

COMPUTED TOMOGRAPHY PERFUSION

Maja Ukmar

PERFUSION CT

- **No contrast**
- **Administration of contrast media**



Vascular studies
Perfusional studies



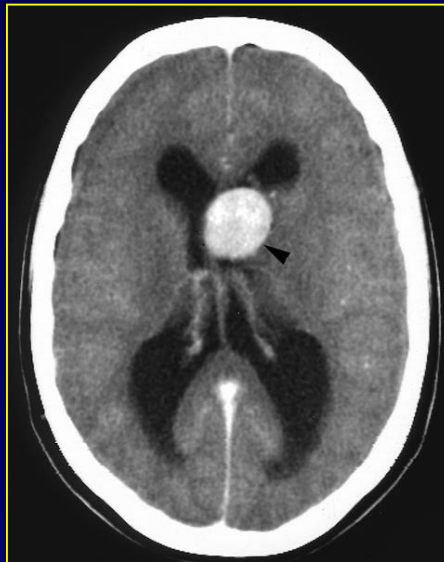
Parenchymal studies

PERFUSION CT

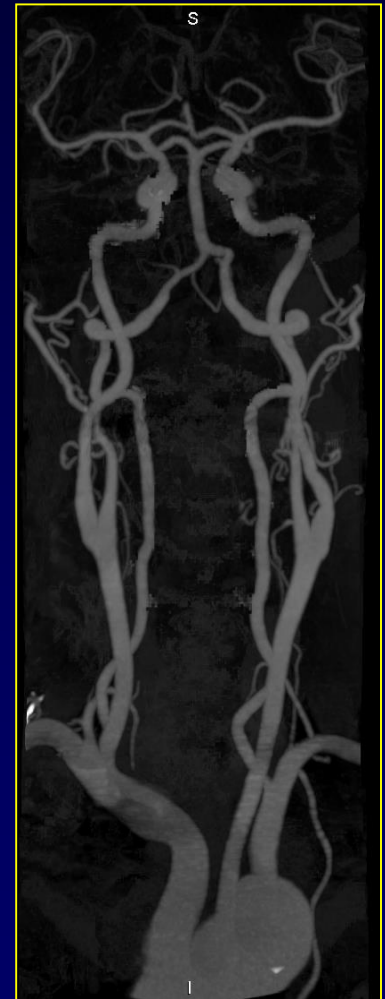
- Iodinated contrast



Parenchymal study



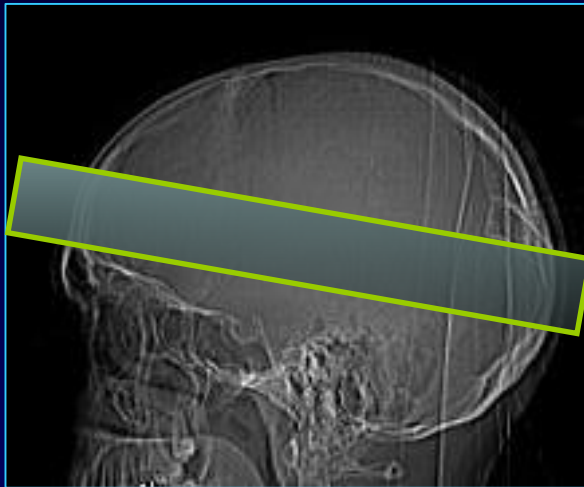
Vascular



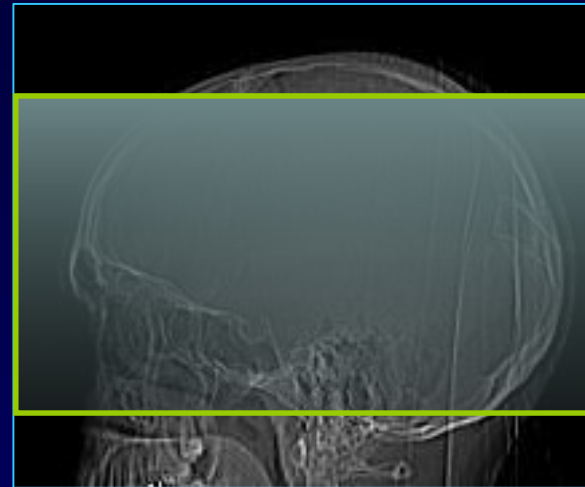
PERFUSION CT

- With perfusion we monitor the first pass of an iodinated contrast agent bolus through the cerebral vasculature
- CT perfusion allows us to follow temporal course of the iodinated contrast media by performing several dynamic scans on the same cerebral volume

PERFUSION CT



3,2 cm

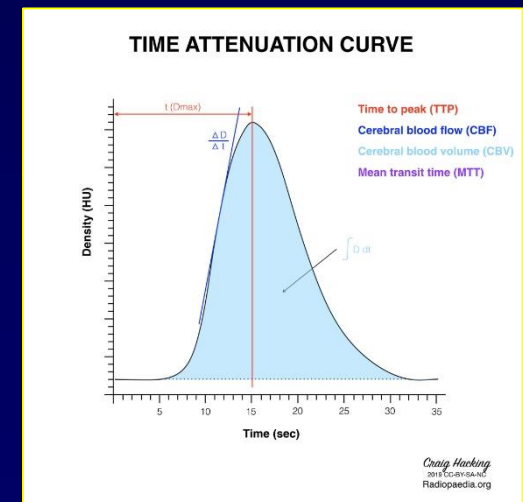
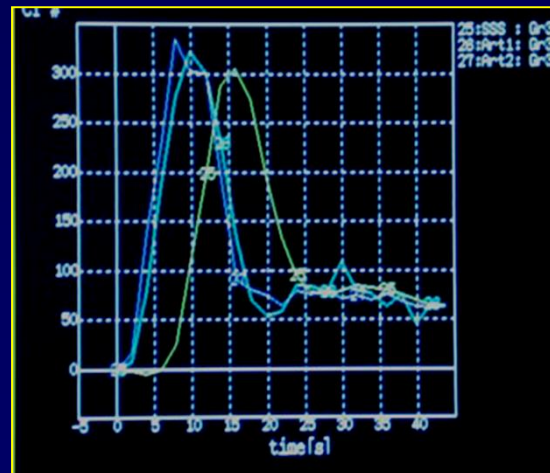


16 cm

- 50 ml of contrast, 4 ml/s, acquisition every 4s, scan duration 60 sec, 80kv, 150 mAs

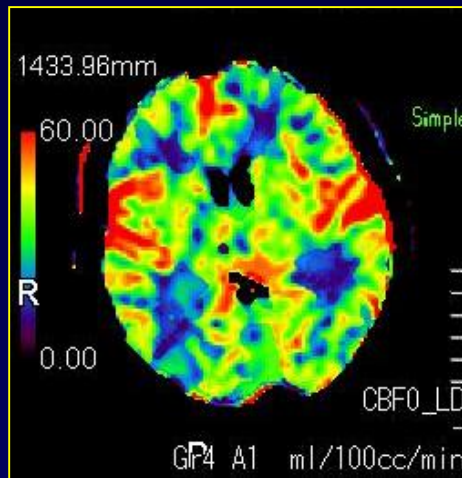
PERFUSION CT

- Arterial input function, venous output
- Reconstruction algorithm: “maximum slope algorithm”
“deconvolution algorithm”.....
- delay insensitive, delay sensitive

