
NeurologyResidents.Net

NEURO-Imaging

CTP – Perfusion & RAPID

CT Perfusion

Overview

CT Perfusion basics:

THERE ARE 3 MAPS PRODUCED BY CT PERFUSION.

- CBF:
 - o **Stands for:** Cerebral blood flow
 - o **Means:** volume of the blood moving through a given volume of the brain.
 - o **Measurement:** mL/100gm brain tissue
 - o **Normal values:** 60ml/100gm in gray matter – 25ml/100gm in white matter
 - o **Look at:** tissues that is irreversibly injured (CBF < 30).
- CBV:
 - o **Stands for:** Cerebral blood volume
 - o **Means:** volume of flowing blood through a given volume of the brain
 - o **Measurement:** ml/100gm brain tissue
 - o **Normal values:** 4ml/100gm in gray matter – 2ml/100gm in white matter
 - o **Looks at:** tissue that is irreversibly injured
- MTT:
 - o **Stands for:** Mean transit time
 - o **Means:** time it takes the blood to transit through the given volume of the brain.
 - o **Measurement:** in seconds
 - o **Normal values:** 4 seconds in gray matter – 4.8 seconds in white matter
 - o **Looks at:** decreased flow – tissue at risk

THERE ARE 4 STATES OF BLOOD FLOW AND TISSUE VULNERABILITY:

- **Normal flow:** Higher CBV and CBF in gray matter compared with white matter.
- **Core infarction:** Decreased CBV < 40% of normal, CBF < 30% of normal with increased MTT. CBV is more sensitive and specific for defining the unsalvageable core, CBF may overestimate the core infarction.
- **Penumbra:** Normal CBV, mildly decreased CBF and markedly increased MTT > 6 seconds (CBV/MTT mismatch). CBV may be increased due to cerebral autoregulation producing vasodilatation.
- **Post-ischemic hyper-perfusion:** Increased CBV, CBF with decreased MTT (all colors are inverted compared with acute ischemia, CBV, CBF are red instead of blue. This means recanalization started, can be misdiagnosed as contralateral ischemia)

N.B: Chronic infarction: Will appear exactly same as acute infarction, decreased CBV, CBF with increased or normal MTT

TECHNICAL ASPECTS:

- **AIF (arterial input function):**
 - It gives the CTP program a sample of normal flow
 - Usually use the A2 segment of ACA, as it travels perpendicular to the axial plan which makes it easily seen on multiple images.
 - Any intracranial or extracranial artery can be used instead.
- **VOF (Venous output function):**
 - It gives the CTP program a sample of venous drainage flow
 - Usually one of the dural venous sinuses is used.

ASSESSING CEREBROVASCULAR RESERVE: (CTP with acetazolamide challenge)

- In case of arterial stenosis, the brain compensates with 2 mechanisms:
 - In acute stenosis: Autoregulatory vasodilatation, to bring more blood to the post-stenotic area.
 - In chronic stenosis: building collateral circulation
- Acetazolamide causes vasodilatation, so with CTP obtained before and after acetazolamide, area of the brain with marked change in MTT (increased) represents areas at risk.

ASSESSING VASOSPASM:

- MTT will be increased in area of vasospasm
- Can be used to evaluate patients after intra-arterial vasodilatation of stenting.

SEIZURES:

- Asymmetric hyper-perfusion of the ictal area occurs during seizures.
- It may give the impression of contralateral hypoperfusion

