tissue for rCBF. The default approaches of different software packages are not always clear, especially if CTP softwares are “black box” regarding the various steps of post processing. Contralateral mirror region selection is prone to anatomical error or errors caused by previous infarcts/injury in the contralateral hemisphere.

**Reference**s:

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2. Copen WA, Deipolyi AR, Schaefer PW, Schwamm LH, Gonzalez RG, Wu O. Exposing hidden truncation-related errors in acute stroke perfusion imaging. *AJNR. American journal of neuroradiology*. 2015;36:638-645

3. Roberts HC, Roberts TP, Smith WS, Lee TJ, Fischbein NJ, Dillon WP. Multisection dynamic ct perfusion for acute cerebral ischemia: The "toggling-table" technique. *AJNR. American journal of neuroradiology*. 2001;22:1077-1080

4. Lin L, Bivard A, Krishnamurthy V, Levi CR, Parsons MW. Whole-brain ct perfusion to quantify acute ischemic penumbra and core. *Radiology*. 2016;279:876-887

**SUPPLEMENTAL FIGURE TITLES AND FIGURE LEGENDS:**

Figure S1: Misclassification of core and penumbra

The CTP automated maps (A and B) demonstrate misclassification error with a matched defect with ischemic core (pink) and penumbra (green) in the region of an old infarct in the baseline head CT (C). The CTA demonstrated a chronic occlusion of the left ICA. This case highlights the importance of interpreting the CTP in conjunction with the non-contrast head CT and CTA studies.

Figure S2: CTP in a subacute infarct

61 y/o male with left MCA syndrome demonstrates a subacute infarct on NCCT (A). The CTP CBF (B) defined ischemic core is 0 ml with a large penumbra (C). This example illustrates that subacute infarcts will not meet the core CBF thresholds and hence will not be seen in the CTP maps.

Figure S3. CTP in chronic carotid occlusion

42-year-old male with known right ICA carotid chronic occlusion and remote right MCA strokes presented with seizures. (A) CTP source images demonstrate remote right MCA infarct and an extensive area of acute ischemia in left MCA and part of left ACA territory. CTA neck shows a chronic occlusion in right carotid (B) and a large thrombus in left ICA (C).

The CTP automated output (D) shows large ischemic core in left hemisphere (pink) and bilateral hypoperfusion (green). Note that the software calculates the total mismatch utilizing both acute (left) and chronic (right) areas of hypoperfusion and erroneously marks it as a high mismatch ratio. Given the large matched defect in the left hemisphere, patient did not receive endovascular treatment.

Figure S4. Chronic bilateral hypoperfusion and an acute PCA occlusion

The patient presented with a NIHSS of 8, was treated with rtPA and reperfused fully to have a good clinical outcome with a 90-day mRS of 1.

Figure S5. CTP in a posterior fossa stroke

36 y/o with basilar occlusion beyond 48 hours. Patient had Deep Brain Stimulation and hence could not get an emergent MRI. CTP showed no core/mismatch. But visual images and NCCT showed pons and left cerebellum infarcted with a matched defect of CBF and Tmax. Tmax of 4 secs was abnormal but no hypoperfusion for Tmax 6 secs. No intervention performed. Follow up MRI showed infarct in pons.