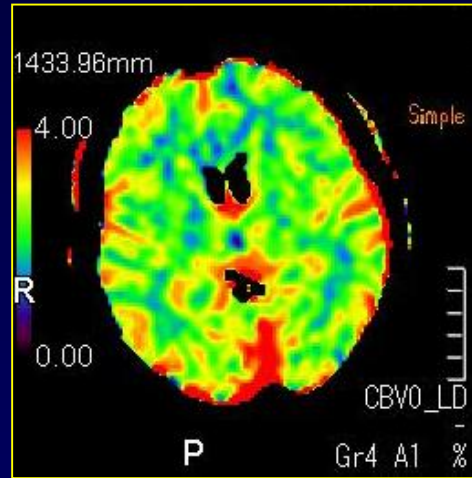


$$CBF = CBV / MTT$$

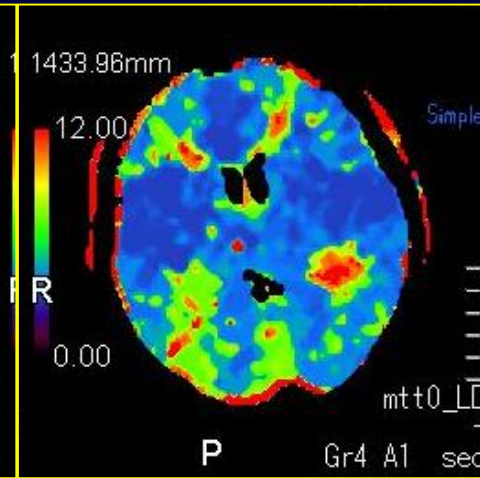
PERFUSION CT



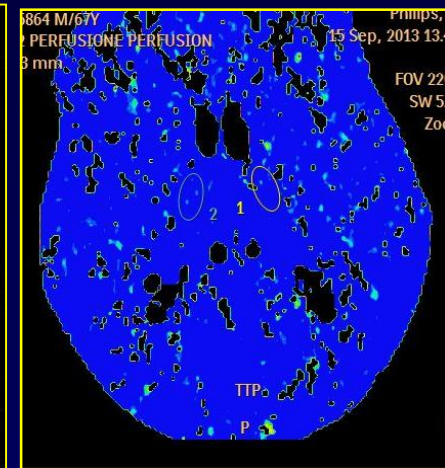
CBF- ml/100 g/min
(50 ml/100g/min)



CBV - ml/100 g (4
ml/100g)



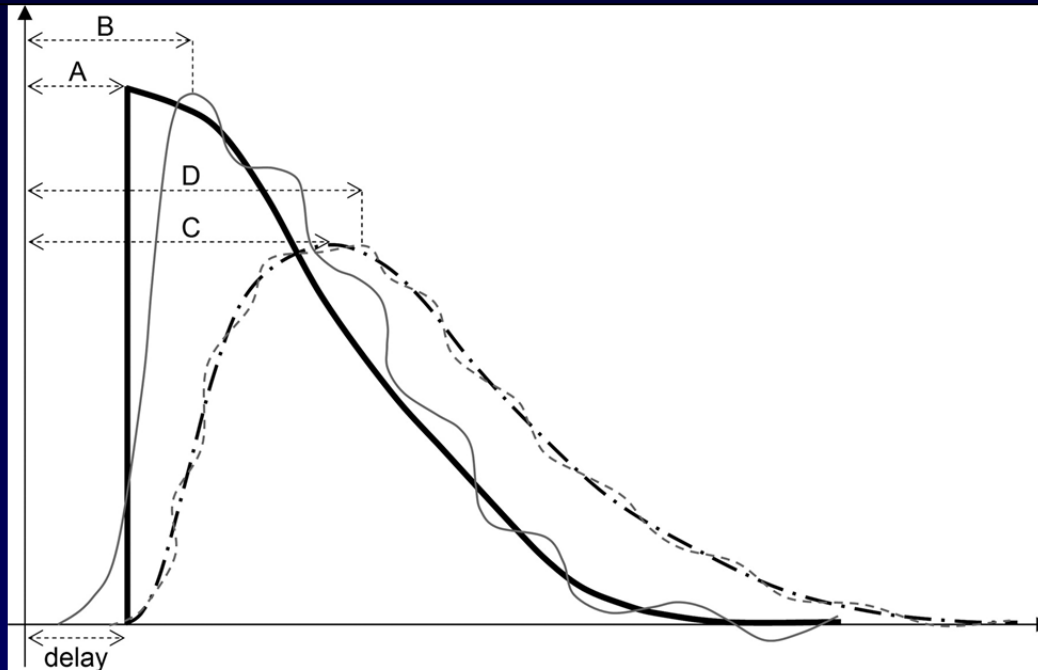
MTT- mean transit
time(5 s)



TTP- time to peak
(s)

➡ The absolute values could depend on different vascular pathology

PERFUSION CT

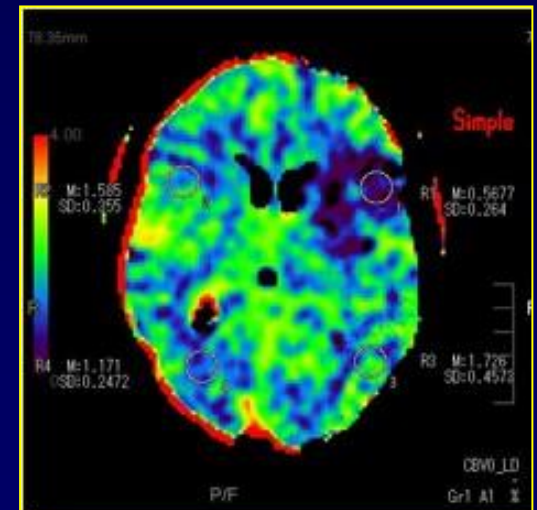
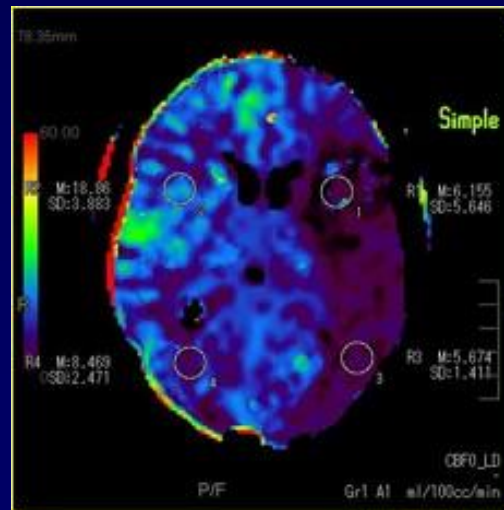
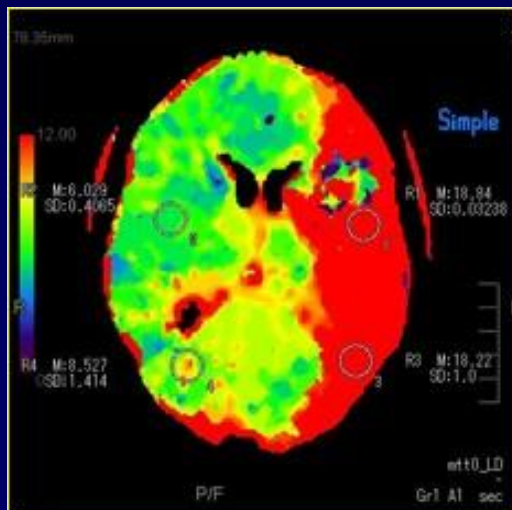