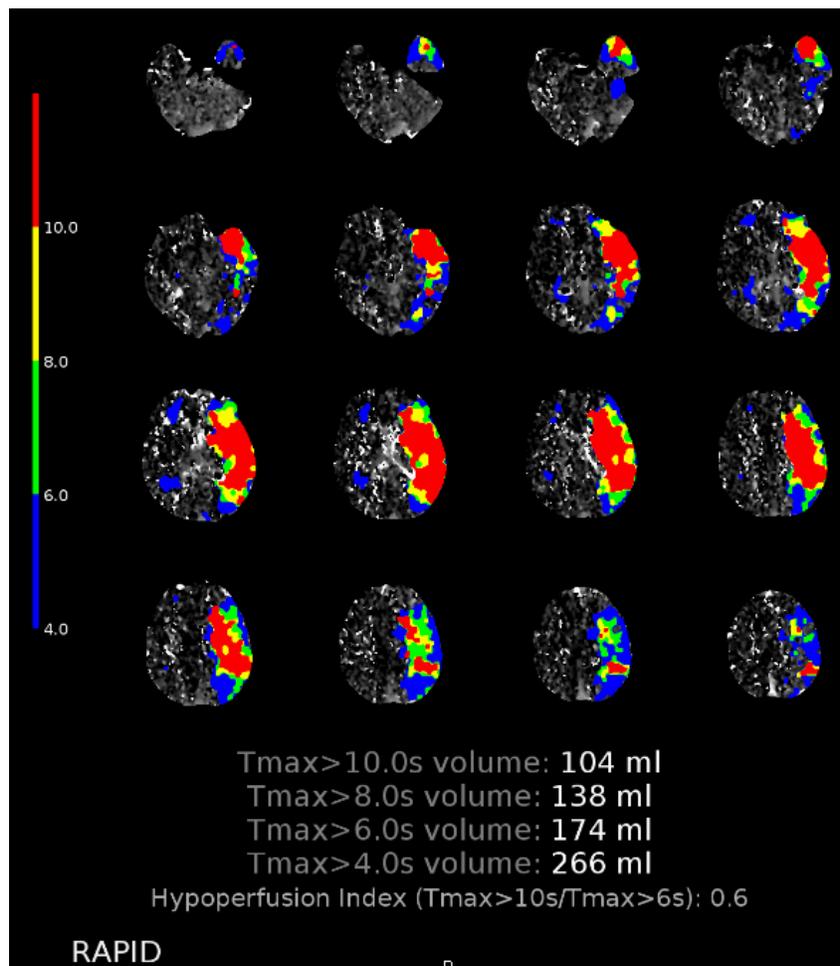
Tissue	CBV	CBF	MTT or Tmax
Core Infarction	Decreased <40%	Decreased <30%	Increased > 6s
Penumbra	Normal	Mildly decreased	Increased > 6s
Luxury hyperperfusion	Increased	Increased	Decreased

RAPID Software

Maps

Tmax map:

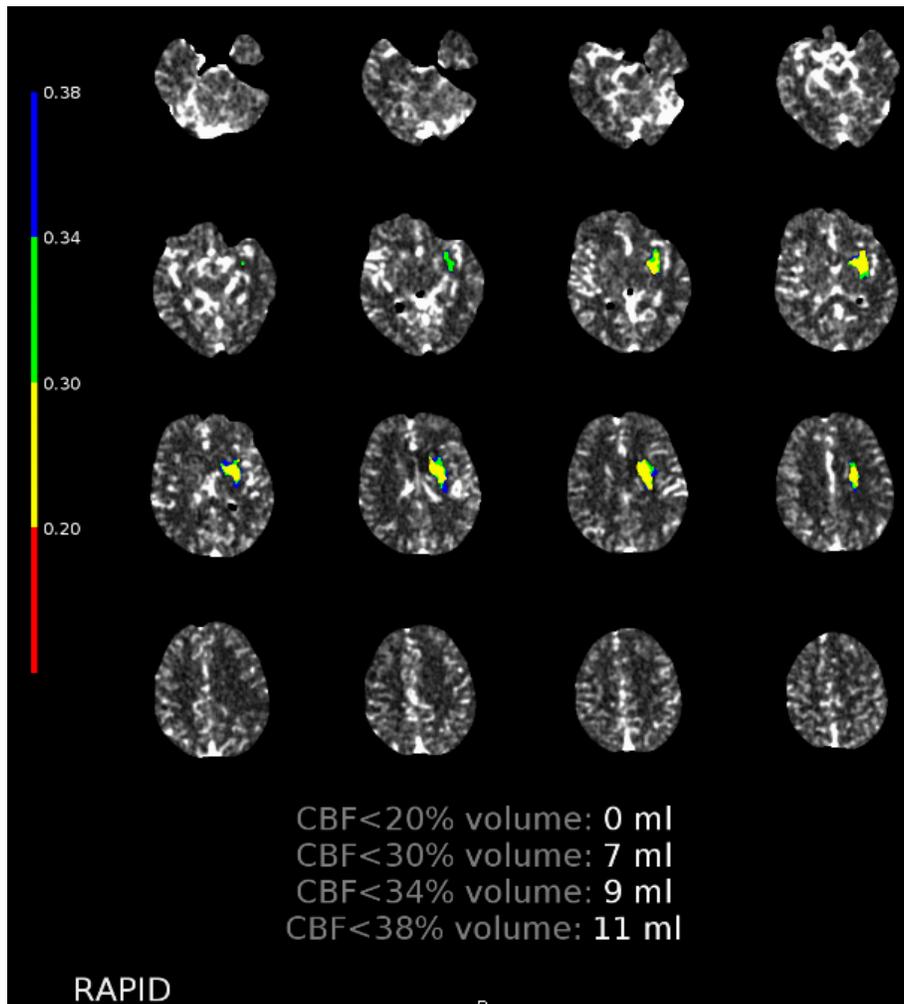
- Looks at tissue with delayed perfusion (includes both infarcted and penumbra tissue)
- Tmax > 6s is considered penumbra (likely going to be infarcted)
- Rapid multi-threshold Rapid map colors:
 - Tmax < 4s doesn't get colored
 - Tmax 4-6s: blue -> mild delay -> unlikely to infarct
 - Tmax 6-8s: green
 - Tmax 8-10s: yellow
 - Tmax >10s: red -> represents tissue with poor collateral flow -> rapidly growing infarct.