The Physiological Significance of the Time-to-Maximum (Tmax) Parameter in Perfusion MRI, Volume: 41, Issue: 6, Pages: 1169-1174, DOI: (10.1161/STROKEAHA.110.580670)

- T max (s): reflects the time delay between the contrast bolus arriving in the proximal large vessel arterial circulation (arterial input function) and the brain parenchyma

PERFUSION CT

- Quantitative evaluation
- Qualitative evaluation (comparison between healthy and affected area)



PERFUSION CT

Role of CT-perfusion

- **Acute Ischemic stroke**
- Tumor evaluation (neoangiogenesis)  MRI perfusion

IMAGING ACUTE ISCHEMIC STROKE

Computed Tomography

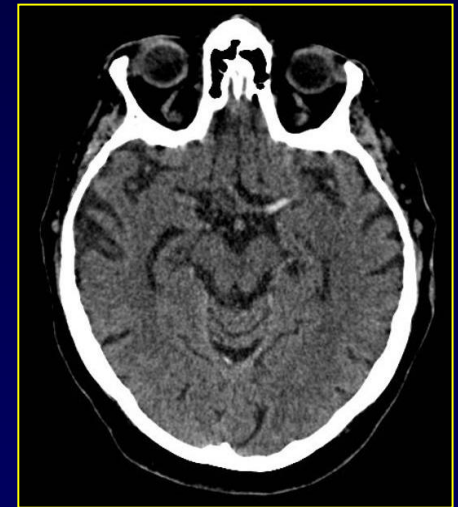
- *Identify early sign of acute stroke*



Obscuration of lentiform nucleus



Hypodense area, sulcal effacement



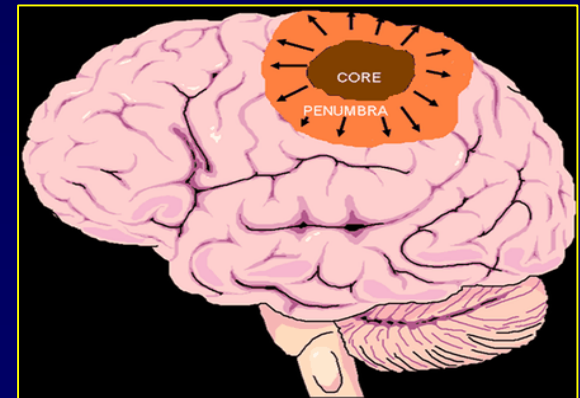
Dense MCA sign

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

- Identify ischemic lesion
- Differentiate between not perfused tissue but still viable tissue
- ($\uparrow$ MTT $\uparrow$ CBV $\downarrow$ CBF) and irreversibly damaged tissue ($\uparrow$ MTT $\downarrow$ CBV e $\downarrow$ CBF)

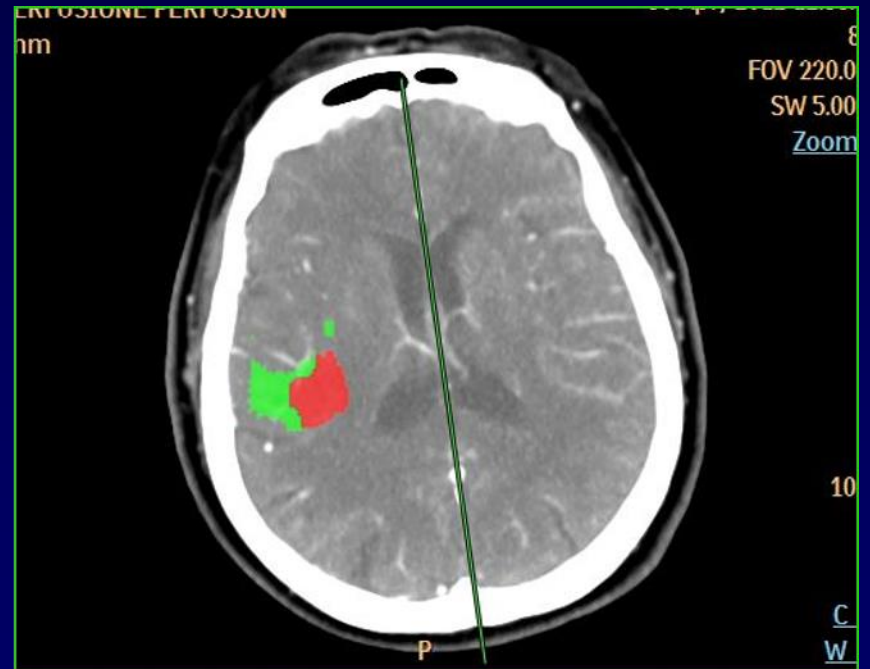
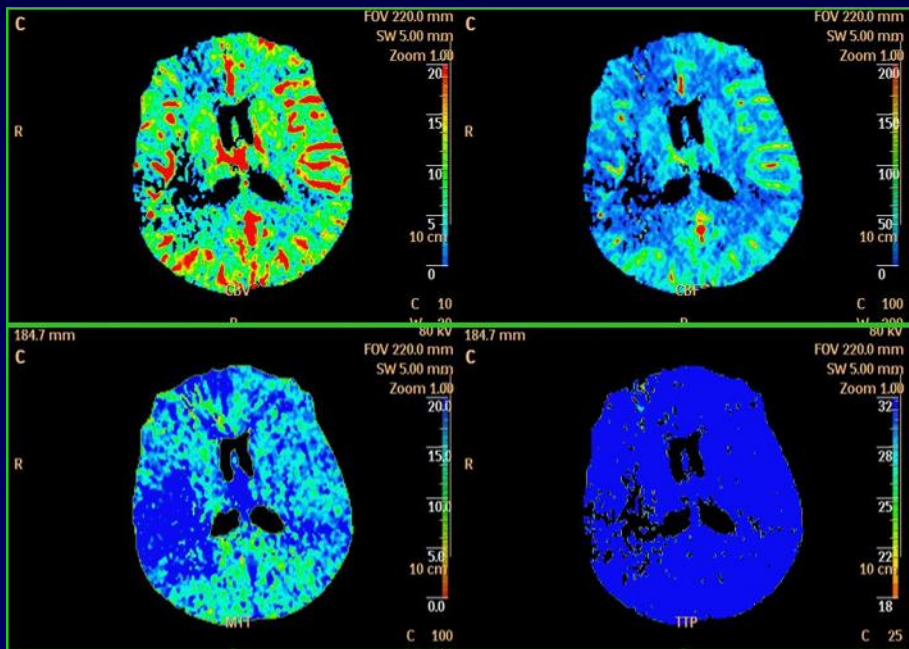
- Penumbra: mismatch between CBV/MTT or CBF, salvageable tissue with appropriate therapy
- Core: irreversible damage tissue



IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

- Automatically generate maps



IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

- *Wintermark*
 - Core: $CBV < 2 \text{ ml/100 g}$
 - Penumbra : $MTT > 145\%$, $CBV > 2\text{ml/100 g}$
- *Bivard*
 - Core: $CBF < 40\%$, $DT > 2 \text{ s}$
 - Penumbra: $CBF > 40\%$ e $DT > 2\text{s}$
- *RAPID software*
 - Core: $CBF < 30\%$
 - Penumbra: $T_{max} > 6\text{s}$

Wintermark et Al, Stroke 2006
Campbell et Al, Stroke 2011
Bivard et Al, Radiology 2013
Huang et Al, J Neuroimaging 2017

Potter et Al, Radiographics 2019
Demeestere et Al, Stroke 2020
Chen et Al, Front Neurol 2021

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Right hemiparesis



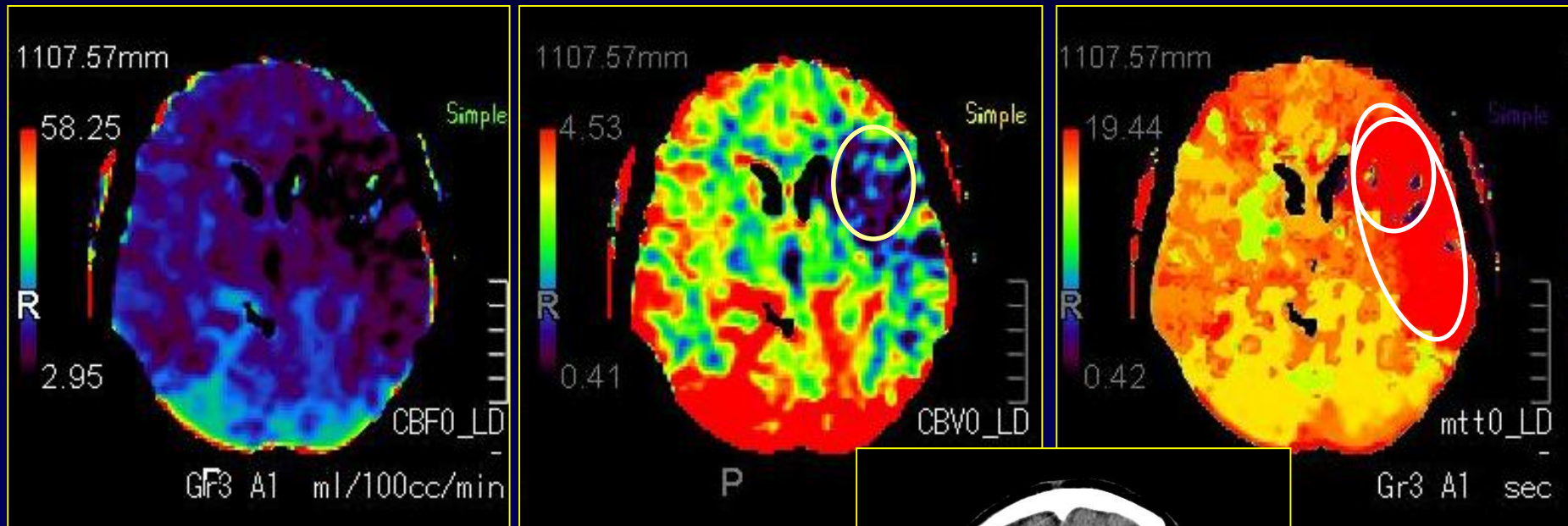
Unenhanced CT



CT perfusion

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



CBV/MTT mismatch



IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Left hemiparesis



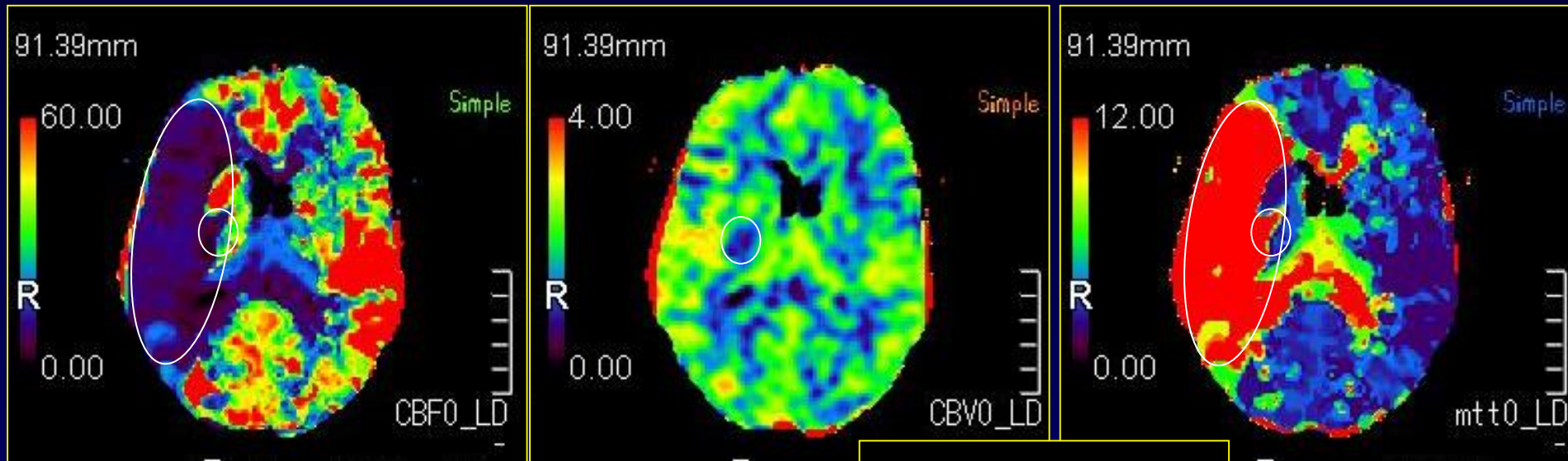
Unenhanced CT



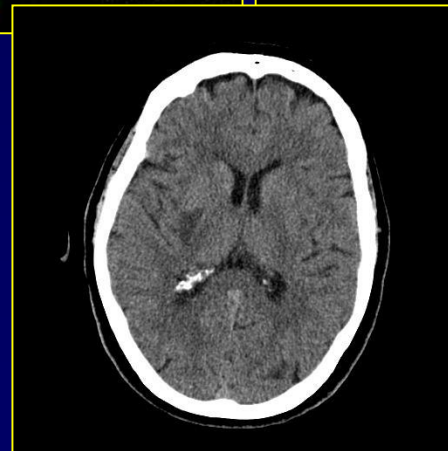
CT perfusion

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



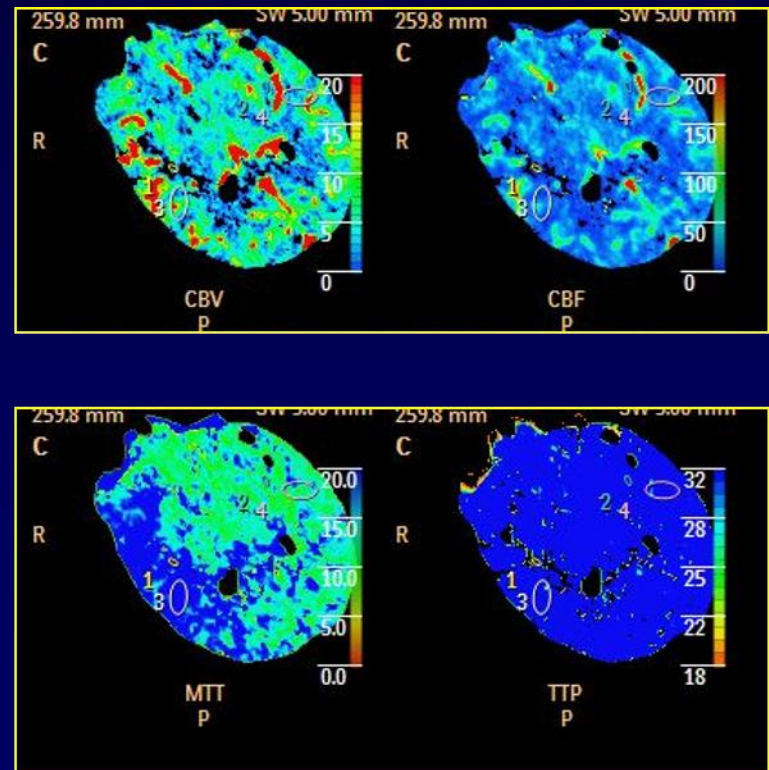
CBV/CBF mismatch
CBV/MTT mismatch



IMAGING ACUTE ISCHEMIC STROKE

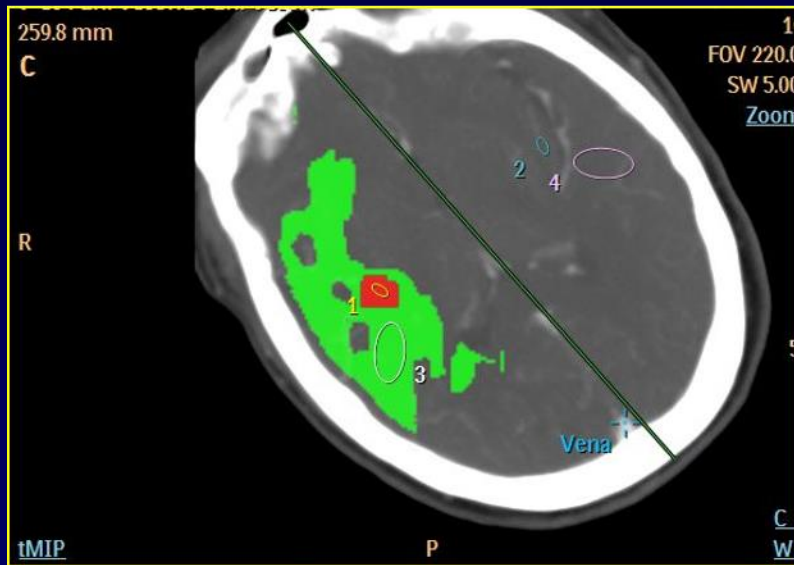
CT-perfusion

Left hemiparesis



IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



Automatically generated map

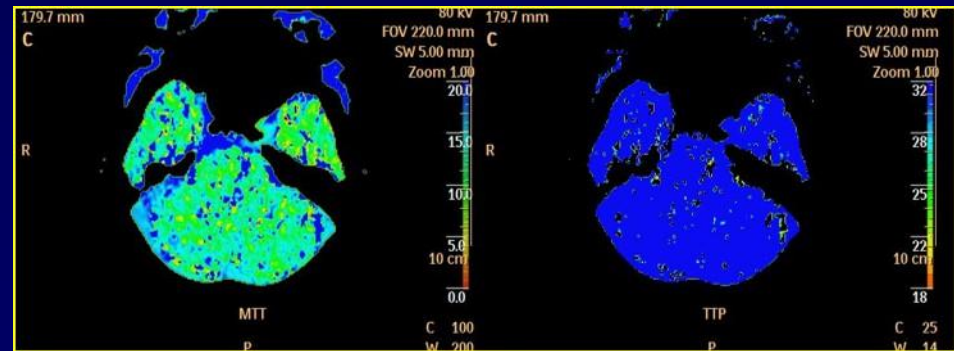
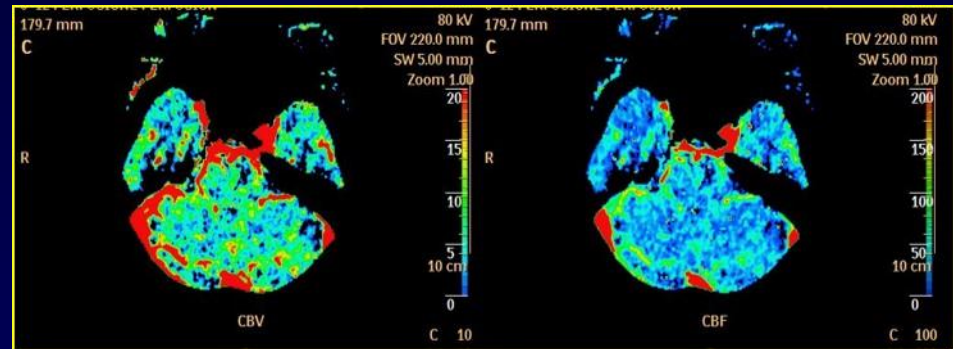


Unenhanced CT-control