Green, yellow and red represent ischemic tissues with the red close to get irreversible injury

CBF map:

- Looks at tissues that irreversibly injured (infarcted, restricting diffusion on MRI)
- CBF < 30% is likely infarcted
- Rapid multi-threshold CBF map colors:
 - CBF < 30% volume: yellow
 - CBF 30-34% volume: green
 - CBF 34-38% volume: blue



Yellow means irreversible injury (Infarct core)

Tmax/CBF mismatch:

- It shows both CBV and Tmax maps together to determine size of penumbra.
- Penumbra equals the Tmax region (green) minus the core infarct (purple)
- Mismatch volume indicates how much tissue is still at risk (penumbra volume)

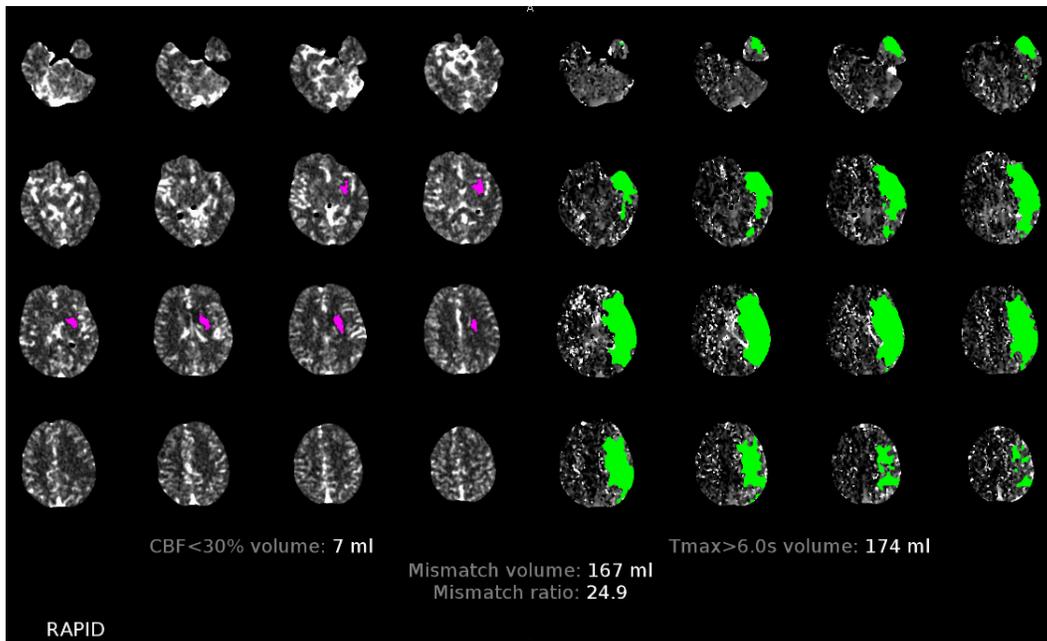
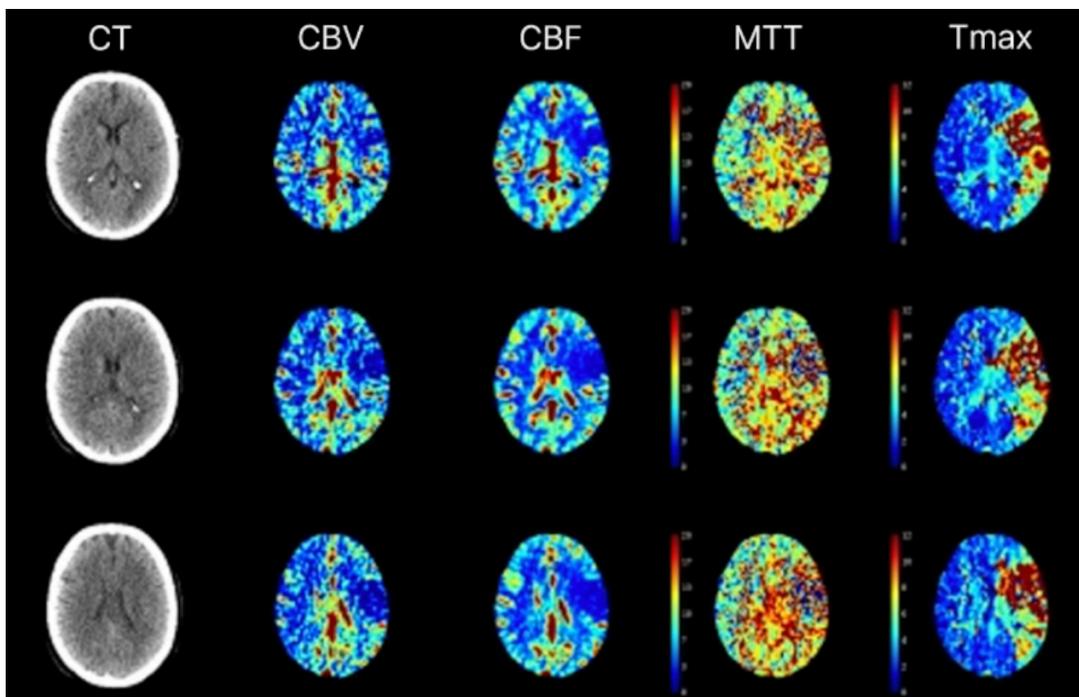