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Dysarthria



No mismatch

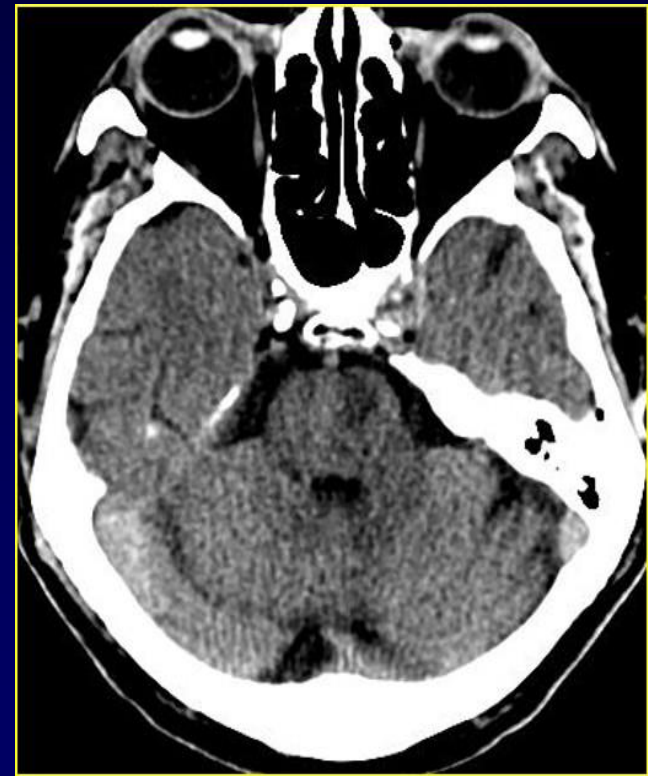
IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Dysarthria



Automatically generated map



Unenhanced CT-control

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Indications

- Thrombectomy
- Symptoms onset > 4.5 hours
- Unknown onset of symptoms
- Patients stratification

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

- thrombectomy
 - Presence of mismatch, large therapeutical window (up to 24 hours if favourable mismatch)
 - Optimal mismatch: core < 70 ml, penumbra > 15 ml, ratio core/penumbra >1.8, Tmax >10 s

Lansberg et Al, Ann Neurol, 2017
Potter et Al, Radiographics 2019
Jovin et Al, Int J of Stroke 2017
Nogueira RG et Al, N Engl J Med 2018
Albers GW et Al, N Engl J Med 2018

IMAGING ACUTE ISCHEMIC STROKE

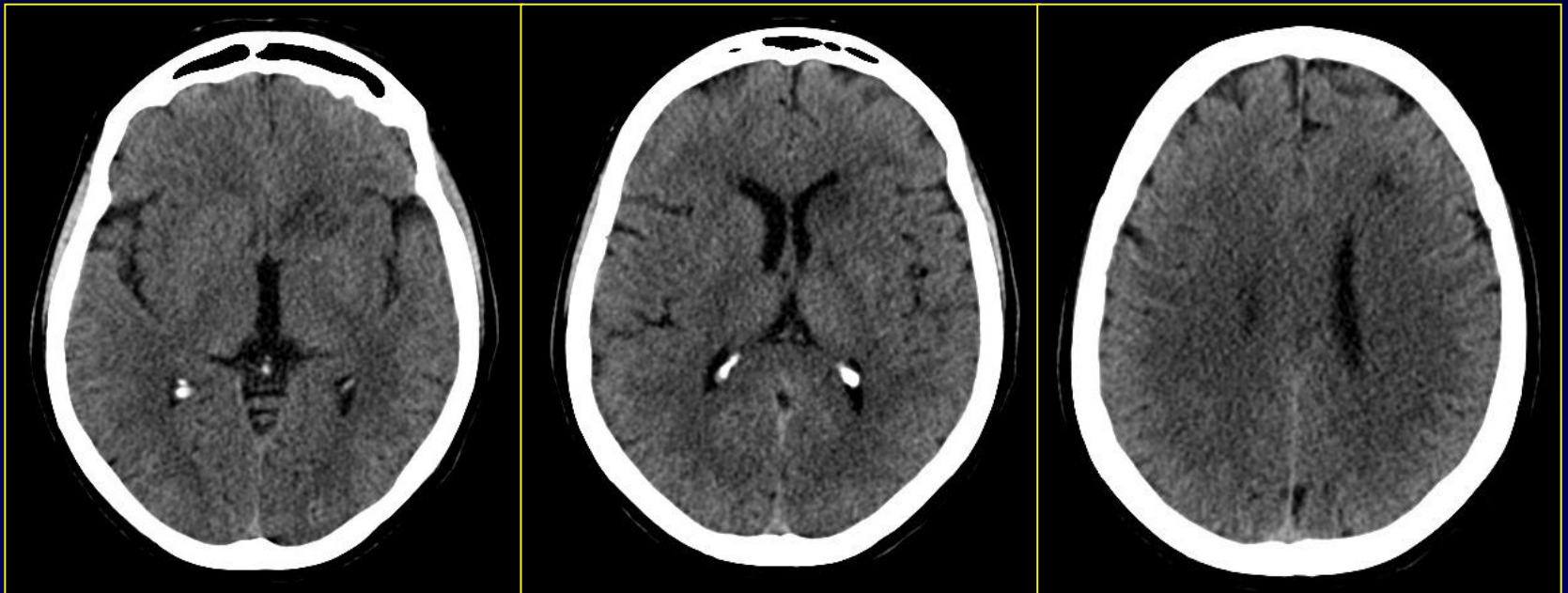
CT-perfusion

- thrombectomy
 - In the absence of mismatch thrombectomy is contraindicated
 - The presence of mismatch is an indication for thrombectomy not always correlate with the outcome
 - Evaluation of collaterals is fundamental
 - *Basilar artery thrombus: treat if possible*

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Aphasia, right hemiparesis



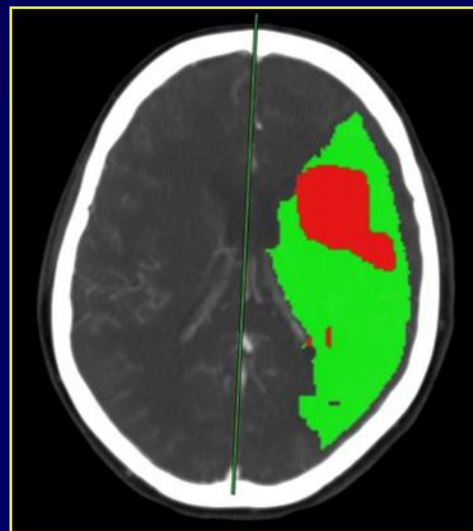
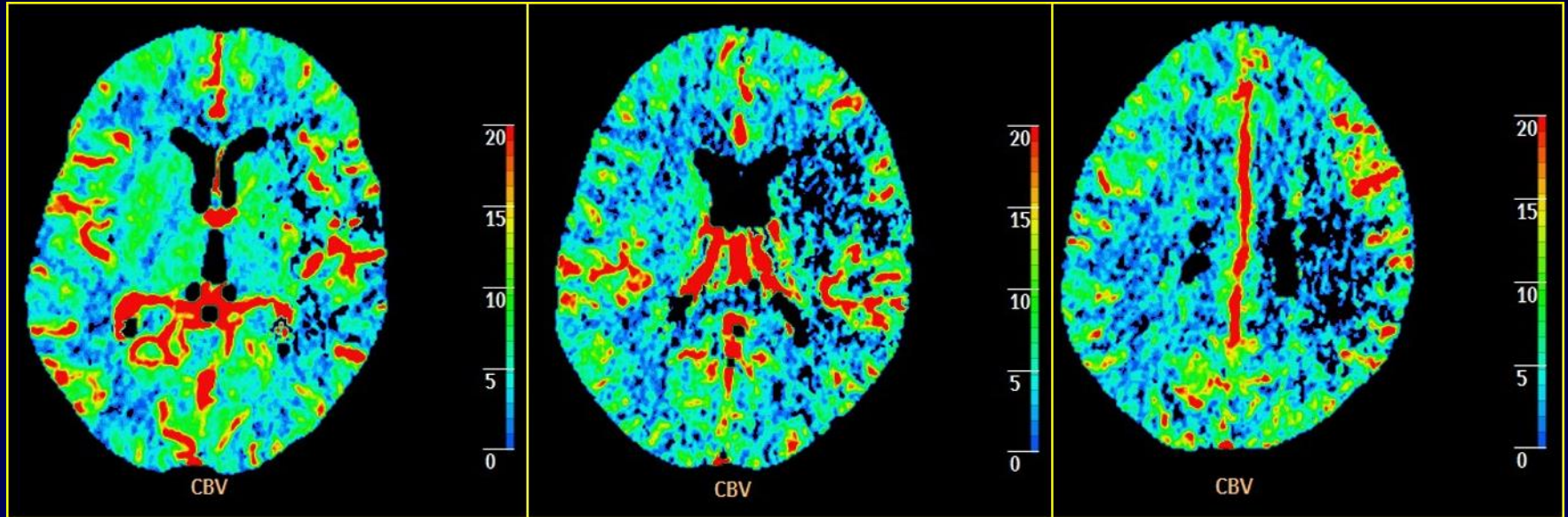
IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