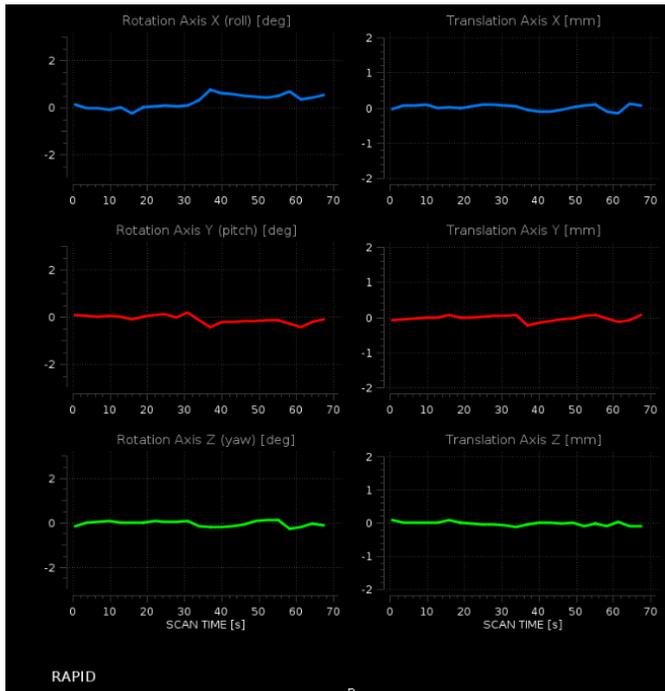
Image Columns:

- It shows all raw images close to each other for easy comparison, no threshold values are applied. Compare perfusion scans with regular CT to rule out chronic ischemic lesions.
- Note that CBV overestimates the core infarction when compared with CBF

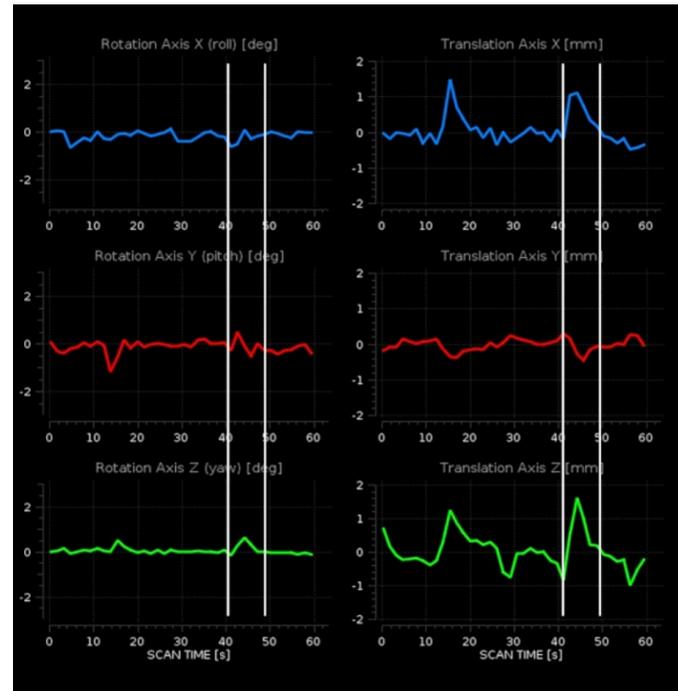


Movement map:

- To evaluate if patient had moved during the scan which may affect the results.
- It shows both rotation and translocation in X – Y and Z axis.
- If all lines are straight horizontal lines, then no marked movement was identified and CTP should be accurate.
- If there is a large spike in some of the lines, it indicates movement during the scan, results may be inaccurate.



No marked movements during the scan



Patient had moved twice during the scan.

Arterial input and venous output curves:

- It shows the rate of contrast flow in the chosen artery (red) and contrast drainage in the chosen venous sinus (blue) along with rate of contrast injection (green)
- Used to make sure the chosen artery and vein are patent with no marked stenosis. (In case of arterial stenosis, the peak will be very small or no peak with marked delay between arterial and venous phases).