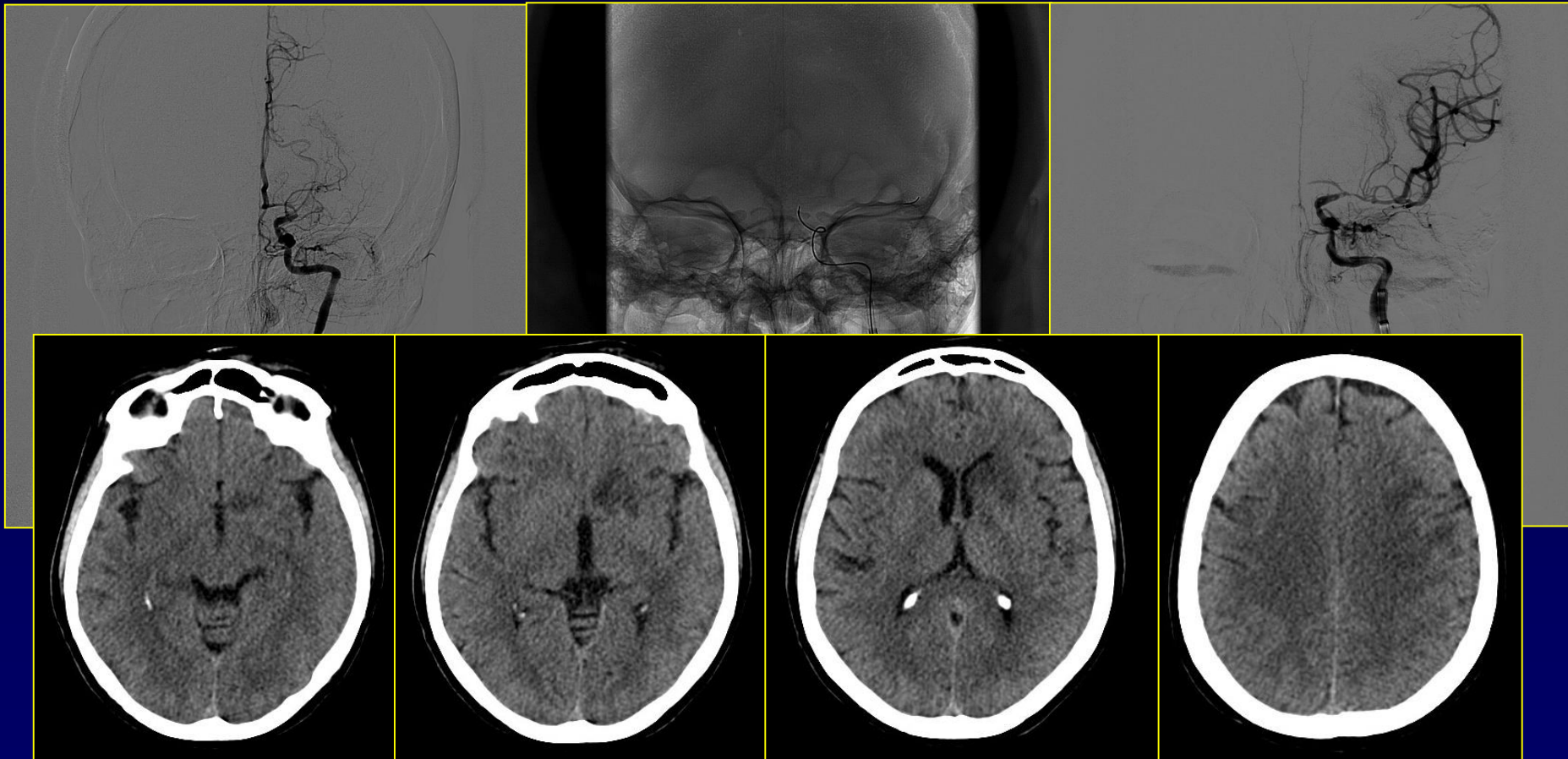
IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



IMAGING ACUTE ISCHEMIC STROKE

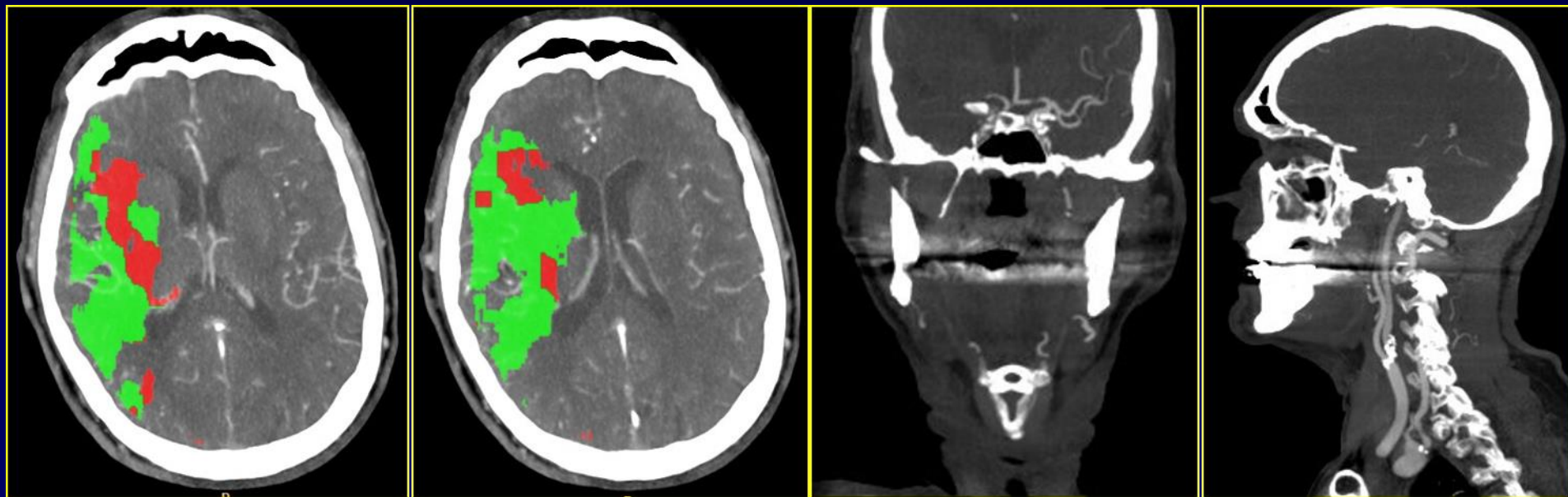
CT-perfusion



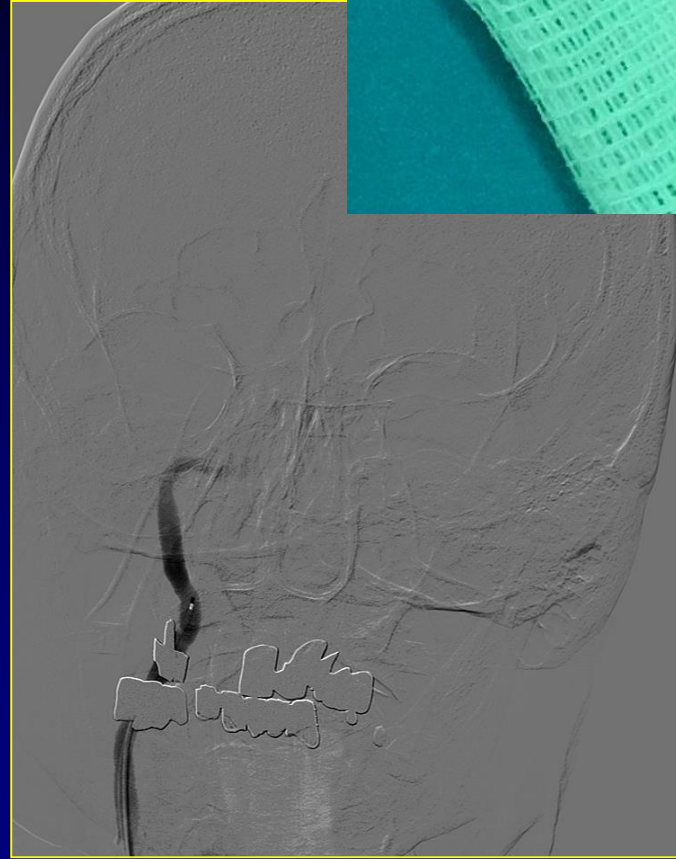
IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Left hemiparesis, 86 years



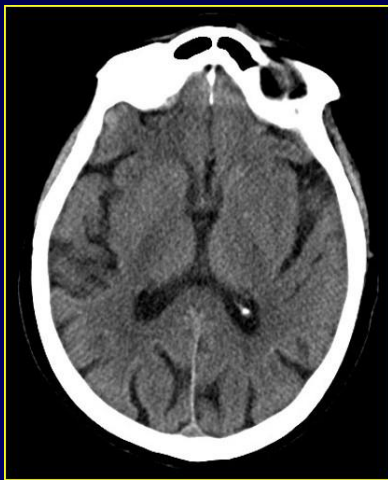
IMAGING ACUTE ISCHEMIC STROKE



IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

- Symptoms onset > 4.5 hours, unknown onset of symptoms
- Identify patients with favourable mismatch, could be treated up to 9 hours



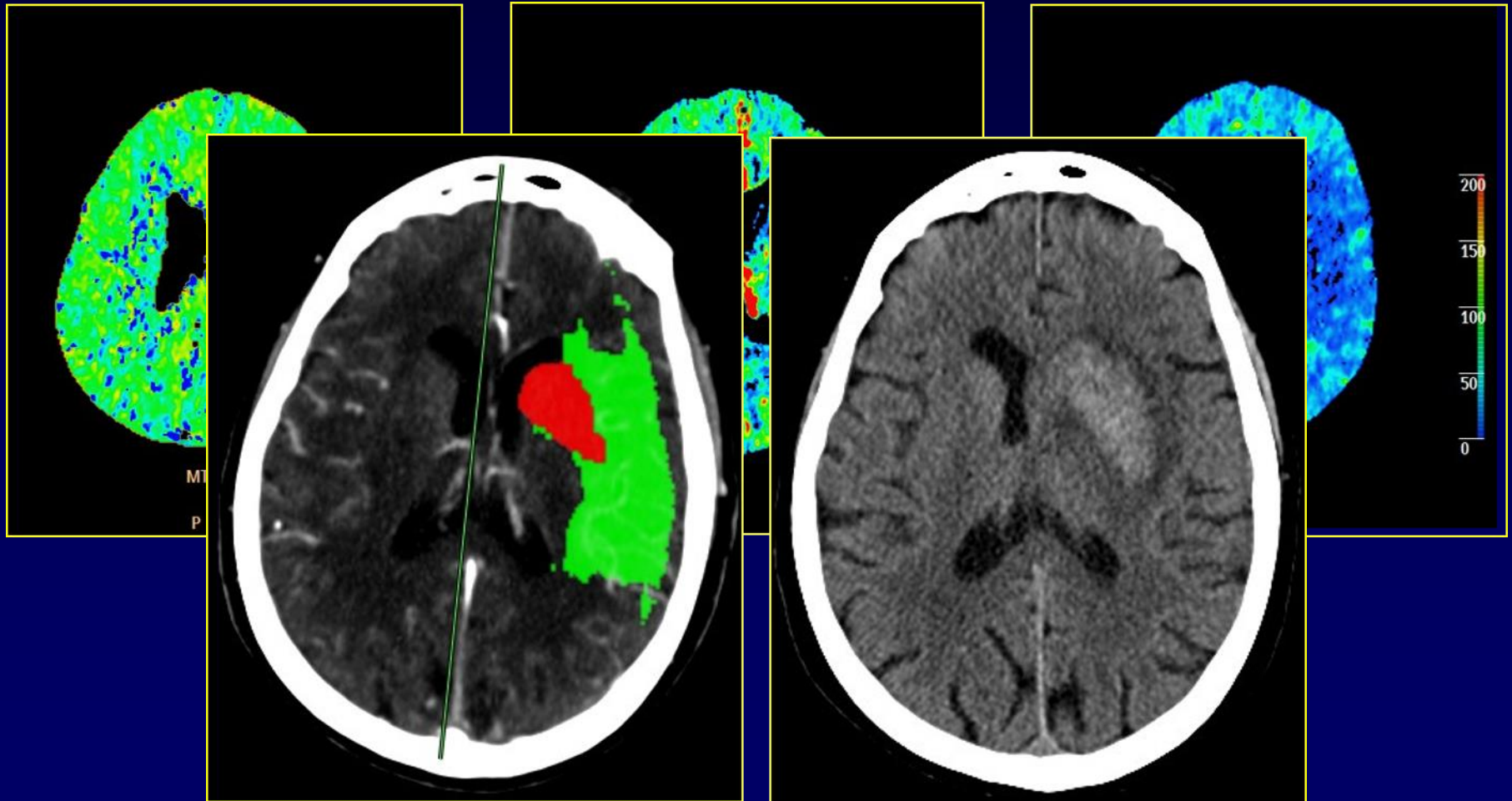
Right hemiparesis



Caruso et Al, Neurol Sci 2018
Campbell et Al, The Lancet 2019

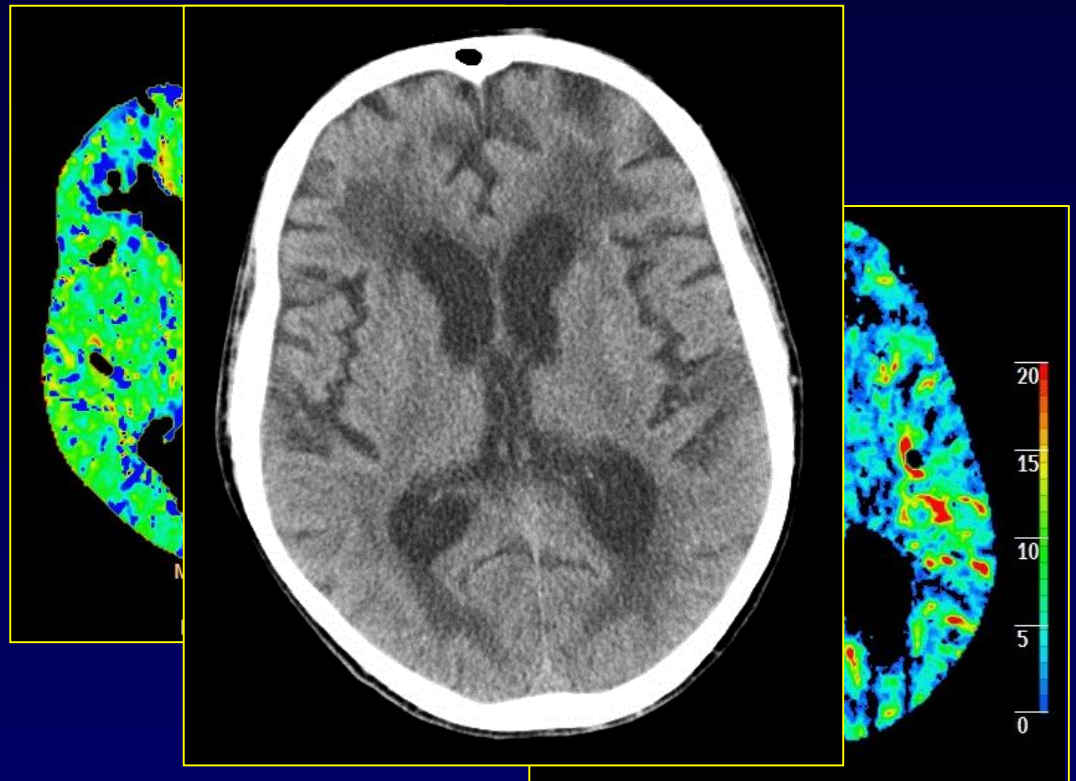
IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion



Right hemiparesis

IMAGING ACUTE ISCHEMIC STROKE

CT-perfusion

Limits

DD between oligoemia and penumbra

- Oligoemia : a window where brain tissue continues to function normally and can remain mildly hypoperfused without progressing to infarction

